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SRI AND ENERGY TRANSFORMATION ON THE WAY TO SUSTAINABLE COMPETITIVENESS

Russia's war against Ukraine turns into a challenge for the whole world. The full scope of consequences is difficult to assess now, but some of them have been already clear. As a result, the world economy is under exposures of inflation, disruptions on GDP growth, food and energy crises and further supply-chain pressures. Energy prices volatility adds uncertainty to the whole system of socio-economic relations. Energy turns into a weapon against the world stability. The paper concentrates on the idea that current situation in the energy sector calls for a prompt response to challenges, including the war consequences. That, in turn, requires sustainable and responsible investment (SRI) and financial innovations for the immediate energy transformation, which is an essential element of the sustainable competitiveness of countries.

The research is aimed at studying interconnection between SRI and energy transformation on the way to sustainable competitiveness.

The processes on the global energy market were investigated and the main weak points which are sources of risks for the world economy were defined. Three significant energy-related weak points which turned into risks for the world are highlighted: the level of dependency from imported gas (for European countries dependency from Russian gas in particular); energy prices volatility; energy structure (nonrenewable vs renewable).

The governmental approaches in the energy transformation sphere, which are caused by the combination of energy security issues and climate ambitions, were generalized. The paper contains an assumption about correlation between SRI and countries' sustainable competitiveness. This hypothesis is confirmed using correlation analysis (biserial correlation) for five countries (Germany, the USA, Canada, Australia and Japan). Strong relationship between these variables is shown. This allows to make a conclusion that increasing of SRI volumes in general and clean energy projects in particular are the predominant conditions for the sustainable competitiveness of the country, which is oriented to the long-term prospective and based on effective usage of all available sources, including energy, fast transformation of energy systems to the renewable sources.

Keywords: energy system transformation, renewable energy, sustainable and responsible investment, global competitiveness index

JEL*: O13, Q01, Q20*

Війна Росії проти України перетворюється на виклик для всього світу. Повний обсяг наслідків зараз оцінити складно, але деякі з них вже зрозумілі. Як результат, світова економіка пе-

ребуває під впливом інфляції, сповільненні зростання ВВП, продовольчої та енергетичної кризи та подальшого тиску на ланцюги поставок. Волатильність цін на енергоносії додає невизначеності всій системі соціально-економічних відносин. Енергія перетворюється на зброю проти світової стабільності. Стаття містить ключову ідею, що поточна ситуація в енергетичному секторі вимагає швидкої реакції на виклики, включаючи наслідки війни. Що, у свою чергу, вимагає стійких та відповідальних інвестицій (SRI) та фінансових інновацій для негайної енергетичної трансформації, що є важливим елементом стійкої конкурентоспроможності країн.

Дослідження спрямоване на вивчення взаємозв'язку між SRI (сталими та відповідальними інвестиціями) та енергетичною трансформацією на шляху до стійкої конкурентоспроможності.

Розглянуто процеси на світовому енергетичному ринку та визначено основні слабкі місця, які є джерелами ризиків для світової економіки. Виокремлено три суттєві слабкі місця, пов'язані з енергетикою, що перетворилися на ризики для світу: рівень залежності від імпортного газу (для європейських країн залежність, зокрема, від російського газу); волатильність цін на енергоносії; енергетична структура (невідновлювана енергія проти відновлюваної енергії).

Узагальнено підходи державної політики у сфері трансформації енергетики, зумовлені поєднанням проблем енергетичної безпеки та кліматичних амбіцій. Стаття містить припущення про кореляцію між SRI та стійкою конкурентоспроможністю країн. Цю гіпотезу підтверджено за допомогою кореляційного аналізу (бісеріальної кореляції) для п'яти країн (Німеччина, США, Канада, Австралія і Японія). Виявлено міцний зв'язок між цими змінними. Це дозволяє зробити висновки, що збільшення обсягів SRI в цілому і проектів чистої енергетики зокрема, є суттєвими умовами стійкої конкурентоспроможності країни, яка орієнтована на довгострокову перспективу і базується на ефективному використанні всіх доступних джерел, включаючи енергію, швидкій трансформації енергетичних систем у бік відновлюваних джерел.

Ключові слова: трансформація енергетичної системи, відновлювана енергетика, сталі та відповідальні інвестиції, індекс глобальної конкурентоспроможності

JEL*: O13, Q01, Q20*

Introduction. Now Ukraine and world suffer from the most significant crisis event of 2022 from a social, political, economic and even ecological point of view - Russian invasion to Ukraine. Serious consequences are projected by world economic organizations. As a result of war, the world's economic recovery from the COVID-19 pandemic is under exposure because of inflation, food security, energy security and further supply-chain pressures.

Russia's aggression against Ukraine has triggered the biggest energy price shock since the 1970s, which is weighing heavily on the world economy.

Since 1970, OECD countries have experienced two big energy crises in 1973 and in 1979 when energy expenditure accounted for 14.3% and 17.8% of GDP respectively. Based on preliminary calculation, in 2022 the estimated share of GDP spent on energy end-use expected to be 17.7% [1]. Current situation in energy sector with growing energy consumption and 84% of nonrenewable energy sources doesn't give a chance for sustainable development and war become a trigger for more intensive transition of energy system. It requires significant investment in clean energy and energy efficiency projects. The abovementioned makes the current research relevant and required.

Literature review. Energy issues are also actively developed by numerous economists and environmentalists. For example, the relationship between economic growth (EG) and energy consumption (EC) for the 34 OECD countries over the period 1990–2015 was investigated by B. Kahouli [2]. Obtained results support a feedback effect between EG and EC, contain suggestions and recommendations about energy and economic policies implications for OECD policymakers. This ensures sustainable economic development and serves as a motivation to search for alternative energy sources to meet the burgeoning energy demand in these countries.

Complex approach to energy sector, economic activity, financial sector and the environment are used by the team of authors and edited by Ch. Floros, I. Chatziantoniou

(2022) in "Application to Energy Finance" [3]. The authors concentrated on the implications of energy sector for stock markets and economic activity in the light of climate change.

Issue of energy prices fluctuation (oil in particularly) and its influence on economic stability was considered by J. Peng, Zh. Li, B. Drakeford [4]. The authors decompose crude oil price fluctuation and construct a model to compare the effects of different types of events on crude oil price fluctuations.

B. M. Kuhn emphasizes that now SDG achievement is under threat again and the next challenge after COVID-2019 is Russian aggression, energy crises and possible food crises. That is why re-directing investment, e.g. from fossil-fuel industries to clean-technology industries, needs political guidance, new laws and regulations and a series of stimuli [5].

World institution's concerns about global war consequences and energy crises are subject of their current reports [1, 6, 7, 8].

Our paper is an attempt of interdisciplinary research of the abovementioned challenge considering specifics of world energy system, war consequences, countries sustainable competitiveness and sustainable investment prospective.

Our **hypothesis** is the following: the growth of SRI and green investment into energy transformation, as part of it, leads to increasing of sustainable competitiveness of countries.

The research purpose is to investigate interconnection between SRI and energy transformation on the way to countries' sustainable competitiveness.

Methods. Traditional and specific methods are used in the research. To describe the general trends in the development of the world economy, processes taking place in the world energy market, analysis and synthesis of the war consequences are used. Method of theoretical generalization is applied to summarize government approaches which are required for energy transformation.

The assessment of price volatility on energy as a source of significant risk for the world economy is conducted on based on 30-years monthly data using statistical risk measures. Data on monthly prices of main energy sources such as oil, gas and coal are analysed.

For the verification of a hypothesis about the correlation between SRI and GCI, the correlation analysis (biserial correlation) method is used. Solving the problems of this class is carried out using the Pearson's point biserial correlation coefficient. Biserial correlation is a method of correlation analysis between two variables, one of which can be measured on a dichotomous scale. The target indicator of the volume of investments in green energy (under the Net zero emissions scenario - NZE) is set at the level of 4,200 billion dollars. [8] Therefore, the SRI variable is expressed through a dichotomous scale using the characteristics 'high/low'.

The main material of the study. In subsequent decades, spending on oil products has been a key driver of the evolution of energy expenditures, reflecting oil's large share in consumption volumes and its relatively high degree of price volatility. In 1979, the second oil crisis due to **decreased oil output** in the wake of the Iranian Revolution resulted in an increase in energy expenditure of 3.5% of GDP over two years and energy expenditure reached 17.8% of GDP. Then after the mid-1980s oil glut spending declined by around 8% and stabilized at around 10% of GDP. It was relatively stable period until the second half of the 2000s, then energy expenditures started to increase again, peaking in 2008 at around 13% of GDP. More than 60% of the increase could be explained by spending on oil products. The relative stability of energy expenditures from the mid-1980s to the early 2000s hid a decline in energy intensity (energy consumed per unit of real GDP) of about 15% which was offset by a similar increase in the relative (weighted) price of energy. Indeed, energy intensity in OECD economies has declined steadily since the first oil crisis (in the year 1973), falling by more than 50% over the period 1971-2021. This was driven by falls in the GDP intensity of oil and

coal, with intensity remaining relatively stable for electricity and increasing for gas. [1, pp. 35-36]

In 2022 Russia's aggression against Ukraine has triggered the biggest energy price shock since the 1970s. **Prices for spot purchases of natural gas have reached levels never seen before, regularly exceeding the equivalent of USD 250 for a barrel of oil.** Coal prices have also hit record levels, while oil rose well above USD 100 per barrel in mid-2022 before falling back. High gas and coal prices account for 90% of the upward pressure on electricity costs around the world. To offset shortfalls in Russian gas supply, Europe is set to import an extra 50 billion cubic metres (bcm) of liquefied natural gas (LNG) in 2022 compared with the previous year. This has been eased by lower demand from China, where gas use was held back by lockdowns and subdued economic growth, but higher European LNG demand has diverted gas away from other importers in Asia [8].

The rise in energy prices has negative consequences for the whole world economy: inflation, recession, falling incomes and purchasing power as a result. Thus, expected pressure on inflation level is 1.3% for OECD countries and 0.7% for world, while forecasted disruptions on GDP growth is estimated at -1.4% in OECD Europe and -0.5% in the world economy [1]. As a result, the UN expects more people to suffer from food insecurity and extreme poverty by year-end. The World Food Programme (WFP) estimates that in 2022, 345 million people will be acutely food insecure or at a high risk of food insecurity in 82 countries [6]. The rapid rise in estimated OECD-wide energy expenditures this year is a warning signal about the near-term risk of widespread recessions among OECD economies [1]. Higher energy prices are also increasing food insecurity in many developing economies for the households with a larger share of income spent on energy and food. Some 75 million people who recently gained access to electricity are likely to lose the ability to pay for it, that means that the total number of people worldwide without electricity access has started to rise. It also has an environmental negative consequence, because almost 100 million people may started again to use firewood for cooking instead of cleaner and healthier solutions [8].

Three significant energy-related weak points which turned into risks for the world could be highlighted: 1) the level of dependency from imported gas (for European countries dependency from Russian gas in particular); 2) energy prices volatility; 3) energy structure (nonrenewable vs renewable).

The level of European economy dependency form Russian gas differs significantly and hesitates from 0% (Croatia, Ireland) to 100% (Bulgaria, Latvia) as for 2021 (Table 1). The biggest EU-economy is Germany and share of Russian natural gas in total natural gas demand is 46% there, the next largest is France which has this indicator on the level 20%, and the next economy by size is Italy and its level of dependency from Russian gas is 41%. These countries have the most demand on natural gas in general (>20 bcm). In 2022, 14 countries stopped partially or completely receiving natural gas from Russia [8].

The crisis has destroyed energy relationships with Russia built on the assumption of trust and secure supplies, and led to a reappraisal of energy security needs in many countries.

However, under such energy structure high energy consumption makes countries vulnerable to uncertainty caused by prices volatility and high level of dependency from imported oil and gas.

Prices for oil (like Crude Oil Brent) during the period 1990-2022 hesitates in a range from 9.16 USD/BBL till 140 USD/BBL, for gas – from 1.04 till 15.78 USD/MMBtu, coal – from 21.25 to 32.82 USD/Metric Ton. Level of risk for all these energy sources based on variation coefficients calculated for 30-years period assessed as high (Fig.1, Table 2). [9,10]

Table 1

Level of dependency of EU members states and the UK from Russian gas, 2021

Country	Market size	Share of Russian gas in total natural gas demand, %
Germany	>20 bcm	46
United Kingdom		3
Italy		41
France		20
Netherlands		36
Spain		11
Poland	10-20 bcm	46
Belgium		7
Romania		6
Hungary	5-10 bcm	78
Austria		74
Czech Republic		67
Portugal		10
Slovak Republic	<5	76
Ireland		0
Denmark		60
Greece		39
Bulgaria		100
Croatia		0
Finland		68
Lithuania		50
Latvia		100
Sweden		14
Slovenia		12
Luxemburg		25
Estonia		46

Source: Data retrieved from [8]

Fig. 1. Prices for energy sources, 1992-2022
Source: plotted by authors based on [9, 10]

Table 2

The risk of energy sources price volatility, 1992-2022

Energy	Dispersion	Standard deviation	Variation coefficient
Oil	1086,74	32,96	0,58
Gaz	4,69	2,17	0,549
Coal	2239,4	47,32	0,664

Source: calculated by authors based on data obtained from [9,10]

The energy sector impacts macroeconomic and financial variables. Meanwhile the recent financialization of crude oil has resulted in energy markets and financial markets coming closer together and they are under influence of the recent debate on climate change and sustainable development [3].

Dependency from dirty energy is a risk and disadvantage not only because of GHG/CO2 emissions which leads to a global warming, risk of not achievement goal of zero-emission, but also as war-supporters and weakness of such country's economies.

In 2020-2021, global primary energy structure on average was the following: oil 31.54%, coal 27.48%, gas 24.9%, hydropower 6.94%, nuclear 4.37%, wind 2.8%, solar 1.55%, other renewables 0.49%. It means that almost 84% belongs to non-renewables and turns into the risks for world economy (authors' calculations based on [11].

It is very clear that a substantial transition towards renewable energy should be made. In the period 1980-2022, global energy production almost doubled, however non-renewable sources prevail in the global energy [3, p. 17]. Despite a rapid increasing in green energy during the last years, it's share remains not high and volume is not sufficient to assure country competitiveness and sustainable development.

And such a transition requires financing. The European Commission (2020) estimated that for the EU alone, more than EUR 270 billion of investment per year would be necessary to achieve an 80% reduction of emissions by 2050 [12]. Globally it is required USD 4200 billion in 2030 to follow the net-zero scenario (NZS) [8]. Besides, energy consumption and economic growth are country/regionally specific. Ways of financing depends also on the stock market or credit market orientation of the country (for example, the USA are more stock market oriented, while the credit market demonstrates a dominating role in Europe). The appropriate research gave evidence that policymakers should facilitate renewable financing through proper policy designs. Financial opportunities and governance issues on country and local levels should go hand in hand [3, pp.17-18; 13; 14; 15; 16]

J. Liu, D. Zhang and others [14] analyses how cross-country differences in legal systems and national governance influence renewable energy investment in an international context. Authors gave a new insight into how the contention between economic gains and long-term environmental goals has retarded the transition from fossil fuels to non-polluting sources of energy, suggesting how this can be ameliorated by favorable government policies, benign regulation and financial support from government, creditors and investors to stimulate private-sector investment. Their research is based on the legal origin theory, which argues that differences between legal systems give rise to differences in the ways business systems function. The theory maintains that *a common law system* supports shareholder protection and a laissez-faire, market-driven approach; whereas *a civil law system* takes a stakeholder view, prompting government and regulatory intervention in public policy [14]. Empirical studies offer support for the thesis that the regulatory frameworks of common law countries tend to encourage market value-driven investment in renewable energy sources.

In common law systems, well-developed and strongly regulated stock

markets dominate, protecting shareholders by enforcing corporate transparency and accountability, under-pinned by company law and mandatory accounting standards [17]. While policies in civil law countries, and especially those in Scandinavia with the highest corporate social responsibility ratings [18], tend to encourage investment in renewable energy sources. Accent here should be made on banking system because in civil law countries universal banking takes a more active role, mobilizing capital, overseeing investment decisions of corporate managers, providing risk management vehicles, exerting central control and imposing regulation [14].

The authors concluded that:

1) more universal agreed world policy aimed to transformation on sustainable energy is required ("creation of a system of global governance to coordinate the world's response to the climate change crisis, extending and enforcing mandatory regulations and supra-national strategies and action plans'' [14, p. 605];

2) social acceptance is critical to success, especially at this stage of consolidation in sustainable energy development;

3) creation of sustainable business models to support renewable energy development;

4) commercial and socially acceptable financial support mechanisms need to be developed (innovative financial tools, securities, easy access to capital, marketplace lending, crowdfunding, etc.)

So, countries should use this crisis to take short, medium and long-term measures in government energy policy and invest in safeguarding the UN Sustainable Development Goals and accelerate efforts to limit global warming to 1.5°C. [6]. Governments need to ensure that the goals of energy security and climate change mitigation are aligned. The scope of supply- and demand-side measures have to be implemented: alternative fuel supplies, adequate gas storage, increasing electrification, financing of new renewables projects; energy efficiency increasement [1, p.33].

Reducing the material supply chain bottlenecks, diversifying suppliers and boosting manufacturing capacities, especially in developing countries, are key measures to accelerate the energy transition to low-carbon supply [6].

According to the United Nations and McKinsey recommendations for actions that governments could take to unlock these solutions include the following:

1. Accelerate permitting for new renewables projects (wind, solar).

2. Improve energy efficiency through public interest and financing programs.

3. Rapidly electrify fossil fuel–intensive industrial processes.

4. Develop and move quickly on strategies to secure equipment and raw materials for the energy transition.

5. Scale up the workforce needed to enable the clean-energy transition, to build human resource capacity.

6. Invest in temporary floating storage regasification units (FSRUs) on short-term contracts [6; 7].

Empirical studies also concluded that way to sustainability comes through change the world energy infrastructure and substantial transformations towards renewable energy; appropriate financing (SRI, innovative financial products); supporting investment in energy transition by proper governance and by improving energy efficiency (incl. innovations) [3; 14]. Based on the results of scientific elaboration, it is visible that there is a very strong motivation for EU countries to search for alternative energy sources to meet the burgeoning energy demand and ensure sustainable economic development. As a suggestions and recommendations about energy and economic policies implications for OECD policymakers there are the following: first of all, invest in production infrastructure using renewable energy (hydro, solar, wind); secondly, integrate energy into national and sectoral development strategies; thirdly, promote the establishment of new production units in the industrial sector [2].

Global renewable power capacity is now expected to grow by 2,400 gigawatts (GW) over the 2022-2027 period. It is equal to the power capacity of China currently [19].

The global energy crisis has kicked renewables into an extraordinary new phase of even faster growth as countries seek to apitalize on their energy security benefits. The world is set to add as much renewable power in the next 5 years as it did in the previous 20 years," said IEA Executive Director Fatih Birol. "This is a clear example of how the current energy crisis can be a historic turning point towards a cleaner and more secure energy system. Renewables' continued acceleration is critical to help keep the door open to limiting global warming to 1,5 °C." [19]

The war in Ukraine is a decisive moment for renewables in Europe where governments and businesses are looking to rapidly replace Russian gas with alternatives.

For the reduction of the future price volatility and getting track for zero emissions by 2050, a significant increase in energy investment is essential. According to the estimation based on different scenario, investment should be increased from USD 1.3-1.4 trillion today till above USD 2-2.5 trillion by 2030 in the **Stated Policies Scenario (**STEPS) or till above USD 4 trillion in the net-zero emission (NZE) scenario. The role of the government here is to develop a strategic view, a system of incentives for private investors. Today, for every USD 1 spent globally on fossil fuels, USD 1.5 is spent on clean energy technologies. By 2030, in the NZE Scenario, every USD 1 spent on fossil fuels is outmatched by USD 5 on clean energy supply and another USD 4 on efficiency and end-uses [8].

As a financial source for transition, they consider private capital attracting in volume of 2/3 of the required general investment in clean energy. There is an important role of decentralization within the EU-discussion on energy sector transformation also. For example, Germany discusses the project "Energy sharing". According to the estimation, more than 90% of German households could participate in the energy sharing. This project can assure 35% of the required energy and requires EUR 6.5-12.8 billion of private investment.

Clean energy becomes a huge opportunity for growth and jobs, and a major arena for international economic competition. There are some examples of targets and initiatives all over the world. Due to the US Inflation Reduction Act, in the USA by 2030 annual solar and wind capacity additions grow 2.5 times over today's levels, while electric car sales increase in 7 times. New targets continue to increase clean energy in China, meaning that its coal and oil consumption will peak before the end of this decade. Faster deployment of renewables and efficiency improvements in the European Union bring down EU natural gas and oil demand by 20% this decade, and coal demand by 50%, a push given additional urgency by the need to find new sources of economic and industrial advantage beyond Russian gas. Japan's Green Transformation programme gives a big funding boost for technologies including nuclear, low-emissions hydrogen and ammonia. And Korea is also attempting to increase the share of nuclear and renewables in its energy structure. India makes further progress towards its domestic renewable capacity target of 500 gigawatts (GW) in 2030, and renewables meet nearly 2/3 of the country's demand for electricity [8].

Sustainable and responsible investment (SRI) considers like a mechanism for accumulation of the required financial sources for the energy transformation [6; 7; 14].

The appearance and evolution of SRI demonstrated its development as a new institute. It is a new paradigm, community reaction on challenges and deep changes in the system of economic relations on the way to sustainable development. The volume of global SRI reached USD 35.3 bln and demonstrated the growth at 165% on the last decade. Share of assets which are managed sustainably is near 36% all over the world (Table 3).

Table 3

SRI volumes, bln. USD

Region	2012	2014	2016	2018	2020
EU	8,758	10,744	12,039	14,100	12,016
USA	3,740	6,572	8,723	11,995	17,081
Canada	589	728	1,086	1,699	2,423
Australia and New Zealand	134	148	515.7	734	905.7
Japan	10	7	474	2,180	2,874
Total	13,300	18,900	22,890	30,683	35,301
SRI share in total assets under management, %	21.50	31.20	26.30	31.2	35.9

Source: GSIA reports, 2012-2021 [20]

The more and more attention of institutional and private investors is paid to ESG-factors, and climate change has become a salient issue for investors. Obviously, they need some more time for deeper understanding and reflection and also there is a need in time to see this shift [21]. It is visible now in the USA and will be seen in the global scope soon.

SRI mechanism includes issuers which are follow ESG-issues, sustainable and responsible institutional and private investors. There are opportunities to issue stocks and bonds with green orientation. Green bonds have a great potential for direct clean energy projects financing [3].

SRI influences the country's competitiveness. Analyses of different competitiveness and sustainability indexes show that environmental footprint, renewable energy consumption share, energy efficiency, energy efficiency regulation and renewable energy regulation are important indicators of countries' competitiveness on the way to a sustainable development. Let's take well-known Global competitiveness index (GCI) of World Economic Forum which covers 12 pillars and clearly demonstrates now that "there are no inherent trade-offs between economic growth and social and environmental factors if we adopt a holistic and longer-term approach" [22].

Turning back to the research hypothesis, we investigate interconnection between SRI and GCI.

For calculations, the method of correlation analysis - biserial correlation (Table 4) was used. Solving the problems of this class is carried out using the Pearson point biserial correlation coefficient. Biserial correlation is a method of correlation analysis between two variables, one of which can be measured on a dichotomous scale.

The target indicator of the volume of investments in green energy (under the Net zero emissions scenario - NZE) is set at the level of 4,200 billion dollars [8]. Therefore, the SRI variable can be expressed through a dichotomous scale using the characteristics 'high/low'.There are some assumptions in the conducted analyses due to the availability of specific data. GSI for EU region is taken as index for Germany, which is the biggest economy in the EU.

If variable X is measured on a strong scale, and variable Y is measured on a dichotomous scale, then the point biserial correlation coefficient is calculated using the formula

$$r_{pb} = \frac{\bar{x}_1 - \bar{x}_0}{s_x} \cdot \sqrt{\frac{n_1 n_0}{n(n-1)}}, \qquad (1)$$

where $\bar{x}_1$ – average value for X objects with a value of "unit" by Y;

$\bar{x}_0$ – average value for X objects with a value of "zero" by Y;

s_x – average square deviation of all values by X;

Table 4

Calculations for the point biserial correlation coefficient determining

Average GSI, 2012–2020 pp., x_i		Average SRI, 2012–2020 pp. (bln USD), Y	Dichotomous scale for Y		$x_i - \bar{x}$	$(x_i - \bar{x})^2$	Y 1	Y 0
Germany/EU	28.97	11,531.40	high	1	0.28	0.08	28.97	
USA	29.46	9,622.20	high	1	0.77	0.59	29.46	
Canada	28.37	1,305.00	low	0	-0.32	0.10		28.37
Australia	27.82	487.48	low	0	-0.87	0.75		27.82
Japan	28.82	1,109.00	low	0	0.13	0.02		28.82
Total	143.45					1.54	58.43	85.02

Source: calculated by authors based on [20; 23]

n_1 – number of objects "unit" by Y, n_0 – number of objects "zero" by Y;

$n = n_1 + n_0$ – sample size.

The point biserial correlation coefficient can also be calculated using other equivalent formulas:

$$r_{pb} = \frac{\bar{x}_1 - \bar{x}}{s_x} \cdot \sqrt{\frac{n_1 n}{n_0 (n-1)}}, \quad (2)$$

$$r_{pb} = \frac{\bar{x} - \bar{x}_0}{s_x} \cdot \sqrt{\frac{n_0 n}{n_1 (n-1)}}, \quad (3)$$

where $\bar{x}$ – total average value for variable X.

The conditions of the dichotomous scale for the variable Y are: $n_1 = 2$, $n_0 = 3$; sample size $n = 5$; the number of degrees of freedom $df = 3$.

We find the average values for the variable X and the mean square deviation S_x and the value of the point biserial correlation coefficient:

$\bar{x} = 28.69$; $\bar{x}_1 = 29.22$; $\bar{x}_0 = 28.34$;

$S_x = 0.56$;

$$r_{pb} = \frac{\bar{x}_1 - \bar{x}_0}{s_x} \cdot \sqrt{\frac{n_1 n_0}{n(n-1)}} = 0.86.$$

$$r_{pb} = \frac{\bar{x}_1 - \bar{x}}{s_x} \cdot \sqrt{\frac{n_1 n}{n_0 (n-1)}} = 0.86.$$

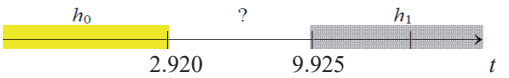
$$r_{pb} = \frac{\bar{x} - \bar{x}_0}{s_x} \cdot \sqrt{\frac{n_0 n}{n_1 (n-1)}} = 0.86.$$

Point biserial coefficient r_{pb} takes values in the range from –1 to +1. We examine the hypothesis about the significance of the point biserial correlation coefficient using the Student's test. The empirical value of which is calculated by the formula

$$|t| = \frac{|r_{pb}|}{\sqrt{1 - r_{pb}^2}} \cdot \sqrt{n-2}.$$

$$|t| = \frac{0.86}{\sqrt{1 - 0.86^2}} \cdot \sqrt{3} = 2.97$$

We find the critical values of the Student's criterion $t_\alpha(df)$ in statistical tables for the number of degrees of freedom df = 3.



If the condition $|t| \le t\alpha(df)$ is fulfilled, the null hypothesis $\rho = 0$ is accepted. If the condition $|t| > t\alpha(df)$ is fulfilled, then the null hypothesis $\rho = 0$ is not accepted. Empirical value of $|t| = 2.97$ and falls into the critical region, which allows rejecting the null hypothesis $\rho = 0$.

The correlation coefficient ($r_{pb} = 0{,}86$) is significantly different from zero, and therefore we have a *close/strong* relationship between SRI and GCI.

The use of Microsoft Excel to perform correlation analysis and determine the relationship between SRI and GCI also gave results that indicate the existence of a moderate relationship between the specified variables.

These calculations were performed using the function wizard and the necessary category - statistical and Correl functions.

So, we have $\rho = 0{,}75$. The density of the linear relationship between the SRI and GCI variables is defined as *close/strong.*

The coefficient of determination in this case is equal to $R^2 = 0{,}57$

The coefficient of determination is a dimensionless integral value varying from 0 to 1 (it is often expressed as a percentage). It shows the proportion of total variation in one variable due to variability in another variable.

Now we should give a statistical assessment of the performed calculations, that is, examine the adequacy of the considered event. To do this, it is necessary to compare the calculated values of the coefficient $\rho = 0.75$ with the table index r_{crit}.

We find that for the level of significance $\alpha = 0.05$ (that is, the probability of an acceptable error in the forecast) and the given number of measurements n=5, the table value $r_{crit} = 0.754$.

As can be seen, the relation $|r_{calc} \geq r_{crit}|$, is fulfilled, and therefore with 95% confidence it can be assumed that there is a correlation between the considered numerical population.

Thus, the results of the study indicate a strong relationship between SRI and GCI.

Correlation analysis, which was conducted, allows to make conclusions that increasing of SRI volumes in general and clean energy projects in particular, are predominant conditions for the sustainable competitiveness of country, which is oriented to the long-term prospective and based on effective usage of all available sources, including energy, fast transformation of energy systems to the renewable sources. All the above mentioned will lead to the decreasing of risks for countries' economies and sustainable development achievement in a global scope.

Conclusions. The paper investigates the processes taking place in the global energy. And it was concluded that Russia's aggression against Ukraine had triggered the biggest energy price shock since the 1970s. This energy crisis affects on the world economy: inflation, recession, falling incomes and purchasing power.

The analysis of the current structure of energy consumption showed that the energy structure is unsatisfactory, the level of renewable sources is only 16%. It leads to risks for the world economy and doesn't give a chance for sustainable development. Three main weak points which are sources of risks for the world economy were defined and deeper analyzed: 1) the level of dependency from imported gas (for European countries dependency from Russian gas in particular); 2) energy prices volatility; 3) energy structure (nonrenewable vs renewable).

The research helped to realize that war gave a strong impulse for more intensive transition of energy system and substantial transition towards renewable energy should be made to overcome crisis and increase the level of energy safety. Despite a rapid increasing in green energy during the last years, it's share remains not high and volume is not sufficient to assure country competitiveness and sustainable development.

Generalization of governmental policy in the energy transformation sphere led to conclusions that countries should use current crisis to take short, medium and long-term measures in government energy policy and invest in safeguarding the UN Sustainable Development Goals: financing of new renewable projects; energy efficient improvement; rapid electrification; fast development and fulfilment of energy transition strategies, enlarging of required workforce; investing in FSRUs; alignment of energy security goals and climate change mitigation.

The conducted analysis led to the opinion that the higher level of addictiveness of not green energy, the worse the situation: the less probability of sustainable development achievement, the more risks because of volatility of prices for energy sources and environmental threats. Climate change has already become a salient issue for investors and SRI is considered as a mechanism for accumulation of the required financial sources for the energy transformation.

Correlation analysis, which was carried on, allows to make conclusions that increasing of SRI volumes in general and clean energy projects in particular are predominant conditions for the sustainable competitiveness of country. Sustainable competitiveness is based on effective usage of all available sources, including energy, fast transformation of energy systems to the renewable sources and orientation to the long-term perspective. In a global scope this will contribute to the diminishing of risks for countries' economies and sustainable development achievement.

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SRI AND ENERGY TRANSFORMATION ON THE WAY TO SUSTAINABLE COMPETITIVENESS

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Russian war against Ukraine turns to challenge for the whole world. The full scope of consequences is difficult to assess now, but some of them have been already clear. As a result, the world economy is under exposures of inflation, disruptions on GDP growth, food and energy crises and further supply-chain pressures. Energy prices volatility adds uncertainty to the whole system of socio-economic relations. Energy turns to weapon against the world stability. The paper concentrates on the idea that current situation in the energy sector calls for a prompt reaction on challenges, including war consequences. That, in turn, requires sustainable and responsible investment (SRI) and financial innovations for immediately energy transformation, which is an essential element for sustainable competitiveness of countries. It is also crucial not to lose a track for net zero emissions by 2050. Such investment which combines financial goals with ecological, social and governance issues are covered by umbrella term "sustainable investment". Sustainable investment became a strong trend on global financial market, which is popular with institutional and private investors. Investment in renewable energy is a part of SRI and countries' sustainable competitiveness depends on the SRI volumes.

The research is aimed at studying interconnection between SRI and energy transformation on the way to sustainable competitiveness.

The processes on the global energy market are investigated and main weak points which are sources of risks for the world economy are defined. Three significant energy-related weak points turned into risks for the world are highlighted: the level of dependency from imported gas (for European countries dependency from Russian gas in particular); energy prices volatility; energy structure (nonrenewable vs renewable).

It is generalized governmental approaches in the sphere of energy transformation driven by a combination of energy security concerns and climate ambitions. The paper contains an assumption about correlation between SRI and countries' sustainable competitiveness. This hypothesis is confirmed using correlation analysis (biserial correlation) for five countries (Germany, the USA,

Canada, Australia and Japan). Strong relationship between these variables is shown. This allows to make conclusions that increasing of SRI volumes in general and clean energy projects in particular, are predominant conditions for the sustainable competitiveness of country, which is oriented to the long-term prospective and based on effective usage of all available sources, including energy, fast transformation of energy systems to the renewable sources.

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