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IN SEARCH OF A FINANCIAL MODEL FOR A SUSTAINABLE ECONOMY

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Abstract. The links between the real and financial spheres are well recognized in the literature. However, under the conditions of sustainability, both the perception of the real and financial spheres, as well as the relations between them, change. The aim of this article is to show that sustainable finance has an impact on building a sustainable economy, and the model of sustainable finance increases the degree of adjustment of the financial sphere to the real economy. The research was conducted based on 86 articles. The methodology is based on log-linear models. As a result, it was proved that sustainable enterprises and finances are the factors that most frequently interact with other variables describing a sustainable economy. The study proposes the financial model for sustainable economy, this is the main novelty and contribution of the study. The original contribution of the study includes: the comprehensive analysis of the factors and relationships between sustainability, economy and finance; building a triple layered finance model for sustainable economy taking into account governance, society and environment from sustainable perspective; proposing the model of financing for the circular economy in terms of sustainability in terms of the process and defining the model of sustainable finance 4.0.

Keywords: sustainable economy, sustainable finance, financial model, sustainability, circular economy, triple layered model.

JEL Classification: G14, G15, G18, G21, G23, O16, O44, Q01.

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Introduction

The real and financial spheres are changing in terms of sustainability and non-financial risk (Söderholm, 2020). As a consequence, both economic models (including circular economy) and models of its financing (sustainable financing) are changing (Schoenmaker, 2020). The

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financial sphere is a derivative of events and operations taking place in the real economy, but it can also stimulate this economy to develop in the desired directions, ensuring a better match between the real and financial spheres (Park & Kim, 2020). Both for the real and financial spheres, a significant stimulus for change is sustainability, which conditions decision-making processes in both spheres, as well as the approach to managing the risk of non-financial factors (Deloitte, 2018).

Matching the real and financial spheres is important from the point of view of achieving the goals of sustainable development and thus the effectiveness of activities in this area (Monkelbaan, 2021). Building a sustainable economy takes place through the implementation of SDGs, and at the same time it is not possible without the effective financing of these goals with the use of financing sources dedicated to sustainable development (Sustainable Development Goals, 2019).

There is a research gap in the field of research into factors and relationships between the financial model and the economic model. Few publications are devoted directly to this issue (Ziolo et al., 2021). Typically, studies focus on the relationship between sustainability and the economy (green, sustainable, circular) (D'Amato et al., 2017), sustainability and finance (Fullwiler, 2015), or the achievement and financing of SDGs (Morton et al., 2017). The original approach presented in the article is expressed through a comprehensive analysis of the factors and relationships between sustainability, economy and finance, which fills the gap in the existing achievements. The contribution to the current state of knowledge is the proposition of an original financing model for the economy under the conditions of sustainability. The article diagnoses the state of knowledge in the field of factors influencing building a sustainable economy with particular focus on the role of sustainable finance. For this purpose, 86 articles were analyzed, which allowed to define the subject, and thus the scope of the study.

The aim of the article is to show that sustainable finance has an impact on building a sustainable economy, and the model of sustainable finance increases the degree of cohesion of the financial sphere with the real economy. The analysis of the literature that the sustainable finance model increases the degree of adjustment of the financial sphere to the real economy and ensures a more effective spread of the process of self-sustaining development in relation to the traditional model. Furthermore the following research questions were raised:

- What is the state of research on the real and financial spheres under the conditions of sustainability?
- Which of the factors have the greatest impact on building a sustainable economy and does the geographic and topographic factor influence the strength of this impact?
- Does the model of the financial system matter in the discussion on the influence of finance on the real sphere in terms of sustainability?
- What recommendations should be formulated in the field of the sustainable finance model to ensure its best adjustment to the real economy?

The paper is organized as follows: in Section 1, the theoretical aspects related to finance, economy and sustainability are presented. Section 2 the methodological approach, data collection procedure, and description of the methods are described. Section 3 discusses the research results, and the last Section is the conclusion.

1. Literature review

Limited natural resources and growing awareness of the impact of human activities on the environment result in growing importance of the concept of sustainable development, which is confirmed by the increasing number of scientific publications on this subject. The review of the literature on sustainable development allowed authors to distinguish the main directions of the research conducted in this area (Table 1).

The concept of sustainable development is implemented through the realization of the sustainable development goals. Research in this area focuses on the analysis of the impact of SDG on the way companies operate (strategies) and investors' decisions in the capital market (responsible investing). Relations between SDGs and finance are also examined, including sustainable finance and Islamic finance.

The dissemination of the concept of sustainable development has contributed to the increased interest in the circular economy concept, which is analyzed both in relation to SDG and sustainable development. In the literature, there are studies that treat the circular economy as both a necessary condition for a sustainable economy (United Nations Environment Programme [UNEP], 2006) and a necessary but insufficient condition (Nakajima, 2000).

Table 1. Research directions in the field of sustainable development

	Research directions
Sustainable Development Goals	– impact on development (Gupta & Vegelin, 2016) and enterprises (Pedersen, 2018; Mio et al., 2020; Garcia-Sanchez et al., 2020; Haffar & Searcy, 2018), – relationship with finance (Sachs, 2015; Sachs et al., 2019; Georgeson & Maslin, 2018; Kedir et al., 2017; Kharas et al., 2015; Nilsson et al., 2016; Khattak, 2019), sustainable finance (Ziolo et al., 2021), Islamic finance (Khan, 2019), – policy coherence to achieve SDGs (Collste et al., 2017), – responsible investing (Khan, 2019; Liang & Renneboog, 2020; Soppe, 2009), – circular economy (Sharma et al., 2021; Schroeder et al., 2019; Rodriguez-Anton et al., 2019; Dantas et al., 2021), – risk ESG (Folqué et al. 2021, Lokuwaduge & Heenetigala, 2017; Muñoz-Torres et al., 2018).
Sustainable development and economy	– economy (Gambetta et al. 2019, Haffar & Searcy, 2018), – circular economy (Suárez-Eiroa et al., 2019; Geissdoerfer et al., 2017; Andesen, 2017; Allwood, 2014; Bocken et al., 2014), – green economy (Bina, 2013; Aldieri & Vinci, 2018; Barbier, 2011; Marco-Fondevila et al., 2018; UNEP, 2020), – business model, sustainable model business, business model innovation (Breuer et al., 2018; Schoormann et al., 2016; Geissdoerfer et al., 2018; Lüdeke-Freund et al., 2018).
Sustainable development and finance	– financial system (Aspinall et al., 2018; de Carvalho Ferreira et al., 2016), – sustainable finance (de Carvalho Ferreira et al., 2016; Ryszawska, 2016; Zioło et al., 2021; Wang et al., 2019; Schoenmaker, 2018; Fullwiler, 2015; Pisano et al., 2012), – green financing (Muktadir-Al-Mukit & Hossain, 2020; Stephens & Skinner, 2013; Schmidt-Traub & Sachs, 2015), – climate finance (Steckel et al., 2017; Dasgupta et al., 2019), – banking sector (Kumar & Prakash, 2020; Liang et al., 2018; Razaque & Nayak, 2017, Hwang et al., 2017; Nosratabadi et al., 2020), – risk ESG (Mezzanotte, 2020; Sciarelli et al. 2021).

There are also studies showing a negative relationship between the circular economy and sustainable development (Andersen, 2007).

The impact and importance of green economy for sustainable development are also the subject of research. Barbier (2011) points out that the transition to the green economy requires overcoming market, political and institutional barriers. In the financial dimension, filling the gap between the benefits of the created ecosystems and the costs of their maintenance becomes a challenge for sustainable development. Another subject of interest is the impact of the concept of sustainable development on business models of enterprises, including sustainable business model and business model innovation. Cross-sectional studies in this area were carried out by Geissdoerfer et al. (2017). Bocken et al. (2014) developed a sustainable business model archetypes that are widely used in scientific research.

The implementation of sustainable development is impossible without effective financing. The relationships between sustainable development and finance have been the subject of research by Aspinall et al. (2018) and Wang et al. (2019). Ryszawska (2016) drew attention to the importance of sustainable finance in the transformation of the economy towards sustainability. Stephens and Skinner (2013), on the other hand, emphasized the importance of banks for the implementation of sustainable development, especially in the social and environmental aspect. Nosratabadi et al. (2020) indicated that the implementation of a sustainable business model by banks translates into economic (cost reduction) and non-economic (reputation) benefits and may be a source of competitive advantage.

The role of banks and the tools they use to support the transformation of the economy towards sustainable development are different depending on the applicable banking system model: Anglo-Saxon or German-Japanese. Banks provide most of the capital in the German-Japanese model, while in the Anglo-Saxon model, this role is performed by the capital market. Therefore, in the case of the German-Japanese model, the terms of the loan agreement with the bank are of greater importance, and in the case of Anglo-Saxon model – the sustainable bonds.

An important direction of research is also the analysis of the role and significance of ESG risk. The concept of sustainable development requires considering non-financial risk in the decision-making process (Deloitte, 2018). Research in this area was conducted, among others, by Folqué et al. (2021), Lokuwaduge and Heenetigala (2017), and Mezzanotte (2020). Sciarelli et al. (2021) showed that the inclusion of ESG factors in the decision-making process is integrated into the concept of responsible investing.

The economic transformation toward sustainability should be conducted in such a way that the increase in the quality of living of the society does not take place at the expense of excessive exploitation and degradation of the environment and climate change. Synthetically presented research directions in the field of sustainable development (Table 1) showed that the issues related to the impact of sustainable finance and sustainable financial systems are dealt with very fragmentarily in relation to their impact on the economic model. Therefore, in our study, we want to show that there are relationships between the sustainable financial model and the economic model. In our opinion, presenting the relationships between the sustainable financial model and the economic model is intended to provide a starting point for the arrangement of the concept of sustainable finance 4.0 in the sustainable financial system.

Economic development should be based on the principles of sustainable development, but also on sustainable financing, based on an efficiently operating sustainable financial system with the use of sustainable financial instruments. ESG risk should also be included in the activities towards a sustainable economy but also be analyzed in financial terms. Such important and fundamental change requires, first of all, the introduction of systemic solutions in the economic development policy of individual countries, but also requires the development of a directional, multi-factor model of the relationship of a sustainable financial system with a sustainable economy and the definition of the impact of sustainable finance on a sustainable economy.

2. Methods and results

The first step of the research was defining the keywords for searching through the databases. The following keywords were selected: sustainable economy, sustainable finance, sustainable finance model, sustainable capital market, sustainable financial system, sustainable finance AND banks, green credit/loan/lending, green insurance. The searched databases were: ScienceDirect, Google Scholar and ResearchGate. The process of articles analysis is presented in Figure 1. The papers selected for statistical analysis are listed in Table 1A (Supplementary material).

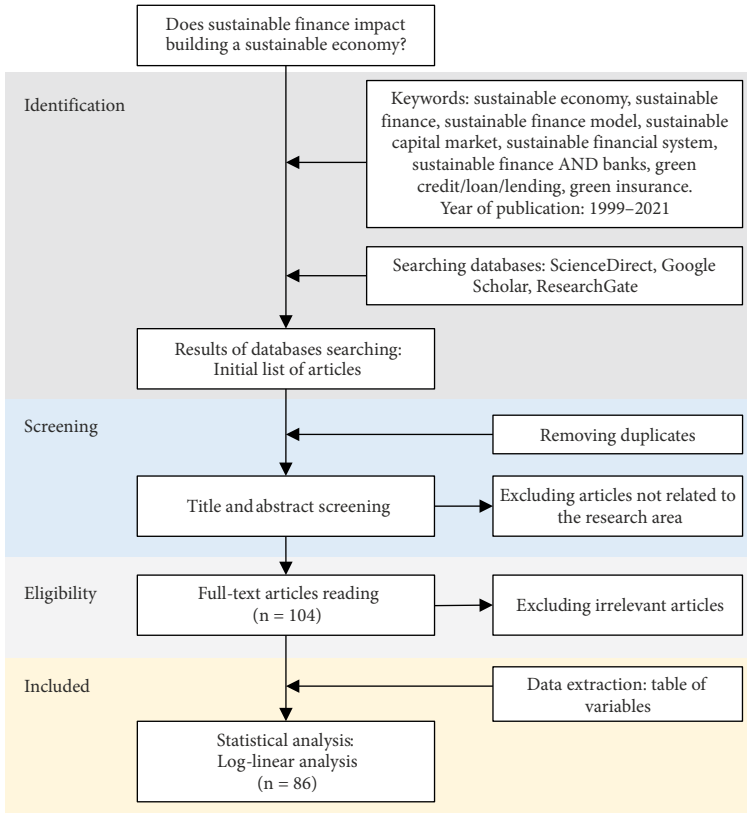

Figure 1. The flow diagram of analysis steps

Research results published in 86 articles were analysed. Due to the purpose of the article, a dichotomous dependent variable indicating the functioning of a sustainable economy (Y) was distinguished. The following variables were included in the set of independent variables: X_1 – Industry; X_2 – Banks; X_3 – Investment funds/Asset managers; X_4 – Insurance; X_5 – Enterprises; X_6 – SME sector; X_7 – Large enterprises; X_8 – Developing countries; X_9 – Environmental; X_{10} – Social; X_{11} – Governance; X_{12} – Sustainable finance.

In addition, variables related to the geographic location of the continents surveyed were included: Europe (X_{13}), North America (X_{14}), Latin America (X_{15}), Asia and Australia (X_{16}), Africa (X_{17}).

The variables mentioned above were presented in the form of categorical variables, taking the value of 1 when the phenomenon under study occurs (relevant studies were found in the literature) and 0 otherwise. The first step examined which of the variables show a significant relationship with the dependent variable. For this purpose, the test of independence was used. Table 2 contains the values of the test statistic and test probabilities *p*, for variables that appeared statistically significant at the significance level of 0.05.

Table 2. χ^2 statistical values and test probabilities p

Variable	χ^2 statistical values	Test probability *p*-value
X_2	8.3551	0.0038
X_5	4.5957	0.0321
X_9	19.5034	0.0163
X_{12}	20.7604	0.0000
X_{13}	15.8910	0.0208

The variables presented in Table 2 will be used to select the optimal set of factors affecting a sustainable economy. Log-linear analysis was used since the study considered mainly factors. It allows a more accurate description of the relationships between categorical variables than the measures used to assess the interdependence of qualitative features. An additional advantage of log-linear analysis is the possibility of considering the impact of interactions between variables.

2.1. Research method

Log-linear models are now a fundamental method for analyzing data contained in contingency tables. The development of methodologies based on this technique for analyzing qualitative data began in the 1960s. Goodman (1964, 1968, 1969) was one of the first researchers to popularize log-linear models in the social sciences (Beręsewicz et al., 2019).

The log-linear analysis is particularly applicable in biological, agricultural (Szwedziak, 2005), and medical sciences, where many phenomena are qualitative (Żołnierczuk-Kieliszek et al., 2006). It is also used in economic research, e.g., to select factors describing the economic situation of households (Salamaga, 2008), to estimate price models and housing price indices (Tomczyk & Widłak, 2010), or to identify factors influencing decisions on the amount of spending on recreation and culture in pensioners' households (Bak, 2013). This method enables a more accurate description of the relationship between categorical variables than

measures used to assess the interdependence of qualitative features. An additional advantage of log-linear analysis is the possibility to consider the impact of interactions between variables (Stanisz, 2007).

The starting point in the log-linear analysis are the expected frequencies for each level of categorical variables (Dobosz, 2004). If the interaction components are insignificant and the class frequencies depend only on the main factors, it means that there are no interactions between the categorical variables. The fitted log-linear model is hierarchical, which means that if a particular interaction component is included in the model, all other combinations of factors in that component must be included in the model.

In the log-linear model, the natural logarithm of the expected value of the frequency in a cell in the independence table is assumed to be a linear function of the factors. Assuming that there are the following factors: factor C_1 with p_{c1} levels, factor C_2 with p_{c2} levels, …, factor C_m with p_{cm} levels, the generalized form of the model is as follows (Salamaga, 2008, p. 41):

$$lnln\left(\hat{n}^C\right)=\overline{n}+\sum_{i=1}^{p_{c_1}}\lambda_i^{C_1}+\ldots+\sum_{j=1}^{p_{c_2}}\lambda_{ij}^{C_1C_2}+\ldots+\sum_{k=1}^{p_{c_m}}\lambda_{ij,\ldots,k}^{C_1C_2,\ldots,C_m}, \tag{1}$$

where: $\hat{n}^C$ – is a vector $\left[\hat{n}_i^{C_1},\hat{n}_{ij}^{C_1C_2},\ldots,\hat{n}_{ij,\ldots,k}^{C_1C_2,\ldots,C_m}\right]$, whereas $\hat{n}_i^{C_1}$ denotes the expected frequency of the i-th level of the factor C_1, $\hat{n}_{ij}^{C_1C_2}$ – the expected number of interactions i-th level of factor C_1 and j-th level of factor C_2,..., $\hat{n}_{ij,\ldots,k}^{C_1C_2,\ldots,C_m}$ – the expected number of interactions i-th level of factor C_1 and j-th level of factor C_2, … and k-th level of factor C_m, $\overline{n}$ – mean of natural logarithms of all observed frequencies determined according to the formula:

$$\overline{n}=\frac{1}{n}\sum_C\sum_i lnln\left(n_i^C\right), \tag{2}$$

where: $\sum_C$ – summing up after all the factors; $\sum_i$ – summing up after all levels of factors; $\lambda_i^{C_1}$ – index of i-th level of factor C_1; $\lambda_{ij}^{C_1C_2}$ – second-order interaction index of i-th level of factor C_1 and j-th level of factor C_2; $\lambda_{ij,\ldots,k}^{C_1C_2,\ldots,C_m}$ – m-order interaction index between i-th level of factor C_1, j-th level of factor C_2, … and k-th level of factor C_m.

A correctly constructed log-linear model gives the best prediction of frequencies with the least number of interactions included in the model. Considering all factors and their interactions gives the best-fitting model but is not always convenient in practice, as the impact of some factors and interactions may be insignificant compared to the other components of the model. The measures of model fit to the results are Pearson's χ^2 statistics and χ^2 of maximum likelihood. The Pearson's χ^2 test consists in comparing the observed frequencies f_{ij} with the expected frequencies $n\pi_{ij}$ under the assumption that the null hypothesis (that there is no relationship between the variables) is valid. If there is no relationship between the variables, one should expect roughly equal expected and observed frequencies. The χ^2 test becomes significant as the expected frequencies begin to differ from the observed frequencies. A measure of the difference between the theoretical and observed frequencies is the statistic (Dobosz, 2004, p. 46):

$$\chi^2=\sum_{i=1}^{k}\sum_{j=1}^{p}\frac{(f_{ij}-n\pi_{ij})^2}{n\pi_{ij}}, \tag{3}$$

where k and p are the category numbers of the variables under consideration.

In general:

$$\chi^2 = \sum_{i_1=1}^{p_1} \sum_{i_2=1}^{p_2} \ldots \eta_{i_1 i_2 \ldots}, \tag{4}$$

where

$$\eta_{i_1 i_2 \ldots} = \frac{(f_{i_1 i_2 \ldots} - n\pi_{i_1 i_2 \ldots})^2}{n\pi_{i_1 i_2 \ldots}}, \tag{5}$$

whereas p_j is the number of *j-th* variable levels, $j = 1, 2, \ldots$.

The χ^2 maximum likelihood test verifies the same hypothesis as Pearson's χ^2 test, but its calculation is based on the theory of maximum likelihood. This approach uses a property of the statistic that is the likelihood ratio (Dobosz, 2004, p. 359). For each cell of the multidimensional table, the so-called maximum likelihood component $c_{(ijk\ldots)}$ is determined, which is proportional to the natural logarithm of the ratio of the observed frequency $f_{(ijk\ldots)}$ the expected frequency (fitted by the model) $\hat{f}_{(ijk\ldots)}$ according to the formula:

$$c_{(ijk\ldots)} = 2 f_{(ijk\ldots)} lnln \frac{f_{(ijk\ldots)}}{\hat{f}_{(ijk\ldots)}}. \tag{6}$$

The highest-probability test statistics is determined as the sum of the highest-probability components from all cells in the contingency table, i.e., as:

$$\chi^2{}_{NW} = 2 \sum_i^a \sum_j^b \ldots c_{(ijk\ldots)}. \tag{7}$$

In practice, the χ^2 maximum likelihood statistics generates results close to Pearson's χ^2 statistics.

Once the order of interactions has been determined, they should be included in the model. However, the question arises which interactions of a given order (between which factors) should be included in the model. The analysis of partial and boundary dependencies may help resolve this dilemma. Partial dependencies tell us whether the relevant interactions are statistically significant when all other factors of the same order are already in the model. It is verified with Pearson's χ^2. Boundary dependence analysis, on the other hand, indicates the existence of the influence of specific interactions when no same-order interaction is yet included in the model. It is carried out using the χ^2 likelihood-ratio test.

Log-linear models are very similar to models for quantitative variables used in the analysis of variance; the difference is in the interpretation. In addition, the log-linear analysis focuses mainly on interaction effects rather than main effects.

2.2. Results

The following variables were entered into the log-linear model and the Y variable for sustainable economy: X_2, X_5, X_9 X_{12}, X_{13}. In order to determine the model specification, the order of interactions was determined. The test results of all interactions are summarized in Table 3, which shows that the analyzed model should include, apart from the main factors, the interactions of at most the third order. This is indicated by the probability test *p*-values corresponding to the χ^2 values of maximum likelihood test statistics and Pearson's χ^2. Partial

and boundary tests were used to assess which interactions should be included in the log-linear model (Table 4). Due to many possible interactions for the six factors, the authors limited themselves to presenting a maximum of second-order interactions because none of the higher-order interactions proved to be statistically significant in the sense of the partial and boundary test. Interactions for which partial and boundary interactions are significant are shown in bold in Table 4.

The results of the partial and boundary tests indicate the need to include two main factors in the log-linear model, as well as those second-order interactions that occur between the variables identified as independent and the dependent variable. An effect representing all interactions between the independent variables should be included in the model (Stanisz, 2007)[1] to avoid a significant reduction in the degree of fit connected with removing interactions between the independent variables. Finally, the relationships between a sustainable economy and the following variables were considered:

- Enterprise (X_5),
- Sustainable finance (X_{12}),
- Sustainable finance and Banks ($X_2\ X_{12}$),
- Enterprise and Europe (X_5X_{13}),
- Banks and Europe (X_2X_{13}).

The log-linear model then takes the following form:

$$ln ln\left(\hat{n}_{(ijklmno)}\right) = \overline{n} + \lambda_i^{Y} + \lambda_j^{X_2} + \lambda_k^{X_5} + \lambda_l^{X_9} + \lambda_m^{X_{12}} + \lambda_n^{X_{13}} + \lambda_{ik}^{YX_5} + \lambda_{im}^{YX_{12}} + \lambda_{ijm}^{YX_2X_{13}} + \lambda_{ikn}^{YX_5X_{13}} + \lambda_{ijn}^{YX_{12}X_2} + \lambda_{jklmno}^{X_1X_3X_4X_5X_6}.$$

Sustainable economy is also affected by second-order interactions for the following pairs of variables (Table 3):

- Enterprise and Sustainable finance (X_5X_{12}),
- Sustainable finance and Europe ($X_{12}\ X_{13}$).

The factors that most often interact significantly with other variables describing a sustainable economy are Enterprise and Sustainable finance.

Table 3. The results of variable interaction tests (source: own computation)

Degree of interaction	Degree of freedom	Value χ^2 NW	Probability p	Pearson's χ^2 value	Probability p
1	6	46.56234	0.000000	101.4042	0.000000
2	15	43.07155	0.000153	55.7795	0.000001
3	20	24.46041	0.222859	25.1789	0.019467
4	15	4.48893	0.995640	4.4160	0.996023
5	6	1.07126	0.982766	1.0939	0.981802
6	1	0.02575	0.872524	0.0258	0.872499

[1] Omitting the effect representing all interactions between the independent variables resulted in the significance of the Persona and maximum likelihood tests and therefore the need to reject the estimated model.

Table 4. Excerpts from the results of partial and boundary tests between variables: Y, X_2, X_5, X_9 X_{12}, X_{13} (source: own computation)

Factors	Degree of freedom	Partial relationship χ^2	the *p*-value in partial relationship	Boundary relationship χ^2	the *p*-value in boundary relationship
Y	1	0.3052	0.5807	0.3052	0.5807
X_2	**1**	**21.8709**	**0.0000**	**21.8709**	**0.0000**
X_5	1	0.3052	0.5806	0.3052	0.5806
X_9	**1**	**21.8709**	**0.0000**	**21.8709**	**0.0000**
X_{12}	1	0.0339	0.8539	0.0339	0.8539
X_{13}	1	2.1762	0.1402	2.1762	0.1402
YX_2	1	1.3657	0.2426	0.7592	0.3836
YX_5	**1**	**1.5621**	**0.2114**	**5.9505**	**0.0147**
YX_9	1	2.2206	0.1362	1.3598	0.2436
YX_{12}	**1**	**9.9431**	**0.0016**	**15.4147**	**0.0001**
YX_{13}	1	0.7633	0.3823	2.0000	0.1573
X_2X_9	1	1.5505	0.2131	1.2379	0.2659
X_2X_{13}	1	0.4015	0.5263	0.2858	0.5929
X_5X_2	1	0.0102	0.9194	0.0030	0.9564
X_5X_{13}	1	0.0129	0.9096	0.6737	0.4118
X_9X_2	1	0.5534	0.4569	0.2878	0.5916
X_9X_5	1	0.2466	0.6195	0.1236	0.7251
$X_{12}X_2$	1	0.0547	0.8150	0.0137	0.9070
$X_{12}X_5$	**1**	**10.2965**	**0.0013**	**15.2483**	**0.0001**
$X_{12}X_9$	1	0.0547	0.8150	0.0137	0.9070
YX_2X_{13}	**1**	**2.7106**	**0.0997**	**5.1041**	**0.0239**
YX_5X_{13}	**1**	**2.3272**	**0.0127**	**4.1684**	**0.0412**
$X_{12}X_{13}$	**1**	**3.0498**	**0.0807**	**5.1309**	**0.0235**
$YX_{12}X_2$	**1**	**2.0020**	**0.0157**	**4.2645**	**0.0389**
YX_5X_2	1	1.3424	0.2466	3.6075	0.0575
YX_9X_2	1	0.0097	0.9216	0.2538	0.6144
YX_9X_5	1	0.6024	0.4377	0.2270	0.6338
YX_9X_{13}	1	0.2446	0.6209	0.4836	0.4868
$YX_{12}X_5$	1	0.5985	0.4392	0.0411	0.8393
$YX_{12}X_9$	1	0.4811	0.4879	0.1597	0.6894
$YX_{12}X_{13}$	1	0.0023	0.9618	0.3322	0.5644
$X_5X_2X_{13}$	1	2.3200	0.1277	0.5322	0.4657
$X_9X_2X_{13}$	1	0.0039	0.9504	0.0752	0.7840
$X_9X_5X_2$	1	0.0221	0.8818	0.2404	0.6239
X_9X5X_{13}	1	0.5810	0.4459	1.7610	0.1845
$X_{12}X_2X_{13}$	1	3.0271	0.0819	3.4614	0.0628
$X_{12}X_5X_2$	1	0.7517	0.3859	1.7639	0.1841
$X_{12}X_5X_{13}$	1	0.7992	0.3713	1.3460	0.2460
$X_{12}X_9X_2$	1	0.0718	0.7888	0.0594	0.8075
$X_{12}X_9X_5$	1	2.1657	0.1411	1.7264	0.1889
$X_{12}X_9X_{13}$	1	0.0199	0.8879	0.2961	0.5863

The estimated model fits well the empirical data as evidenced by the values of the χ^2 maximum likelihood statistics of 37.324 (p = 0.959) and Pearson's χ^2statistics of 40.567 (p = 0.912). The values of both statistics are not significant, so the model fits the empirical data. This is also confirmed by Figure 2, showing the observed frequencies against the fitted frequencies. Many of the variables analyzed in economic science research are qualitative. The methods of analyzing this kind of data are most often based on the tool created by Karl Pearson, which is the χ2 test. However, these methods do not allow assessing the relationship between three or more variables because analyzing the dependencies of several features based on them is reduced to examining all possible combinations of two qualitative features, on the basis of which the value of the χ2 independence test is calculated. The information obtained based on such analyses is valuable, but it does not allow the extraction of key factors determining the studied phenomenon among numerous variables. A more accurate statistical tool is log-linear analysis, enabling a more precise description of the relationships between the categorical variables under study and assessing the impact of interactions between variables (Stanisz, 2007; Helmy et al., 2010; Zhu et al., 2012; Nyman et al., 2016). The information obtained in this way can be an important guideline for implementing specific practical measures to reduce or increase the severity of the phenomenon under study.

The application of the log-linear model enabled isolating the factors that influence a sustainable economy. The analysis revealed that not all variables considered in the study showed a significant relationship. The analysis of the publications included in the study showed that the dependent variable (Y) was mainly influenced by research related to sustainable finance and companies that use ESG in their operations.

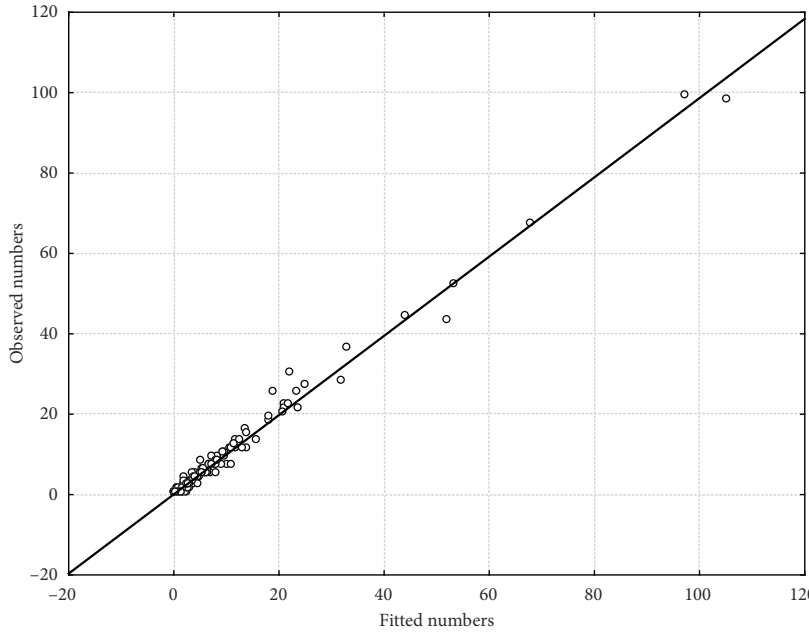

Figure 2. Distribution graph of observed frequencies versus fitted frequencies

3. Discussion and recommendations

Our research shows that the factors that most often interact significantly with other variables describing a sustainable economy are Enterprise and Sustainable finance. The novelty of the subject of this study makes it difficult to find the results of similar research in the literature. Based on meta-analysis and systemic review, Meemken (2020) studied economic effects of sustainability standards implemented by farmers. The study showed that farmers certified under sustainability standards benefit from higher prices (20–30%) in comparison to non-certified farmers. Blättel-Mink (1998) confirmed the hypothesis that integration of economy and ecology becomes a competition element and dynamic and innovative companies will act proactively in this area. Environmental aspects will be one of the elements of economic strategies. Cai and Guo (2021) came to a similar conclusion, claiming that due to the environmental problems businesses are under a huge pressure to implement sustainable activities in the corporate culture. The relationship between economic and social performance has been studied by López-Arceiz et al. (2018). Based on the meta-analysis, revealed a positive relationship between economic and social performance, although they noticed differences in the sign depending on the type of examined organization and used measurement instrument.

Ryszawska (2016) presented the role of sustainable finance in the process of transition towards sustainability. According to her, the role of finance is changing from profit maximization and ensuring wealth for shareholders, to supporting sustainable development, cow carbon economy, green economy, and mitigation of climate change. Schoenmaker (2018) drew attention to the importance of finance in sustainable development. He claims that frontrunners' investments in sustainable companies and projects are increasing, which is aimed at creation of a long-term value for the broader community (Sustainable Finance 3.0). Xu et al. (2020) based on the meta-analysis of 30 empirical studies found a significant positive correlation between green finance and enterprise green performance and revealed moderate impact of region and company type on the relationship between green finance and enterprise green performance.

Our research has shown the mutual dependence between banks, their role in the financial system and sustainability. This impact translates into financial systems push towards sustainability. Showing this link affects the actors of the financial system, and in particular, enterprise (which our research has also shown). Therefore, we have indicated the concept of a financing model for the economy in the conditions of sustainability. The model consists of three elements that result from the sustainability paradigm and the concept of ESG risk, which is very important for financial systems: environmental perspective, social perspective and governance perspective. The idea of a triple layered sustainable finance model with consideration of environmental, social and governance perspective is presented in Figure 3. Then this ideological scheme for each perspective is developed (see Figures 4–10).

The concept of a financing model for the economy in the conditions of sustainability taking into account the environmental perspective is presented in the Figures 4–6. The financing model for the economy in the conditions of sustainability taking into account the social perspective is presented in the Figures 7–8 and the influence governance perspective to financing for the economy in the conditions of sustainability is presented on Figures 9–10.

Environmental changes influence the perception of risk by financial institutions, especially banks. Environmental changes imply a number of risks that affect banks and financial markets, in particular the products offered by banks (e.g. "green" products) and the types of securities traded (e.g. "green" bonds). The impact of this risk is shown in Figure 4. The environment forces the perception of ESG risk, but also environmental risk as an important area when making decisions on financing and selecting instruments. Environmental risk, including climate risk, ESG risk and financial risk are equal risks in the decision-making process of investors and capital donors. This is how decisions are made regarding the financing of the real economy in a circular economy. Environmental implications, especially risks, affect changes both on the part of the economy and imply adjustment measures in the financial system.

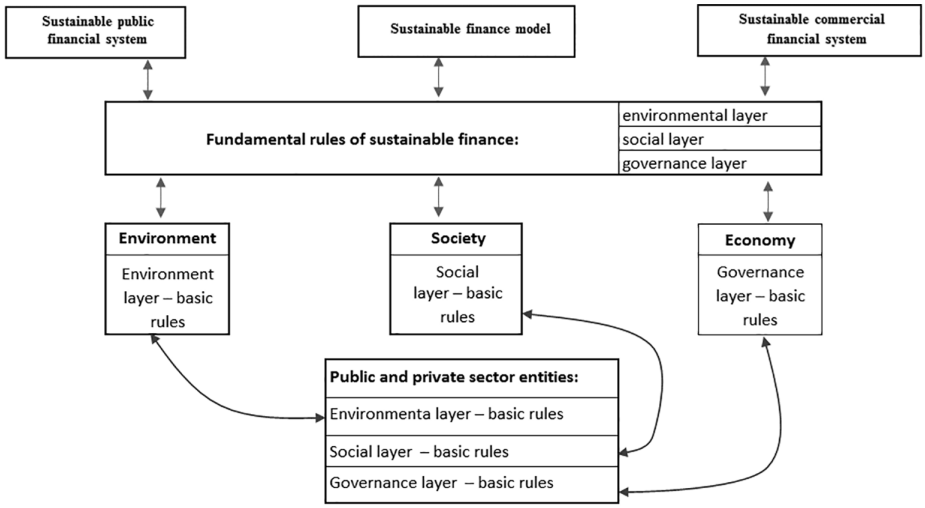

Figure 3. The triple layered sustainable finance model

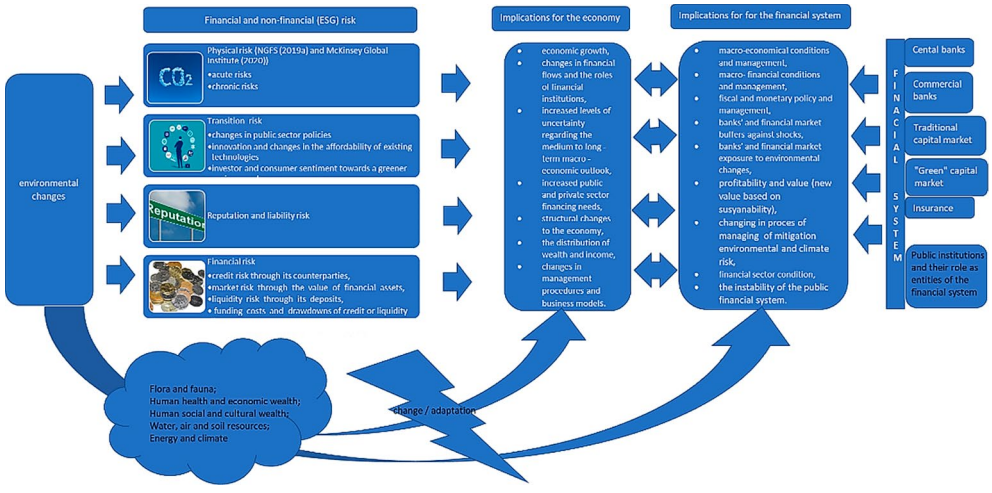

Figure 4. Sustainable finance model – environmental sustainability

In addition, the most important actors in the financial system (central banks, commercial banks, pension funds, insurance companies or government entities) are taking action to change financial products towards sustainability. The impact of environmental changes, environmental risk, ESG and financial risk imply, on the one hand, changes in the financial system (adaptation to sustainability and implementation of SDG's goals), and on the other hand, environmental awareness, creating new value, changing the perception of profit as a final effect for financial markets and banks becomes become the engine of changes in the systems of financing the economy.

Figure 5 presents the triple layered sustainable finance model for sustainable economy, which takes into account the influence of the dependencies shown in Figure 4. We recognize that the financial system is permeated by the interdependencies between the market and the public financial system. Thus, they create fundamental rules of sustainable finance. These principles are developed taking into account the SDG's objectives for the environment, as shown in Figure 5. These principles include: sustainability as the overarching principle, protection of resources and respect of environmental rights, precautionary principle, pollution prevention, polluter pays, cumulative impacts, intergenerational equity, public participation, environmental responsibility, ensure independent environmental audit, take into account climate risk and ESG risk. It should be remembered that an important aspect is the system of environmental monitoring and reporting of all actors of the financial system, both governments and their entities, the financial institutions themselves, and the entire economy.

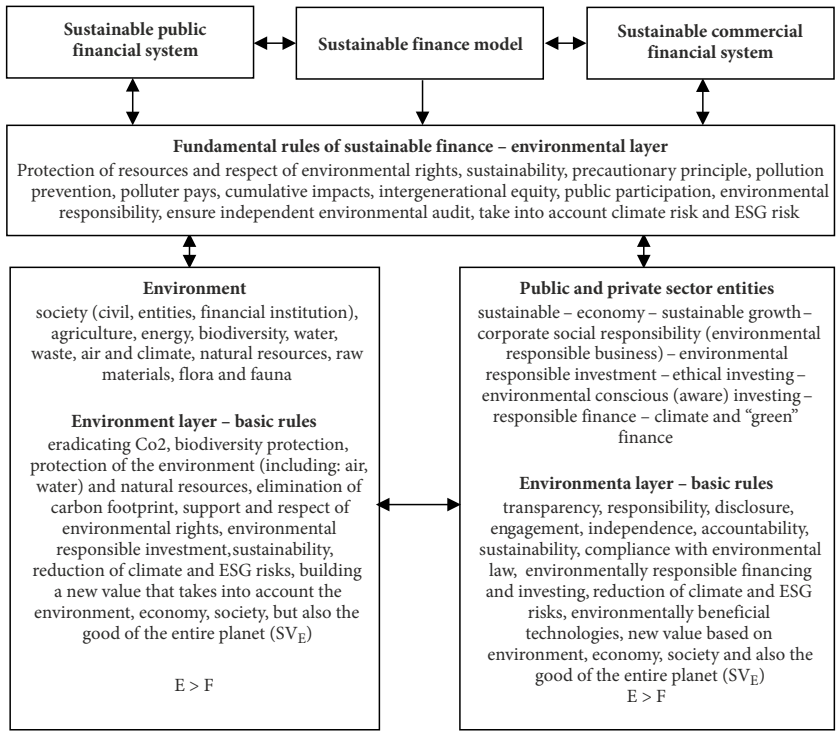

Figure 5. Triple layered sustainable finance model – environmental perspective

An important aspect is the incorporation of environmental principles to business models in the economy (the impact of the market and public financial system through access to financial products and services), compliance with them and running a business in such a way that it is socially responsible for the environment, which also means socially responsible financing according to the rules sustainability. A common relationship is E (environmental impact) > F (financial value) -> (towards) Sustainability (SVe- good of the entire planet).

Triple layered sustainable finance model for sustainable economy, taking into account the environmental perspective, based on obtaining answers to the following questions:

1. How key components and functions, or parts, are integrated to deliver value to the environmental and for the economy?
2. How those parts of financial system are interconnected within the economy and throughout its supply chain of financial products (e.g. green products, green investment) and stakeholder / stakeholder networks?
3. How the financial system / public or commercial system / financial institution generates value, or creates profit, through those interconnections and how is it possible to have green value generated by the entire economy using the environmental principles of the financial system?

Sustainable finance model for sustainable economy, taking into account the environmental perspective, takes into account, on the one hand, key components and functions and parts, and on the other, shows and takes into account their integration to deliver value to the environmental and for the economy (Figure 6).

Figure 6 shows the combination of parts of financial system within the economy (entities, organizations, society, etc.) And throughout its supply chain of financial products (e.g. green products, green investment) and stakeholder / stakeholder networks. Figure 6 also answers the question about changes caused in the environment (Figure 4) translate into changes in the current roles and positions of elements of the financial system (Figure 6). Answer the question how the financial system / public or commercial system / financial institution generates value, or creates profit, through those interconnections and how is it possible to have green value generated by the entire economy using the environmental principles of the financial system? it is not simple. Figure 6 shows the mutual interactions between: "entities, enterprises, society", "financial institutions", "Public sector institutions", the impact of legislative action on environmental taxonomy and the new dimension of risk (traditional perception – ESG – CSR) in creating a new approach to value, which can be described as good of the entire planet (SVe).

Sustainable finance that integrates social aspects into the financial decision-making process leads to more long-term investments in sustainable economic activities and projects (Figure 7). Social considerations may refer to issues of support and respect of human rights, social equity, social inclusion, gender equality, community development, shareholder rights, stakeholder engagement, labour rights, placemaking, social capital, cultural competence, staff training, and social responsibility. The impact of sustainable finance model on economy is visible from both the society and companies perspective.

Sustainable finance model for sustainable economy – social perspective (Figure 8) presents segments of the financial markets along with financial instruments, disclosure rules and social taxonomy that support the development of a sustainable economy.

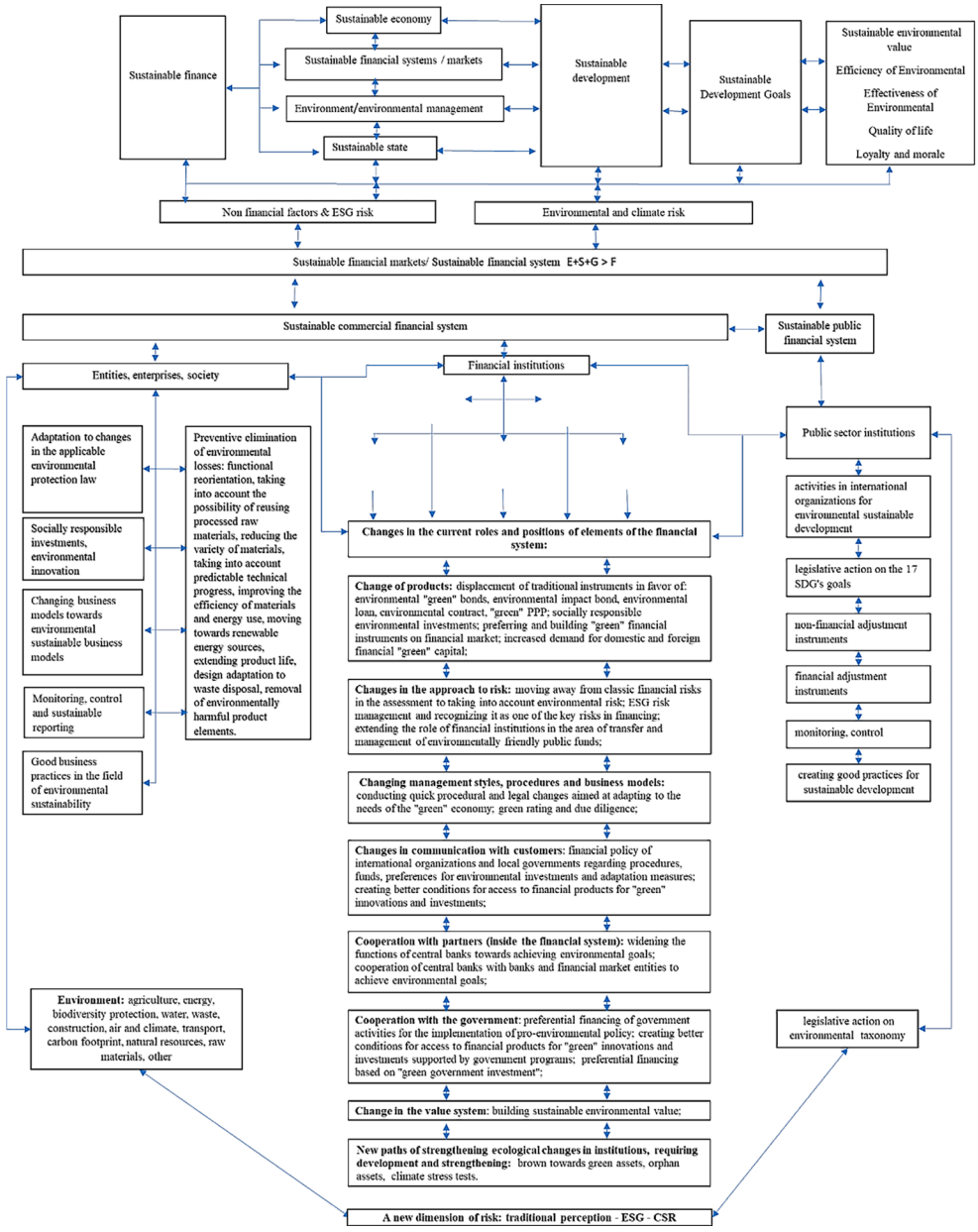

Figure 6. Sustainable finance model for sustainable economy – environmental perspective

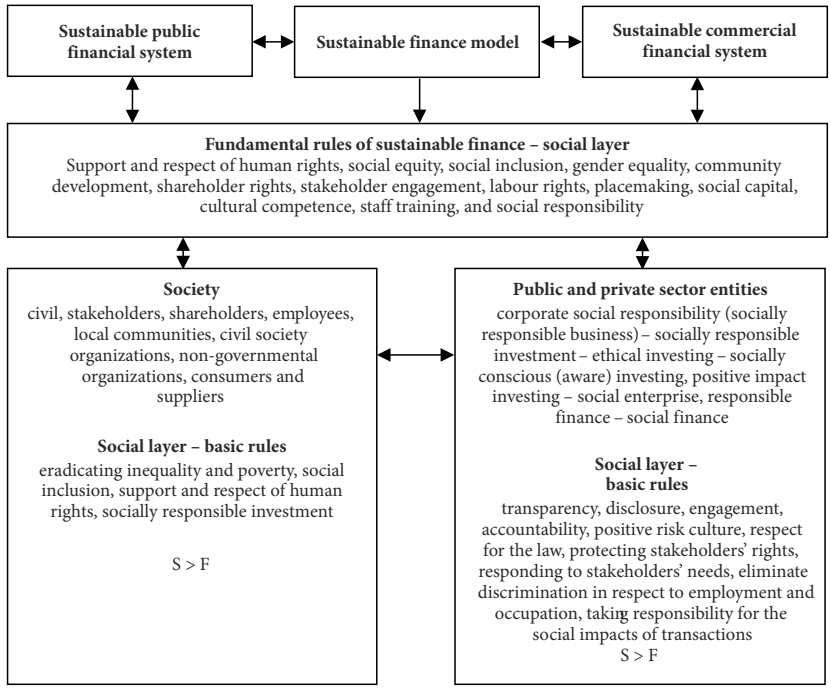

Figure 7. Triple layered sustainable finance model – social perspective

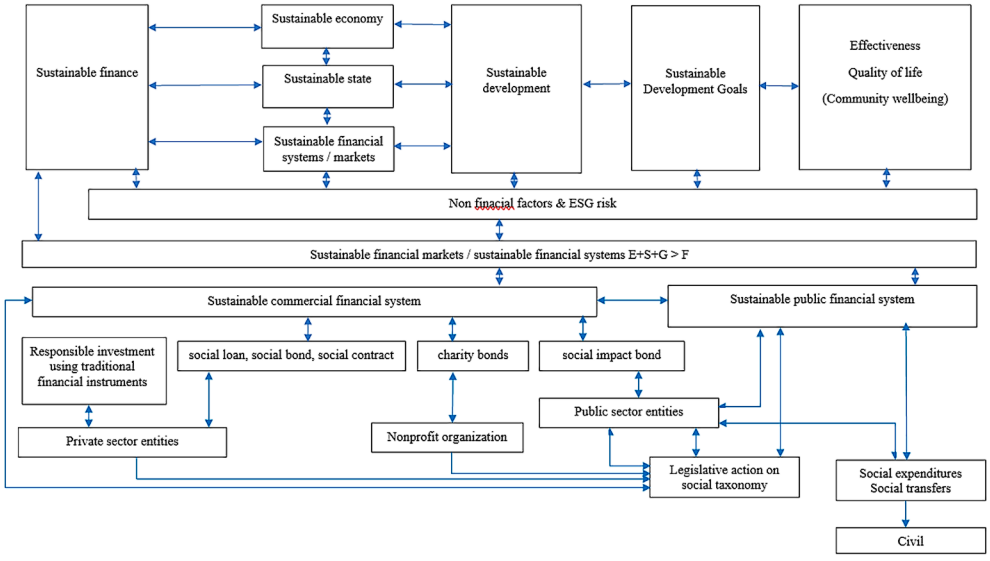

Figure 8. Sustainable finance model for sustainable economy – social perspective

Governance layer of sustainable finance model (Figure 9) is in line with "G" in ESG risk concept. The governance layer corresponds to the "G" in the ESG risk concept. Governance is important from the point of view of ESG risk management, including by ensuring gender parity in the composition of management boards of companies, which translates into financial decisions and ESG risk management, as different attitudes towards risk are represented by women and other men. Another issue is the remuneration policy and compliance with the basic rules of corporate governance. The governance layer in a sustainable financial model is responsible for ensuring equal participation of women and men in financial decisions and risk management, ensuring openness, transparency, completeness and transparency of information for stakeholders, ensuring compliance with the codes of professional ethics and respecting the rights of clients and employees, eliminating corruption and pathological phenomena affecting the healthy functioning of the organization, ensuring an organizational culture based on sustainability and implementing best practices. Sustainable finance model for sustainable economy – governance perspective (Figure 10) presents segments of the financial markets, principles and guidelines that contain a reference to "governance" and help to ensure corporate governance in the financial institutions.

The thinking about sustainable finance has gone through different stages over the last few decades, concretized by Schoenmaker (2017). Table 5 shows the arrangement of the concept of sustainable finance in sustainable financial system, taking into account factors such as F – financial value; S – social impact; E – environmental impact; T – total value. The evolution of the concept from "Finance-as usual" was presented, without taking sustainability into account, to the formulation of a "Sustainable Finance 4.0" concept based on financing and the research carried out. The basis of the proposed "Sustainable Finance 3.0" concept was the concept of Schoenmaker (2017). There is a need to develop Sustainable Finance 3.0 concept with new elements related to value creation and new elements influencing the shaping of people and planet (P&P) relations. It should also be pointed out that there is a need to define the directions of adjusting the financial system to the new values related to sustainability. The financial system is determined with the need to maintain its stability, the need to determine the impact of ESG factors on it as well as the directions of adaptation to sustainability (e.g. changes in the law, the influence of partners and stakeholders towards sustainability, social pressure). The individual components and equations, the resulting elements of which are presented in Table 5, are presented below.

Sustainable financial systems 3.0. = E + S + G > F,
Sustainable financial systems 4.0 – model: E' + S' + G' > F + SV (for F').

Factors creating new value for Sustainable Finance 4.0 and for Sustainable Financial Systems 4.0 are shown in parentheses. Factors equations influencing the formulation of the concept of Sustainable Finance 4.0 and Sustainable Financial Systems 4.0 are shown. Thus, the impact and lasting combination of the concept of Sustainable Finance 4.0 and Sustainable Financial Systems 4.0 is visible. The existing components (S), (E), (G) are enhanced with the influence of sustainable value (SV) and create the individual new components (S'), (E'), (G'). For Sustainable Financial Systems 4.0, both the components and the factors that determine

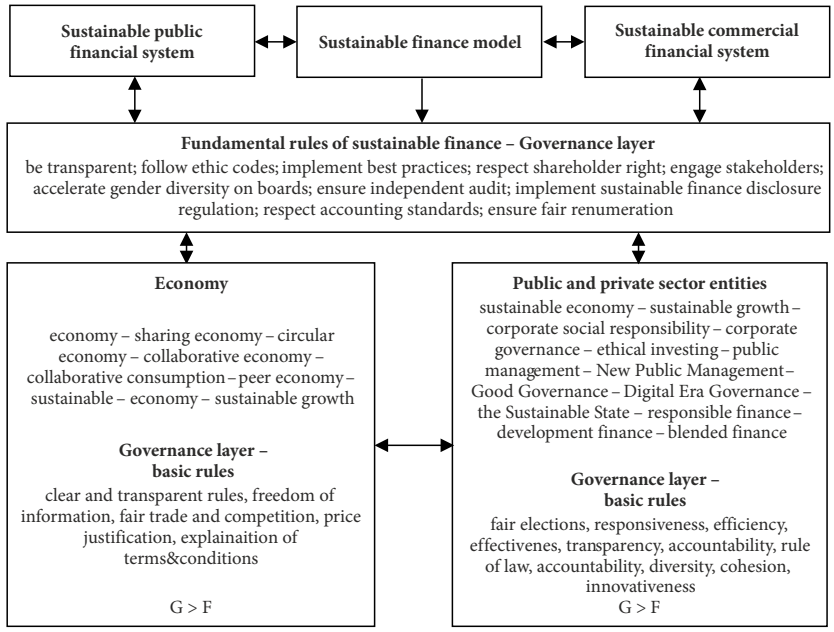

Figure 9. Triple layered sustainable finance model – governance perspective

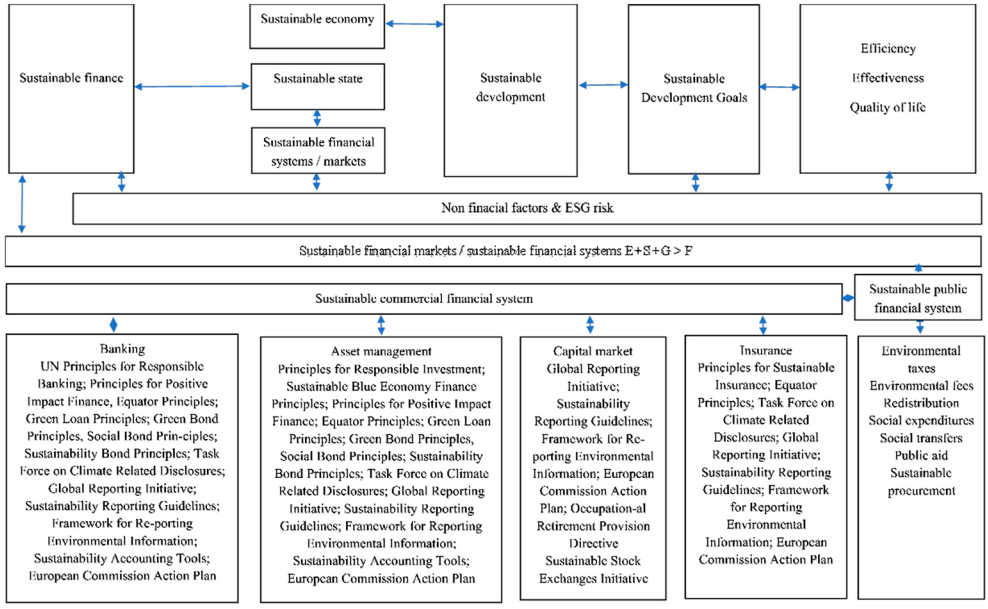

Figure 10. Sustainable finance model for sustainable economy – governance perspective

them were given in parentheses. The individual new components (S‘), (E’), (G‘) and sustainable value (SV) with its components are also defined below:

E’ = E + SV_E, E – environmental factor impact; SV_E – sustainable value for E factors.

SV_E = Er + Ac + Bm + GI (Er – environmental and climate risk; Ac – Adaptation to climate action and respect for fauna and flora, pollution, e.i.; Bm – “green” Business models towards SDG’s; GI – new application areas for “green financial instruments” towards SDG’s).

S’ = S + SV_S, S – social factor impact; SV_S – sustainable value for S factors.

SV_s = R + Se + L (R – responsible investment; Se – social expenditures; L – legislative action).

G’ = G + SV_G, G – governance factor impact; SV_G – sustainable value for G factors.

SV_G = B + A + C + I + Et (B – banking; A – asset management; C – capital market; I – insurance; Et – environmental taxes).

For Sustainable Finance 4.0. Sustainable value must meet the following relationship:

T (total value) ≠ SV (sustainable value) ≠ F (financial value).

The value (V) itself takes into account the following components:

V = T = Sh (Shareholder value) + St (Stakeholder value) + C_{GV} (common good value) + P (people & planet value).

Sustainable total value for individual components of the financial system was determined by the following factors:

SV (for E’) = Et + Ac + Bm_E + GFM (Ac – Adaptation to climate action and respect for fauna and flora, pollution, e.i; Bm_E – “green” Business models environmentally oriented; GFM – green financial markets and instruments).

SV (for S’) = RI + Se + RP+ L + Bm_S + SRFM (RI – responsible investment; Se – social expenditures; L – legislative action; Bm_S – “green” Business models socially oriented; RP – redistribution policy; socially responsible financial markets).

SV (for G’) = Ec + T + ACP + FT + Bm_G + CG (Ec – ethical codes; ACP – Anticoruption policy; T – transparency; FT – fair trade; Bm_G – “green” Business models governmentally oriented; CG - corporate governance).

SV (for F’) = sustainable financial value = SV (for E’) + SV (for S’) + SV (for G’).

The evolution highlights the broadening from shareholder value to people and planet value. This value is created by a financial system with respect for the environment (social perspective – Figure 4), human rights (social perspective – Figure 6) and good governance (governance perspective – Figure 8). Next, the table indicates a shift from economic goals first to societal and environmental challenges and the role of financial system towards changing rules of the economy. Importantly, the horizon is coordinated to accommodate changes and respond smoothly, taking into account both the short, medium and long-term perspectives of the economy.

Table 5. Framework for Sustainable Finance and people and planet value (source: own elaboration based on Schoenmaker, 2017)

Sustainable Finance Typology	Value Created (V)	Ranking factors	Optimisation	Horizon
Finance-as usual	Shareholder value	F	Max F	Short term
Sustainable Finance 1.0	Refined Shareholder value	F > S and E	Max F subject to S and E	Short term
Sustainable Finance 2.0	Stakeholder value	T = F + S + E	Optimise T	Medium term
Sustainable Finance 3.0	Common good value	S and E>T	Optimise S and E subject to F	Long term
Sustainable Finance 4.0	P&P value	E + S + G > F + SV	Max $SV_{E,S,G,F}$ in process	Short term and medium term and long term in process

Note: *P&P people and planet; * in process – circular economy process approach.

Conclusions

Our research confirmed that matching the real and financial spheres is important from the point of view of achieving the sustainable development goals. In addition, we have shown that a special role in achieving the SDGs objectives is played by financing dedicated to the sustainable development of financing sources. Thus, we developed the concept of Monkelbaan (2021) and the research demonstrated in Financing the SDGs (Sustainable Development Goals, 2019). Our contribution is based on examining the factors and relationships between the financial model and the economic model (in our case, we demonstrated the importance of the circular economy model). Research has shown that sustainable finance has an impact on building a sustainable economy. The circular economy is based on a business model that emphasize reducing, reusing, recycling and recovering materials in production, distribution and consumption processes, therefore, in order to be able to achieve the goals of circular economy in enterprises, it becomes necessary to ensure consistency between financing, meeting the financial goals of the company's stakeholders and the company's business model. Therefore, it is important that sustainable financial systems take into account not only the specificity of the circular economy. Sustainable financial systems should also take into account the process nature of the circular economy, as we have shown in our research.

In our research, we confirmed the relationship between the variables: Enterprise (X_5), Sustainable finance (X_{12}), Sustainable finance and Banks (X_2X_{12}), Enterprise and Europe (X_5X_{13}), Banks and Europe (X_2X_{13}). The literature on the subject shows the role of banks to play both as a leader in the circular economy and as a lender to the circular economy. The environmental threats and the consequences of its degradation affect not only the environment, but also banks, in particular their functioning and the success of their business models. Our research has confirmed not only the relationship between Enterprise and Europe (X_5X_{13}), Sustainable finance and Banks (X_2X_{12}), but will show the close relationship between the coherence of the financial sphere and the real economy, which is in line with the claim that

the transition to a sustainable circular economy is not possible without a purposeful public policy, and in particular without financial support.

Financial institutions, including banks are profit-seeking entities that make investment and lending decisions based on rigorous cost-benefit and risk analyzes. ESG risk management as part of sustainable finance facilitates the aggregation of dispersed information about business entities and thus increases the efficiency of investing. Considering that the links between Enterprise (X_5) and Sustainable finance (X_{12}) shown in the research will affect risk management, especially ESG, our research complements Levine's (1991) approach.

The paper focuses on making a comprehensive analysis of the factors and relationships between sustainability, economy and finance (see Figures 2–8). We show them through the prism of three planes, i.e. environmental, social and sustainable economy. The originality of our approach also consists in expanding models of sustainable financial systems with the model of sustainable finance 4.0. This model is based on research results and takes into account factors and relationships between sustainability, economy and finance. We also showed how significant the new value (P&P value) is and its place in a sustainable financial system.

Given that Europe is making a particular contribution to the development of sustainable financial systems, we see research alternatives to deepen our research. These research alternatives are possible for Asia, Africa and America country. We recognize that it is worth looking for information on the factors of mismatch for these countries in order to be able to more efficiently build sustainable financial systems for individual continents, taking into account the specificity of their financial systems. The intention of the authors is to conduct such research in the future.

The original contribution of this research to the field includes: the identification and comprehensive analysis of the factors and relationships between sustainability, economy and finance; building a triple layered finance model for sustainable economy taking into account governance, society and environment sustainable perspective; proposing the model of financing for the circular economy in terms of sustainability in terms of the process and defining the model of sustainable finance 4.0.

Our research will allow for the practical development of new assumptions for business models of financial institutions taking into account the P&P value. This new value should be incorporated into business models to better meet SDG's goals. Proposing a financing model for the economy in terms of sustainability in terms of processes allows for changes in the processes in the circular economy and a better adjustment of financing in terms of sustainability.

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Author contributions

Concept: M.Z.; methods: I.B.; software: I.B.; validation: I.B.; formal analysis M.Z., I.B., B.Z.F., A.S.; investigation: M.Z.; resources: MZ. I.B., B.Z.F, A.S.; data curation: I.B.; writing original draft preparation: M.Z. I.B., B.Z.F., A.S.; writing review and editing: M.Z. I.B., B.Z.F., A.S.; visualization: M.Z. I.B., B.Z.F., A.S.; supervision: M.Z.; project administration: M.Z.; funding acquisition: M.Z.

Disclosure statement

Authors do not have any competing financial, professional, or personal interests from other parties.

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