SUSTAINABLE TECHNOLOGY AND BUSINESS INNOVATION FRAMEWORK – A COMPREHENSIVE APPROACH

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Abstract
Despite of the rising awareness of the urgency in finding more efficient and effective ways to achieve sustainable development, comprehensive and consistent meaning is still elusive both in theory and practice. The aim of this paper is to create a more structured theoretical framework related to macro and micro perspectives of sustainable development, relevant also to enhancing sustainable practices. We here propose a comprehensive framework model for structuring multiple sustainability principles and practices, detected in the literature as different sustainability categories related to both macro and micro perspectives of sustainability in the economy and society. The focus is on relevant sustainability principles of technology and business innovation in relation to basic technology and business innovation models as a contribution to less investigated theoretical aspects of sustainable business development. We developed a set of related matrices indicating the relevant roles and relationships between these principles in achieving sustainable business goals related to sustainable economy dimensions. Finally, the paper shows that the proposed Related Matrices Framework fulfils the main objective set in the initial research stages, i.e. to be of both theoretical and practical relevance. As a contribution to the theory it meets the need of building a structured, integrated, comprehensive model that serves the needs of better understanding different sustainability of macro and micro categories, indicating mutual relations and influences. In a practical sense, it can be used as a tool to support the management of change in companies oriented at achieving sustainable business goals based on sustainable technology and business innovation.

Keywords: sustainable economy dimension, sustainable business development goal, sustainable technology and business innovation, business model innovation

JEL Classification: Q01, Q56, O32, M21

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Introduction

Sustainable technology and business development is considered the central pillar of sustainable development (SD). Relevance of the subject is based on the necessity for firms to reconcile sustainability aspects, simultaneously fulfilling all stakeholders' needs while reaching profitability and respecting diversified demands of social goals fulfilment (Adams, 2014; Epstein and Roy, 2001; Levi Jakšić, 2015). Traditional technology and business innovation models need rethinking (Ricart, 2014; Chesbrough, 2006a, 2014).

SD is most commonly defined as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987). The interest of researchers and practitioners in sustainable technology and business innovations rises constantly especially when it comes to technology innovation embedded in business environment contributing to the development of sustainable economies and societies (Boons and Ludeke-Freund, 2013; Bocken et al., 2014; Rainey, 2006). The challenge for SD lies in transforming goals, objectives, and principles into concrete actions, behaviours, and attitudes at all levels of the economy and society. Here, we transformed the key dimensions of sustainable development (SD) into sustainable business goals and further extended to technology and business innovation principles related to these goals.

Sustainable business development rests upon sustainable technology and innovation; managing technological change directly influences sustainable competitiveness of business operations (Popa, 2014; Rainey, 2006; Chesbrough, 2006b). The literature and practice reviews show that in some cases sustainable solutions in industrial practice appear to be ahead of academia in exploring and developing novel business models (Bocken et al., 2014; Chesbrough, 2014; Moore, 2014).

The remainder of the paper is organized as follows: Section 2 presents literature review and basic concepts elaborating the main objectives and hypotheses of a comprehensive approach towards sustainable technology and business (ST&B) innovation. Section 3 elaborates on the relations between SD dimensions, sustainable business (SB) goals, and sustainable technology and business (ST&B) innovation by developing a set of related matrices. Section 4 deals with concluding remarks, indicates limitations and elements of future research. Finally, the references are presented.

1. Theoretical background – basic concepts of Technology and Business Innovation Models

The aim of this paper is the development of a comprehensive framework model for structuring multiple sustainability principles and practices, seen in the relevant literature as different sustainability postulates, related to both macro and micro perspectives of sustainability in the economy and society. The focus is on relevant sustainability principles of technology and business innovations elaborated in relation to basic technology and business innovation models as a contribution to less investigated theoretical aspects of sustainable business development. The relevance of the research lies in fulfilling its main objectives i.e. achieving both theoretical and practical results. As a contribution to theory, the research is conducted in the response to the need of building a structured, integrated, comprehensive model that serves the needs of better understanding of different

sustainability-oriented macro and micro categories indicating mutual relations and influences. In a practical sense, the proposed theoretical framework could be used as a tool to support the management of change in companies oriented at achieving sustainability business goals based on sustainable technology and business innovation in a more efficient and effective way.

We have postulated two main hypotheses.

- **Hypothesis 1:** Sustainable technology and business model innovation are the pillars of sustainable business development.

- **Hypothesis 2:** Sustainable development is an integrated, holistic concept that diminishes the boundaries between the macro and micro perspectives and approaches, and is represented by an integrated, comprehensive framework.

The main Hypothesis 2 is further elaborated by the following hypotheses:

- **Hypothesis 2.1**. Different sustainability postulates belong to the categories of SD dimensions, SB goals and STBI principles,

- **Hypothesis 2.2.** SE dimensions are related to SB goals,

- **Hypothesis 2.3.** SB goals are based on STBI principles,

- **Hypothesis 2.4.** STBI principles are related to T&B model innovation

We approached the issue through developing a model of related matrices establishing a relationship between SD dimensions, SB goals and T&B model innovations.

The technology used in business operations affects environment, society and economy, which makes technology and business enterprises generators of potential damage and unwanted effects to the global environment, but also the key solutions to these problems by developing sustainable technology for sustainable businesses. In the Society and Environment Pull Business Model (Levi Jakšić, 2015), the external and internal factors of the firm's environment are interrelated in a virtuous cycle model with social and environmental objectives affecting sustainable business strategy, leading to business and technology innovation, further affecting the processes of creating and delivering value in the form of goods and services for customers, affecting consumption and further influencing the fulfilment of initial social and environmental objectives.

By the definitions of business model it is evident that the concepts of technology and business innovation are closely linked. A business model is a conceptual tool to help understand how a firm does business and can be used for analysis, comparison, and performance assessment, management, communication and innovation (Osterwalder, Pigneur and Tucci, 2005). The relevance of business model innovation in delivering greater social and environmental sustainability is increasingly recognized and all the relevant components of the business model are to be included (Bocken et al., 2014). According to the literature, a business model consists of different blocks: value proposition, value architecture, and economic equation (Sempels and Hoffman, 2013), or value proposition, supply chain, customer interface, financial model (Boons and Ludeke-Freund, 2013). Here we defined a business model by three elements: value proposition, value creation, and delivery and value capture.

Regarding sustainable innovation frameworks for business, Varadarajan (2017) suggests the conceptual model which separates drivers and outcomes of sustainable innovations. It also makes difference among 1) three innovation types: business model,product-service system, and technological innovation; 2) threelifecycle product: manufacture, use, and end-oflife; and 3) sustainability effects: ecological, social, andeconomic (Varadarajan, 2017). Hansen, Große-Dunker, and Recihwald (2009) presented another framework – the Sustainability innovation cube. This framework examines the sustainability effects of product innovations. It is a three-dimensional framework which measures 1) Needs: Culture, Usage system, and Technology; 2) Life cycle: Production & logistics, Usage, End of life;and 3) Target: Ecological, Social, and Economic effects. It describes 27 different areas in which sustainability effects may occur with different combination of sub-dimensions. Companies perform a cost-benefit-analysis by selecting the 27 areas which should be assessed (Hansen, Große-Dunker and Recihwald, 2009).

Technology innovation is approached here by adopting the OECD definition (1997): "Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation is implemented if it is introduced to the market (product innovation) or used within a production process (process innovation)". This definition comprises 'product' not only as manufacturing output, but also as services (Cetindamar, Phaal and Probert, 2009).

The answer to the dilemma concerning the relations between business model and technology innovation, i.e. which is more significant - "the hen or the egg", is found in a brief statement by Chesbrough (2014) "Innovate the business model, not just the technology" further explicated as "a better business model often beats a better technology". The article argues that sustainable technology innovation is inseparable from sustainable business, as presented in the Sustainable Technology and Business Innovation Push - Pull Model (Levi Jakšić, 2015).

2. Sustainable Business Models – "Push" from the practice

In order to provide the postulates related to the Hypothesis 1, we conducted the research on innovative company practices by the steps given in Table no. 1a and Table no 1b.

Table no. 1a: Aims and research steps of the research

H1:	Sustainable technology and business model innovations are the pillars of sustainable business development.	
Research steps	**Findings**	
1. Identify a relevant sample of innovative companies. 2. Examine the sustainable orientation of the defined set of companies. 3. Examine the predominant type of innovation (technology, business model, or both) in the defined set of companies. 4. Examine the sustainability aspects on which the observed companies focus.	**H1**	Table no. 3 (Section 3.1) – original findings

Table no. 2b: Aims and research steps of the research

H2:	Sustainable development is an integrated, holistic concept that diminishes the boundaries between macro and micro perspectives and approaches and is represented by an integrated, comprehensive framework.

Research steps	**Findings**	
1. Identify a list of different sustainability postulates found in the relevant literature and reports from practice related both to macro and micro sustainability perspectives. 2. Specify their main meaning and characteristics. 3. Investigate their affiliation to the categories defined as Sustainable Economy dimensions at macro level, Sustainable Business goals and Sustainable Technology and Business Innovation Principles and models., 4. Establish essential relationships between different categories represented by a set of matrices, and 5. Develop a comprehensive framework model for a holistic approach that integrates sustainable business development based on innovation within the general perspective of sustainability.	**H2**	Figure no. 1 (Section 3.2) original findings Further elaborated through H2.1 - H2.4
	H2.1	Table no. 4 (Section 3.2) systematization of relevant literature; original findings
	H2.2	Table no. 5 (Section 3.2) original findings
	H2.3	Table no. 6 (Section 3.2) original findings
	H2.4	Table no. 7 (Section 3.2) original findings

3. Identifying a growing interest and need for theoretical concepts

Business models have captured a great attention both in literature and industry (Baden-Fuller and Mangematin, 2013; DaSilva and Trkman, 2014; Zott, Amit and Massa, 2011). It is increasingly suggested that business model innovation is the key to business success (Chesbrough, 2006b, 2007; Boons and Ludeke-Freund, 2013; Bocken et al., 2014). As discussed by Chesbrough (2010), businesses usually focus on exploring and investing new technologies and ideas, but still have little ability to innovate their business models, being unaware that the same idea or technology will yield two different economic outcomes when taken to market through two different business models. Baden-Fuller and Haefliger (2013) formulated the relationship between technology and business models in a two-way manner, observing business models as mediators between technology and business performance, and secondly considering that the development of the appropriate technology depends on business model characteristics.

The main issue is how to encourage corporate innovations to ensure greater sustainability. SB models come to the forefront when it comes to business model innovations. "Sustainable business models with a focus on technological innovation are market devices that overcome internal and external barriers of marketing clean technologies: a business model ability to create a fit between technology characteristics and (new) commercialization approaches that both can succeed on given markets" is of significance (Boons and Ludeke-Freund, 2013). There is much discussion in the literature on business models' role in achieving the corporate sustainability (Schaltegger et al., 2012; 2016). However, a theoretical foundation is still lacking.

3.1. Sustainability goals in innovative company practices

The qualitative research we conducted to test the main hypothesis 1 gives rise to a series of issues concerning the specific nature of sustainability built in innovative solutions in regard to technology and business models. In the effort to shed more light on these matters, with a general aim to identify to which extent the global innovative practice is oriented towards sustainability, we investigated the most innovative companies registered in the available global company lists. The research was based on a sample of 100 most innovative companies and was oriented towards searching for answers to some of the crucial sustainability issues of innovative companies. The research was conducted based on secondary data, no primary research was conducted.The data was retrieved from the official *FastCompany* list for 2015 (FastCompany, 2015) and 2016 (FastCompany, 2016) and it consists of 50 most innovative companies in 2015 and 50 in 2016. For each company,*FastCompany* publishes a report with company's profile and specific business details. They list:1) qualitative data describing the innovations introduced, company's historical data, business and revenue model description; 2) quantitative data about company's value, revenue, and number of employees. Facebook, Netflix, Amazon, Google, Apple, GE, HBO, Tesla, and Toyota are some of the companies which are listed. Besides the innovativeness criteria, what makes this sample relevant is its structure. In the sample there are private (64%) and public companies (32%), as well as non-profit ones (4%). The size of companies is also diverse. There are 35% of small-sized enterprises (up to 200 employees), 10% of medium-sized enterprises (200-500 employees), and 54% of large firms. Regarding industry, there is the greatest variety. Companies belong to 20 different branches: fashion, biotechnology, computer games and software, consumer electronics and goods, design, e-learning, electronic manufacturing, entertainment, financial services, fitness, health care, internet, tourism, marketing, music, pharmaceuticals, restaurants, telecommunications, TV industry, and venture capital. Additionally, the list includes both young and old companies, listing firms established at the end of 19th century (Bristol-Myers Squibb or GE), as well as those founded in the last 10 years (Kit & Ace, Uber, etc.). This variety enables better insight in sustainability aspects of innovative companies despite their differences.

Some of issues and points to be clarified as the result of the research were:

- how important are sustainable business and technology innovations in the most successful innovative companies chosen for analysis, i.e. in order to have the most innovative and successful business, is it enough "just" to innovate or is it imperative to innovate sustainably,
- which types of innovation are predominant: technology, business model or both,
- what is the specific nature of sustainability involved in these companies, i.e. do they focus more on sustainable technologies or sustainable business models and what aspects of sustainability are mostly present in the sample companies.

To perform the analysis we constructed a matrix presented in Table no. 2 showing the basic combinations that exist between Technology and Business Model, indicating five combinations for sustainability solutions.

Table no.3: Extended sustainable business/technology innovation model combinations

		BUSINESS MODEL		
		Existing	**New**	**Sustainable**
TECHNOLOGY	**Existing**	Not considered here (NCH)	Traditional relations (NCH)	3
	New	Traditional relations (NCH)	Traditional relations (NCH)	4
	Sustainable	1	2	5

Notes:

- *Combination 1. With sustainable technology innovation we use existing business models. This situation can be described as missed opportunity in that the sustainable technology innovation is not fully exploited, its potential value is not fully appreciated, and the traditional business model lacks recognition of the full potentials resulting in under-usage of all business potentials in different spheres.*

- *Combination 2. Sustainable technology and new business model without all the elements of sustainability is again a missed opportunity although in a traditional sense the business model is innovated but not completely meeting the complex needs of sustainability. This can be described as a partial solution, still lacking all the necessary dimensions that would lead to a sustainable business model.*

- *Combination 3. SB model based on existing technology is the "PULL" strategy, going ahead of technological solutions, introducing sustainability strategic goals, organizational configurations and conditions that are a precondition to introducing sustainable technology innovation.*

- *Combination 4. SB model developed, but the technology innovation management is still not achieving the full potentials but is a step forward in finding optimal sustainable technologies. This can be referred to as the partial solution.*

- *Combination 5. SB model well suited to the potentials of sustainable technologies, the PUSH-PULL balance is achieved for future SB development.*

Analysing the companies' reports we firstly identified why they are on these lists: is it because of the technological innovations or business model innovations? We also examined whether these innovations are sustainable. The results of this first part of the analysis show the rising relevance of sustainable goals embedded in technology and business model innovation. Among the observed companies, there are no companies which use existing technology and existing business model. This is not surprising, having in mind that the list measures innovativeness. On the other hand, 73.20% of companies have at least one sustainable innovation (technology and/or business model). When it comes to companies which sustainable innovate business models, 17.53% of them use existing technologies, and the same share uses new ones. Regarding sustainable technology, 13.4% of them have existing business model, while 4.12% have new business model. It is interesting to notice that the majority of companies sustainably innovate both technology and business model (20.62%). The results of this analysis are in accordance with other innovative performance measures found in the literature (Epstein and Roy, 2001; BRW, 2015; FastCompany, 2015; FastCompany, 2016; FORBES, 2016) which also identify sustainability goals as the main driving force for innovation. More deeply, we analysed which aspect of sustainability is in

the focus of these companies – environmental, economic or social. Two cases were observed: sustainable aspects of technology and of the business model. The results are presented in table 3. Values in the table refer to the share of companies which include the observed sustainability aspect of technology (table no. 3 (3A)) and of business model (table no. 3 (3B)). Table no. 3 (3A) refers to the analysis of sustainability aspects of technology, examining whether a company has existing, new, or sustainable business model. It is evident that in most of these cases the main focus is on economic and social aspect of sustainable technology (69-100% in each category), no matter whether the business model is existing, new or sustainable. Still, it is important to emphasize that all the three aspects of sustainable technology are embraced with 25% or more.

Table no.4: **Analysis of sustainability aspects in technology and business models**

3A SUSTAINABLE TECHNOLOGY ASPECT		**Environment**	**Economic**	**Social**
BUSINESS MODEL	**Existing**	38.46%	92.31%	69.23%
	New	25.00%	100.00%	100.00%
	Sustainable	45%	80%	85%
3B SUSTAINABLE BUSINESS MODEL ASPECT		**Environment**	**Economic**	**Social**
TECHNOLOGY	**Existing**	41.18%	88.24%	88.24%
	New	35.29%	88.24%	100.00%
	Sustainable	30%	88.24%	100.00%

Table no. 3 (3B) refers to the analysis of sustainability aspects of the business model, testing three technology cases (existing, new or sustainable). The results indicate that although companies focus mostly on economic and social aspects of the business model (88-100% in each category), environmental aspect of sustainable business model is present in 30-42% of the companies. Again, it is evident that all the three aspects of sustainable business model are present in the world's most innovative companies for 2015 and 2016.

This analysis justifies the conclusion that the world's most successful practice is highly oriented towards sustainable innovations both in technological and business models, and proves the claims stated in the Hypothesis 1. The companies put emphasis on new SB models and call for academia to set clear theoretical concepts for successful future of businesses, focusing on developing the theoretical framework of sustainable business models.

3.2. The related matrices of SE dimensions, SB goals and ST&B innovation

As emphasized in Table no. 1, the research related to Hypothesis 2 is conducted by developing a set of related matrices. Further, the set of related matrices are established in relation to the particular hypothesis 2.1 – 2.4.

The complex goals of sustainable development (SD) focussing on sustainable corporate goals involve a more balanced view of corporate objectives that include a set of social, economic and environmental considerations described as the notion of Triple Bottom Line (Rainey, 2006, Sempels and Hoffmann, 2013) also noted as the Triple Integrated Equation (TIE) (Levi Jakšić, 2015); striving to "a holistic view of the business environment taking into account social, economic and environmental considerations as well as more conventional concerns of customers, markets, and competition" is involved (Rainey, 2006).

The crucial goals of SD are examined in the literature as specific "routes" or "principles" leading to sustainable economy and society.

The Related Matrices Framework (RMF) is introduced in this section. The fields of matrices show the relation of the dimensions observed. RMF consists of 3 matrices which note the following relations:

- Sustainable Economy (SE) dimensions and Sustainable Business (SB) goals;
- Sustainable Business (SB) goals and Sustainable Technology & Business Innovation (STBI) principles;
- Sustainable Technology & Business Innovation (STBI) principles and Technology and Business (T&B) models.

Matrices are chosen as a useful tool for supporting the concepts in technology and innovation management, which provide conceptual understanding of the observed phenomena. To use this tool it is essential to identify key dimensions of the examined problem and put them into orthogonal framework which should recommend concrete managerial actions (Phaal et al., 2006). The idea of this part is to use matrices which match the relationships between the concepts listed above. The first matrix identifies the relations between SE dimensions and SB goals. In the second matrix, the horizontal dimension (SB goals) translates into the vertical and is connected with the STBI principles. Using the same transformation, we examine the connection between these principles and the T&B model components (Figure no. 1). The final goal is to identify which technology and business model dimensions a company has to focus on to achieve the defined SB goals through satisfying the STBI principles. Additionally, following the cascading framework in the opposite direction, a company can identify which dimension(s) of the sustainable economy it contributes to. This framework supports the concepts given in Hypothesis 2, that the SD diminishes boundaries between macro and micro level.

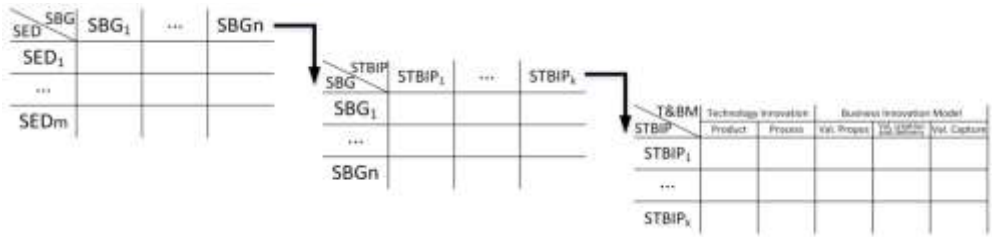

Figure no. 1: **Related Matrices Framework (RMF)**

To further elaborate Hypothesis 2, it was necessary to define the concrete elements of the proposed concept, stated in Hypotheses 2.1-2.4. These findings primarily rely on the literature and practice review presented in the previous section (examination of the most innovative companies). The "route to sustainable economy" (Jackson, 2011) postulates the characteristics of a sustainable economic system. "Hannover" principles were developed to articulate the basis for integrating business management with the realities of humanity and nature (Rainey, 2006).

Based on the literature review we have identified the dimensions of SE. *Circular economy*, defined by the rule of transforming 'waste' into a productive resource and transformation

from linear to circular flows in the economy, cited as the "new industrial system that replaces 'end/of life' concept by restoration and regeneration by intention and design" (Sempels and Hoffman, 2013; Andersen, 2007; Yuan et al., 2006). *Substituting with renewables, alternatives and natural processes* in order to preserve the natural environment and reduce the exploitation of scarce natural resources (Mohanty et al., 2002; Wei et al., 2010). *Minimizing consumption* is related to the overall change of attitudes and behaviour of all the actors in the economy and society, based on a new philosophy of economic and social relations (Lorek and Spangenberg, 2014; Jackson, 2005). *Establishing S-E benefit/cost relationship*, related to maximizing S-E benefits and minimizing S-E costs based on rethinking and reconsideration at a global scale the principles and models developed in the traditional approaches and applied in practice (Barr, 2012; Harte, 1995). Rethinking business models includes efforts to appraise the costs and revenues in a broad social and environmental perspective, and some solutions introduce Costs and Benefits for Society and the Environment in the sustainable business models (Sempels and Hoffmann, 2013). *Positive and motivating work* experiences enhancing human creativity and skills emphasize the satisfaction of working population as a driving force of creativity and innovation (Shipton et al., 2006; Ramus, 2001). *Collaboration and sharing* rather than aggressive competition is a quest for more integration and cooperative solutions in the activities of the agents in the economic system (Kim and Mauborgne, 2015; Orsato, 2009; Gupta and Benson, 2011). It means strategic orientation towards the Blue Ocean strategy (Sempels and Hoffmann, 2013). *Factor 4* describes a new form of progress - resource productivity. This concept, firstly devised by Von Weizsacker et al. (1998), holds that the amount of wealth extracted from one unit of natural resource can quadruple. It is defined as a strategy of halving resource use and doubling wealth, indicating integration of the triple equation goals (Bardy and Massaro, 2013; Von Weizsäcker, 2006).

Table no.5: **Elements of the RMF framework: dimensions, goals, and principles**

SE DIMENSIONS	SB GOALS	STBI PRINCIPLES
Circular economy	Max. material and energy efficiency	Open, agile T&B innovation platforms
Substitute with renewables	Create value from waste	Cradle-to-cradle
Minimize consumption	Zero waste & emissions	Use-oriented Product-Service Systems
Maximize social and environmental benefit	Deliver functionality rather than product ownership	Reuse, Recycle
Positive work experiences enhancing creativity & innovation	Stakeholder satisfaction	Eco-efficiency, Eco-design
Collaboration and sharing	Reduce costs	Value constellation platforms
Factor 4		Decouple product from revenue

The same literature analysis was conducted for determining SB goals. *Maximize material and energy efficiency* based on material productivity resource efficiency and waste reduction (Rosen et al., 2008; Omer, 2008). It means doing more with fewer resources and generating less waste, emissions and pollution (Chien and Hu, 2008; DeSimone and Popoff, 2000). *Create value from waste* is the concept by which waste is eliminated by turning waste streams into useful and valuable input to other production and making better use of underutilized capacity (Womack and Jones, 2015; Morgan and Liker, 2006). *Zero waste*

&emissions goal sets high business operations quality management standards and procedures. *Delivery of functionality rather than product ownership* is a strategic goal to provide services that satisfy users' needs without having to own physical products (Bocken et al., 2014; Baines et al., 2007; Ebbesen and Hope, 2013). *Stakeholder satisfaction* identifies the interests of firm's various stakeholders and articulates the specific goals and strategy to satisfying these goals. The company responds to all stakeholders' needs: consumers', employees', suppliers', local community and other stakeholders' (Adams, 2014, Garvare and Johansson, 2010; Matos and Silvestre, 2013). *Reduce costs* is specified also in relation to identifying all the costs in the long-term perspective of business operations affecting the society and the environment, including all the costs: direct, indirect, hidden, external and publicly imposed (Hart, 1997; Ageron et al., 2012; Rainey, 2006).

The literature analysis was used to establish the main dimensions and create the relations between them as presented in the Table no. 5where the dimensions of sustainable economy are related to Sustainable Business Goals (SBG) and presented in a matrix relationship model. It is noted that the elements of the matrix do not represent an exhaustive list; it is open for new considerations.

Table no.6: **Matrix relationship between SE dimensions and SB goals**

SB goals / SE dimensions	Max. material & energy efficiency	Create value from waste	Zero waste & emissions	Deliver functionality rather than product ownership	Stakeholder satisfaction	Reduce costs
Circular economy		✖	✖		✖	✖
Substitute with renewables	✖		✖		✖	✖
Minimize consumption				✖	✖	
Maximize social and env. benefit	✖	✖	✖		✖	
Positive work experiences enhancing creativity & innovation					✖	
Collaboration and sharing			✖	✖	✖	
Factor 4	✖	✖	✖			✖

Further literature review resulted in identified Sustainable Technology and Business Innovation principles. *Open, agile T&B innovation platforms*, open models of technology and business often cited in the literature as frugal, lean, sustainable, eco innovation and business models (Caetano and Amaral, 2011). Open innovation models (Chesbrough, 2006a, 2006b, 2014) integrate a significant number of players across multiple roles in the innovation process expanding beyond the limits of a single organization. Open innovation is a process that makes more effective use of internal and external knowledge in every organization (Chesbrough, 2014). *Cradle to cradle* principle, also referred to as the "idea to idea" and complete "life cycle assessment - LCA" concepts and approaches (Sempels and Hoffmann, 2013), rests upon a holistic and continuous perspective of innovation (Braungart et al., 2007; Adams et al., 2014). *Use-oriented Product-Service Systems* are based on the

transition from products to use- oriented services aimed to redefine the relation with 'tangible' goods, by making them available without transfer of ownership with numerous examples and possibilities: hiring, leasing, pooling, and shared consumption, often cited as "servicification, service transition, product-service systems (PSS), integrated product service engineering" (Reim et al., 2015; Beuren et al., 2013; Sempels and Hoffman, 2013). *Reuse, and recycle*, also referred to as re-manufacture, up-cycle or down-cycle means reuse of non-renewable materials including fossil fuels, which means that waste and emissions are either avoided or up-cycled (DeSimone and Popoff, 2000). Up-cycling (Bardy and Massaro, 2013) denotes up-cycling as a kind of recycling that produces materials of at least equal quality while down-cycling converts materials and products into new raw materials of lesser quality. *Eco-efficiency and eco-design* refers to a principle of "doing more with fewer resources" both in products and services (DeSimone and Popoff, 2000; Tseng et al., 2013). It comprises "reconsideration of the design of a product, a service or a process to decrease its environmental impact" (Sempels and Hoffman, 2013).*Value constellation platforms* are related to reframing the company activity considering the stakeholders in the value constellation instead of the value chain alone (Sempels and Hoffman, 2013; Cho and Lee, 2015). *Decouple product from revenue*, i.e. decouple revenue generation from raw materials and energy consumption based on the approach 'guarantee of result' instead of the sale of the means to reach that result, which entails the transition from product to result based integrated solutions (Sempels and Hoffman, 2013).

Based on the identification of STBI principles, Table no. 6 shows the matrix relations between SB goals and established (but not close-listed) STBI principles.

Table no.7: **Matrix relations between SB goals and STBI principles**

STBI principles / SB goals	Open, agile T&B innovation (platforms)	Cradle-to-cradle	Use-oriented Product-Service Systems	Reuse, Recycle	Eco-efficiency Eco-design	Value constellation platforms	Decouple product from revenue
Max. material and energy efficiency	✖			✖	✖	✖	✖
Create value from waste		✖		✖	✖	✖	✖
Zero waste and emissions				✖	✖		
Delivery of functionality rather than product ownership	✖		✖			✖	✖
Stakeholder satisfaction	✖	✖	✖			✖	✖
Reduce costs	✖			✖	✖		

Finally, Table no. 7 illustrates the matrix relations between STBI principles and Technology and Business (T&B) Innovation Models. Technology Innovation Model is defined by the innovation of products and innovation of process, while the business innovation model is represented by the innovation of the basic business model components: value proposition, value creation and delivery, and value capturing. The assertion is that

with careful business model redesign and sustainable technology innovation it is possible for mainstream businesses to readily integrate sustainability into their business and for new start-ups to design and pursue sustainable business from the outset (Bocken et al., 2014).

The RMF is constructed to contribute to more precision, clarification and to systematize many new notions and terms that have emerged with the rising need to introduce sustainability dimensions into our practices at different levels of the economy and society. Its main relevance is in the theoretical construct and contribution to more theoretical foundations of sustainable technology and business development. However, it should be noted that it has also practical relevance as it may present a tool for strategic management at a company level, enabling efficient recognition of the paths and changes to be introduced leading to sustainable business development.

Table no.8: Matrix relations between STBI principles &technology &business models

T & B Model / STBI principles	Technology innovation		Business Model Innovation		
	Product	Process	Value Proposition	Value creation and delivery	Value Capture
Open T&B innovation (platforms)	✖	✖	✖	✖	✖
Cradle-to-cradle	✖	✖			
Use-oriented Product-Service Systems			✖	✖	✖
Reuse, Recycle	✖	✖			
Eco-efficiency Eco-design	✖	✖			
Value constellation platforms			✖	✖	✖
Decouple Product from Revenue			✖	✖	✖

Having in mind practical implications of the RMF, we here present an explanation of this process on an example in more details. We can observe the "*Circular economy"* dimension and focus on achieving it by "*Create value from waste*" business goal. This goal can be accomplished by using the following STBI principles: "*Cradle-to-cradle*", "*Reuse, Recycle", "Eco-efficiency", "Eco-design", "Value constellation platforms"* and *"Decouple product from revenue*". If a company puts forward the business goal to *create value from waste* as its priority, it can accomplish this goal by a set of concrete measures and principles included as part of its strategy for fulfilling the goal. For example, by following the principle of "*Cradle-to-cradle*" it focuses on technological innovation of its products and processes contributing to achieving the goal of "*Creating value from waste*", while simultaneously contributing to the sustainable economy dimension of "*Circular economy"*.

These matrices support Hypotheses 2.1-2.4. Firstly, for proving H2.1 we examined literature and practice and identified the elements of each category defined: SD dimensions, SB goals, and STBI principles. Further, to examine the relations between these categories, we created matrices and identified the relationships between the elements. Thus we proved Hypothesis 2 by giving the framework which overcomes the boundaries between macro and micro perspectives of sustainable development.

Conclusions

The research in the field of sustainable development has been intensified in the last decades since the times when the core definition has been established in the often cited Brundtland Report in 1987, outlining the general goals and concepts. The theoretical and empirical research results reported in the relevant literature and traced in the practical solutions of the companies, point to the rising interest of academia and in practice of both macro and micro SD aspects, with special interest and research aimed at highlighting sustainable business development issues which have been less investigated in the past, as reported in multiple works and research results on this topic. The overall conclusion based on relevant literature analysis indicates that the comprehensive and consistent meaning is still elusive both in theory and practice.

The research conducted and the results presented in this paper are viewed in this context. The research is especially focused at developing a more structured comprehensive framework model for structuring multiple sustainability goals, principles and practices, detected in the literature as different sustainability categories, related to both macro and micro perspectives of sustainable development, relevant also for improving sustainable practices.

As a result of the literature review and analysis of the main concepts introduced in this paper, we have come to the conclusion that the concepts of sustainable innovation and sustainable business converge. It is difficult to draw a line as innovation is seen as commercialization of invention (idea), referring to its market entry and transfer. The focus on technology and innovation for economic growth and socio-economic development puts stress on technology innovation for achieving sustainable socio-economic development. "Research and experimental development (R&D), when appropriately valorised, lead to technological innovation in the form of new products and processes, which contributes to growth, competitiveness and job creation, producing other societal benefits" (Delanghe and Muldur, 2014).

The first step of the research has been to analyze the backbone of the framework determining sustainable technology and business model innovation as the pillars of sustainable business development. It is argued that managing technological change directly influences sustainable competitiveness of business operations. Relevant literature analysis in the field of sustainable development theory and practice shows that in some cases sustainable solutions in industrial practice appear to be ahead of academia in exploring and developing novel business models. In the effort to shed more light on these matters, with a general aim to identify to which extent the global innovative practice is oriented towards sustainability, we investigated the most innovative companies registered in the available global company lists. The research was conducted on a sample of 100 most innovative companies within the *FastCompany* (FastCompany 2015; 2016) list chosen for its relevance. The analysis focused crucial sustainability issues and innovative solutions in technology and business models found in the practice of the companies in 2015 and 2016. The findings of the research analysis indicate innovation of both technology and business models being present in all the companies within the sample, and the innovative solutions being strongly sustainability oriented. This is a point which strongly supports the conclusion of innovative sustainability drivers being dominant in the economy today justifying the claims postulated in the Hypothesis 1 of the research in this paper.

Relevant practice shows that sustainability benefits are achieved only when combining several approaches, and synergy effects are present by combining sustainability efforts in both technology and business innovation. It is also ascertained that not all the technological solutions are in line with SD goals. The necessity to develop sustainable technological innovation and sustainable business models based on the Triple Integrated Equation involves a change and rethinking of our traditional technology and innovation models within an integrated, comprehensive and consistent approach.

It is the companies placing strong emphasis on new Sustainable Business models creating a "push" towards research leading to the creation of a general comprehensive theoretical framework enabling the diffusion of efficient and effective sustainability solutions to be widely used in practice thus creating substantial contribution to sustainable development at different levels of the economy. In answer to this need, the next research step presented in this paper has been oriented at establishing a systematized and clear theoretical framework for better understanding the essential concepts and relations between sustainable economy dimensions, business development goals and technology and business model innovations. The aim was to develop a comprehensive framework of sustainable development as an integrated, holistic concept that diminishes the boundaries between the macro and micro perspectives and approaches, and is represented by an integrated, comprehensive framework. The proposed Related Matrices Framework model, as an argument and justification of Hypothesis 2 of the research, is argued to be of both theoretical and practical relevance. As a contribution to the theory it meets the need of building a structured, integrated, comprehensive model that serves the needs of better understanding different sustainability of macro and micro categories, indicating mutual relationships and influences. In a practical sense, it can be used as a tool to support the policies aimed at enhancing sustainable development of the economy and companies based on sustainable technological and business model innovations.

The Related Matrices Framework model has been chosen for its flexibility and openness to introducing new factors as the basic dimensions in the relevant matrices within the integrated model. Flexibility is an important feature for creating responsiveness to the dynamics of frequent changes in the intensively evolving field of sustainable development. It also has the advantage of simplicity in usage when creating a holistic overview of the interrelations among different dimensions, goals and principles. In this paper it has been implemented as a tool in building an overall framework for improving our understanding of the relevant forces driving the companies, the economy and society towards higher sustainability standards and solutions simultaneously fulfilling complex economic, social, and environmental goals.

Some of the concerns and disadvantages of the Related Matrices Framework model may be found in the absence of concrete policy measures and instruments that are related to the set of essential dimensions, goals and principles presented. The set of policy instruments and measures would complement the general framework construct that could be used to enhance innovative sustainable solutions in the economy and at the company level. In this way the RMF Model would be more practice-oriented and further complemented by developing criteria for priorities and selection of the measures and instruments to be used for developing sustainable innovativeness of the overall ecosystem comprising multiple actors in the economy and society. This is viewed as a track for future research which would highlight an important aspect of applicability of the framework for effective

intervention aimed at enhancing sustainability at all levels of the economy. It would also be complemented by identifying the basic actors in the socio-economic environment with specific roles and responsibilities of the government, business and scientific and research organisations in the process.

It is noted that the research and analysis presented in this paper is in essence based on qualitative research findings. While it serves the purposes set out as the research goals of this project, in the future research we see the efforts to introduce more quantitative research methods for developing models, indicators and indices serving specific needs of policy decision makers. This would be oriented at developing more evidence-based innovative strategies for enhancing sustainability which would support planning, monitoring and controlling the effects of the actions aimed at enhancing sustainable development.

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