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The evolution of sustainability model patterns among winning participants of the Horizon Europe EIC Accelerator funding program

DOI: 10.29180/9786156342386_3

Abstract

How many of the recently emerged and described sustainability models bring success to companies in the practice on the European level? In this study, prior winning participants of the Horizon Europe funding framework's EIC Accelerator program were analyzed regarding their extent of implementing various sustainability models described in the widely established 40 Circular Economy Business Model Patterns sustainable model categorization framework proposed by the BMI Institute to understand the relevance and applicability of sustainability models in practice in the European Union. During the study, a list of 391 former EIC Accelerator winning companies was retrieved from the EIC Accelerator Data Hub from the years of 2020 and 2021, which were manually analyzed and categorized into 13 distinct thematic categories based on the official Horizon Europe topic keywords. Among these, 31 startups falling into the Earth/Environmental Sciences category were individually analyzed to understand their applied business models and product functions to forecast their extent of including the 40 sustainability model patterns. Results showed that among the 40 patterns, 3 sustainability models, namely the 'Produce on Demand', 'Eco Lock-in', and 'Eco-Efficiency' were identified to have the highest level of implementation among the 31 winning thematic companies. Interestingly, insignificant difference was observed for the appearance rate of other sustainability models among all winning participants and the selected group of those participants which already deployed the most frequently used 'Produce on Demand' model. Finally, the trends of model emergence and decline were analyzed for the 40 models over the 2020 and 2021 period among the winning participants, where significant changes were observed in the appearance of novel sustainability models, with 'Servitisation' and 'Smart Assets' being the most dominantly emerging patterns, and 'Eco-Efficiency' and 'Communicate Responsibility' being the most declining patterns in 2021. The conclusion of initial results assume only a distant relationship between how the combination of various sustainability models would influence each other, suggesting that the implementation of different sustainability models is rather impacted by other factors, e.g. the company's technology and the implemented business model rather than the direct presence of other sustainability models. Furthermore, results also suggest the increase of complexity in the applied sustainability models over the years, likely driven by societal trends and the evolution of business model design.

Keywords: sustainability, sustainable development, sustainability models, technology funding, Horizon Europe, EIC Accelerator

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Introduction

Integrating sustainability and circular economy approaches into the business plan of companies has been at the forefront of business model innovation practices for the past years given their tremendous contribution to process optimization (Mukherjee, Sengupta & Sikdar, 2015), cost efficiency (Girotra & Netessine, 2013), customer appeal (Kumar & Christodoulopoulou, 2014), and indirect socio-environmental impact creation, among other advantages (Reddy, Sadasivam & Adams, 2014). Because sustainability is a recently emerging topic that is still dynamically changing (Geissdoerfer, Savaget, Bocken & Hultink, 2017), during the past years, a plethora of sustainability models have been identified along with several theoretical frameworks that have been established to holistically structure sustainability models, categorize them based on various factors, and identify their connection to a company's competitiveness. Such notable frameworks include the 40 Circular Economy Business Model Patterns (Takacs, Frankenberger & Stechow, 2020) by the BMI Institute ("Circular Economy — Business Model Innovation Lab", 2022), the 30 Questions to Kickstart Your Circular Business by Innovate UK's network partner, the Knowledge Transfer Network ("30 Ideas to Kickstart your Circular Business – Innovation Canvas", 2022), and the CIRCit Circular Economy Business Model Configurator (P. P. Pieroni, C. McAloone & C. A. Pigosso, 2019) ("Expert System Circular Economy Business Model Configurator", 2022), among others. However, there is no clear understanding on which models are the most impactful and relevant in real life settings for companies in terms of the successful implementation of projects (Silvius & Schipper, 2022) or the development of innovations (Adams, Jeanrenaud, Bessant, Denyer & Overy, 2015).

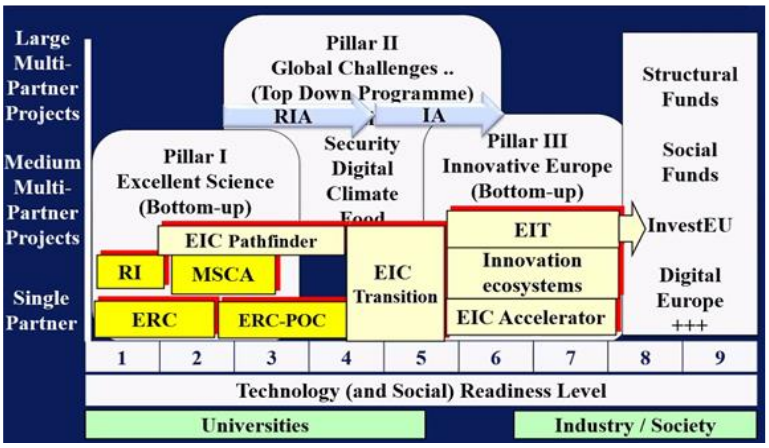
Previous research shows that there are different sustainability models which are more relevant in certain application domains, however their connection to the company’s competitiveness and the achievable success in relation to their integration to the company’s best business practices is unclear (Nosratabadi et al., 2019). Therefore, the aim of this study was to understand whether there are various sustainability models which are especially relevant to a wider range of companies regardless of sector in terms of bringing performance improvement and ensuring a more robust impact creation potential which improves the company’s competitiveness. Moreover, whether there is any clear trend among these models in terms of their adoption, emergence, or decline, that would indicate specific changes in sustainability models, implying their evolution, or becoming more impactful and applicable to innovative companies.

Connecting sustainability models to exponential impact creation: the Horizon Europe EIC Accelerator funding program

Considering the extent of innovative business and sustainability model adoption, various studies have indicated the inclusive and agile business strategy development of young, innovative firms (Pellegrino & Piva, 2019) (Souto, 2015) (Roberts, Murray & Kim, 2022). Concerning the application of the most recently emerging sustainability models, early-stage innovative companies can thereby serve as a relevant study group that can allow the observation of the dynamics in emergence or decline in the adoption of the most recent sustainability model patterns in business model design in practice.

Among the various funding frameworks available in the European Union, the Horizon Europe technology funding framework is the most recognized that provides funding to support the emergence and market launch of the most innovative, exponential technologies across the different member states of the European Union (González Fernández, Kubus & Mascareñas Pérez-Iñigo, 2019). The Horizon Europe funding framework includes a variety of funding programs clustered into three main program pillars covering the support of early-stage innovations from the concept level to their prototyping stage and eventual market launch, based on the internationally recognized technology readiness level scale (see Figure 1 below).

Figure 1. Structure of the Horizon Europe technology funding framework. Technology funding programs under Pillar I, Pillar II, and Pillar III were primarily designed to provide support for innovations with technology readiness level 1-3 (ideation to proof-of-concept), 4-6 (prototyping), and 6-8 (validation and pre-commercialization), respectively.



Being the key and thereby most popular founding framework for facilitating breakthrough R&D activities across the EU (European Commission, Directorate-General for Research and Innovation, 2016), the various funding programs under both the current Horizon Europe funding framework and its predecessor Horizon 2020 framework are characterized by a particularly low success rate (European Commission, Directorate-General for Research and Innovation, 2018) due to the strict criteria and evaluation system for applicants to apply robust models to prove their future large-scale, distributed impact creation potential to the European Union. Therefore, participant early-stage companies are characteristically keen to apply the latest business and sustainability models to diversify their proposal to not only demonstrate their technical excellence but also showcase a solid impact creation potential to the European Union (De Marco, Martelli & Di Minin, 2020) (Veugelers et al., 2015). Therefore, this study was designed with a focus on understanding how participant companies apply the different sustainability models in their business model design practices, being the early indicators of the emergence of the latest sustainability models and the early decline of less relevant, older sustainability models.

Methodology

During the first step of establishing the structure of the research project, a variety of sustainability model categorization frameworks were analyzed in terms of their clarity and applicability for practical innovation cases. For this, an initial extensive literature search was conducted through search engines (Google) and scientific publication engines (e.g. Google Scholar, ScienceDirect) to identify publications and whitepapers that elaborate on different sustainable model categorization approaches to understand their extent of applicability to the potential technologies of applicants from the Horizon Europe funding framework. Relevant keywords during the literature search included “sustainable models”, “sustainable model patterns”, “sustainability design”, “circular economy model design”, “sustainability design toolkit”, “sustainability strategy”, and “sustainability blueprint”.

The most notable identified sustainable model categorization frameworks included the 40 Circular Economy Business Model Patterns by the BMI Institute, the 30 Questions to Kickstart Your Circular Business by Innovate UK's network partner, the Knowledge Transfer Network, and the CIRCit Circular Economy Business Model Configurator. Upon further analyzing the structure of the proposed model categorization systems, the 30 Questions to Kickstart Your Circular Business was identified to provide an approach to incorporating sustainable models into the business plan of companies through

proposing open-ended questions about the potential applicability of various sustainability patterns to stimulate business development managers to redesign their company's current strategy, but without precisely defined use cases or definitions. Therefore, such categorization system was eventually excluded from the study. On the other side, the CIRCit Circular Economy Business Model Configurator system was identified to be too specific for the study, only focusing on subsegments or more narrowly defined areas of sustainability, such as involving rather model integration aspects of specific supply chain-related circular economy model practices, therefore this system was eventually excluded from the study, as well.

Therefore, at the end, the 40 Circular Economy Business Model Patterns categorization framework from the BMI Institute was identified to be the most applicable to the current study due to its holistic approach in listing a well-defined portfolio of current sustainability models that allows for a clear, step-by-step assessment of each model's presence in case of the identified innovations of the selected applicants.

Selection of the eventual source of innovative companies under the Horizon Europe funding framework

Secondly, after identifying the appropriate sustainable model categorization framework to retrieve the latest and most relevant sustainable models to be compared with the practices of innovative companies, the eventual source of innovative companies was identified. As the provided technology funding programs under the various Horizon Europe pillars are tailored for early-stage innovative companies with different stages of technological maturity, the level of sustainability model adoption of these companies differs based on the readiness of their technology and associated business strategy. As the likelihood of innovative companies including sustainability model design practices among the prioritized activities at the specific readiness levels is highly different, each program under the Horizon Europe framework was analyzed to understand its potential to be a source of relevant applicants to the study.

Programs under Pillar I and Pillar II are focused on providing financial support to innovative companies at their earliest technological development stages where sustainable model integration in the business model design practices is underrepresented due to the presence of a vague business and commercialization plan, given the concept or proof-of-concept level of the developed technology. On the other side, programs tailored at early-stage companies that have already reached technology readiness level 9 (such as structural funds and social funds) are comprised of applicants which are already on the market with a mature business strategy and therefore likely have lower willingness or need to change, as their models are proven, so their likelihood to necessary involve the latest sustainability models in their practices is lower. Therefore, during this study, the focus was narrowed further to early-stage companies under the Pillar III Innovative Europe technology funding program group.

Within the Innovative Europe technology funding program group, 3 notable funding program schemes were identified, namely the EIT-related calls, the Innovation Ecosystems calls, and the EIC Accelerator calls. Considering that the EIT-related calls are operated semi-externally from core European bodies by the European Innovation and Technology Institute and the Innovation Ecosystems calls are rather focused on providing funding opportunities for setting up innovation ecosystems instead of particularly financing individual companies, these calls were further excluded from the scoping process. On the other side, the EIC Accelerator calls were identified to be operated by the European Innovation Council, serving as the core of the Horizon Europe funding framework. Moreover, the EIC Accelerator primarily supports companies between technology readiness level 5-8 to reach market readiness. These innovative applicants already have working prototypes and are very close to the market, indicating a defined business plan which can be still flexibly modified to prove the impact creation potential during the funding application. Given that the EIC Accelerator applicant companies are under much pressure

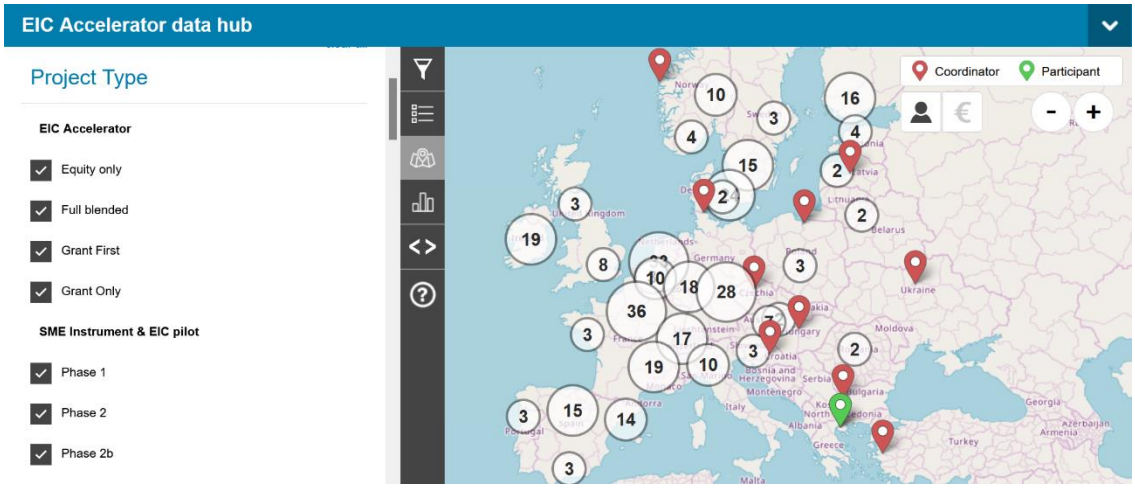
to show the technology grant evaluators that their business model can be adapted to a variety of future target markets to rapidly scale up their innovation, they are likely willing to incorporate the latest sustainability models into their business plan to enhance their competitiveness at the funding program. Therefore, these companies were concluded to be the primary focus of this study to understand the applicability of the latest sustainability models in practice.

Finally, upon identifying the Horizon Europe EIC Accelerator applicants as a potential target pool of companies, the applicant pool was further analyzed to identify the most relevant cases to obtain practically relevant insight on the applicability of sustainability models. Thus, applicants of the program were further grouped into potential applicants, current applicants, and previous applicants. As the European Innovation Council already evaluated the impact creation potential of previous applicants, the scope was further narrowed down to this group of applicants to satisfy the practicality aspect. At this point, the pool of previous applicants was further divided into previous winners and losers of the grant program. Given that in case of previous winners, the assigned evaluators of the European Innovation Council already concluded that these companies include models with strong impact creation potential for the EU, the applicability in practice of the applied models was confirmed. Therefore, previous winning participants of the EIC Accelerator program were eventually selected to be the primary study group where the analysis of the applied sustainability models was assumed to give the most precise indication of what sustainability models can be useful in practice and which are potentially the most relevant for young innovative companies in diverse sectors across the EU.

Step-by-step design of the research project: download the EIC Winner Database

After finalizing the structural design of the research project, during the first step, the list of previous winning companies of the EIC Accelerator was retrieved from the EIC data hub website (see Figure 2. below). Applicants from 2020 and 2021 were obtained to represent the latest complete year of the funding program and the previous year to allow for identifying trends in the emergence and decline of various models across the time span. During this step, a list of 391 former EIC Accelerator winning participants were retrieved.

Figure 2. The EIC Accelerator data hub provides comprehensive information about the description and statistics of projects & companies funded under the EIC Accelerator, along with an interactive map.



Source: https://sme.easme-web.eu/

Categorize the companies

In the second step, the previously obtained list of 391 winning companies was narrowed down to focus the study on applicants with higher likelihood of variably applying a larger combination of sustainability models to give better insight on how various sustainability models are related to each other, allowing a better clustering of their relationship. Therefore, the 391 winning applicants were further categorized into 13 distinct thematic categories based on the official Horizon Europe topic keywords. The categorization process included the manual revision of each company's description that was retrieved from the EIC Accelerator data hub profile of the applicant and its matching with the different Horizon Europe topic keywords. Each company was placed into one of the 13 distinct thematic categories based on the highest relevancy of the present keywords in its description (see Figure 3. below).

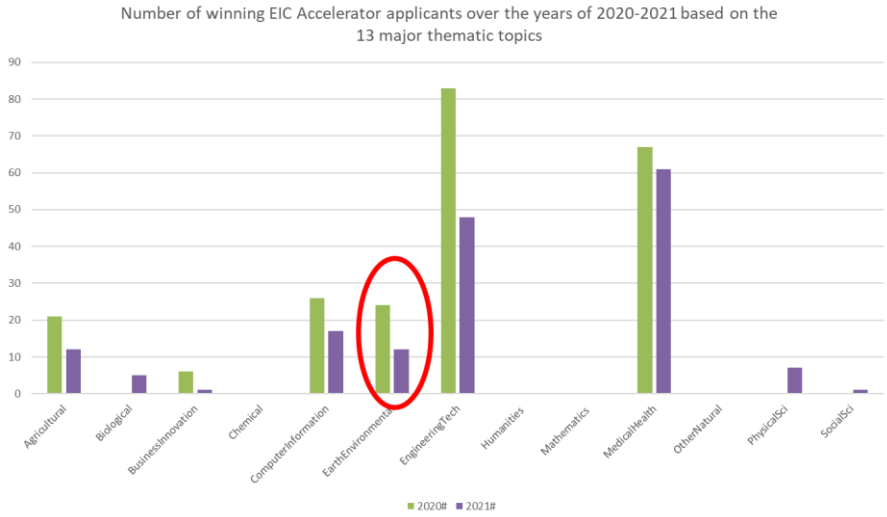
Figure 3. Summary table regarding the distribution of the number of winning EIC Accelerator participants within the year 2020 and 2021 according to the 13 thematic Horizon Europe EIC Accelerator categories.

Horizon Europe EIC Accelerator Category	Winning Applicants 2020#	Winning Applicants 2021#
Agricultural	21	12
Biological	0	5
Business Innovation	6	1
Chemical	0	0
Computer Information	26	17
Earth/Environmental	24	12
Engineering/Tech	83	48
Humanities	0	0
Mathematics	0	0
Medical/Health	67	61
Other/Natural	0	0
Physical Sci	0	7
Social Sci	0	1

Select the most relevant thematic category

After categorizing the 391 companies into the 13 thematic categories, the Earth/Environmental thematic category was identified with the highest likelihood to include applicants with a particular focus and strong relation to involving sustainability practices and the potential inclusion of a variety of sustainable model pattern combinations (see Figure 4. below). In this way, the sample pool of applicants for the study was narrowed down to a targeted group of 36 companies within the Earth/Environmental category.

Figure 4. Summary diagram regarding the distribution of the number of winning EIC Accelerator participants within the year 2020 and 2021 according to the 13 thematic Horizon Europe EIC Accelerator categories, highlighting the Earth/Environmental category with a particular focus and strong relation to involving sustainability practices and the potential inclusion of a variety of sustainable model pattern combinations.



Clean the selected dataset

After identifying the distinct list of 36 winning companies within the Earth/Environmental thematic category, each of the included applicants were manually checked in order to confirm that the description regarding their proposed technology and business model is available in adequate quantity and quality of details which enables the comparison of the outlined business plan with the potential 40 sustainability models. During this data cleaning process, 5 companies were removed from the applicant pool due to very limited available information about them on their EIC Accelerator data hub applicant profile which prevented their further analysis. At the end of this process, 31 former winning EIC Accelerator applicants were selected for the eventual analysis.

Matching the sustainable models with the former winning EIC Accelerator applicants

After selecting the eventual list of 31 former winning EIC Accelerator applicants, the proposed technology of each innovative applicant was analyzed and individually compared to each of the 40 sustainability models categorized within the 40 Circular Economy Business Model Patterns categorization framework from the BMI Institute to identify the applicability of each model that can be applied to the particular technology and associated business plan of each applicant.

During the sustainable model pattern matching process, value ‘0’ was given to a particular sustainability model which didn’t appear in the description of the selected 31 former EIC Accelerator winner applicants, or its inapplicability could be safely assumed based on the available technological description including the applicant’s business model. In a similar manner, value ‘1’ was given to a sustainability model which was likely to be present in the business model of the applicant based on the retrieved technological project description (see Figure 5. below).

Figure 5. Snapshot of the sustainable model pattern matching table. Value ‘0’ was given to a particular sustainability model which didn’t appear in the description of the 31 selected former EIC Accelerator winner applicant, or its inapplicability could be safely assumed based on the available technological description including the applicant’s business model. In a similar manner, value ‘1’ was given to a

sustainability model which was likely to be present in the business model of the applicant based on the retrieved technological project description.

Data normalization

Upon finalization of the sustainable model pattern matching table and the allocation of '0' and '1' values to each of the 40 sustainability models in case of the 31 winning applicants, a data normalization process was undertaken. As the number of retrieved companies from 2020 and 2021 were different, the rate of presence of the different models for the two observed years were normalized to avoid any data misinterpretation issue that would arise from one sustainable model being considered to have too high appearance, while, in reality, its emergence would only happen due to more companies analyzed in that particular year, and not due to increased popularity of the model.

	A	B	C	D	F	G	H	I	J	K	L	M	N
1	Participant	Project acronym	Project title	Year	S1 - Product Reuse	S2 - Part Reuse	S3 - Re-& Upcycling	S4 - Intelligent Assembly & Modularsation	S5 - Biodegra-dability	S6- Waste as input	S7-Reverse Logistics	D8 - Increased Longevity	D9 - Smart Assets
2	BIOWEG	Bioweg	A zero waste process for producing all natural, biodegradable rep	2021	0	0	0	0	1	1	0	0	0
3	CO2BioClean GmbI	CO2TEXTILE	0vel business model enabled by a patented fermentation tech0log	2021	0	0	1	0	1	1	1	0	0
4	Circular Materials	STOP WASTIN' MI	Supercritical Treatment of Process Wastewaters from Surface Tre	2021	0	0	1	0	0	0	1	1	0
5	Kaffe Bue0	KB-BIOREFINERY	A biorefinery for upcycling coffee waste into sustainable, healthy,	2021	0	0	1	0	1	1	0	0	0
6	LEKATECH OY	RHI0	Electric bReaker Hammer transforming the mIning aNd cOnstructi	2021	0	0	0	1	0	0	0	1	1
7	Minalyze AB	SensAI Mining	SensAI: The digital transformation of the mining industry that will	2021	0	0	0	1	0	0	0	0	1
8	Ocean Oasis AS	ReWater	Offshore renewable and clean desalination of sea water	2021	0	0	0	0	0	0	1	1	0
9	Orbisk BV	Binspector	Cutting-edge food waste solution for restaurants	2021	0	0	0	1	0	0	0	0	1
10	PlanBlue GmbH	BLUESURVEY	Unlocking the value of a blue eco0my with a revolutionary Underv	2021	0	0	0	1	0	0	0	0	1
11	Recycleye Ltd	RESOURCE	REcovery of target materialS frOm mUnicipal solid waste stReams	2021	0	0	0	1	0	0	0	0	1
12	Seqana	Seqana	Seqana GmbH	2021	0	0	0	1	0	0	0	0	1
13	iFLUX nv	iFLUX	Real-time flow and flux measurements for combating groundwate	2021	0	0	0	1	0	0	0	0	1
14	Brite Hellas SA	PanePowerSW	Transparent Solar Panel Tech0logy for Energy Auto0mous Greenh	2020	0	0	0	0	0	0	0	1	0
15	CELLUGY	EcoFLEXY	A natural and biodegradable na0cellulose alternative to plastic bar	2020	0	0	0	0	0	1	0	0	0
16	HYDRO VOLTA	SonixED	Desalination tech0logy for the water challenge of the 21st century	2020	0	0	0	0	1	0	0	1	0
17	KEYOU GmbH	H2Engine	Sustainable. Clean. Uncompromising. The Internal Combustion En	2020	0	0	0	0	1	0	0	1	0
18	N2 APPLIED AS	SmartNitroFarm	Local fertiliser production by plasma treatment	2020	0	0	0	0	1	0	0	0	0
19	NVP ENERGY LIMI	AMBI-ROBIC	AMBIent Temperature AnaeROBIC Treatment of Municipal Sewag	2020	0	0	1	0	1	1	0	1	0
20	OTECHOS AS	CRCP	First liquid tolerant Centric Reciprocating Compressor enabled to I	2020	0	0	0	0	1	0	0	1	0
21	OXYLE AG	WATERACT	WAstewater Treatment using Efficient Reactors integrated with Ad	2020	0	0	1	0	1	1	0	1	0
22	PLANET CARE RESI	Fibrestop	0vel in-build filters for washing machines to stop microfibres poll	2020	0	0	0	1	0	0	0	0	0
23	RANMARINE TECH	WasteShark	The mission of RanMarine Tech0logy is the design, development a	2020	0	0	0	1	0	0	0	0	1

Creation of sustainability model distribution diagram

After the data was collected, analyzed, and normalized, sustainability model distribution diagrams were created to visualize the frequency of the different sustainability models and look for different trends among the companies during the selected timespan.

Elimination of subjective bias

As the last step of the methodology, upon observing visually apparent differences in the depicted data regarding the frequency of sustainability model integration, each case was carefully checked to avoid that a particular difference is considered to be relevant subjectively, while in reality, the objective assessment would indicate that the identified difference happened due to the relatively small pool of analyzed applicants forming the scope of the project.

Results

The evaluation of the depicted overall distribution of sustainability model patterns across the Horizon Europe EIC Accelerator winning participants in the Earth/Environmental category across 2020-2021 showed that among the 40 individually analyzed sustainability model patterns, 3 sustainability models, namely the 'Produce on Demand', the 'Eco Lock-in', and the 'Eco-Efficiency' were the most applicable sustainability model patterns for the 31 winning thematic companies (see Figure 6. below).

Figure 6. Distribution diagram of sustainability model patterns across Horizon Europe EIC Accelerator winning participants in the Earth/Environmental category across 2020-2021. 3 sustainability models, namely the 'Produce on Demand', the 'Eco Lock-in', and the 'Eco-Efficiency' were the most applicable sustainability model patterns for the 31 winning thematic companies.

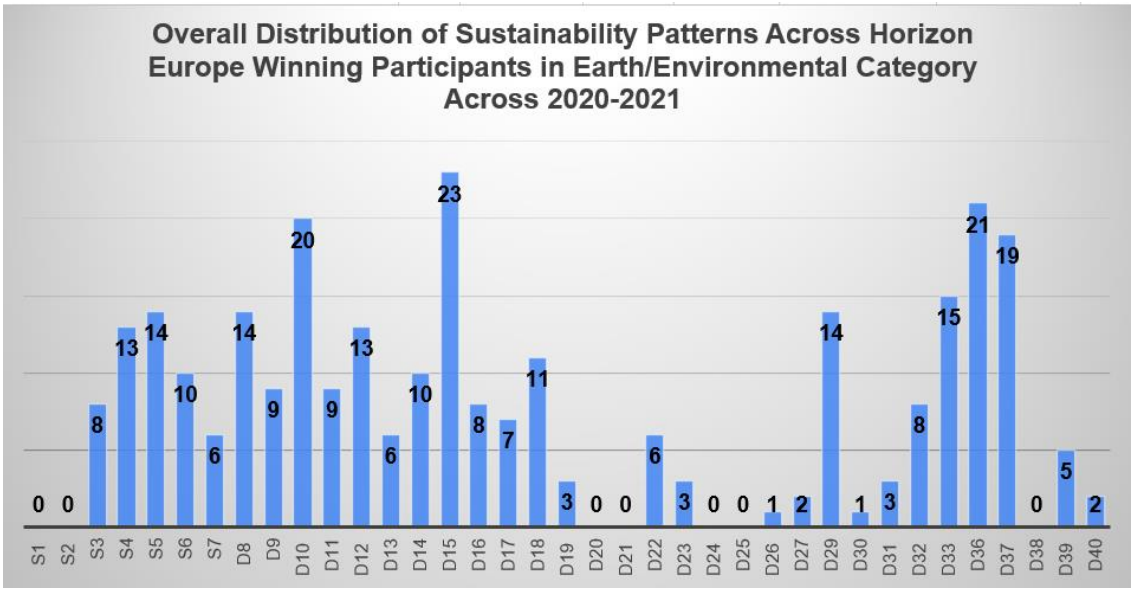


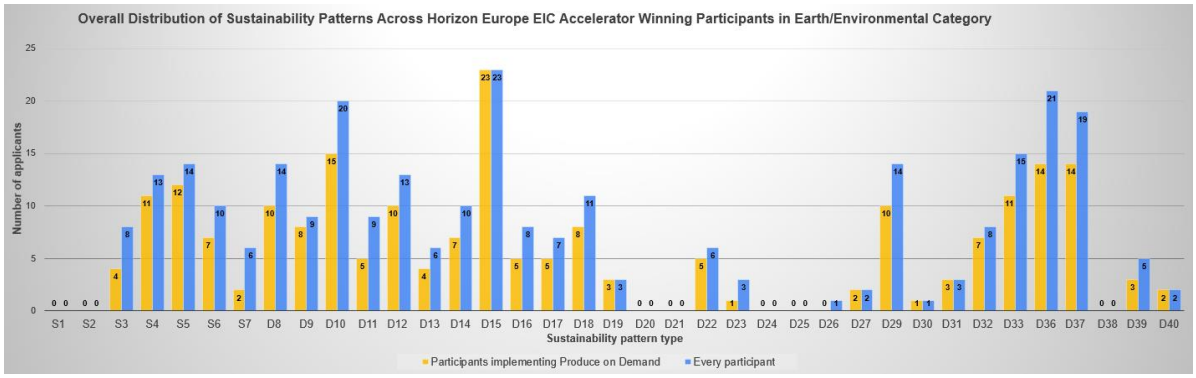
Diagram annotations:

S1 - Product Reuse	D20 - Rent instead of buy
S2 - Part Reuse	D21 - Performance-based contracting
S3 - Re- & Upcycling	D22 - Subscription
S4 - Intelligent Assembly & Modularsation	D23 - Fractionalised Ownership
S5 - Biodegradability	D24 - Dynamic Pricing
S6 - Waste as input	D25 - Revenue Sharing
S7 - Reverse Logistics	D26 - Crowdfunding
D8 - Increased Longevity	D27 - Take-back
D9 - Smart Assets	D29 - Servitisation
D10 - Eco-Efficiency	D30 - Circu-luxury
D11 - De-Materialisation	D31 - Experience Selling
D12 - Eco-Materials & Sourcing	D32 - Marketplace
D13 - Increased Functionality	D33 - Prosumer
D14 - Localisation	D36 - Eco Lock-in
D15 - Produce on demand	D37 - Communicate Responsibility
D16 - Detox	D38 - Sharing
D17 - Energy Recovery	D39 - Robin Hood
D18 - Renewable Energy	D40 - Mass customization
D19 - Pay per use	

The significant applicability of the 'Produce on Demand' sustainability pattern to innovative early-stage companies across a variety of industry sectors apparently indicated that the 'Produce on Demand' pattern many times combines with other sustainability models. Therefore, the potential connection of the 'Produce on Demand' pattern to the other 39 models within the BMI Institute's categorization framework was analyzed to understand to reason behind the extraordinarily high appearance of this pattern by potentially discovering underlying connections with other sustainability models. However, no difference was observed for the distribution of other models among all winning applicants and the selected group of applicants implementing the 'Produce on Demand' model, as no difference was observed between the frequency of appearance of the other 39 models for this particular group (see

Figure 7. below).

Figure 7. Comparison diagram depicting the distribution of sustainability model patterns across Horizon Europe EIC Accelerator winning participants in the Earth/Environmental category (blue group) and the selected group of participants implementing the ‘Produce of Demand’ model (red group).



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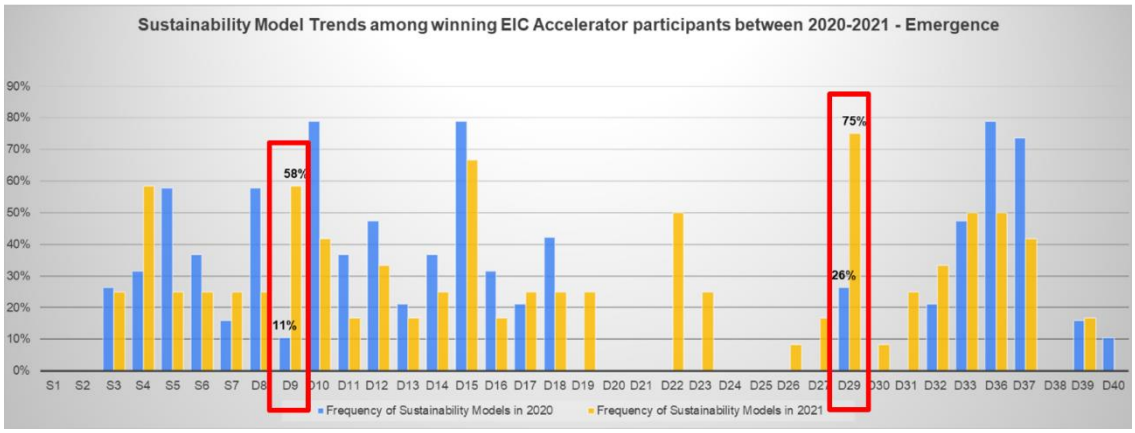
D18 - Renewable Energy	D40 - Mass customization
D19 - Pay per use	

Subsequently, the distribution of the different sustainability models in 2020 and 2021 was analyzed to identify potential trends of new model emergence or old model decline within the analyzed timespan, suggesting the potential evolution of sustainability model patterns.

As for emerging new models, significant changes were observed in the appearance of novel sustainability models with ‘Servitisation’ and ‘Smart Assets’ being the most dominantly appearing patterns in 2021 (see Figure 8. below).

Figure 8. Comparison diagram depicting the change in the frequency of appearance of different sustainability models across Horizon Europe EIC Accelerator winning participants in the Earth/Environmental category in 2020 (blue group) and in 2021 (red group). Red rectangles highlight ‘Servitisation’ and ‘Smart Assets’ as the most dominantly appearing patterns in 2021.



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S1 - Product Reuse	D20 - Rent instead of buy
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D18 - Renewable Energy	D40 - Mass customization
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Finally, in regard of declining old models, similarly significant changes were observed in the disappearance of old sustainability models with ‘Eco-Efficiency’ and ‘Communicate Responsibility’ being the most significantly declining old patterns in 2021 (see Figure 9. below).

Figure 9. Comparison diagram depicting the change in the frequency of disappearance of different sustainability models across Horizon Europe EIC Accelerator winning participants in the Earth/Environmental category in 2020 (blue group) and in 2021 (red group). Red rectangles highlight 'Eco-Efficiency' and 'Communicate Responsibility' as the most significantly declining old patterns in 2021.

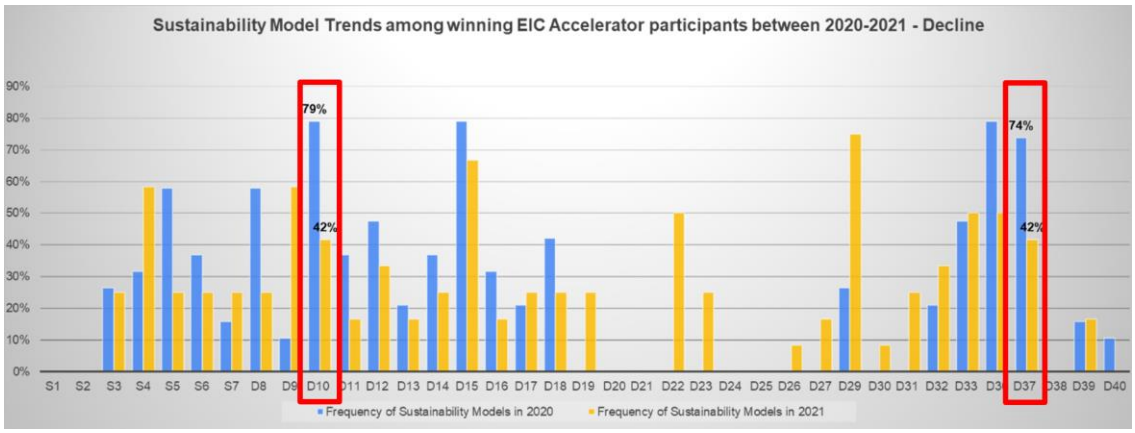

Diagram annotations:

S1 - Product Reuse	D20 - Rent instead of buy
S2 - Part Reuse	D21 - Performance-based contracting
S3 - Re- & Upcycling	D22 - Subscription
S4 - Intelligent Assembly & Modularsation	D23 - Fractionalised Ownership
S5 - Biodegradability	D24 - Dynamic Pricing
S6 - Waste as input	D25 - Revenue Sharing
S7 - Reverse Logistics	D26 - Crowdfunding
D8 - Increased Longevity	D27 - Take-back
D9 - Smart Assets	D29 - Servitisation
D10 - Eco-Efficiency	D30 - Circu-luxury
D11 - De-Materialisation	D31 - Experience Selling
D12 - Eco-Materials & Sourcing	D32 - Marketplace
D13 - Increased Functionality	D33 - Prosumer
D14 - Localisation	D36 - Eco Lock-in
D15 - Produce on demand	D37 - Communicate Responsibility
D16 - Detox	D38 - Sharing
D17 - Energy Recovery	D39 - Robin Hood
D18 - Renewable Energy	D40 - Mass customization
D19 - Pay per use	

Conclusion

The distribution of the different sustainability model patterns showed that the is no significant difference between the frequency of how the different sustainability business model patterns are connected to each other in general and in case of the presence of the mostly applicable 'Produce on Demand' pattern. Based on this, the conclusion of initial results suggests that there is only a distant, less relevant direct relationship between various sustainability models, particularly regarding the connection of various sustainability business models and the 'Produce on Demand' pattern, indicating a low potential influence on each other.

This suggests that the combined use of different models is rather influenced by other aspects of the business plan designed for the implementation of the innovative technology, for example, the early-stage company's specific technology and the specific business/sales model that it used to reach the particular environment in the targeted markets.

Furthermore, the changes in the frequency rate of different sustainability models between 2020 and 2021 contributed to the observation of significant dynamic changes both in the appearance and disappearance of various sustainability models across this timespan.

Several new sustainability models appeared in 2021 from a zero presence from 2020, where an initial conclusion can be drawn given the number of different appearing novel sustainability models. This suggests an increasing complexity in the applied sustainability model patterns over the years.

In a similar fashion, several older sustainability model patterns from 2020 started to disappear in 2021, although no models disappeared completely. Among the 40 analyzed sustainability models, only the column in association with the 'Mass Customization' pattern was observed to have disappeared. However, given that this particular sustainability model was significantly underrepresented in the study group with having the lowest frequency diagram for 2020 among all patterns, the disappearance of the column in 2021 is assumed to happen due to the limited number of applicants forming the study group of the research project.

The continuously growing number of implemented sustainability model patterns indicate that innovative early-stage companies need to apply a more and more complex combination of sustainability model patterns in their business development strategies over the years. This complexity is likely driven by societal trends and the evolution of more and more complex business model design.

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