ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

RELATIONSHIP BETWEEN SDG-ORIENTATION AND TOTAL FUNDING AMOUNT OF EUROPEAN DIGITAL SUSTAINABLE STARTUPS: A TWIN TRANSITION PERSPECTIVE

Ph.D. THESIS

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

AVRUPA'DAKİ DİJİTAL SÜRDÜRÜLEBİLİR GİRİŞİMLERDE SÜRDÜRÜLEBİLİR KALKINMA HEDEFLERİNE YÖNELİM İLE TOPLAM FONLAMA MİKTARI ARASINDAKİ İLİŞKİ: İKİLİ GEÇİŞ PERSPEKTİFİ

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Onur DEMİREL, a Ph.D. student of İTU Graduate School student ID 403192004, successfully defended the dissertation entitled "RELATIONSHIP BETWEEN SDG-ORIENTATION AND TOTAL FUNDING AMOUNT OF EUROPEAN DIGITAL SUSTAINABLE STARTUPS: A TWIN TRANSITION PERSPECTIVE", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To the journey, unfinished by design.

FOREWORD

This dissertation is not just a final academic requirement, but a reflection of my long journey of change which started back in 2019. Throughout these years, from the long days and nights of studying to the final lines of this research, Istanbul Technical University (ITU) has given me so much more than just a degree. I honestly feel proud to meet the ITU culture of being a part of the ITU family.

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December 2025 Onur DEMİREL (Lecturer)

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ABBREVIATIONS

CI	: Confidence Interval
CR	: Composite Reliability
DE	: Digital Entrepreneurship
DSE	: Digital Sustainable Entrepreneurship
DSS	: Digital Sustainable Startup
DT	: Digital Technology
d_G	: Geodesic Disperancy
d_ULS	: Squared Euclidean Distance
DV	: Discriminant Validity
EU	: European Union
GDP	: Gross Domestic Product
GNP	: Gross National Product
HTMT	: Heterotrait-Monotrait Ratio
IR	: Indicator Reliability
IT	: Innovation Type
NUTS	: Nomenclature of Territorial Units for Statistics
PCA	: Principal Component Analysis
PLS-SEM	: Partial Least Squares Structural Equation Modeling
SD	: Standard Deviation
SDG	: Sustainable Development Goals
SE	: Sustainable Entrepreneurship
SRMR	: Standardized Root Mean Square Residual
SS	: Sustainable Startup
TBL	: Triple Bottom Line
TFA	: Total Funding Amount
UN	: United Nations
VIF	: Variance Inflation Factor

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RELATIONSHIP BETWEEN ADOPTED INNOVATION TYPES AND FUNDING PERFORMANCE OF EUROPEAN DIGITAL SUSTAINABLE START-UPS: A TWIN TRANSITION PERSPECTIVE

SUMMARY

Organizational research and practice evaluated the concept of “performance" primarily in economic terms, and ignored the environmental and social costs for a long period. In this respect, the fully economic perspective is widely criticized within the social, environmental, and economic dimensions. Today, in parallel to the growing orientation towards sustainability, both scholars, practitioners, and policy makers also increasingly adopt to a more value-driven approach rather than the conventional understanding of organizational performance. In this respect, long-term competitiveness is even linked to the strategic orientation towards sustainability. In this respect, the concept of innovation which is identified as a driving force for sustainability is also defined as critical factor for disrupting the markets towards sustainability. On the other hand, as a carrier of innovation, the startups are also identified as potential actors to disrupt the markets through sustainability.

Drawing on the two main agendas for sustainability, this thesis specifically focuses on the direct and indirect relationships among SDG-orientation and economic performance of the digital sustainable startups (DSS). In this respect, the twin transition agenda (TT) of the European Union (EU), assesses the DSSs as small sized and innovative businesses, which employ digital technologies in providing sustainability-oriented value propositions, which positions at the forefront of this shift due to their innovating capacity. Adopting to a TT perspective, which suggests the employment of DTs and greening of the economy as interconnected processes, our research aims the shad a light on the integration of the green and digital dimensions, in explaining the variations within the economic performance of the European sustainability-oriented digital startups.

Second, aiming to illuminate the factors which influence the economic performance of digital sustainable startups (DSSs) in the European context, this research also adopts to the Sustainable Development Goals (SDGs) of the United Nations (UN). In this context, the SDGs provide a globally recognized framework, which also enables academically established proposed keywords and search queries to be operationalized within textual data. Aiming to identify the integration of the green and the digital dimensions in explaining variations in total funding amount (TFA) of the European DSSs, this thesis tests the influence of SDGs-orientation as a strategic direction through the specific SDGs which shapes the organization and, in turn, affects TFA of the entrepreneurial action.

Methodologically, this research adopts to a formative measurement model, based on secondary cross-sectional data, which is retrieved from Crunchbase database[1], which is considered as a robust repository of startup data, which enables operationalization of an economic dependent variable within the thesis research. In this context, the use of the secondary data is also expected to enable wide range of samples from the digital entrepreneurial which orients towards sustainability. Considering the "outcomes" definition of Cohen (2008), 17 results are retrieved for "pre-money valuation" data, 42 results are obtained for "money raised" data. Further, 101 results are collected from Crunchbase database for total funding amount (TFA) data, which also validates the sample of the study (n = 101).[2] On the other hand, the SDGs which provide a globally recognized framework, also provides academically established search queries for each SDG, also enables SDG-oriented research capabilities within textual data. Borrowing these standardized search queries ensure that the identification of the SDG-orientation remains objective and replicable within the sampled DSSs. In this respect, SDG-orientations of the European DSSs are analyzed by conducting the conceptual content analysis on the organizational texts, which is collected from organizational websites and organizational business profile pages on Crunchbase website. Further, DT and IT adoption of the European DSSs are analyzed employing the same organizational texts by conducting manual analysis. Both the SDG-orientation, and the DT and IT preferences of the European DSSs are first binary coded. Data is also collected from multiple sources to enable NUTS2-level regional-GDP (GDP) variable, that is an economic variable, which is also assumed to reflect the entrepreneurial ecosystems effect on startup's access to funding.

Further, TFA and GDP data are log-transformed within the data preparation process, to normalize the skewed data and stabilize the variance. Moreover, factor-cluster analysis is conducted on DT preferences and IT adoption data. Consequently, DT and IT data are operationalized as clustered latent constructs, which reflect the underlying concepts rather than the direct measurement of the variables as factor scores. The data analysis is conducted using Partial Least Squares Equation Modeling (PLS-SEM) in SmartPLS software. Selection of the research method based upon the requirement for analysis capabilities within (1) simultaneous analysis capability on direct, mediating and moderating influences, (2) analysis on complex formative and reflective relationships (3) with relatively smaller sample sizes (Elshaer et al. 2023), (4) which is also identified as accurate within the investigation of early levels of theory development (Elshaer et al. 2023). In this respect, a bootstrapping analysis is operationalized, as a powerful and significant non-parametric method, which is employed to estimate the precision of the statistical results, while ensuring the robustness and stabilization of the findings. In this respect, this research adopts to 90% CI and bootstrapping procedure with 50.000 subsamples to ensure the robustness of the results, and follows the guidelines of Hair et al. (2019).

Our results indicate a positive and significant direct influence of the SDG-orientation on TFA within the European DSSs within the main model of this study (Model 1). Consequently, despite the insignificant formative indicator weights and loadings, the H_1 hypothesis of this research is supported at the construct-level, which reflects the

[1] http://crunchbase.com/

[2] Data Retrieval Date: 3rd of November 2023.

positive effect of SDG on TFA. Further, the results also point that the effect of SDG on TFA is also observed to be contingent to higher GDP levels. Reflecting low to medium effect sizes, the main research model also explains weak potion of variance in TFA, which indicates a limited overall explanatory power, despite significant contribution of SDG at the construct-level (Hair et al. 2019). In this respect, Model 1 also represents a good level of fit.

Within this thesis study, four models are tested, and Model 3 is observed to represent the strongest overall statistical performance. In this respect, at the indicator-level, SUINRC (Sustainable Industries and Responsible Consumption) which covers SDG9 (Industry, Innovation and Infrastructure) and SDG12 (Responsible Consumption and Production), and HAREC which covers SDG3 (Good Health and Well-being) and SDG11 (Sustainable Cities and Communities), while SUINRC slightly outperforms HAREC as indicator of SDG construct. Further, at the construct-level, the direct influence of SDG on TFA is, also outperforms the direct influence of GDP on TFA in Model 3, which is also significant, and results in the acceptance of H_1 hypothesis within the main research model (Model 1), with medium effect sizes, the findings demonstrate weak explanatory power, but structural stability and good model fit.

In this respect, this thesis research contributes to the literature by conducting an organizational-level empirical analysis on the economic performance of DSSs, which are politically, theoretically, and practically examined as critical actors within the sustainability context. Further, our analysis points to a positive and significant relationship between SDG-orientation and TFA within the European DSSs, despite the respectively small samples size. On the other hand, the small sample size also resulted in the model to generally represent a weak explanatory power. Considering digital sustainable entrepreneurship (DSE) as niche area of the research on entrepreneurship, and our considerable effort within the comparison of potential data sources, in our definition the collected Crunchbase data which represents the sample of our research, also represents the available population for the collectable data within the field of research, considering the day of data retrieval.

AVRUPA'DAKİ DİJİTAL SÜRDÜRÜLEBİLİR GİRİŞİMLERDE SÜRDÜRÜLEBİLİR KALKINMA HEDEFLERİNE YÖNELİM İLE TOPLAM FONLAMA MİKTARI ARASINDAKİ İLİŞKİ: İKİLİ GEÇİŞ PERSPEKTİFİ

ÖZET

Örgütsel alanda yapılan araştırma ve uygulamalar, "performans" kavramını uzun süre boyunca yalnızca ekonomik bir bakış açısı ile değerlendirerek, çevresel ve sosyal maliyetleri ise göz ardı etmiştir. Günümüzde ise tamamen ekonomik ve kâr odaklı bakış açısı, hem sosyal, hem çevresel hem de ekonomik bağlamlar çerçevesinde eleştirilmektedir. Bugün, sürdürülebilirlik kavramına yönelik artan eğilimin paralelinde, politika yapıcıların, akademisyenlerin ve yenilikçi fikirleri uygulayarak sürdürülebilirlik odağında değer yaratacak aktörlerin, performans kavramını geleneksel anlayıştan ziyade, giderek daha değer odaklı bir yaklaşım çerçevesinde benimsediği de gözlenlenmektedir.. Bu bağlamda, uzun vadeli rekabet gücü kavramı dahi, bu güncel yaklaşım ile kurumun sürdürülebilirliğe yönelik stratejik yönelimi ile ilişkilendirilmektedir. Bu bağlamda, sürdürülebilirliğin itici gücü olarak tanımlanan inovasyon kavramı, piyasaları sürdürülebilirliğe doğru dönüştürmek için kritik bir faktör olarak tanımlanmıştır. Öte yandan, inovasyonun taşıyıcısı olarak girişimler de sürdürülebilirlik odağı ile pazarları dönüştürebilecek potansiyel aktörler olarak tanımlanmaktadır.

Bu tez çalışması, sürdürülebilirlik odağında yürürlüğe girmiş iki ana politik çerçeveden yola çıkarak, özellikle dijital sürdürülebilir girişimlerin, Sürdürülebilir Kalkınma Hedefleri yönelimleri ile ekonomik performansları arasında yer alan doğrudan ve dolaylı ilişkilere odaklanmaktadır. Bu bağlamda, sürdürülebilirlik odağında değer önerileri sunmak adına dijital teknolojileri kullanan, yenilikçi kapasiteleri nedeniyle bu değişimin ön saflarında yer alan küçük ölçekli ve yenilikçi işletmeler, Avrupa Birliği'nin ikili geçiş gündemi çerçevesinde tanımlanmış en kritik aktörlerdir. Dijital teknolojilerin kullanımını ve ekonominin yeşilleştirilmesini birbirine bağlı süreçler olarak öneren ikili geçiş gündemini benimseyen araştırmamız, Avrupa'daki dijjital sürdürülebilir girişimlerin ekonomik performansındaki farklılıkları açıklamak için yeşil ve dijital boyutların entegrasyonuna ışık tutmayı amaçlamaktadır.

Bu bağlanda, Avrupa merkezli dijital sürdürlebilir girişimlerin ekonomik performansını etkileyen faktörleri aydınlatmak adına bu araştırma, Birleşmiş Milletler'in Sürdürülebilir Kalkınma Amaçlarını da benimser. Bu tez çalışması, dijital sürdürülebilir girişmler için en destekleyici sistem ve politik desteğe sahip bölgesinde yer alan girişimlerin, toplam fonlama miktarındaki farklılıkları açıklamak adına yeşil ve dijital boyutların entegrasyonunu belirlemeyi amaçlayarak, organizasyonu şekillendiren ve dolayısıyla girişimci faaliyetin toplam yatırım miktarını etkileyen belirli Sürdürülebilir Kalkınma Amaçları aracılığıyla stratejik bir yönelim olarak bu hedeflere odaklanmanın etkisini test etmektedir. Diğer taraftan,

Sürdürlebilir Kalkınma Amaçları akademik olarak belirlenmiş önerilen anahtar kelimelerin ve arama sorgularının metinsel veriler içinde işlevselleştirilmesini de sağlayan, küresel olarak tanınan, ve metin biçimindeki veriler ile analiz imkanı sağlayan bir çerçeveyi de beraberinde getirmektedir.

Metodolojik olarak, sürdürülebilirlik odağında değer önerileri sunan Avrupa merkezli dijital girişimlere odaklanan, ve ekonomik bir bağımlı değişkeni operasyonelleştirmeyi amaçlayan bu tez çalışmasında, güvenilir bir girişim veri deposu olarak kabul edilen Crunchbase veritabanından[3] elde edilen ikincil kesitsel veriler kullanılmış ve biçimlendirici bir ölçüm modeli benimsenmiştir. Bu bağlamda, ikincil verilerin kullanımı sayesinde sürdürülebilirlik odağında faaliyet gösteren dijital girişimler gibi göreli olarak yaygın olmayan bir girişim türüne ait kabul edilebilir sayıda gözlem elde edilmesinin sağlanması amaçlanmaktadır. Cohen'in (2008) "sonuçlar" tanımını dikkate alarak, "yatırım öncesi değerleme" verileri için 17 sonuç, "toplanan yatırım tutarı" verileri için ise 42 sonuç elde edilmiştir. Ayrıca, “toplam yatırım miktarı” verileri için Crunchbase veritabanından 101 adet sonuç elde edilmiştir[4]. Elde edilen 101 adet gözlem, aynı zamanda bu tez çalışmasının örneklemini doğrulamaktadır (n = 101). Öte yandan, küresel olarak tanınan bir çerçeve sağlayan Sürdürülebilir Kalkınma Amaçları (SDG'ler), her bir SDG için akademik olarak oluşturulmuş arama sorguları da sunarak metinsel veriler içinde SDG odaklı araştırma yeteneklerini mümkün kılmaktadır. Bu standartlaştırılmış arama sorguları, SDG yöneliminin organizasyonel düzeyde, objektif ve tekrarlanabilir kalacak şekilde belirlenebilmesini mümkün kılmaktadır. Bu bağlamda, Avrupa merkezli dijital sürdürlebilir girişimlerin, Sürdürülebilir Kalkınma Hedefleri yönelimi, kurumsal web sitelerinden ve Crunchbase web sitesinde yer alan kurumsal şirket profili sayfalarından toplanan kurumsal metinler üzerinde kavramsal içerik analizi yapılarak analiz edilmiştir. Ayrıca, Avrupa bağlamında incelenen dijital sürdürülebilir girişimlerin, kullandıkları dijital teknolojiler ve benimsedikleri inovasyon türleri, aynı kurumsal metinler kullanılarak manuel analiz yöntemi ile incelenmiştir. Bu bağlamda, her girişimin Sürdürülebilir Kalkınma Hedefi yönelimi ve dijital teknoloji ve inovasyon türü tercihleri öncelikle ikili kodlamaya tabi tutulmuştur. Diğer taraftan, girişimcilik ekosistemlerinin girişimlerin finansmana erişimi üzerindeki etkisini yansıttığı varsayımından yola çıkarak, ekonomik bir değişken olan NUTS2 düzeyinde bölgesel gayri safi milli hasıla (GSYH) değişkenini analiz edilmiştir. Bu değişkene ait verinin toplanması adına birden fazla kaynaktan veri toplanmıştır. In that respect also a bibliometric analysis has been conducted on the concept of DSE research emloying PRISMA with the aim to discover current trends within the field of research.

Ayrıca, çarpık verileri normalleştirmek ve varyansı dengelemek için veri hazırlama sürecinde toplam yatırım miktarı ve bölgesel GSYİH verileri logaritma dönüşümüne tabi tutulmuştur. Diğer taraftan, girişimlerin dijital teknoloji ve inovasyon türü benimseme verileri üzerinde faktör kümeleme analizi yapılmıştır. Sonuç olarak, DT ve inovasyon türü verileri, değişkenlerin faktör puanları olarak doğrudan ölçülmekten ziyade, altlarında yatan kavramları yansıtan kümelenmiş gizli yapılar olarak işlevselleştirilmiştir. Veri analizi, SmartPLS yazılımında Kısmi En Küçük Kareler Denklem Modellemesi (PLS-SEM) kullanılarak gerçekleştirilmiştir. Araştırma yönteminin seçimi (1) doğrudan, aracı ve düzenleyici etkiler üzerinde eş

[3] https://www.crunchbase.com/

[4] Veri erişim tarihi: 3 Kasım 2023.

zamanlı analiz yeteneği, (2) karmaşık biçimlendirici ve yansıtıcı ilişkiler üzerinde analiz kabiliyeti ve (3) nispeten daha küçük örneklem boyutları ile çalışabilme gereksinimlerine karşılık verilmesi ile alakalıdır. Bu bağlamda, istatistiksel sonuçların doğruluğunu tahmin etmek ve bulguların sağlamlığını ve istikrarlılığını sağlamak için kullanılan güçlü ve önemli bir parametrik olmayan yöntem olan bootstrap analizi uygulanmıştır. Bu bağlamda, bu araştırma, sonuçların sağlamlığını sağlamak için %90 güven aralığı ve 50.000 alt örneklemle bootstrap prosedürünü benimsemiş ve Hair vd. (2019)'un yönergelerini izlemiştir.

Sonuçlarımız, bu çalışmanın ana modelinde (Model 1) Avrupa DSS'lerinde SDG yöneliminin TFA üzerinde pozitif ve anlamlı bir doğrudan etkisi olduğunu göstermektedir. Sonuç olarak, önemsiz biçimlendirici gösterge ağırlıklarına ve yüklemelerine rağmen, bu araştırmanın H_1 hipotezi yapısal düzeyde desteklenmekte olup, SDG'nin TFA üzerindeki pozitif etkisini yansıtmaktadır. Ayrıca, sonuçlar SDG'nin TFA üzerindeki etkisinin daha yüksek GSYİH seviyelerine bağlı olduğunu da göstermektedir. Düşük ila orta etki büyüklüklerini yansıtan ana araştırma modeli, yapısal düzeyde SDG'nin önemli katkısına rağmen, TFA'daki varyansın zayıf bir bölümünü açıklamaktadır; bu da genel açıklayıcı gücün sınırlı olduğunu göstermektedir (Hair vd., 2019). Bu açıdan, Model 1 de iyi bir uyum seviyesini temsil etmektedir.

Bu tez çalışmasında dört model test edilmiş ve Model 3'ün genel olarak en güçlü istatistiksel performansı gösterdiği gözlemlenmiştir. Bu bağlamda, gösterge düzeyinde, Sürdürülebilir Sanayiler ve Sorumlu Tüketim (SUINRC), Sürdürülebilir Kalkınma Hedefi 9 (Sanayi, İnovasyon ve Altyapı) ve Sürdürülebilir Kalkınma Hedefi 12'yi (Sorumlu Tüketim ve Üretim) kapsarken, HAREC ise Sürdürülebilir Kalkınma Hedefi 3 (İyi Sağlık ve Refah) ve Sürdürülebilir Kalkınma Hedefi 11'i (Sürdürülebilir Şehirler ve Topluluklar) kapsamaktadır. SUINRC, Sürdürülebilir Kalkınma Hedefi yapısının göstergesi olarak HAREC'ten biraz daha iyi performans göstermektedir. Ayrıca, yapı düzeyinde, Sürdürülebilir Kalkınma Hedeflerinin TFA üzerindeki doğrudan etkisi, Model 3'te GSYİH'nin TFA üzerindeki doğrudan etkisinden daha iyi performans göstermekte, bu da anlamlıdır ve ana araştırma modelinde (Model 1) H_1 hipotezinin kabul edilmesini sağlamaktadır. Orta düzeyde etki büyüklükleri ile bulgular, zayıf açıklayıcı güç, ancak yapısal istikrar ve iyi model uyumu göstermektedir.

Bu bağlamda, bu tez çalışması, sürdürülebilirlik açısından kritik aktörler olarak politik, teorik ve pratik taraflarca incelenen dijital sürdürülebilir girişimlerin ekonomik performansına ilişkin örgütsel düzeyde ampirik bir analiz gerçekleştirerek literatüre katkı sağlamaktadır. Ayrıca, nispeten küçük örneklem boyutuna rağmen, analiz sonuçları Avrupa dijital sürdürülebilir girişimlerinin Sürdürülebilir Kalkınma Amaçları yönelimi ile toplam yatırım miktarı arasında pozitif ve anlamlı bir ilişkiye işaret etmektedir. Öte yandan, küçük örneklem boyutu, modelin genel olarak zayıf bir açıklayıcı güce sahip olmasına da neden olmuştur. Dijital sürdürülebilir girişimcilik kavramını, girişimcilik araştırmalarının göreli olarak daha dar bölümü olarak ele aldığımızda, ve potansiyel veri kaynaklarının karşılaştırılması konusundaki önemli çabalarımızı göz önünde bulundurduğumuzda, tanımımıza göre araştırmamızın örneklemini temsil eden Crunchbase verisini, araştırma alanındaki toplanabilir veriler için mevcut popülasyon olarak da kabul etmekteyiz.

1. INTRODUCTION

As a continuation to Millennium Development Goals (UN, 2000), the declaration of the Sustainable Devleopment Goals (SDGs) by the United Nations (UN) in 2015 (UN, 2015) marked a global consensus towards the achievement of environmental, social and economic sustainability. With the participation of 193 UN member states, 17 SDGs have been approved with the aim to develop an environmentally, socialy and economically sustainable planet which are planned to be accomplished by 2030 (UN, 2015).

On the other hand, it is observed that the conventional growth methods which are developed within the economic paradigm, remain inadequate in adressing sustainability and the SDGs (Bonilla et al. 2018; Schaltegger & Wagner, 2011). As a result, it has been vital to provide new ways of growth (Schaltegger & Wagner, 2011). Holding that perspective, the concept of innovation that reflects an economic and profit-oriented way of understanding (Drucker P., 1985; OECD, 2010a; Schumpeter J, 1934), and which is mainly associated with competence throughout the economic frame, the concept is also observed to shift to a sustainability-oriented way of thinking to address environmental, and social problems as well as economic growth sustainably (Bossle et al. 2016; Elkington, 2013; Maier et al. 2020; OECD, 2018; Slaper, 2011; UN, 2015). As a result, new research areas elaborated successively with the aim to expand the understanding on consolidation of sustainability-oriented innovation concepts (Boons & Lüdeke-Freund, 2013; Van Der Panne et al. 2003) which aim to balance the private benefits with social benefits (Nosratabadi et al. 2019; Schaltegger & Wagner, 2011).

Following the SDGs of the UN (2000), the European Union (EU) also declared the Twin Transition (TT) agenda which embraces the use of digital technologies through the achievement of social, environmental and economic sustainability (EC, 2022). Also, two novel terms were coined by the declaration with the aim to empower the society and the businesses through sustainability. In this respect, “green transition” term posits to achieve social, environmental and economic sustainability, and “digital transition" term promotes utilizing digital technologies through achievement of sustainability targets (EC, 2022). Related terms are also defined to reinforce each other throughout better management, monitoring, tracking, maintenance, increased productivity and recycling, communication between technical elements and stakeholders, and other specific solutions (EC, 2022). The EU also defined green digital solutions to be delivered by small and medium-sized organizations and startups for a healthy ecosystem to enable competition and innovation (EC, 2022).

Consequently, the concept of entrepreneurship which is conventionally defined to provide higher potential in realizing innovative opportunities rather than the established companies (OECD, 2008, 2010b), and defined as a carrier for innovation (Drucker P., 1985), has increasingly begun to be characterized as enablers of the SDGs (OECD, 2018). As a result, the concept of entrepreneurship also diversified in parallel to the orientation towards sustainability, as did the concept of innovation. In that respect, sustainability-oriented forms of entrepreneurship (Tunçalp & Yıldırım, 2022), which are mainly characterised with their focus on environmental and social advancement as well as economic development, are also perceived as vital actors in establishing a sustainable development (Schaltegger & Wagner, 2011), especially with the capability to provide radical value propositions (Nosratabadi et al. 2019).

Given the criticality of sustainability concerns, ongoing political advancements, and advancement on digital technologies, practice and research gained valuable momentum towards the concept of Digital Sustainable Entrepreneurship (DSE), which points to employment of digital technologies (Andersen et al. 2021; Bednarčíková & Repiská, 2021; Xu et al. 2022) by entrepreneurial action (Cohen & Winn, 2007; Greco & De Jong, 2017; Koe et al. 2014; Soubbotina et al. 2004; Weidinger et al. 2014) in achieving sustainability (Andersen et al. 2021; Bednarčíková & Repiská, 2021; Gregori & Holzmann, 2020; Xu et al. 2022) through SDGs (Berawi, 2019), as an intersection of digital technological innovation, entrepreneurship and sustainability concepts. Prior to formulating the theoretical framework of this thesis research, a bibliometric analysis was also conducted within the field of DSE research.

In this respect, results of our research points to SUINRC (Sustainable Industries and Responsible Consumption) which covers SDG9 (Industry, Innovation and Infrastructure) and SDG12 (Responsible Consumption and Production), and HAREC which covers SDG3 (Good Health and Well-being) and SDG11 (Sustainable Cities and Communities), while SUINRC slightly outperforms HAREC as indicator of SDG construct. Further, at the construct-level, the direct influence of SDG on TFA is, also outperforms the direct influence of GDP on TFA in Model 3, which is also significant, with medium effect sizes, the findings demonstrate weak explanatory power, but structural stability and good model fit.

On the other hand, the literature holds a significant gap in regard to the knowledge on how economic performance of DSSs correlate with SDGs, adopted digital technologies and innovation types (ITs), and NUTS2 level GDP. This thesis seeks to address this valuable gap by employing the main research problem as "what are the influencing factors of economic performance of DSSs?"

1.1 Purpose of Thesis

Building upon the political framework and the given concepts, the primary purpose of this research is to develop, empirically test and discuss the relationship between SDG-orientation and total funding amount (TFA) of European DSSs. Adopting to an organizational level of analysis, this research mainly follows the TT agenda of the EU (EC, 2022), and focuses on the DSSs whose headquarters are located in the EU region, and which employ digital technologies to deliver value propositions directed to sustainability and the SDGs (Gregori & Holzmann, 2020).

Consequently, the central research question is of this thesis is: "What are the factors that impact the TFA of DSSs in the EU context?" To address this important question, four sub-questions have been formulated:

- RQ1: Does SDG-orientation influence the total funding amount of European DSSs?
- RQ2: How does the adopted digital technologies and innovation types mediate the total funding amount of European DSSs?
- RQ3: How does the NUTS2-level regional GDP moderate the relationship between the SDG-orientation and the total funding amount of European DSSs?

Those valuable research questions aim to provide insights about the relationship between SDG-orientation and TFA which is also mediated by DT and IT adoption, and moderated by regional GDP of the European DSSs, which may also potentially benefit from broader political support considering the political framework and the TT agenda (EC, 2022). The existing research has examined the outcomes of sustainable startups (SSs) employing economic indicators at the individual-level of analysis (Gu & Wang, 2022; Gunarathne, 2019; Mansouri & Momtaz, 2022; Sargani et al. 2020). Even variety of theoretical research have been conducted on sustainable entrepreneurship, research is scarce which focuses on the factors which influence the economic performance of DSSs, while DSSs are increasingly recognized as key actors in advancing the TT agenda of the EU (EC, 2022), and (2) OECD (2018) highlights the lack of knowledge on innovation paths, business models, and entrepreneurial models that link to sustainable development.

1.2 Significance of Thesis

Within the economic requirements, this thesis has a direct political alignment with two of the most critical sustainability-oriented agendas (1) SDGs of the the UN (2015), and (2) the twin transition agenda of the EU (EC, 2022). By examining the economic performance drivers of DSSss, and aims to provide contributions both to policy, theory, and practice. In this respect, the research provides evidence-based insights for policymakers within the influence of strategic orientation towards SDGs, on the economic performace of European DSSs, which also analyzes the moderation effect of regional GDP, and the mediating influences of DT and IT adoption. Related insights may also provide knowledge within the development of more effective support mechanisms, funding models, and regulatory frameworks for digital sustainable innovations. Further, this thesis makes a significant theoretical contribution to the field of DSE research, by providing and empirical research that measure the influencers of the economic performance of DSSs at an organizational level of analysis. Also, providing a comprehensive framework by employing a robust model at an organizational-level of analysis, this thesis also provides practical insights, by maping the SDG-orientation as an enabler of the access to funding.

Consisting of multiple concepts, this thesis conducts a detailed review on the literature to have more in-depth knowledge within the theoretical background of the area of research. As a result, the literature is analysed on (1) economic growth, economic development, sustainable development, and the political background which covers the SDGs and the TT agenda, (2) innovation as a core concept and as an enabler sustainable development, innovation types by object, (3) entrepreneurship as an enabler of sustainable innovation, digital entrepreneurship (DE) and DSE, and the research on the funding of DSSs. Further, also a bibliometric analysis has been conducted on the concept of DSE research emloying PRISMA with the aim to discover current trends within the field of research, analysis of the main research model (Model 1) is conducted within the “Research Model and Hypothesis Testing” section. On the other hand, other analyzed three models within our research, are also discussed within the “Discussion” section, which are represented in in detail within the “Appendix” section, which also covers the SDG-orientation, DT-orientation, and country-based source/location comparison between European DSSs, and the area of DSS research.

2. LITERATURE REVIEW

The literature review of this thesis introduces the research on digital technological sustainable innovation, entrepreneurship and startup funding to demonstrate the theoretical foundation for analyzing the founding performance of the European digital sustainable startups (DSS). In this respect, relevant literature is revieved across multiple concetps such as (1) economic growth, economic development, sustainable development, and the sustainability-oriented political background which cover the Sustainable Development Goals (SDGs) and the twin transition (TT) agenda, (2) innovation as a core concept, including sustainable innovation, digital technological sustainable innovation and innovation types by object (3) entrepreneurship, sustainable entrepreneurship and digital sustainable entrepreneurship, and funding of startups. Aiming to deeply understand the theoretical background, primary and secondary sources are identified, and the key cocepts and their interrelationships were systematically reviewed.

2.1 Sustainable Development

This section provides a structured conceptual and political foundation which enables to understand how the economic progress evolve and move beyond traditional quantitative metrics, and align with sustainability. First, the distinctions are identified between the economic growth which is quantitative, and the economic development which is qualitative, which enables the economic baseline of this research. Second, this section also explores the global transition from a purely profit-oriented economic orientation towards a sustainability-driven paradigm. Lastly, this section contextualizes the related concepts within the political landscape, with the focus on the SDGs (UN, 2015) and the TT agenda (EC, 2022), which aim to drive and institutionalize the related developmental objectives.

In this respect, the concept of economic growth, referring to the expansion of a country's economy, is central for both the developing and the developed countries. Further, the concept of EG, which is also defined to be essential for avoiding recession risks (Edwards, 2021), is also described to occur in two different forms. Accordingly, the first form of the economic growth relates to the “extensive” way of economic growth. This form of economic growth reflects a solely managerial and economic focus, and dominantly promotes profit maximization and wealth generation, refers to a quantitative change in an economy (Soubbotina et al. 2004). Within the extensive economic growth perspective, the human capital is treated as a function of educational attainment and workforce population (Kurniawan & Managi, 2018). On the other hand, the extensive economic growth is also defined to result in lower quality of life, environmental degradation, and reduced economic productivity (Soubbotina et al. 2004), while the concept is also identified to bring higher unemployment, inequalities, weakened cultural identity and democracy (Soubbotina et al. 2004). The extensive way of economic growth is frequently measured by gross domestic product (GDP) or gross national product (GNP) (Kurniawan & Managi, 2018; Soubbotina et al. 2004; Vosylius et al. 2013), which are also criticized as a result of sustainability concerns (Weidinger et al. 2014). Underestimating the social and environmental values (Chai et al. 2021; Cohen et al. 2008; Edwards, 2021; Soubbotina et al. 2004; Vosylius et al. 2013), and characterized as the unsustainable use of natural and physical capital (Edwards, 2021; Fernandes et al. 2021; Kurniawan & Managi, 2018; Soubbotina et al. 2004). the extensive form of economic growth is also conceptualized as the “growth enigma” by Fleming (1992), referring to the growth of economic outputs which exceeds the environmental benefits of the technological advancement.

The second form refers to the “intensive” way of economic growth, which relates to the efficient use of resources more productively, and which requires more than a solely economic way of thinking (Soubbotina et al. 2004). The intensive form of economic growth requires economic development, which is also identified to bring higher per capita income, and higher standards of living (Soubbotina et al. 2004). In this respect, economic development is frequently measured by GDP per capita or GNP per capita, which stands by the “average” well-being of a population and productivity, rather than GDP or GNP (Soubbotina et al. 2004). As a result, “population growth rate,” “human capital stock,” and “national innovation capabilities” become essential concepts, which relate to “per capita” way of economic growth (Soubbotina et al. 2004). Further, calculated by the experts from the World Bank for most of the countries and for all the regions (Soubbotina et al. 2004), the “genuine domestic saving (investment) rate” is identified as an explanatory indicator for the requirements of an economic development, which also reflects the sufficiency of savings and investment as well as proper incentives.

Referring to a qualitative change in an economy (Soubbotina et al. 2004), economic develeopment is also defined to benefit from technological aspects as well as the social facets in order to reconstruct the economy (Soubbotina et al. 2004). In this respect, adaptation of the older technologies in less developed counties is considered to bring environmental damage through economic growth phases, and adaptation of developed countries deliver sustainable consequences together with economic growth (Vosylius et al. 2013). On the other hand, also should be noted that the digital technologies (DT), rather than the older technologies, are also identified as an enabler and as a solution for the creation of sustainable economies for both the developed and the less developed economies (EC, 2022).

As defined, orientation towards a solely economic development is unsustainable (Edwards, 2021; Greco & de Jong, 2017; Hummels & Argyrou, 2021) in parallel to the increased pressure on the planet's natural limits (Ekins, 1993). Consequently, the current argument is re-framed as shifting the economic paradigm towards a more sustainability-oriented order, considering the needs of the future generations (UN, 1987, 2015). Yet, the relation between the concepts of the economy and the sustainability has been widely discussed as a trade-off between social welfare and environmental well-being, and economic profitability (Cohen & Winn, 2007; Cromarty, 2022; Parrish, 2010; UNEP, 2021). On the other hand, the related concepts are currently being referred as integrative, which also enable win-win solutions (Cohen & Winn, 2007; Greco & De Jong, 2017; Weidinger et al. 2014). Consequently, the key to sustainability is defined to lean with a rational management of physical, natural and human capital (Soubbotina et al. 2004).

As a qualitative transformation (Weidinger et al. 2014) which comprises the whole society (Soubbotina et al. 2004; Spangenberg, 2005), achievement of sustainability and the SDGs also require action and collaboration of various members of the society (Cordova & Celone, 2019; UN et al. 2015). In this respect, universities and public research organizations hold a valuable for the consolidation of linkages between researchers and private-sector organizations or policy makers, or directly collaborate by spin-offs (OECD, 2018). Further, NGO's (Porter & Kramer, 2011) provide advocacy, communication, and engagement with private-sector, local or national governments and research centres (Hege & Demailly, 2018). Moreover, the governments (OECD, 2018; Porter & Kramer, 2011) and governmental organizaitons (UN, 2015), are identified to influence the market activity and the private actors through regulations (OECD, 2018) or by superior system of restrictions (Weidinger et al. 2014) and longer-term perspectives (Soubbotina et al. 2004; Spangenberg, 2005), For-profit organizations such as the established companies (Demirel et al. 2019), small and medium enterprises, and startups (Hörisch et al. 2017) are also defined as enablers of the capabilities of investment, productivity and innovation (UN, 2015), and the sustainable economic growth (UN et al. 2015; UNDP, 2015), while the concept of the triple bottom line (TBL) also promotes the evaluation of businesses success considering the environmental, social and economic dimensions at an organizational-level of analysis (Elkington, 2013).

On the other hand, this approach also requires navigation of a complex interplay among economic growth, population growth, environmental degradation, globalization, industrialization and post-industrialization (Soubbotina et al. 2004), health, education, (Kimuli et al. 2020; Soubbotina et al. 2004), energy, carbon emissions, povetry, inequality (Fernandes et al. 2021), hunger and poverty, sustainability of cities, climate change and protection of forests and oceans (Kimuli et al. 2020). Consequently, the measurement of (1) the social sustainability, which reflects income inequality, unemployment, education, public health, tends to be more complex than the evaluation of (2) the environmental protection, which promotes the limitation of resource use for the benefit of the nature and its regeneration process (Azam Roomi et al. 2021; Soubbotina et al. 2004), as well as the economic outcomes. Further, adopting to a more practical lens, the World Bank also defines sustainable development as a diverse portfolio management process of assets, which aim to preserve the environmental, social and economic opportunities (Soubbotina et al. 2004). In that respect, the World Bank considers "genuine domestic savings rate" as an indicator which considers "physical capital," natural capital," "human capital," and "gross national product" for measurement of sustainability (Soubbotina et al. 2004). On the other hand, the integration of each aspect into one indicator is also observed to bring novel problems (Weidinger et al. 2014) such as the convertibility between social environmental and economic values (Soubbotina et al. 2004).

2.1.1 Political background

This research draws on the two main agendas for sustainability. First, this study mainly focuses on the employment of digital technologies towards sustainability, which is dominantly promoted by the TT agenda of the UN (EC, 2022). Consequently, different sources for both declarations are revisited to identify underlying priorities, conceptual boundaries, and relevance for the operationalization process.

2.1.1.1 Sustainable Development Goals

Accepted by 193 members of the United Nations (UN), the SDGs (UN, 2015) are declared in 2015 (UNDP, 2015), as a continuation of Millennium Development Goals (UN, 2000a). As a response to the solely intent to economic value creation for the existing generations (UN, 2015), the 15-year plan primarily aims to develop a sustainable planet for today and for the future generations (UN, 2015). As a call for global action, the 2030 Agenda (UN, 2015) aims to resolve poverty, qualify for better health and education conditions, and fulfill prosperity and well-being, while taking environmental (George et al. 2016; UN, 2015) and economic sustainability into account. Empoying a pragmatic perspective and accepting the momentum of the economic model, the 2030 Agenda also points to a better use of the economic resources, while also promoting socio-economic stability and business competition by optimizing economic goods and services, and attainment of environmental sustainability (Azam Roomi et al. 2021).

Table 2.1 : Definitions of SDGs.

SDGs	Title
1	No Poverty
2	Zero Hunger
3	Good Health and Well-being
4	Quality Education
5	Gender Equality
6	Clean Water and Sanitation
7	Affordable and Clean Energy
8	Decent Work and Economic Growth

Table 2.1 (continued) : Definitions of SDGs.

SDGs	Title
9	Industry Innovation and Infrastructure
10	Reduced Inequalities
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action
14	Life Below Water
15	Life on Land
16	Peace, Justice and Strong Institutions
17	Partnerships for the Goals

In achieving the environmental, social and economic sustainability (Berawi, 2019; UN, 2015), the 2030 Agenda adopts to 17 goals, which are linked to each other and are interdependent (OECD, 2015) as represented in Table 2.1. In brief, SDG1 (No Poverty) can be defined as a commitment to ending the poverty in all its forms and dimensions, while SDG2 (Zero Hunger) points to the achievement of food security, improved nutrition and agricultural sustainability. Also, SDG3 (Good Health and Well-being) aims to ensure healthy lives and weel-being at all ages, while SDG4 (Quality Education) assures inclusive and equitable quality education which empowers lifelong learning opportunities, and SDG5 (Gender Equality) promotes gender equality and empowerment of all woman and girls. On the other hand, SDG6 (Clean Water and Sanitation) promotes availability and sustainable management of water and sanitation, and SDG7 (Affordable and Clean Energy) points to access to affordable, reliable, sustainable and modern energy for all. Aditionally, SDG8 (Decent Work and Economic Growth) draws the attentiton towards a sustained, inclusive and sustainable economic growth considering productive employment and decent work, and SDG9 (Industry, Innovation and Infrastructure) ensures resilient infrastructure, inclusive and sustainable industrialization, and innovation. Further SDG10 (Reduced Inequalities) promotes the reduction of inequalities, SDG11 (Sustainable Cities and Communities) ensures inclusive, safe, resilient and sustainable human settlements, and SDG12 (Responsible Consumption and Production) aims to achieve sustainable production, marketing and consumption patterns. Within an environmental perspective, SDG13 (Climate Action) points to the urgency of climate change and to its impacts, SDG14 (Life Below Water) focuses on conservation ad sustainable use of oceans, seas and marine resources, and SDG15

(Life on Land) promotes the protection, restoration and sustainable use of terrestrial ecosystems, sustainable management of forests, combat against, and elimination of desertification, land degradation and biodiversity loss. Moreover, SDG16 (Peace, Justice and Strong Institutions) promotes building effective, accountable and inclusive institions, and peaceful and inclusice societies with access to justice for all, and SDG17 (Partnerships for the Goals) strengthens the processes towards implementation and empowers the Global Partnership for Sustainable Development (OECD, 2016). In that respect it is obvious that SDGs encompass a broad scope, and address to a wide range of distinct problems, which are separate in structure but interconnected in implementation. Considering the diversity of goals and causes, it is also obvious that SDG-orientation brings new opportunities, economic and non-economic gains for businesses (Sahdev et al. 2025).

Table 2.2 : SDGs clustered into environmental, social and economic pillars.

Environmental Pillar		Social Pillar		Economic Pillar	
6	Clean Water and Sanitation	4	Quality Education	1	No Poverty
7	Affordable and Clean Energy	5	Gender Equality	2	Zero Hunger
12	Responsible Consumption and Production	10	Reduced Inequalities	3	Good Health and Well-being
13	Climate Action	11	Sustainable Cities and Communities	8	Decent Work and Economic Growth
14	Life Below Water	16	Peace, Justice and Strong Institutions	9	Industry Innovation and Infrastructure
15	Life on Land	17	Partnerships for the Goals		

The SDGs are also classified into environmental, social and economic pillars which consists of multiple SDGs, as represented in Table 3.2. In this respect, our research operationalizes SDG pillars of Kostoska and Kocarev (2019), only within the SDG-orientation comparison between the European DSSs, DSS research, and the whole SDG-related literature, as represented in Appendix G.

2.1.1.2 Twin transition agenda

Following the SDGs of the UN (2015), the EU declares the Twin Transition (TT) agenda, which is also intertwined with the EU's strategic frameworks like the European Green Deal which aims to achieve net-zero emissions of greenhouse gases by 2050 (EC, 2019), and the New Industrial Strategy which promotes both the transition towards a climate-neutral economy, and the digital transition to achieve a climate-neutral and sustainable economy (EC, 2020a). Namely the green digital transition, the TT agenda, seeks to realize (1) the green transition, which refers to the achievement of sustainability, and (2) the digital transition, which promotes the employment of DTs in achieving the environmental, social and economic sustainability (EC, 2022). Seeking a dual shift towards sustainability and digitalization, the TT agenda also defines the green transition and the digital transition to reinforce each other throughout better management, monitoring, tracking, maintenance, increased productivity and communication between technical elements and stakeholders, and other specific solutions (EC, 2022).

Aiming to transform the societies and the economies towards sustainability, the TT is not merely about the need for a holistic approach to environmental, social and economic sustainability, but the agenda also dominantly promotes the employment of digital technological innovations (EC, 2022). In this respect, DTs such as 3d printing, artifical intelligence, blockchain, cloud computing, cyber physical systems, data and analytics, information and communication, internet of things, machine learning, augmented and virtual reality, robotics and automation, software and other DTs are considered as enablers of radical and incrennental innovation within the context of sustainability (EC, 2022). On the other hand, defined as new combinations of digital and physical components, DTs are also identified to hold the capability to be adapted, recombined, and applied in different scenarios (John, 2025; Yoo et al. 2010). Improving and differentiating value propositions by advancing to more efficient and effective solutions, and providing new functionalities (Yoo et al. 2010), DTs are also identified to provide more sustainable alternatives across the SDGs (EC, 2022; John, 2025).

On the other hand, the EU also defines small and medium-sized organizations as critical actos in validating a healthy ecosystem which enables competition and innovation through sustainability (EC, 2022). In this respect, that related definition also brings the need for innovative organizations which act as agile drivers of change, and rapidly adapt to emerging sustainability standards and dynamics (OECD, 2020). Supporting multiple actors, the EU also posits the requirement for a policy coherence, financing and investment for green-digital solutions through innovation (EC, 2022), thereby reinforcing the TBL approach (Yang & Luo, 2025). In this respect, the attention also increased towards the concept of entrepreneurship, which is identified as small-sized organizations with a unique potential in enabling increnemntal and radical innovations (Greco & De Jong, 2017; Schumpeter J, 1934; Soubbotina et al. 2004; Tzeng, 2009). Further, the concept of digital sustainable entrepreneurship (DSE) also drew a valuable attention both from scholars and the practitioners. As a composition of entrepreneurial action, digital technological innovation and the sustainability logic (Gregori & Holzmann, 2020; Lüdeke-Freund, 2020; Xu et al. 2022), the concept of DSE is identified as a critical actor for the achievevement of the sustainability (Andersen et al. 2021; Bednarčíková & Repiská, 2021), through SDGs (Berawi, 2019).

2.2 Innovation

The concept of innovation has been identified as "new combinations of new or existing knowledge, resources, equipment, and other factors" by Schumpeter's (1934). Further, Drucker (1985) also defines innovation as "the process of equipping in new, improved capabilities or increased utility." In this respect, employing a business-oriented lens, the fourth edition of Oslo Manual (OECD, 2018) identifies the concept of innovation as "a new or improved product or business processes," which significantly differs from the products and business processes that exist in markets. Further, OECD (2018) also describes that for an innovation, not all the performance specifications or functions are required to be improved. Further, the addition or improvement of a function can also result in combination with decreased performance of other function. (OECD, 2018). Moreover, the concept innovation, which is perceived as a key for economic growth (Chen et al. 2018), is also identified to relate with the concept of core competence, and rapid and profitable growth for organizations (Pandza & Ellwood, 2013). In this respect, innovation also refers to generation of significant level of economic value (Schumpeter J, 1942; Weidinger et al. 2014) and wealth generation (Weidinger et al. 2014). Also employing an economic perspective, OECD (2010) also characterizes the concept of innovation to relate with activities such as research and development, organizational change, training, testing, marketing, and design.

Accordingly, OECD (2018) also points to employment of new technologies, new knowledge, or new combinations or new uses of existing technology and knowledge towards innovation, which also reflects the definition of Schumpeter (1934). Futher, the concept of innovation is also defined to relate with the concept of market imperfections, which is identified as the engine of economic growth in neo-classical theory within a macro-perspective (Hunt, 1997), and as a valuable enabler of business opportunities within a micro-lens (Alderson & Martin, 1965). As a catalyst, the global economy which shifts to be more open, is also accepted trigger the diversification in the sources of innovation both in micro and macro perspectives (Teece, 2007).

The scholarly perspectives on the phenomenon are represented in Table 2.3. In this respect, the concept of innovation is observed to act as a multifaceted and complex construct, which interacts with a diverse range of conceptualizations, and which is conceptualized through distinct research paradigms.

Table 2.3 : Scholarly perspectives on the conceptualization of innovation.

Conceptualizations of Innovation	Scholars
Adaptation	Rodima-Taylor, D., Olwig, M. F., & Chhetri, N., (2012).
Black Box	McDowell, W. C., Peake, W. O., Coder, L., & Harris, M. L. (2018).
Capability	Hamel, G., 2001; Parashar, M., and Singh, S. K., 2005; Perdomo-Ortiz, J., et. al., 2006; Greenway, J. M., and Weiland, J. P., 2000.
Collective Action	Storper, M. (1996).
Consumption	Hienerth, C., von Hippel, E., & Jensen, M. B. (2011).
Core Competence	Kandampully, J., 2002; Waychal, P., Mohanty, R. P., & Verma, A., (2011); Chursin, A., Vlasov, Y., & Makarov, Y., 2016; Banytė, J., & Salickaitė, R., (2008).
Degrees of Innovation	Souto, J. E., (2015); Johannessen, J. A., Olsen, B., & Lumpkin, G. T., (2001).
Determinant of Entrepreneurship	Molina, J. A., & Velilla, J. (2016).
Determinant of Environmental Success	Fraj, E., Matute, J., & Melero, I. (2015).
Determinant of Export Performance	Lages, L. F., Silva, G., & Styles, C., (2009).
Determinant of Suppliers' Roles and Performances	Petroni, A., & Panciroli, B. (2002).
Discipline	Asch, D. A., & Rosin, R. (2015).
Dynamic Capability	Arranz, N., et. al., 2020; O'Connor, G., C., 2008; Furlan, A., and Vinelli, A., 2018.
Economic Power in Global Value Chains	Rikap, C. (2018).
Enabler of Firm Performance	Camisón, C., & Villar-López, A., (2014).

Table 2.3 (continued) : Scholarly perspectives on the conceptualization of innovation.

Conceptualizations of Innovation	Scholars
Evolutionary Process	Ma, T., & Nakamori, Y., (2005).
Evolutionary Tinkering	Sanger, M. B., & Levin, M. A. (1992).
Growth Policy	Mazzucato, M., & Perez, C., (2015).
Guided Activity–Results	Fuglsang, L., Sundbo, J., & Sørensen, F., (2011).
Hallmark of Effective Leadership	Stoller, F. L. (2012).
Interactive Process	Lundvall, B. A., Dosi, G., & Freeman, C., (1988).
Key to Organizational Success	Tohidi, H., & Jabbari, M. M., (2012).
Knowledge Management	Johannessen, J. A., (2008).
Knowledge-Based Outcome	Quintane, E., Casselman, R. M., Reiche, B. S., & Nylund, P. A., (2011).
Learning Process	Beckman, S. L., & Barry, M., (2007).
Loosely Coupled System in Services	Sundbo, J., & Gallouj, F., (2000).
Managing Innovation	Nonaka, I., & Yamanouchi, T., (1989).
Narrative	Borins, S. (2010).
Non-linear Process	Leydesdorff, L., Rotolo, D., & de Nooy, W. (2013).
Part of Management System	Maier, D., et al. (2015).
People Management Challenge	Hotho, S., & Champion, K., (2011).
Policy Disruption	Biber, E., Light, S. E., Ruhl, J. B., & Salzman, J. (2017).
Politics	Perren, L., & Sapsed, J., (2013).
Porcess	Garud, R., Gehman, J., Kumaraswamy, A., & Tuertscher, P., (2016); Garud, R., Berends, H., & Tuertscher, P. (2017).
Promising Phenomenon	Penin, J., Hussler, C., & Burger-Helmchen, T. (2011).
Response to increasing imports and foreign direct investment	Bertschek, I., (1995).
Scientific and Technological Networks	Murray, F., (2002).
Skills and Knowledge	Radcliffe, D. F., (2005).
Social Action	Hellstrom, T., (2004).
Social Change	Mayer, J. P., & Davidson, W. S., (2000).
Social Process	Carlson, W. B. (2003).
Socio-Epistemological Technology	Peschl, M. F., & Fundneider, T., (2014).
Sources of Strategic Fit	Tamayo-Torres, I., Gutiérrez-Gutiérrez, L. J., Llorens-Montes, F. J., & Martínez-López, F. J. (2016).
Strategic Reflexivity	Fuglsang, L., & Sundbo, J., (2002).

Table 2.3 (continued) : Scholarly perspectives on the conceptualization of innovation.

Conceptualizations of Innovation	Scholars
Strategy	Caballero-Morales, S. O., (2021); Vanhaverbeke, W., & Peeters, N. (2005); Hailey, V. H. (2001).
Structural Interest	Burt, R. S., (1980).
System	Patterson, M. L. (2009).
Systemic Phenomenon	Smith, K., (2000).
Uncertainty	Suchman, L., & Bishop, L., (2000).

Considering the diversified scholarly perspectives, it is observed that the phenomenon is also conceptualized throughout multiple epistemological lenses such as (1) the objectivist perspective which analyzes the innovation concept as a "process," "capability" or" system," or (2) the interpretivist perspective that approaches to the concept as "narrative" or "politics," or (3) the pragmatic or functionalist lens which relates innovation with "strategy," "enabler of firm performance," "key to organizational success" or "growth policy," or (4) the systemic perspective that focuses the concept of innovation as "nonlinear process," "adaptation," "systemic phenomenon," "evolutionary tinkering," or "loosely coupled system." Also covering micro, meso and macro levels of analysis, the phenomenon is also perceived as social construct, as a determinant for entrepreneurship, which also relates to environmental, social and economic sustainability.

2.2.1 Sustainable innovation

On the other hand, created by the capitalist system, and which traditionally refers to commercialized invention (Schot & Steinmueller, 2018), the fully-economic concept of innovation is also identified to hold the potential to cause unexpected consequences and impacts in longer periods (Lubberink, Blok, van Ophem, et al. 2017), as the global innovation capacity exceeds the ability to innovate sustainably (Pandza & Ellwood, 2013). Consequently, more sustainable ways and practices of value creation and delivery become essential (Berawi, 2019; Bonilla et al. 2018; Nosratabadi et al. 2019; OECD, 2018; Schaltegger & Wagner, 2011; UN, 2015) for the progress towards a more sustainable growth (OECD, 2010b, 2010a, 2018; UN, 1987, 2015; UN et al. 2015). In this respect, the concept of innovation, which is frequently related with creation, diffusion and use of new knowledge (Carayannis &

von Zedtwitz, 2005), and which is identified as a driver of economic growth, has also began to be perceived as a driving force for sustainability (Bonilla et al. 2018; Carayannis & von Zedtwitz, 2005; Cordova & Celone, 2019; European Commission, 2017; Gault, 2016; Kivilä et al. 2017; Kroll et al. 2019; Lüdeke-Freund, 2020; Maier et al. 2020; Miklian & Hoelscher, 2018; OECD, 2010b, 2010a, 2018; UN et al. 2015; UN DESA, 2022), in addressing the progress through both environmental, social and economic challenges (Ahmad et al. 2020; Cordova & Celone, 2019; OECD, 2016, 2018; Sinha et al. 2020; UN, 2015; UN et al. 2015; UN DESA, 2022; Velenturf et al. 2018) in the decade of action (UN, 2020b; UN ECLAC, 2022). In parallel, the market imperfections which are assessed as sources of the conventional modes of innovation (Alexis et al. 2017; Cohen et al. 2008; Cohen & Winn, 2007) which frequently underestimate the environmental and social priorities, are also defined as market opportunities for sustainability-oriented innovative organizations (Azam Roomi et al. 2021; Cohen & Winn, 2007; Dean & McMullen, 2007; Hockerts & Wüstenhagen, 2010; Koe et al. 2014), which aim to replace the market imperfections (Lüdeke-Freund, 2020) with sustainability-oriented innovations (Lüdeke-Freund, 2020), and transform industries and markets towards sustainability (Cohen et al. 2008; Hockerts & Wüstenhagen, 2010) at large (Greco & De Jong, 2017; Schaltegger & Wagner, 2011) throughout environmental, social (Cohen & Winn, 2007; Gerlach, 2003; Hockerts & Wüstenhagen, 2010) and economic opportunities (Dean & McMullen, 2007; Gerlach, 2003; Hockerts & Wüstenhagen, 2010). Hereby, the understanding of the innovation concept shifts from a wholly economic context, to a sustainability-oriented context, which is referred as sustainability-oriented innovation (Klewitz & Hansen, 2014) with the focus on empowering the TBL, and promoting new ways of innovative thinking (Bossle et al. 2016; Elkington, 2013; Slaper, 2011; Soubbotina et al. 2004).

In parallel, scholars define this change as frame changes, and even as paradigm shifts. Accordingly, Chen et. al. (2018) identifies three paradigm shifts within the understanding of innovation concept adopting to a Kuhnian approach (Kuhn, 1962). According to Chen et. al., (2018) the first paradigm which roots in the American scholarship, is highly market oriented, and mainly focuses on the concept of innovation with an economic frame. Within this paradigm, the scholars have examined the means of creative destruction (Schumpeter J, 1942), the relationship between industrial research and technological innovation (Mansfield, 1968), value creation by innovation (Teece, 1986), user innovation (von Hippel, 1986), disruptive innovation (Christensen, 1997), open innovation (Chesbrough, 2003), and within the relationship between technological innovation, economic growth, and social competitive advantage (Crossan & Apaydin, 2010). Further, Chen et. al., (2018) also describes the second paradigm which roots from the national innovation practices adopted by the Asian countries. Within that paradigm, knowledge-based innovation (Nonaka, 2007), lean production (Womack et al. 2007), convergence innovation (Lee, 2015), indigenous innovation (Li et al. 2010), total innovation (Xu et al. 2007), secondary innovation (Wu et al. 2009), business-model innovations (Wu et al. 2010), and embracing innovation (Li-Hua, 2014) concepts are discussed. Chen et al. (2018) also describes the third innovation paradigm to originate from the European scholars. Within that paradigm, Chen et al. (2018) defines the concept of innovation as integrating technological innovation paradigm with humanitarian, social, and value driven models. The third innovation paradigm also involves the concepts of design-driven innovation (Verganti, 2009), responsible innovation (Owen et al. 2013), and public innovation (Bason, 2010).

Following a similar perspective, Schot and Steinmueller (2018) has also identified three frames of innovation-based approaches. In this repect, the first frame examines the role of innovation for economic growth and mainly focuses on industrial productivity, mass production, consumption and financial return on investment; which remains unexamined until after the Second World War. The second frame, which emerges by the 1980s, is defined to keep the economic perspective as the first frame. This frame is identified to root from the concepts of globalization and international competition, and examines the "national systems of (Schot & Steinmueller, 2018). Further, the third frame differs from the other frames with the orientation towards sustainability rather than the economic priorities. Schot and Steinmueller (2018) also defines the main characteristic of the third frame by the utilization of science and technology in addressing social, environmental, and economic problems on a global scale. This frame is also identified to be supportive on the SDGs, which also promotes a transformative change through sustainability (Schot & Steinmueller, 2018).

Across all paradigms and frames, economic priorities shaped the evolution of innovation studies. Throughout these shifts, new research areas and novel practices have emerged which reflect the broadening scope of the concept of innovation, from the market-oriented and nationally driven perspectives, to socially and environmentally oriented approaches. Considering the planet as an interconnected system which is on its environmental, social (Chapin et al. 2010; Parikh et al. 2018), and economical (Spangenberg, 2005) limits, it is critical to adopt to the necessary transformations in this decade to to prevent ecologically irreversible or socially and economically costly problems (UN ECLAC, 2022).

Table 2.4 : Sustainability-related research on innovation taxonomies.

Area of Research	Scholars
Eco-Innovation	Bossle et al. 2016; OECD, 2009; Schiederig et al. 2011.
Frugal Innovation	Albert, 2019; Hossain, 2018; Zeschky et al. 2011.
Grassroots Innovation	Hossain, 2016; Seyfang & Smith, 2007; A. Smith et al. 2017.
Green Innovation	Khan et al. 2021; Schiederig et al. 2011; Zhou et al. 2020; Magee, 2015; Y. S. Chen, 2008.
Inclusive Innovation	George et al. 2012; Patnaik & Bhowmick, 2020; European Commission, 2017.
Public Innovation	Bason, 2017; TIPC, 2022.
Responsible Innovation	Lehoux et al. 2018; Lubberink, Blok, van Ophem, et al. 2017; Pandza & Ellwood, 2013; da Silva et al. 2019.
Social Innovation	Eichler & Schwarz, 2019; Leal Filho et al. 2022; Morrar et al. 2017; Portales, 2019; Vallaster et al. 2019; Varadarajan & Kaul, 2018.
Sustainable Innovation	Cillo et al. 2019; Gottardo et al. 2021; Guo et al. 2020; Schaltegger & Wagner, 2011.

As a result of the shift from the economic and profit-oriented understanding of innovation (Drucker P., 1985; OECD, 2010a; Schumpeter J, 1934) to the sustainability-oriented innovation perspective (Bossle et al. 2016; Elkington, 2013; OECD, 2018; Slaper, 2011; UN, 2015), novel research areas have elaborated successively including sustainable innovation (Boons & Lüdeke-Freund, 2013; Cillo et al. 2019; Gunarathne, 2019; Miklian & Hoelscher, 2018; Nosratabadi et al. 2019), social innovation (Mulgan, 2006; Nicholls & Murdock, 2012), responsible innovation (Chen et al. 2018; Lubberink, Blok, Ophem, et al. 2017; Miklian & Hoelscher, 2018), public innovation (Chen et al. 2018; Fuglsang & Sörensen, 2011), eco-innovation (Bossle et al. 2016; OECD, 2009; Schiederig et al. 2011), green innovation (Chen, 2008; Chen et al. 2006), grassroots innovation Mann et al. (2024), which operationalizes SDG-orientation as an independent variable, and productivity as a dependent variable whic(Seyfang & Smith, 2007), frugal innovation (Hossain, 2018; Zeschky et al. 2011), and inclusive innovation (George et al. 2012; Schot & Steinmueller, 2018). Table 2.4 represents sustainability-oriented innovation tipologies within the literature.

2.2.2 Digital technological sustainable innovation

Each organizational practice is defined to be bounded with materiality (Orlikowski, 2007) which includes both visible (vehicles, chairs, desks, computers, documents, etc.) and less visible forms of technology (digital networks, data, software, electricity, etc.) (Orlikowski, 2007). Materiality is also identified to bring affordances within the organizational researches, which refer to possibilities of action which differs from actor-to-actor, and from context-to-context (Hutchby, 2001). As digital forms of artefacts (Gregori & Holzmann, 2020), DTs are also entitled as enablers of radical and incremental innovation (Andersen et al. 2021; Bednarčíková & Repiská, 2021; Xu et al. 2022), organizational performance (Andersen et al. 2021; Lin & Mao, 2024), competitive advantages (Gregori & Holzmann, 2020; Lüdeke-Freund, 2020; Tohănean et al. 2020; Xu et al. 2022), efficiency (Bednarčíková & Repiská, 2021), process effectiveness (Berawi, 2019), new skills (Andersen et al. 2021), safer material (Berawi, 2019), transparency (Nishant et al. 2020), integration (Andersen et al. 2021; Gregori & Holzmann, 2020; Tohănean et al. 2020), cooperation (Xu et al. 2022), coordination (Xu et al. 2022), accessibility (Gregori & Holzmann, 2020), perceptibility (Andersen et al. 2021), cost reduction)(Andersen et al. 2021; Gregori & Holzmann, 2020; Xu et al. 2022), analyticity (Xu et al. 2022), communication h r(Bednarčíková & Repiská, 2021), simplification of operational flows (Andersen et al. 2021), co-creation of value with users (Gregori & Holzmann, 2020; Xu et al. 2022), traceability (George et al. 2019), connectivity eflect(Bednarčíková & Repiská, 2021; Xu et al. 2022), evaluation (Xu et al. 2022), monitoring (Nishant et al. 2020), risk modelling (Ginters & Dimitrovs, 2021; Tohănean et al. 2020), intelligence (Xu et al. 2022), prediction (Xu et al. 2022) and successive replication capabilities (Schneider, 2019).

On the other hand, orientation towards sustainability also brings the attention towards the employment of DTs in the achievement of sustainability (EC, 2022; Xu et al. 2022). In this respect, DTs which are defined to reinforce green transitions by the TT vision of the EU (EC, 2022), are also described to hold a transformative role (Nishant et al. 2020) in embedding environmental, social and economic objectives (Bednarčíková & Repiská, 2021; Xu et al. 2022), and scale up the value propositions across communities and national borders (Andersen et al. 2021; Gregori & Holzmann, 2020). Offering a wide range of tools and solutions, and bringing competitive advantages (Andersen et al. 2021; Bednarčíková & Repiská, 2021; Xu et al. 2022), DT are also characterized by bringing transformative solutions to sustainability-related market imperfections (Bednarčíková & Repiská, 2021; Xu et al. 2022), and contributing to SDGs (Berawi, 2019; Gregori & Holzmann, 2020). In that respect, Table 2.5 represents the research on the use of DTs for sustainability.

Table 2.5 : Research on digital technologies and sustainability.

Context	Scholars
3D Printing and Sustainability	Gebler, M., Schoot, Uiterkamp, A., & Visser, C., 2014; Baiano, A., 2022.
Artificial Intelligence (AI) and Sustainability	Khakurel, J., et, al., 2018; Nishant, R., Kennedy, M., & Corbett, J., 2020; Goralski, M., & Tan, T., 2020; Nishant, R., Kennedy, M., & Corbett, J., 2020; Vinuesa, R., 2020; Tanveer, M., Hassan, S., & Bhaumik, A., 2020; Yigitcanlar, T., & Cugurullo, F., 2020.
Augmented Reality (AR) and Sustainability	Abad-Segura, E., et, al., 2020; Kościelniak, H., Łęgowik-Małolepsza, M., & Łęgowik-Świącik, S., 2019.
Big Data Analytics and Sustainability	Singh, S., & El-Kassar, A., 2019; Dubey, R., et. al., 2019; Raut, R., et. al., 2019.
Blockchain and Sustainability	Giungato, P., & Rana, R., 2017; Rejeb, A., & Rejeb, K., 2020; Upadhyay, A., et, al., 2021; Galaz, V., et, al., 2021; Park, A., & Li, H., 2021.
Cloud Computing and Sustainability	Chang VWills GDe Roure D., 2010; Garg, S., & Buyya, R., 2012; Timčenko V., et. Al., 2016.
Digital Platforms and Sustainability	Kolk, A., & Ciulli, F., 2020; Bhaskara, S., & Bawa, K., 2021; Hellemans, I., Porter, A., & Diriker, D., 2022.
Internet of Things (IoT) and Sustainability	Manavalan EJayakrishna K., 2019; Nižetić, S., et. al., 2020.
Renewable Energy and Sustainability	Chel, A., & Kaushik, G., 2018; Østergaard, P., et, al., 2020.
Robotics and Sustainability	Bugmann, G., Siegel, M., & Burcin, R., 2011; Ogbemhe, J., Mpofu, K., & Tlale, N., 2017; Shehu, N., Abba, N., Johor Malaysia, S., 2019; Guenat, S., et, al., 2022.

Table 2.5 (continued) : Research on digital technologies and sustainability.

Context	Scholars
Software and Sustainability	Durmanov, A., et, al., 2019; Iatsyshyn, A., et, al., 2020; Swacha, J., 2022.
Virtual Reality and Sustainability	Atwa, S., et, al., 2019; Scurati, G., et, al., 2021; Jamei, E., et, al., 2017.

In this respect, DTs as non-human artefacts (Pinch & Bijker, 1984) or as actants (Latour, 1996; Latour & Woolgar, 1979), which are employed by the sustainability-oriented organizations to support the creation of novel and enhanced sustainability-driven value propositions include (1) artificial intelligence (AI), as a powerful option to required human intelligence, which also covers machine learning (ML) (Schneider, 2019), enables improvement of problem-solving, decision-making and operations, optimized predictions, automation of tasks (Andersen et al. 2021) and reduction on environmental and social impact (Nishant et al. 2020; Schneider, 2019; Xu et al. 2022), (2) cloud computing which enables businesses to access computing resources on demand, reducing the need for on-premises infrastructure regardless of place and time and improving resource efficiency; which enables reducing carbon emissions, energy consumption and physical footprint and resource use, and adopting more agile and flexible business models (Bednarčíková & Repiská, 2021; Chang et al. 2010; Garg & Buyya, 2012; Timčenko et al. 2016), (3) data analytics, that enables gathering, processing, and analyzing large sets of data for identifying trends, patterns, and opportunities for improvement, and also enable data-driven decisions that support their sustainability-related objectives (Bednarčíková & Repiská, 2021; Dubey et al. 2019; Raut et al. 2019; Singh & El-Kassar, 2019; Xu et al. 2022) (4) IoT, as an interconnected network of sensors, devices, and other digital technologies that can communicate, interact and share data with one-other (Schneider, 2019), and enable monitoring and optimization on operations (Bednarčíková & Repiská, 2021; Manavalan & Jayakrishna, 2019; Nižetić et al. 2020; Schneider, 2019), (5) blockchain, as a decentralized, distributed ledger technology, and as a peer-to-peer network (Nishant et al. 2020; Schneider, 2019) which enables tracking and verifying the sustainability of supply chains and transactions throughout transparent and secure record-keeping (Nishant et al. 2020; Park & Li, 2021; Rejeb & Rejeb, 2020; Schneider, 2019) and digitalization of transactions (Schneider, 2019), (6) 3D printing, enables reduction on waste, energy consumption, and transportation costs throughout creation of physical objects by laying down successive layers of material based on a digital design (Baiano, 2022; Gebler et al. 2014), (7) augmented reality (AR), enables improvement in efficiency and effectiveness of operations, and engage with customers and stakeholders through innovative ways, throughout use of digital information and graphics (Schneider, 2019) to enhance the user's perception of the real world (Galaz et al. 2021; Khakurel et al. 2018; Nishant et al. 2020; Schneider, 2019), (8) virtual reality (VR), enables improving efficiency and effectiveness of operations, and addressing potential problems, reducing waste and improving resource efficiency by providing by visualizingand testing ideas, processes, and products in a simulated environment throughout computer-generated simulations which also allow stakeholders to interact and experience virtual environments in a realistic way (Atwa et al. 2019; Jamei et al. 2017; Scurati et al. 2021), (9) robotics and automation, enables organizations to automate tasks, improve efficiency, reduce environmental impact and improving sustainability practices use by employing industrial robots and autonomous vehicles (Bednarčíková & Repiská, 2021; Bugmann et al. 2011; Guenat et al. 2022; Ogbemhe et al. 2017; Pan et al. 2018; Shehu et al. 2019), (10), digital platforms as enablers of direct communication, interaction, and transactions between actors (Schneider, 2019), where attractiveness and success of the platforms are related to the quality and quantity of actors on each side (Schneider, 2019), and where each actor has the potential to influence one-another and group of actors (Gregori & Holzmann, 2020), and (11) software that enables organizations through business analytics (Xu et al. 2022), improved decision-making, sustainable product design, efficiency, optimization on supply chain management (Tohănean et al. 2020) and resource use, waste reduction, innovation, facilitation of collaboration, increasing transparency, communicating organizational sustainability efforts and goals, engaging with stakeholders, and contributes to circular economy initiatives through a sustainability.

2.2.3 Innovation types by object

This research operationalizes the adopted ITs of the European DSSs as a mediator variable within the empirical research. Consequently, the literature on innovation taxonomies is revisited. In this respect, it is observed that two main taxonomies arise within the literature (1) novelty-based innovation taxonomies, and (2) innovation taxonomies by object. Also identified that, even if new descriptive concepts arise within the sustainability-orientated forms of innovation, taxonomies on the innovation types by object have been more stable (OECD, 1997, 2005, 2018).

2.2.3.1 Novelty-based innovation taxanomies

Major research on the novelty-based taxonomies, analyzes innovation types as "radical" or "incremental" which keeps its dominant position both in the literature and in practice (Lazzarotti et al. 2011; OECD, 2018). In this respect, the concept of increnmental innovation is the described by OECD (2018) as improvements of existing practices by (1) addition of new functions, (2) function improvements, or (3) improvements on user utility. Further, the concept of radical innovation which is also associated with the disruptive theory of Schumpeter (1942) and refers to the theory of "creative destruction," which focuses on replacing the existing products and existing habits with new ones by disrupting the elder (Lazzarotti et al. 2011) and transform the markets (OECD, 2018).

Employing a sustainability-oriented lens, radical innovation can be linked to the concept of transformative innovation, which are characterized as sustainability-driven radical innovations (Maier et al. 2020; Miklian & Hoelscher, 2018), that result in environmental and social progress as well as economic advancement (Boni et al. 2021; Miklian & Hoelscher, 2018; Velenturf et al. 2018). In this respect, transformative innovations are also supported by the Transformative Innovation Policy Consortium (TIPC, 2022) which is formed as an initiative (Schot & Steinmueller, 2018) with the aim to consolidate the cooperation between research, policy making, experimentation, evaluation, training, capacity building, and communications, which also promotes the collaboration between academicians, policy makers and innovation funding organizations. On the other hand, the concept of incremental innovation is charaterized as significant or advanced changes (Lazzarotti et al. 2011) within the existing value propositions, which are cumulative (UN et al. 2015). Within a sustainability-oriented perspective incremental innovations are also related with the recommendation on the consideration which assesses the entire value chain as a source of improvement (UN et al. 2015). In this respect, the sustainability-oriented increnmental innovations focus on supply and inbound logistics, production and operational cycles, distribution, product use and product lifecycles at the center of the areas of improvement (UN et al. 2015).

Further, the practitioners are also aiming to decrease energy and material usage by adopting sustainable ways of cleaner production, considering the environmental damage throughout the whole product lifecycles (OECD, 2009) to decrease the environmental impact to enable incremental innovations (Schiederig et al. 2011)

Further, the novelty-based innovation taxonomies also cover (1) new to the firm innovations which refer to the diffusion of the existing innovations by other organizations, (2) new to the market innovations which focus on the intofuction of existing innovations to other markets, and (3) new to the world innovations which refer to the innovations which are new to the whole markets and industries in a global perspective (OECD, 2018).

2.2.3.2 Innovation types by object

As an early and a major approach, Schumpeter (1934) describes the taxonomy of innovation as (1) new goods or services, (2) new methods or new production processes, (3) opening new markets, (4) employing new source of raw materials or components of goods, and (5) establishment ofa new organizations new business or new market structures (Ireland et al. 2003; Lazzarotti et al. 2011).

Further, Oslo Manual, as an international reference for portrayment and measurement of innovation which basis on, and aligns with the statistical classifications of the UN (OECD, 2018) defines, classifies and revises the innovation types by object, with a more of a practical lens. In this repsect, the first edition of Oslo Manual (1992), innovation types are described as (1) technological product and (2) technological process innovations which highly reflects an orientation towards manufacturing (Gault, 2016; OECD, 2018). With the second edition of Oslo Manual, service innovations were added to the exsiting taxonomy, which includes technological product and technological process innovations (OECD, 2018). Further, the third edition of Oslo Manual, which is influenced by Bogota Manual (2001), also focuses only on businesses, proposes four innovation types which include (1) product innovations, (2) process innovations, (3) organizational innovations, and (4) marketing innovations (OECD, 2005, 2010a).

Moreover, the fourth edition of Oslo Manual (OECD, 2018), as the only edition which is released after the agreement for the 2030 Agenda (UN, 2015), classifies the concept of innovation by addressing its common usage, in terms of its “object” or its "purpose" (e.g. delivery system innovations). In this respect, the concept of innovation is classified into two broader categories and eight sub-categories which include (1) product innovations; which involves of two sub-categories as (a) product innovations, and (b) service innovations, and (2) business process innovations category which include the innovations which relates to (a) production of goods or services , (b) distribution and logistics, (c) marketing and sales, (d) information and communication systems, (e) administration and management, (f) product and business process development (OECD, 2018). Also identified by Oslo Manual, an innovation can include combinations of types of product and business process innovations as new technology, new knowledge, or new combinations or new uses of existing technology and knowledge is employed throughout the innovation process (OECD, 2018).

Table 2.6 : Innovation taxonomy of Oslo Manual (2018).

Innovation Taxonomy	Description
(1) Product Innovation	New or improved good or service that differs significantly from the firm's previous goods or services.
(a) Goods Innovation	Tangible objects and some knowledge-capturing products which ownership rights can be established and transferred through market transactions.
(b) Services Innovation	Intangible activities that are produced and consumed simultaneously, can also include some knowledge-capturing products.
(2) Business Process Innovation	New or improved business process for one or more business functions.
(a) Production of Goods and Services Innovation	Activities that transform inputs into goods or services and support production (engineering, technical testing, analysis, certification).
(b) Distribution and Logistics Innovation	Transportation and service delivery, warehousing, order processing.
(c) Marketing and Sales Innovation	Marketing methods including advertising (promotion, packaging), direct marketing, exhibitions and fairs, market research and other activities to develop new markets, pricing strategies and methods, sales and after-sales activities.
(d) Information and Communication Systems Innovation	Maintenance and provision of hardware and software, data processing and database, maintenance and repair, web-hosting and other computer-related information activities.

Table 2.6 (continued) : Innovation taxonomy of Oslo Manual (2018).

Innovation Taxonomy	Description
(e) Administration and Management Innovation	Strategic and general business management (cross-functional decision-making), including organising work responsibilities, corporate governance (legal, planning and public relations), accounting, bookkeeping, auditing, payments and other financial or insurance activities, human resources management (training and education, staff recruitment, workplace organisation, provision of temporary personnel, payroll management, health and medical support), procurement, managing external relationships with suppliers, alliances, etc.
(f) Product and Business Process Development Innovation	Activities to scope, identify, develop, or adapt products or a firm's business processes; which can be conducted within the firm or obtained from external sources.

Product innovations

Considering the term "product" as the economic outputs of the production activities, Oslo Manual considers product innovation as entirely new or improved or a goods or services (Klewitz & Hansen, 2014; OECD, 2018), which bring significant improvements in a single or multiple characteristics, or for performance specifications of the related product (OECD, 2018). The stated improvements are also expected to bring new function additions, function improvements, or improvements in the user utility (OECD, 2018), which can also result in a loss or decreased performance on other functions (OECD, 2018). Further, Oslo Manual also identifies that product innovations cover functional characteristics such as; quality, economic efficiency, technical specifications, reliability, convenience, durability, affordability, user friendliness and usability (OECD, 2018). Further, the characteristics of product innovations are also related to financial attributes such as financial convenience or affordability, or to the design that influences the appearance or the utility of users (OECD, 2018).

On the other hand, OECD (2018) defines product innovations to serve to the end-users or used as inputs for other goods and services or assessed as an investment (OECD, 2018). Further, product innovations are also defined to include but not limited to; design for the environment/eco-design, ecolabels (e.g. fair trade or organic certification), life-cycle-analysis, lifecycle-costing, materials (replace, reduce, sustainable; e.g. biodegradables or recycled materials), packaging, organic and fair trade goods and services (Klewitz & Hansen, 2014).

In this respect, Oslo Manual (OECD, 2018) classifies product innovations as (1) “goods” as the economic outputs of production activities which are tangible, for which the ownership can be established and transferred through market transactions, and (2) “services” as the economic outputs of production activities which are intangible, and described to be produced and consumed simultaneously, which also changes the psychological and/or physical conditions of the users, and which may also include knowledge-capturing products” (OECD, 2018).

Business process innovations

On the other hand, business process innovations characteristically refer to new or improved business processes which significantly differentiate from the previously employed business processes of the organization (OECD, 2018). In this respect, the improvement of business processes may apply to one or multiple business functions (OECD, 2018). Business processes innovations can relate to each transformation process of inputs into outputs, and handling of each procedure and activities (OECD, 2018). Further, the areas of business process innovations are frequently defined to relate with policies of the organization which enable the overall strategy that drives activities of units, cost reductions, development of product quality, improvement of working conditions, and fulfillment of the regulatory imperatives (OECD, 2018). Consequently, business process innovations are frequently influenced by the focus on efficiency, convenience, affordability, usability, resilience and reliability (OECD, 2018). In this respect, sustainability-oriented business process innovations may also include but not limited to eco-efficiency, cleaner production, and logistics (Klewitz & Hansen, 2014). Additionally, Oslo Manual (OECD, 2018) points to “implementation” which refers the organization to employ the innovated business process into its ongoing operations. On the other hand, each function of the innovation, can also be implemented by internal sources or external contractors (OECD, 2018).

Further, a similar classification of Porter (1985) on the value chain, which is similar in structure and purpose, but represents dissimilarities in context. In this respect, Porter’s innovation taxonomy refers to business processes which include (1) primary activities such as inbound logistics, outbound logistics, sales, marketing, service, and

(2) support activities such as technology development, human resources management, and procurement which are in relation with organizational infrastructure (Porter, 1985). On the other hand, Klewitz and Hansen (2014) identifies that sustainability-oriented business process innovations include but not limited to; reconfiguration of operations through the value chain for optimization of resource use, management of supply chain management, cleaner and eco-efficient production activities, effective logistics, effective management of non-product output (sewage, hazardous materials, waste, etc.), management of stakeholders and optimization of innovation processes.

Combining all the mentioned concepts and definitions, it is required to give a decision on the innovation taxonomy to be operationalized by the empirical research. In that repsect, decision on the degree for novelty-based taxonomies can be challenging (OECD, 2018) as a result of insufficient conceptual distinction between related typifications (OECD, 2018). Novelty-based taxonomies which include categorizations as (1) the taxonomy with radicality of innovations with radical and incremental innovations, and (2) the taxonomy with “new to firm,” “new to market,” and “new to the world” innovations, both require distinct experimentation for a proper measurement (OECD, 2018). In this respect, conducting a survey with novelty-based taxonomies, may also result in difficulty on respondent’s estimations (OECD, 2018). On the other hand, approaches of the innovation taxonomies of Schumpeter (1934) and Oslo Manuals (OECD, 2018) are similar in purpose, but the taxonomy of Oslo Manual (OECD, 2018) includes wider and more detailed descriptions. Further, the taxonomy of Oslo Manual (OECD, 2018) is the only classification which is released after the declaration of the SDGs (UN, 2015), Consequently, this research will adopt to the innovation taxonomy of OECD (2018) to be operationalized as a mediator variable within the empirical research.

2.3 Entrepreneurship

On the other hand, considering the shift from a managerial economy to an entrepreneurial economy (Greco & de Jong, 2017; Schaltegger & Wagner, 2011a), the concept of entrepreneurship is frequently described as the source of innovation (Greco & De Jong, 2017; Schumpeter J, 1934; Soubbotina et al. 2004; Tzeng, 2009), which enables implementation (OECD, 2018), diffusion (Rogers, 1962) and economic returns (Schumpeter J, 1934; Tzeng, 2009) which are frequently described as requirements for an innovation.

As a social phenomenon (Koe et al. 2014), the concept of entrepreneurship is also identified to relate with "exploration" which refers to term such as risk taking, search, experimentation, flexibility, variation, discovery, and innovation, and with "exploitation" which refers to refinement, production, choice, selection, efficiency, implementation, and execution (March, 1991). The concept of entrepreneurship is also frequently recognized with the capabilities of capturing market opportunities, promoting productivity (Entrepreneurship Monitor, 2022) and performance (Gu & Wang, 2022), risk taking (Greco & De Jong, 2017; Kraus et al. 2018), innovativeness and proactiveness (Kraus et al. 2018). Considering entrepreneurship as combination of innovation and venturing (Greco & De Jong, 2017; Hayton, 2005; Shahid, 2022), the entrepreneurs are also characteristically defined as creative individuals (Greco & De Jong, 2017) who hold higher tendency, and aim to discover the opportunities to shape markets (Teece, 2007). The entrepreneurial activity which is predominantly associated with creation of novel industries (Schumpeter, 1911) as cited by Cohen et. al. (2008), is also identified as one of the major driving forces behind economic growth (Dhahri & Omri, 2018; Fernandes et al. 2021; Greco & de Jong, 2017; Gu & Wang, 2022; Henrekson & Sanandaji, 2019; Lazzarotti et al. 2011; Schumpeter J, 1942; Tzeng, 2009) and economic development (ICC, 2012; Koe, Majid, et al. 2014; Naudé, 2008; Schumpeter J, 1934; Soubbotina et al. 2004).

On the other hand, as one of the fundamental drivers of economic growth and economic development, entrepreneurial activities do not necessarily focus on environmental and social impacts (Azam Roomi et al. 2021; Greco & de Jong, 2017; Gu & Wang, 2022; Zeng, 2018), which even oppose with environmental and social priorities (Azam Roomi et al. 2021; Cohen & Winn, 2007; Edwards, 2021; Greco & de Jong, 2017; Koe, Majid, et al. 2014; Nosratabadi et al. 2019). On the other hand, considering the increasing tendency towards sustainability (Shahid, 2022) especially after the financial crisis in 2007 (Kraus et al. 2018), the conventional understanding on value creation has extended to cover both economic and non-economic values (Azam Roomi et al. 2021; Koe et al. 2014; Lüdeke-Freund, 2020; Sarango-Lalangui et al. 2018; Schaefer et al. 2015; Shepherd & Patzelt, 2011; Thelken & de Jong, 2020; Zeng, 2018) which are decisive for individuals, society, environment and for the economy.

In this respect, rather than the conventional and solely-economic understanding of entrepreneurship (Lazzarotti et al. 2011; Matzembacher et al. 2020; Schumpeter J, 1934, 1942), which creates non-economic value as a by-product (Dixon & Clifford, 2007; Seelos & Mair, 2005), the concept is also defined as a key for the sustainable development (Cohen & Winn, 2007; Hoogendoorn et al. 2019; ICC, 2012; Koe et al. 2014; Rahdari et al. 2016; Soubbotina et al. 2004; Weidinger et al. 2014; Zeng, 2018), and for the creative destruction which is required for meeting the scale of the challenge (Dixon & Clifford, 2007; Hockerts & Wüstenhagen, 2010; OECD, 2020). In this context, entrepreneurship is considered as a solution both for (1) environmental sustainability which refers to reduction on exploitation of resources, creation and usage of environmentally harmful products, intermediate products and substances, reduction of waste production and environmental pollution (Kraus et al. 2018(OECD, 2018; Porter & Kramer, 2011) and to (2) social sustainability which refers to promoting the integration of the society, bringing solutions to stability, safety and justice, protection and advancement of human rights, equality diversity, and securing the livelihoods of the society at large (Kraus et al. 2018).

2.3.1 Sustainability-oriented entpreneurship models

Private business activity, innovation and investment are identified as the major drivers of productivity, economic growth (UN et al. 2015) and sustainable economic growth (UN et al. 2015; UNDP, 2015). In this respect, the engagement of private-sector organizations is also identified as critical for sustainable development (ICC, 2012; Kramer, 2014) as a result of their innovating capacity and the capability of delivering innovative solutions into markets (Kramer, 2014; OECD, 2018). In tis repsect, UN calls businesses to take action (UN et al. 2015), which also represents the SDG Compass (UN et al. 2015) with the aim to empower and guide businesses in aligning their strategies and measuring their contribution to SDGs (Gault, 2016; UN et al. 2015).

In this context, established companies (OECD, 2008, 2010b) are frequently described as less explorative and less exploitative (Greco & De Jong, 2017), which especially tend to have difficulties in realizing radical innovations (Schaltegger & Wagner,

2011) as a result of settled organizational procedures, administrative systems and demands from diverse shareholders (Greco & De Jong, 2017). On the other hand, the concept of entrepreneurship is defined as an indispensable source (Schumpeter J, 1934), and as a carrier for innovation (Drucker P., 1985). Moreover, OECD refers younger companies as crucial enablers of innovation rather than the established companies (OECD, 2008, 2010b). Considering these perspectives and definitions, and the requirement for radical innovations throughout the achievement of sustainability, it is obvious that entrepreneurship is a vital actor in "creation, diffusion and application of new knowledge" (OECD, 2010b) in addressing the SDGs (Entrepreneurship Monitor, 2022). On the other hand, entrepreneurs also perceive sustainability-orientation as the biggest economic opportunity in the history (Dean & McMullen, 2007; Dixon & Clifford, 2007) which also stimulates the linkage between business strategies and global priorities (UN et al. 2015).

Consequently, sustainability-oriented novel concepts have emerged successively in the field of entrepreneurship, such as the concept of social entrepreneurship which prioritizes (Raudeliuniene et al. 2014) and even combines environmental and social objectives (Dixon & Clifford, 2007; Porter & Kramer, 2011) at large (Schaltegger & Wagner, 2011), with a nicher-position with the perception of non-profits (Schaltegger & Wagner, 2011) and the characteristics of hybrid organizations , 2019; York et al. 2016), as a critical actos for the reqlization of the SDGs (Choi & Majumdar, 2014; Cordova & Celone, 2019). Social entrepreneurship also benefits from "empathy" as a driving force (Bacq & Alt, 2018) which involves voluntarily and collective ways of organizing, as the collaboration of diversified individual and organizational members is required (Azam Roomi et al. 2021; Mitzinneck & Besharov, 2019), while ensuring the financial viability of business models with an economic understanding (Belz & Binder, 2017; Hwee Nga & Shamuganathan, 2010; Kraus et al. 2018; Seelos & Mair, 2005; York et al. 2016). Further, the concept of eco-entrepreneurship, which aims to posit bottom-up and economically sustainable solutions (Mars & Lounsbury, 2009) to ecological problems (Dixon & Clifford, 2007; Schaltegger & Wagner, 2011), seeks for the cooperation of public and private domains in most cases (Mars & Lounsbury, 2009), also promotes entrepreneurial-activism and giving value to "empathy" as the concept of social entrepreneurship (Moon, 2018), and se(Moon, 2018), and seeks for economic profit (Muñoz & Cohen, 2018). Also, considered as a key actor for a green economy (O'Neill & Gibbs, 2016), the concept of green entrepreneurship mainly promotes environmental (Demirel et al. 2019; Mrkajic et al. 2019; Muo & Azeez, 2020; O'Neill & Gibbs, 2016) and social innovations (Demirel et al. 2019; O'Neill & Gibbs, 2016), which supports environmentally and socially sustainable business practices (Demirel et al. 2019; O'Neill & Gibbs, 2016) and aims to transform the industries (Figge et al. 2002; O'Neill & Gibbs, 2016) towards a more sustainable business paradigm (O'Neill & Gibbs, 2016). Further, the concept of environmental entrepreneurship which also shares the ultimate characteristics of social entrepreneurship and its hybrid way of organizing (York et al. 2016) and reflects most characteristics of green entrepreneurship (Koe et al. 2014; Zeng, 2018), mainly aims to preserve the ecological environment (Kimuli et al. 2020; York et al. 2016) and seeks to bring solutions for diversified problems and related inter-relationships (Keogh & Polonsky, 1998) by promoting societal change, and even influencing regulations and market-conditions, also seeks for economic efficiency and profitability (Schaltegger & Wagner, 2011). Moreover, the concept of sustainable entrepreneurship or sustainopreneurship (Aghelie et al. 2016) also aims to shape the markets (Schaltegger & Wagner, 2011) by discovering, evaluating and exploiting (Tunçalp & Yıldırım, 2022) radical sustainable value propositions (Nosratabadi et al. 2019; Schaltegger & Wagner, 2011), which also benefits from replacement of traditional production processes, products, market mechanisms and consumption models, with environmentally and socially sustainable alternatives (Schaltegger & Wagner, 2011), also holds pivotal roles (Tunçalp & Yıldırım, 2022) in addressing both societal (Schaltegger & Wagner, 2011) and environmental problems (Tunçalp & Yıldırım, 2022).

As defined, sustainability-oriented concepts of entrepreneurship are in relation, while some concepts cover one another, and even some of these concepts are used interchangeably. For instance, the concept of green entrepreneurship is occasionally named as eco-entrepreneurship (Schaltegger, 2002), and frequently defined as a form of sustainable entrepreneurship (Koe et al. 2014; Kraus et al. 2018; Raudeliuniene et al. 2014; Schaltegger & Wagner, 2011), which results in the interchangeable use of these concepts (Dixon & Clifford, 2007; Koe et al. 2014; Schaltegger & Wagner, 2011; Shepherd & Patzelt, 2011). Further, the concept of environmental entrepreneurship is also widely used interchangeably with the concept of sustainable entrepreneurship (Cohen & Winn, 2007; Dean & McMullen, 2007; Dixon & Clifford, 2007; Hockerts & Wüstenhagen, 2010), which is also identified to be covered by the concept of sustainable entrepreneurship (Dean & McMullen, 2007; Kimuli et al. 2020; Kraus et al. 2018). Moreover, considering the shared common goals, the concept of social entrepreneurship also holds variety of similarities with sustainable entrepreneurship (Azam Roomi et al. 2021; Choi & Majumdar, 2014; Hockerts & Wüstenhagen, 2010; Kimuli et al. 2020; Kraus et al. 2018; Lüdeke-Freund, 2020; Muñoz & Cohen, 2018; Schaltegger & Wagner, 2011). On the other hand, concept of sustainable entrepreneurship or referred as sustainopreneurship (Aghelie et al. 2016; Nosratabadi et al. 2019a; Schaltegger & Wagner, 2011; Tunçalp & Yıldırım, 2022), is occasionally identified as a progression of eco-entrepreneurship (Lüdeke-Freund, 2020; Schaltegger & Wagner, 2011). Table 2.7 also represents the priorities, organizing models and consideration of economic factors by sustainability-oriented entrepreneurship models.

Table 2.7 : Sustainability-oriented entrepreneurship models.

Sustainability-oriented Entrepreneurship Models	Priorities	Organizing	Economic Consideration
Eco-Entrepreneurship	Ecological problems (Schaltegger & Wagner, 2011) through bottom-up solutions (Mars & Lounsbury, 2009), emerged as a clean venturing (Chang et al. 2019).	Promotes entrepreneurial-activism, and frequently seeks for cooperation of public and private domains (Mars & Lounsbury, 2009)	Economically sustainable solutions (Mars & Lounsbury, 2009)
Environmental Entrepreneurship	Adresses ecological environment (York et al. 2016).	Hybrid way of organizing, shares characteristics of social entrepreneurship (York et al. 2016).	Economic efficiency and profitability (Schaltegger & Wagner, 2011),

Table 2.7 (continued) : Sustainability-oriented entrepreneurship models.

Sustainability-oriented Entrepreneurship Models	Priorities	Organizing	Economic Consideration
Green Entrepreneurship	Ecological sustainability (OCED, 2011; Gast et al. 2017; De Angelis and Feola, 2020) in strategic business development (Demirel, 2019) by taking advantage of market failures of the existing business practices (Muo, I., and Adebayo-Azeez, A., 2019).	As economic organizations (Demirel, P., 2019).	Economic actors who turn ideas into commercially viable products (Farinelli, F., et. al., 2013; Ning et al. 2015).
Social Entrepreneurship	Combines environmental and societal priorities (Bacq & Alt, 2018; Miklian & Hoelscher, 2018; Mitzinneck & Besharov, 2019; Schaltegger & Wagner, 2011; York et al. 2016) at large (Schaltegger & Wagner, 2011) rather than solely economic expectations (Bacq & Alt, 2018)	Non-Profit (Schaltegger & Wagner, 2011),	Ensuring the sustainability of business practices with an economic understanding (York et al. 2016).
		Hybrid (Mitzinneck & Besharov, 2019; York et al. 2016),	Achievement of social causes a primary motivation; profits as secondary (Ali., M, 2021).
		Voluntarily & Collective (Mitzinneck & Besharov, 2019),	No economic expectations (Mitzinneck & Besharov, 2019).
Sustainable Entrepreneurship	Addresses both societal (Schaltegger and Wagner, 2011; Stubbs, W., 2017), and environmental problems (Tunçalp and Yıldırım, 2022; Stubbs, W., 2017), as well as economic (Majid, I. A., and Koe, W. L., 2012).	As conventional startups (Haldar, S., 2018)	Operates as a for-profit business (Stubbs, W., 2017; Haldar, S., 2018)

Considering the differences (Dean & McMullen, 2007; Koe et al. 2014; Lüdeke-Freund, 2020; Shahid, 2022) and similarities and the common purposes of the sustainability-oriented entrepreneurship concepts, it is obvious that each concept serves to sustainable development (Kimuli et al. 2020; Kraus et al. 2018; Schaltegger & Wagner, 2011). Also described as a broader concept (Dean & McMullen, 2007; Muñoz & Cohen, 2018), and as an umbrella term which covers all types of sustainability-oriented entrepreneurship models (Parrish, 2008; Schaltegger & Wagner, 2011; Tunçalp & Yıldırım, 2022), the concept of sustainable entrepreneurship is observed to refer both to eco-entrepreneurship, environmental entrepreneurship, green entrepreneurship and social entrepreneurship, (Koe et al. 2014; Kraus et al. 2018; Raudeliuniene et al. 2014; Schaltegger & Wagner, 2011; Tunçalp & Yıldırım, 2022), which characteristically prioritizes value creation both for environmental, social and economic sustainability (Cohen & Winn, 2007; Dean & McMullen, 2007; Muñoz & Cohen, 2018; Schaltegger & Wagner, 2011; Shahid, 2022). As a combination of these concepts, sustainable entrepreneurship (SE) is on the agenda of this thesis as an inclusive term which covers all sustainability-oriented forms of entrepreneurship which aim to provide value propositions directed to sustainable development and SDGs (Schaltegger & Wagner, 2011).

2.3.2 Sustainable entrepreneurship

As a multidimensional concept, as a purpose-driven mode of venturing (Muñoz & Cohen, 2018) and as hybrid type of organizing (Greco & De Jong, 2017; Xu et al. 2022), SE characteristically draws on both entrepreneurial-orientation and sustainability-orientation (Belz & Binder, 2017; Kraus et al. 2018; Lüdeke-Freund, 2020). In that respect, SE aims to balance social, environment, as well as economic gains (Greco & De Jong, 2017; Gu & Wang, 2022). On the other hand, the concept of SE is also identified as a key for regional economic growth (Gu & Wang, 2022), sustainable economic development (Greco & de Jong, 2017; Gu & Wang, 2022; Weidinger et al. 2014), and sustainable development (Entrepreneurship Monitor, 2022; Kimuli et al. 2020; Pacheco et al. 2010; York & Venkataraman, 2010) within a TBL approach (Belz & Binder, 2017; Gu & Wang, 2022; Muñoz & Dimov, 2015).

From a micro perspective, SE also requires the abilities of risk-taking, attitude towards innovation together with the interest in social, environmental and economical ethics (Greco & De Jong, 2017), and the focus on creating and distributing solutions for a wider range of stakeholders (Freudenreich et al. 2020; Lüdeke-Freund, 2020; Schaltegger & Wagner, 2011) by discovering, creating and exploiting entrepreneurial opportunities which contribute to social, environmental and economic sustainability (Azam Roomi et al. 2021; Hoogendoorn et al. 2019; Kimuli et al. 2020; Klewitz & Hansen, 2014; Kraus et al. 2018; Muñoz & Cohen, 2018; Nosratabadi et al. 2019; Schaefer et al. 2015; Schaltegger & Wagner, 2011; Xu et al. 2022), which also aims to transform the society towards a more sustainable equilibrium (Kraus et al. 2018).

Consequently, the focal point of SE is to balance the TBL (Cohen & Winn, 2007; Gregori et al. 2019; Lüdeke-Freund, 2020; Nosratabadi et al. 2019; Schaltegger et al. 2016; Schaltegger & Wagner, 2011), while also securing financial viability and profitablity (Choi & Gray, 2008; Gregori et al. 2019; Patzelt & Shepherd, 2011; Xu et al. 2022) throughout commercial activities (Greco & De Jong, 2017; Gregori et al. 2019; Schaltegger et al. 2016), by introducing innovative products and business processes (Shepherd & Patzelt, 2011) into nicher and mass markets (Klewitz & Hansen, 2014), which also holds the capability to radically transform industries (Dhahri & Omri, 2018; Driver, 2012). In this respect, the prescribed transformation may include sustainable value propositions (Boons & Lüdeke-Freund, 2013; Nosratabadi et al. 2019), sustainability-oriented production practices (Gu & Wang, 2022; Klewitz & Hansen, 2014; Schaltegger & Wagner, 2011), sustainability-oriented value chains (Andersen et al. 2021; Tohănean et al. 2020), better use of resources (Azam Roomi et al. 2021), and even differentiation of consumption patterns (Boons & Lüdeke-Freund, 2013; Klewitz & Hansen, 2014; Nosratabadi et al. 2019; Schaltegger & Wagner, 2011) or radical changes on market structures (Klewitz & Hansen, 2014) by eliminating market failures which result in unsustainable results (Alexis et al. 2017; Azam Roomi et al. 2021; Cohen et al. 2008; Cohen & Winn, 2007; Dean & McMullen, 2007).

Table 2.8 : Definitions for sustainable entrepreneurship.

Definition for Sustainable Entrepreneurship	Scholars
"Innovative behaviour of single actors or organizations operating in the private business sector who are seeing environmental or social issues as a core objective and competitive advantage."	Gerlach, A., 2003.
"The process of discovering, evaluating, and exploiting economic opportunities that are present in market failures which detract from sustainability, including those that are environmentally relevant."	Dean, T., and McMullen, J., 2007.

Table 2.8 (continued) : Definitions for sustainable entrepreneurship.

Definition for Sustainable Entrepreneurship	Scholars
"Examination of how opportunities to bring into existence future goods and services are discovered, created and exploited by whom and with what economic, psychological, social and environmental consequences."	Cohen, B., and Winn, B., 2007.
"SE is a process of venture creation that links the activities of entrepreneurs to the emergence of value-creating enterprises that contribute to the sustainable development of the social–ecological system."	O'Neill et al. 2009.
"SE is the discovery, creation, evaluation, and exploitation of opportunities to create future goods and services that is consistent with sustainable development goal."	Pacheco et al. 2010.
"SE is the discovery and exploitation of economic opportunities through the generation of market disequilibria that initiate the transformation of a sector towards an environmentally and socially more sustainable state."	Hockerts and Wüstenhagen, 2010.
"SE is the discovery, creation, and exploitation of opportunities to create future goods and services that sustain the natural and/or communal environment and provide development gain for others."	Patzelt and Shepherd, 2010.
"Realization of sustainability innovations which aimed at the mass market and providing benefit to the larger part of society."	Schaltegger, S., and Wagner, M., 2011.
"SE is focused on the preservation of nature, life support, and community in the pursuit of perceived opportunities to bring into existence future products, processes, and services for gain, where gain is broadly construed to include economic and non-economic gains to individuals, the economy, and society."	Shepherd and Patzelt 2011.
"SE strives to create value that is beneficial for society through opportunity creation, development and impact creation in an uncertain environment."	Greco, A., and Jong, G., 2017.
"The discovery and exploitation of economic opportunities through the generation of market disequilibria that initiate the transformation of a sector towards an environmentally and socially more sustainable state."	Hockerts, K., and Wüstenhagen, R., 2010.
"The discovery, creation, evaluation and exploitation of opportunities to create future goods and services thatis consistent with SDGs."	Pacheco, D., et. al., 2010.
"SE can be described as an innovative, market-oriented and personality driven form of creating economic and societal value by means of break-through environmentally or socially beneficial market or institutional innovations."	Schaltegger and Wagner, 2011.

Table 2.8 (continued) : Definitions for sustainable entrepreneurship.

Definition for Sustainable Entrepreneurship	Scholars
"SE is seen as a way of generating competitive advantage by identifying sustainability as new business opportunities, resulting in new and sustainable products, methods of production or ways of organizing business processes in a sustainable way."	Lans et. al., 2014.

The given definitions on the concept of SE which are chronologically sorted, aim to unfold the similar and dissimilar characteristics between diverse definitions, and which provides a comprehensive focus to the development of the concept of SE. Considering given definitions, SE can be identified as a form of private business (Gerlach, 2003), which explores and exploits (Cohen & Winn, 2007; Dean & McMullen, 2007; Hockerts & Wüstenhagen, 2010; Pacheco et al. 2010), and attains competitive advantage (Gerlach, 2003; Greco & De Jong, 2017; Lans et al. 2014; Majid & Koe, 2012; Nosratabadi et al. 2019; Porter & Kramer, 2011; Weidinger et al. 2014) in realization of the sustainability results (Azam Roomi et al. 2021; Cohen et al. 2008; Cohen & Winn, 2007; Gregori et al. 2019).

2.3.3 Digital sustainable entrepreneurship

Further, the employment of DTs is defined to reinforce the green transitions by the TT agenda of the EU (EC JRC, 2022), and holds a transformative role (EC, 2022; Nishant et al. 2020) in the development of practices and value propositions (Andersen et al. 2021; Bednarčíková & Repiská, 2021; Gregori & Holzmann, 2020; Xu et al. 2022) for the achievement of environmental, social, and economic objectives (Bednarčíková & Repiská, 2021; Xu et al. 2022), and the SDGs (Berawi, 2019). At the center of digital technological innovations (Sahut et al. 2021) DTs, as artefacts (Gregori & Holzmann, 2020; Pinch & Bijker, 1984) also offer and transform the entrepreneurial opportunities (Nambisan, 2017), and enable sustainable value propositions to be scaled up across communities and national (Andersen et al. 2021; Gregori & Holzmann, 2020). Table 2.9 represents the main research on DTs and sustainability.

Table 2.9 : Research on DSE.

Context of DSE Research	Scholars
Impact of DTs on Sustainability	Ginters E., & Dimitrovs, E., 2021; Schneider, S., 2019.

Table 2.9 (continued) : Research on DSE.

Context of DSE Research	Scholars
Impact of DTs on SDGs	Hoosain, M., Paul, B., & Ramakrishna, S., 2020.
Digital Sustainability and SDGs	Sparviero, S., & Ragnedda, M., 2021.
DTs for Business Sustainability	Bednarčíková, D., & Repiská, R., 2021.
Digital Sustainability and Entrepreneurship on SD	George, G., Merrill, R., & Schillebeeckx, S., 2019.
Digitalization and Sustainability	Andersen, A., et. al., 2021.
Business Model Innovation through DTs for Sustainability	Tohănean, D., et. al., 2020.
DTs, SMEs and Sustainability	Vrontis, D., Chaudhuri, R., & Chatterjee, S., 2022.
Economic Aspect of Digital Sustainability	Cricelli, L., & Strazzullo, S., 2021.
Sustainability and Digital Transition: A Literature Review	Rosário, A., & dias, J., 2022.
Digital Transformation and Environmental Sustainability	Feroz, A., Zo, H., & Chiravuri, A., 2021.

As an enabler of digital technological innovations (Sahut et al. 2021), digital entrepreneurship (DE) combines the entrepreneurial action with digital artefacts (Mohamad et al. 2025; Nambisan, 2017; Sussan & Acs, 2017a), which also demonstrates the capability to disrupt and transform the existing businesses (EC, 2015; Kraus et al. 2019; Sussan & Acs, 2017a; Zhao, 2016) and drives social and economic value by creating or employing DTs (Al-Abbadi et al. 2024; EC, 2015; Elhassan, 2025), which also influences the formation of novel regulations (Sussan & Acs, 2017a).

On the other hand, DSE as a social formation which composes entrepreneurial action, DTs and sustainability logic together (Gregori & Holzmann, 2020; Lüdeke-Freund, 2020; Xu et al. 2022), contributes to sustainability (Bednarčíková & Repiská, 2021; Berawi, 2019; Xu et al. 2022) and realization of the SDGs (Berawi, 2019; Gregori & Holzmann, 2020) by enabling variety of radical and incremental solutions to (Xu et al. 2022) poverty (Xu et al. 2022), mitigation (Xu et al. 2022), social inequality (Xu et al. 2022), CO2 emissions and fuel consumption (Andersen et al. 2021; Bednarčíková & Repiská, 2021), greenhouse gas emissions (Andersen et al. 2021; Bednarčíková & Repiská, 2021), pollution (Bednarčíková & Repiská, 2021;

Berawi, 2019), energy (Andersen et al. 2021; Bednarčíková & Repiská, 2021; Berawi, 2019), transportation (Bednarčíková & Repiská, 2021), food production (Andersen et al. 2021), healthcare (Andersen et al. 2021), agriculture (Bednarčíková & Repiská, 2021), water (Bednarčíková & Repiská, 2021), housing (Andersen et al. 2021), banking (Andersen et al. 2021; Xu et al. 2022), maintenance of labor markets (Andersen et al. 2021), peer-to-peer services (Andersen et al. 2021), support to local people (Gregori & Holzmann, 2020), promote voluntary work (Andersen et al. 2021), differentiation of consumption behaviors and social practices (Andersen et al. 2021), better allocation of resources (Bednarčíková & Repiská, 2021), and other sustainability required practices. As an intersection of sustainability, entrepreneurship and digital technological innovation concepts (Figure 2.1), which also offers higher rates of expandability (Xu et al. 2022), the concept of DSE is politically supported by the TT agenda (EC, 2022).

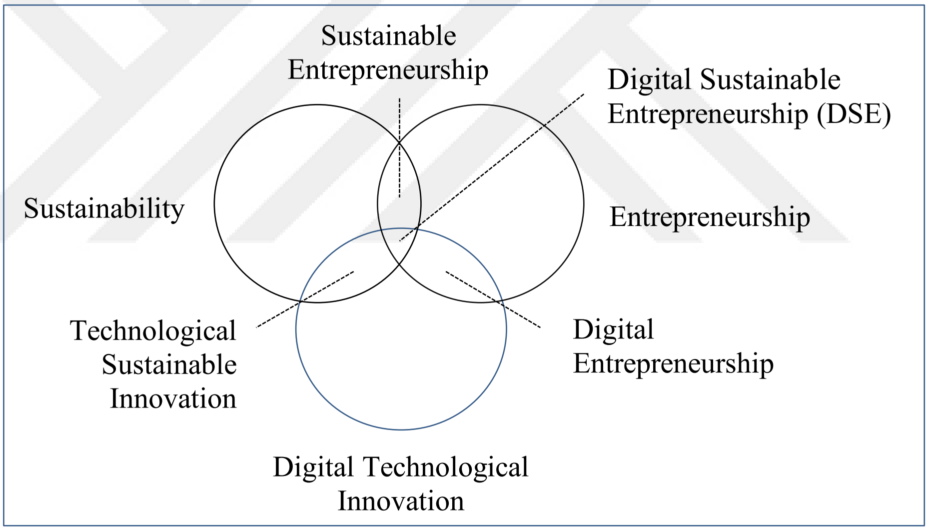

Figure 2.1 : Concept of digital sustainable entrepreneurship.

The literature also holds valuable researches on the concept of DSE. In this respect, it is observed that DSE concept is frequently associated with the concepts of radical and incremental innovation (Andersen et al. 2021; Bednarčíková & Repiská, 2021; Xu et al. 2022), organizational performance (Andersen et al. 2021; Berawi, 2019), competitive advantage (Gregori & Holzmann, 2020; Lüdeke-Freund, 2020; Tohănean et al. 2020; Xu et al. 2022), efficiency (Bednarčíková & Repiská, 2021), process effectiveness (Berawi, 2019), new skills (Andersen et al. 2021), (7) integration (Andersen et al. 2021; Gregori & Holzmann, 2020; Tohănean et al. 2020), cooperation (Xu et al. 2022), coordination (Xu et al. 2022), (10) accessibility

(Gregori & Holzmann, 2020), transparency (Nishant et al. 2020), perceptibility (Andersen et al. 2021), cost reduction (Andersen et al. 2021; Gregori & Holzmann, 2020; Xu et al. 2022), communication (Bednarčíková & Repiská, 2021), traceability (George et al. 2019), connectivity (Bednarčíková & Repiská, 2021; Xu et al. 2022), analyticity (Xu et al. 2022), evaluation (Xu et al. 2022), monitoring (Nishant et al. 2020), risk modelling (Ginters & Dimitrovs, 2021; Tohănean et al. 2020), intelligence (Xu et al. 2022), prediction (Xu et al. 2022), simplification of operational flows (Andersen et al. 2021), co-creation of value with users (Gregori & Holzmann, 2020; Xu et al. 2022) and with successive replication capabilities (Schneider, 2019).

2.3.4 Economic performance indicators of DSSs

The literature is also analysed to identify the organizational-level economic performance indicators within the field of DSE research. On the other hand, it is observed that the current literature is yet to conduct an empirical analysis on performance measurement of DSSs. Further, no standardization for individual-level performance measurement is yet to be formed (Gu & Wang, 2022). Consequently, a systematic approach is deployed on the Scopus database within the literature on SS to identify the potential organizational-level economic performance indicators. Consequently, an inclusive search query is operationalized on the Scopus database as shown in Figure 2.2.

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( TITLE-ABS-KEY ( "sustainable entrepreneurship" ) OR TITLE-ABS-KEY ( "sustainable startup" ) OR TITLE-ABS-KEY ( "sustainable start-up" ) OR TITLE-ABS-KEY ( "eco-entrepreneurship" ) OR TITLE-ABS-KEY ( "eco entrepreneurship" ) OR TITLE-ABS-KEY ( "ecopreneurship" ) OR TITLE-ABS-KEY ( "eco-startup" ) OR TITLE-ABS-KEY ( "eco-start-up" ) OR TITLE-ABS-KEY ( "green entrepreneurship" ) OR TITLE-ABS-KEY ( "green startup" ) OR TITLE-ABS-KEY ( "green start-up" ) OR TITLE-ABS-KEY ( "environmental entrepreneurship" ) OR TITLE-ABS-KEY ( "environmental startup" ) OR TITLE-ABS-KEY ( "environmental start-up" ) OR TITLE-ABS-KEY ( "social entrepreneurship" ) OR TITLE-ABS-KEY ( "social startup" ) OR TITLE-ABS-KEY ( "social start-up" ) OR TITLE-ABS-KEY ( "socio-environmental entrepreneurship" ) OR TITLE-ABS-KEY ( " socio-environmental startup" ) OR TITLE-ABS-KEY ( " socio-environmental start-up" ) AND TITLE-ABS-KEY ( "economic" ) AND TITLE-ABS-KEY ( "performance" ) OR TITLE-ABS-KEY ( "sucess" ) OR TITLE-ABS-KEY ( "growth" ) OR TITLE-ABS-KEY ( "productivity" ) OR TITLE-ABS-KEY ( "efficiency" ) OR TITLE-ABS-KEY ( "effectiveness " ) )
```

Figure 2.2 : Scopus database search query.

Consequently, economic performance indicators are identified within the SE research at an organizational-level of analysis. Employing an economic lens, Schaltegger and Wagner (2011) identifies market impact as a valuable output for SE, which is also defined to be measured by market share, sales growth, and by reactions of competitors as represented in Table 2.10.

Table 2.10 : Economic performance indicators for sustainable entrepreneurship.

Economic Indicator	Scholars
Market Share	Schaltegger and Wagner (2011); Hörisch (2015)
Sales Growth	Schaltegger and Wagner (2011)
Competitor Reactions	Schaltegger and Wagner (2011)

On the other hand, the study of Cohen et., al. (2008), which focuses on "sustainable conceptualization of dependent variables in entrepreneurship research," argues about the requirement for a multi-faceted determination of dependent variables, which is three-pronged and covers measurement of the entire social, environmental and economic value creation by enabling a taxonomy that assesses each value as (1) process, (2) outputs, and (3) outcome as dimensions (Cohen et al. 2008), as represented in Table 2.11.

Table 2.11 : Dependent variables within process, output, outcomes dimensions.

Perspective	Processes - Dependent Variables
Economic	Productivity of Employees, Efficiency on Operations, Risk Management
Social	Reporting, Marketing Communication, Public Relations
Environmental	Life Cycle Assessment (LCA), Design for Environment (DFE), Environmental Auditing
Socio-Economic	Relationship, Service Quality, Quality, Trust, Cooperation, Market Orientation, Strategic Planning, Governance
Socio-Environmental	Environmental Planning, Reporting, Environmental Public Relations
Enviro-Economic	Materials Use, Energy Management, Environmental Risk Management, Green Procurement
TBL	First order Strategic Planning, Ethical Decision Making
Perspective	**Outputs (Activities) - Dependent Variables**
Economic	Dividents & Cash Flows, Royalties & Supply Contracts, Production Level & Intellectual Property (IP) Applications
Social	Stakeholder involvement, Stakeholder interactions, Legislation, law suits, philanthropy

Table 2.11 (continued) : Dependent variables within process, output, outcomes dimensions.

Perspective	Outputs (Activities) - Dependent Variables
Environmental	Environmental Management, ISO 14001, Waste Management, Restoration
Socio-Economic	Market Entry/Exit, Market Penetration, Number of Alliances/Relationships, Customer Retention, Product Mix, Harvest/Exit Readiness
Socio-Environmental	Consumer Education, Reducing Waste, Recycling, Re-use Environmental, Charity Contributions
Enviro-Economic	Cleaner Production, Green Packaging, Production Resource Efficiency, Green-product Development
TBL	Sustainable Innovation, Sustainable Development, Creation of New Sustainable Industries

Perspective	Outcomes (Impacts) - Dependent Variables
Economic	Valuation, Stock Price, Profit, Return, Competitive Advantage, Survival, Knowledge & Assets Controlled
Social	Image/Reputation, Brand Equity, Social-legitimacy
Environmental	Pollution, Emissions
Socio-Economic	Sales, Market Share, Customers, Employees, Employee Development, Satisfaction, Loyalty, Commitment, Venture creation Decision
Socio-Environmental	Env. Reinvestment, Improvements, Environmental Protection, Meaningful Employment, Quality of Work Life, Recognition
Enviro-Economic	Selection by Socially Responsible Investment (SRI) Funds, Reduced Costs, Stability/Longevity
TBL	First Order Competitive Advantage, Market Effectiveness, Employee Satisfaction/Commitment, Increased Quality of Life, Customer Loyalty, Species Survival

In this respect, the dependent variables within the process dimension reflect the internal, external and relational mechanisms and methods for the organizations, but the process dimension dependent variables do not directly measure the final result of the created value. Moreover, the dependent variables within the output (activities) dimension refer to the direct and measurable results of entrepreneurial activities, in which operationalizable data is unavailable, even if data on economic perspective is frequently available for publicly listed companies. On the other hand, dependent variables within the outcome (impact) dimension refer to the final effects of entrepreneurial activities which also offers tangible and measurable final evidence of the economic, social, and environmental value created.

2.3.4.1 Funding of sustainable startups

On the other hand, securing required capital for an entrepreneurial venture is a critical (Delmar & Shane, 2003) and challenging process (Belz & Binder, 2017; Dixon & Clifford, 2007; Zeng, 2018). SSs, which focus on launching businesses within the environmental and social objectives (Dixon & Clifford, 2007; Koe et al. 2014; Majid & Koe, 2012; Raudeliuniene et al. 2014; Zeng, 2018), and which deal with more radical forms of innovation (Hockerts & Wüstenhagen, 2010; Klewitz & Hansen, 2014), also seeks for financial viability (Dixon & Clifford, 2007; Gregori et al. 2019; Lazzarotti et al. 2011; Majid & Koe, 2012; Xu et al. 2022). Even if SSs might afford financial losses by the starting-up period (Zeng, 2018) economic gains are required in further periods at least equally weighted as the social and the environmental dimensions (Majid & Koe, 2012). However, SIs which frequently address nicher markets, also aim to grow and scale (Lazzarotti et al. 2011) and even marketed into mass markets in order to shift into effective SI's (Lüdeke-Freund, 2020), which require capital and funding (Delmar & Shane, 2003; Teece, 2007). At that point, SSs which can utilize personal resources, family and friends, also require external capital and funding (Lazzarotti et al. 2011), as the economic forms of innovative organizations (Davila et al. 2015). In that respect, SSs can raise external funding from crowd-funding, public funding, bank loans (Belz & Binder, 2017; Dixon & Clifford, 2007), sustainable and responsible investments (SRI) (Cromarty, 2022), and from venture capitals (Gompers & Lerner, 2001), rather than allocating own earnings (Lazzarotti et al. 2011; Schumpeter J, 1934) or own capital (Cromarty, 2022; Gu & Wang, 2022; Teece, 2007).

On the other hand, capital firms seek to invest in innovative firms (Davila et al. 2000; Miloud et al. 2012; Montani et al. 2020) which provide higher growth potential (Block et al. 2014; Davila et al. 2015; Hanamura et al. 2011; Köhn, 2018; Mann & Sager, 2007; Miloud et al. 2012; Montani et al. 2020), and higher operating margins (Cromarty, 2022; Jardim-Gonçalves et al. 2017; Mann & Sager, 2007; Miloud et al. 2012; Montani et al. 2020). However, the concepts of profitability and sustainability have been perceived to be antithesis for a long time (Cohen & Winn, 2007; Parrish, 2010; UNEP, 2021) as cited by Cromarty (2022). Yet, the current perception on sustainable-oriented businesses has shifted to support profitability (Greco & De Jong, 2017; Weidinger et al. 2014) and even capture greater profits as compared to traditional entrepreneurship models (Zeng, 2018). Even resulting in some degree of lower stock returns in stock markets (Gasser et al. 2017; Kraus et al. 2018), sustainable-oriented ventures are also perceived to be less-riskier (Gasser et al. 2017; Kraus et al. 2018) and more likely to succeed with the eye of investors (Greco & De Jong, 2017; Guenster et al. 2011; Weidinger et al. 2014). Moreover, SSs also deliver higher valuations rather than the conventional entrepreneurship models (Mansouri & Momtaz, 2022) as a result of (1) financial and non-financial gains for the investors and (2) economic benefits of sustainability-oriented attributes (Mansouri & Momtaz, 2022). Also defined by Mansouri and Momtaz (2022), improving sustainability orientation with one standard deviation results in 28% increase in funding amounts of SSs (Mansouri & Momtaz, 2022).

As a result, sustainability-oriented startups which adopt to novel technologies (Berawi, 2019; Teece, 2007) and digital technologies, also require external funding. On the other hand, priotity of the technology investors are defined to be as economic, while environmental and social aspects come after (Ginters & Dimitrovs, 2021). In that respect, the capital, which is accepted as a catalyst for addressing the TBL (Cromarty, 2022) could also flow through the sustainability-oriented startups, which take the advantage of commercialization of technological innovations for sustainability, and which are even defined to refer to increased productivity and economic growth (Soubbotina et al. 2004).

2.3.4.2 Bibliometric analysis on DSE research

The bibliometric analysis is conducted (Demirel & Yıldırım, 2025) within the field of DSE research, to uncover the patterns of academic knowledge creation and dissemination (Donthu et al. 2021; Ellegaard & Wallin, 2015). Further, the conceptual content analysis is executed on full-text DSE publications by borrowing the SDG-specific search queries of (Jayabalasingham et al. 2019), to identify the SDG-orientation within the field of DSE research in parallel to the bibliometric statistics. In this respect, the bibliometric analysis has four main steps which include (1) PRISMA Protocol, (2) bibliometric analysis, (3) conceptual content analysis on SDG-orientation of DSE research within bibliometric statistics, and (4) thematic analysis on environmental, social, and economic (ESE) pillars-orientation of DSE research (Kostoska & Kocarev, 2019).

To identify the DSE research publications, the Scopus database search is conducted within the same date[5] of Crunchbase data extraction which is operationalized within the empirical analysis on European DSSs, as presented in further sections. Consequently, 39 DSE publications are selected from 229 retrieved publications on the Scopus database, by employing Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). The findings of this bibliometric research are also discussed within the related sections of this thesis research (Demirel & Yıldırım, 2025).

[5] Data Retrieval Date: 3rd of November 2023.

3. RESEARCH MODEL AND HYPOTHESES

This research represents a comphrehensive model which aims to explain the direct and indirect influences of the strategic orientation towards SDGs (SDG) on total funding amount (TFA) of the European digital sustainable startups (DSS), which also integrates the mediating effects of digital technology preferences (DT) and adopted innovation tpes (IT), and the moderating effect of NUTS2-level regional GDP (GDP), which is proposed to represent the entrepreneurial ecosystems effect. In this respect, organizational orientation towards SDGs is proposed as a strategic direction of the entire business and the value proposition, while TFA represents the measurable economic outcome (Cohen et al. 2008) of the entrepreneurial orientation towards SDGs.

Central to the context of DSS research, DT and IT are proposed to mediate the relationship between SDG-orientation and TFA. In this respect, the framework assesses DTs not only as assets or tools, but also as sources and capabilities. On the other hand, adaptation of specific ITs is also evaluated as a strategic decision which results in economic outputs. Moreover, the research framework also points to GDP, which is proposed to moderate the relationship between SDG and TFA of European DSSs.

3.1 Conceptual Model and Hypotheses

Aiming to analyze the influence of the organizational-level orientation towards SDGs on TFA of European DSSs, this research provides an integrated analytical framework. In this respect, the research proposes a conceptual framework which aims to explain the direct and indirect influences of strategic orientation towards SDGs on TFA. Further, this relationship is also proposed to be both mediated by DT preferences and IT adoption, and moderated by GDP at an individual-level of analysis. The conceptual model, which is represented in Figure 3.1, is also followed by the hypothesis of this research.

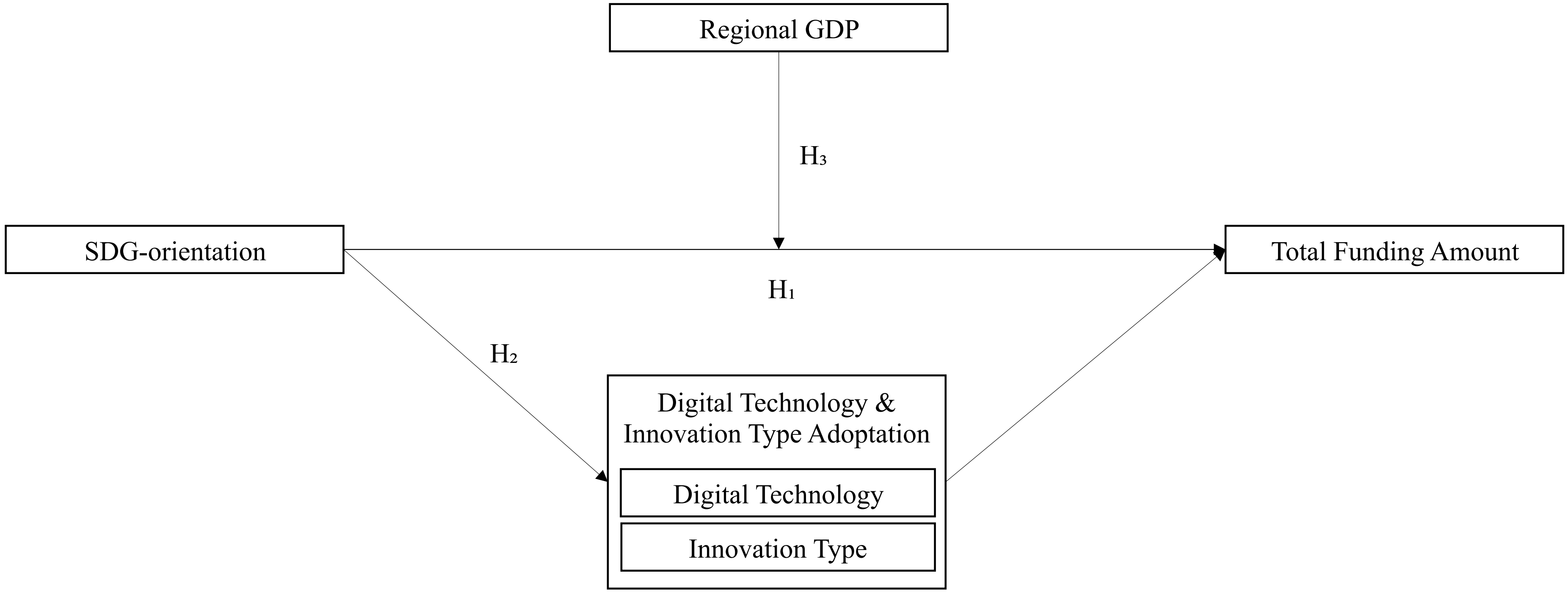

Figure 3.1 : Conceptual model.

3.1.1 Direct and indirect effects of SDG-orientation on TFA

Rather than corporate social responsibility (Sahdev et al. 2025), sustainability reporting (Beretta et al. 2025) or greenwashing (de Freitas Netto et al. 2020), directing the organizational strategies and the value propositions through specific SDGs, require strategic orientation (Gregori & Holzmann, 2020). Reflecting a strategic and fundamental match of the organizational goals with the SDGs (Sahdev et al. 2025), this alignment is proposed to shape the the overall business structure, and influence the organizational inputs, outputs, and influence the economic performance of DSSs in the European context (Bellostas et al. 2023; Mann et al. 2024; Sahdev et al. 2025).

In this respect, current research which illumunates the relationship between SDG-orientation and economic performance of DSSs is scarce. On the other hand, considering a sustainable startup (SS) context, the research of E. C. Mann et al. (2024) operationalizes SDG-orientation as an independent variable and analyzes its influence on organizational productivity (Mann et al. 2024). Further, considering an organizational context, the literature also includes multiple researches which aim to illumunate the relationship between the economic performance of organizations and SDGs (Bellostas et al. 2023), environmental and social SDGs (Khan et al. 2022), environmental performance (Ducassy, 2013; King & Lenox, 2002), environment score (Jyoti & Khanna, 2021). Moreover, considering an established organizations context, the research of Lassala et al. (2021) operationzalizes SDG-orientation as the independent variable and analyses its influence on return on equity (ROE) to reflect economic performance of companies.

Therefore, based on the theoretical and empirical evidence, the following hypothesis is proposed:

> *H_1: Strategic orientation towards SDGs influences the TFA of European DSSs.*

3.1.2 Mediating effects of DT and IT adoption

As digital forms of artefacts (Pinch & Bijker, 1984), and defined as sources of competitive advantage (Böttcher et al. 2024; Chesbrough, 2010; Teece, 2010), scholarly research is rare which analyses DTs as determinant to economic performance of DSSs at an individual-level of analysis. In this respect, the research of Min (2025) which focuses on DTs, points to a significant positive relation between diversification of DTs and economic performance of marine biological startups (Min, 2025). Further the research of Böttcher et al. (2024) also points to a positive relationship between adoption of DTs and economic performance of DSSs at an individual-level of analysis, while Khanzada et al. (2023) also points to a positive relation between DTs and economic performance of SSs. Further, employing a digital startup (DS) context, technologies and DTs are defined to have a positive and significant influence on economic performance of DSs in a Kenya context (Ndei & Ngugi, 2022). Moreover, Shah et al. (2024) points to a positive and significant influence of digital capability, digital orientation and digital transformation on economic performance of DSs. Also considering an entrepreneurial lens, the researches of Bai et al. (2024), and Pham et al. (2025) also point to a positive relation between DT adaptation and economic performance of startups. Further, the research of Teng et al. (2022) also identifies DTs as a key to economic performance within a Chininese startups context. Moreover, considering an organizational lens, economic performance is also identified to positively correlate with DT adoption (Akram et al. 2018; Kahrović & Avdović, 2023; Zhang et al. 2019).

On the other hand, innovation taxonomies of Oslo Manual (OECD, 2005, 2018) have been borrowed by multiple researches to illuminate the relationship between adopted innovation types (IT) and economic performance of organizations. Adopting to an earlier version of the innovation taxonomy (OECD, 2005), the research of Gunday et al. (2011), and the study of Karabulut (2015) both point to an influence of ITs and economic performance of Turkish manufacturing firms. Operationalizing the same taxonomy, the research of Mabenge et al. (2020) also points to the relationship between ITs and economic performance of SMEs in a Zimbabwe context (Mabenge et al. 2020). Further, it is also observed that Gallego et. al., (Martínez-Alcocer et al. 2013) analyses the organizational innovation throughout the lens of Oslo Manual's innovation taxonomy (OECD, 2005) in a European SME context. The research of Edwards-Schachter (2018) also borrows this same taxonomy to identify the nature and the variety of organizational innovation capabilities. Moreover, the research of Arundel et al. (2019), as the only study which operationalizes a novel innovation taxonomy of Oslo Manual (OECD, 2018), points to the alignnment of innovation measurement with policy goals in a public sector context.

In this respect, innovation taxonomies of Oslo Manual (OECD, 2005, 2018) are treated to include real, and measurable variables from a pragmatic or objectivist perspective within mentioned researches. On the other hand, it is also noted that none of the related researches reflect the employment of innovation taxonomies within a sustainability context. This research, borrows the innovation taxonomy within the last issue of Oslo Manual (OECD, 2018), which is also presented after the declaration of the SDGs (UN, 2015).

Based on the theoretical and empirical evidence, the following hypothesis is proposed:

H_2: The influence of strategic orientation towards SDGs on TFA of European DSSs, is mediated by digital technology preferences and innovation type adoption.

3.1.3 Moreating effect of regional GDP

As mentioned, this research aims to analyze the influence of the entrepreneurial ecosystems within the relationship between SDG-orientation and the economic performance of the European DSSs. In this respect, the entrepreneurial ecosystems (Filho et al. 2024; OECD, 2025; Talmar et al. 2020), and the digital entrepreneurial ecosystems (Sussan & Acs, 2017b; Zheng et al. 2024) is prposed to provide access to required resources, markets (Smith & Stevens, 2010), culture (Stam & Spigel, 2016), mentorship, knowledge (Stuart & Sorenson, 2005), social networks, human capital (Stuart & Sorenson, 2005), investors (Smith & Stevens, 2010; Stuart & Sorenson, 2005), critical actors, institutions and to regulatory environment (Smith & Stevens, 2010), and access to different entrepreneurial ecosystems (Stam & Spigel, 2016). This research aims to propose the entrepreneurial ecosystems as an influencing factor on the economic performance of European DSSs, yet there is no aggragated data to be operationalized, and in our definition the influence of the entrepreneurial ecosystems can only be included within a sponsor or a technology development association (such as KOSGEB), which may also additionally narrow the context of this research. Aiming to operationalize the entrepreneurial ecosystems effect, our analysis also operationalizes NUTS2-level regional GDP data as the moderating variable to reflect the ecosystems effect as Bruns et al. (2017) who operationalizes the regional GDP data as a moderating variable.

H_3: The influence of strategic orientation towards SDGs on TFA of European DSSs, is moderated by regional gross domestic product (GDP) at NUTS2 level.

Consequently, the proposed hypothesis that the study aims to analyse, are as listed in Table 3.1.

Table 3.1 : List of proposed hypothesis.

	Hypothesis
H_1	Strategic orientation towards SDGs influences the TFA of European DSSs.
H_2	The influence of strategic orientation towards SDGs on TFA of European DSSs, is mediated by digital technology preferences and innovation type adoption.
H_3	The influence of strategic orientation towards SDGs on TFA of European DSSs, is moderated by regional gross domestic product (GDP) at NUTS2 level.

4. RESEARCH DESIGN AND METHODOLOGY

4.1 Research Design

Adopting to a cross-sectional research design, this study aims to analyze the influence of SDG-orientation on TFA of the European DSSs. The research also aims to identify the mediating effects of DT preferences and adopted ITs, and the moderating effect of GDP on TFA. The research design is explanatory in its nature, and seeks to identify not only direct relationships between variables but also the mediating and the moderating effects. In this respect, the research represents a theoretically comprehensive and empirically rigorous framework in indetification of the influence of multiple factors.

4.2 Sampling and Data Collection

This study, which is at an organizational-level of analysis, and treats each European DSS as a single unit, adopts to a single-level sampling approach. The sampling frame of the research specifically focuses on the Crunchbase-listed[6] European startups which strategically direct value propositions towards sustainability and employ DTs in creation and/or delivery of sustainable value porpositions, rather than sustainability reporting (Beretta et al. 2025), corporate social responsibility (Sahdev et al., 2025) or greenwashing (de Freitas Netto et al., 2020). In this respect, the research also conducts the multi-source data collection strategy to obtain required data.

4.2.1 Identification of dependent variable

Identification of the individual-level economic performance (EP) indicator, which is proposed to be operationalized as the dependent variable, is also expected to enable the sample of this research. In this respect, multiple local and global start-up databases have been visited and analysed in order to identify the accurate data source

[6] [6] http://crunchbase.com/

in enabling individual-level economic performance indicator, which reflects the charasterstics of the “outcomes” definition of Cohen et., al., (2008) as mentioned in prior discussions in Table 2.11.

First, the local data resources are visited. In this respect, Girişimci Bilgi Sistemi, Entrepreneur Information System (G.B.S.), as the local entrepreneurial data center of Republic of Turkey Ministry of Industry has been observed and analysed, but the databases provide economic data only on regional-level or industrial-level. Further, KOSGEB database, as the entrepreneurial ecosystem of the Ministry of Industry which represents data from 3.3 million local startups is visited but no individual-level data was identified. Followingly, incubation centers are identified to be incapabile of data sharing as a result of GDPR. Lastly, employment of survey has also been discussed for local startups, but return rate and potential sample size was expected to be low.

On the other hand, available global data sources were visited. In this respect, aVC, Crunchbase, Dow Jones VentureSource, Global Entrepreneurship Monitor (GEM), TechCrunch, VentureOne, and Venture Xpert databases are visited and analysed in terms of individual-level economic performance indicator data availiability, filtering capabilities, and potential sample sizes within the European DSSs context.

Table 4.1 : Global data sources and availability of required data.

	Crunchbase	Dow Jones VentureSource	Start-Us	Venture Source
Organizational-level Economic Performance Data Availability	+	-	-	-
Advanced Filtering	+	-	+	+
Start-up Data only	+	-	+	+

In this respect, Crunchbase database, which is also recommended by the OECD (Dalle, 2017), is observed to provide advanced filtering capabilities in identification of the European DSSs. Further, the Crunchbase is also observed to be the only database which provides individual-level economic performance data as outcomes of Cohen et al. (2008) as represented in Table 4.1. Further, Crunchbase database is also obsertved to be employed by multiple researches within the area of organizational research. For instance, the research of Färber and Klein, (2021) borrows TFA data of European startups from Crunchbase to analyse the influence of the female foundership on TFA within an EU context. Further, the research of Brahmana et al. (2024) also operationalizes TFA data to identify the influence of startup founders' characteristics. Nigam et al. (2020) also borrows rounds of financing data as the dependent variable within a DS context. In this respect, this thesis also considers Crunchbase startup database as the most accurate data source, which provides organizational-level TFA, money raised and pre-money valuation data which associate with the outcomes (impacts) dimension definition of Cohen et al. (2008). As will be explained in the further section, the Crunchbase database search provides 101 DSSs with TFA data, which also represents the sample of this research. Considering the quality of the conducted analysis on databases and on the availability of operationalizable economic performance indicator data, we also consider retrieved sample as the population of the area of research.

4.2.2 Data sources

Multiple data sources are employed within this research. The organizational-level TFA data, as the dependent variable of this research is retrieved from Crunchbase database. Further, the independent variable and mediator variables of this research are enabled by analyzing the organizaitonal-level textual data which includes (1) mission and/or vision statements, “about us” sections, product and service pages, and other relevant pages as Tunçalp and Yıldırım (2022), and (2) organizational profile pages on the Crunchbase website which includes (a) organizational description, (b) organizational industries, (c) products and (d) organizational specialties, which will be hereinafter referred to as “organizational text,” also includes the last Wayback Machine[7] web copy of the inaccessible web sites. Moreover, the company profile pages on the Crunchbase website are also revisited to enable the moderator variables (Table 4.2).

Table 4.2 : Data sources to be employed within the emprical research.

Variable Type	Variable	Data Source
Dependent	Total Funding Amount	Crunchbase Database

[7] https://web.archive.org/

Table 4.2 (continued) : Data sources.

Variable Type	Variable	Data Source
Independent	SDG-orientation	Organizational Texts
Mediator	Digital Technologies	Organizational Texts
Mediator	Innovation Types	Organizational Texts
Moderator	NUTS2 Level GDP	Crunchbase Database & EU Databases

On the other hand, as a result of unavailability of aggragated data within the ecosystems effect, alternative variables are examined. In this respect, different ranking systems are visited, such has the rankings of the Global Entrepreneurship Monitor of the Global Entrepreneurship Research Association (GERA, 2025), the Global Entrepreneurship Index of the Global Entrepreneurship and Development Institute, the European Index of Digital Entrepreneurship Systems of the European Commission, (EC, 2020b), the Human Development Index of the United Nations Development Programme, (UNDP, 2025), the Global Innovation Index of the World Intellectual Property Organization (WIPO, 2025), has been proposed and discussed. On the other hand, in parallel to the TT agenda of the EU (EC, 2022), and availability of the European Commission's nomenclature of territorial units for statistics (NUTS) data (Vieira et al. 2011), which is expected to reflect the proximity for entrepreneurial ecosystems as a landscape, and which provides the capability for a spatial data enrichment, is also operationalized, which also reflects the context of TT Agenda that mainly influenced this research to conduct the research across Europe. As the only multinational statistical data which standardizes more than 30 countries, NUTS also enables a significant research capability within three different levels of cross-national analysis. In this respect, EU and United Kingdom databases are employed within this research to operationalize NUTS2-level (Vieira et al. 2011) regional GDP data within the EU[8] and the United Kingdom[9] regions as Gavrilă-Paven et al. (2025).

4.3 Data Preperation

The proposed research framework requires multiple data preparation processes. Consequently, diverse data collection methods and processes are operationalized as

[8] https://ec.europa.eu/eurostat/databrowser/view/tgs00003/default/table?lang=en
[9]https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductallnutslevelregions

represented in Table 4.3. Moreover, prior to the structural analysis, data transformation procedures are also applied for multiple variables.

Table 4.3 : Data collection methods.

Variable Type	Variable	Data Collection Method
Dependent	Total Funding Amount	Systematic Database Search/Extraction
Independent	SDG-orientation	Conceptual Content Analysis (Deductive)
Mediator	Digital Technologies	Conceptual Content Analysis (Inductive)
Mediator	Innovation Types	Content Analysis (Deductive)
Moderator	NUTS-2 Level GDP	Secondary Data Collection

4.3.1 Total funding amount

First, a systematic database search is conducted to acquire the TFA data from the Crunchbase database. In this respect, the search query is prepared within the keywords that relate to (1) sustainability (sustain, green, social, environment, goal, sdg and transition), and (2) digital technologies (3d printing, additive manufacturing, automation, artifical intelligence, blockchain, cloud, cyber, data, digital, internet of things, machine learning, reality, robotic, software, web 3.0, and related abbreviations which include ai, a.i., ar, a.r., iot, i.o.t., ml and m.l., vr, v.r.). The operationalized search query is not provided by Crunchbase on the search results page, consequently the search query in Figure 4.1 is manually prepared borrowing the search query format of the Scopus database.

(TITLE-ABS-KEY ("sustain") OR TITLE-ABS-KEY ("green") OR TITLE-ABS-KEY ("social") OR TITLE-ABS-KEY ("environment ") OR TITLE-ABS-KEY ("goal") OR TITLE-ABS-KEY ("SDG") OR TITLE-ABS-KEY ("transition") AND TITLE-ABS-KEY ("3d print") OR TITLE-ABS-KEY ("additive manufacturing") OR TITLE-ABS-KEY ("automation") OR TITLE-ABS-KEY ("artificial intelligence") OR TITLE-ABS-KEY ("blockchain") OR TITLE-ABS-KEY ("cloud") OR TITLE-ABS-KEY ("cyber") OR TITLE-ABS-KEY ("data") OR TITLE-ABS-KEY ("digital") OR TITLE-ABS-KEY ("internet of things") OR TITLE-ABS-KEY ("machine learning") OR TITLE-ABS-KEY ("reality") OR TITLE-ABS-KEY ("robotic") OR TITLE-ABS-KEY ("software") OR TITLE-ABS-KEY ("web 3.0") OR TITLE-ABS-KEY ("a.i.") OR TITLE-ABS-KEY ("ai") OR TITLE-ABS-KEY ("a.r.") OR TITLE-ABS-KEY ("ar") OR TITLE-ABS-KEY ("i.o.t.") OR TITLE-ABS-KEY ("iot") OR TITLE-ABS-KEY ("m.l.") OR TITLE-ABS-KEY ("ml") OR TITLE-ABS-KEY ("a.i.") OR TITLE-ABS-KEY ("a.i.") OR TITLE-ABS-KEY ("a.i.") OR TITLE-ABS-KEY ("a.i.") OR TITLE-ABS-KEY ("v.r.") OR TITLE-ABS-KEY ("vr"))

Figure 4.1 : Crunchbase database search query.

Further, the geographic search filter is employed (3) which include geographic locations (filters which include (a) member countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta , Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) (b) countries which submitted membership applications (Georgia, Kosovo), (c) candidate countries (Albania, Bosnia and Herzegovina, Moldova, Montenegro, North Macedonia, Serbia, Türkiye, Ukraine) (c) countries which submitted membership applications in the past, but subsequently frozen or withdrawn (Iceland, Norway, Switzerland), former member states (United Kingdom), and European Free Trade Association Countries (Iceland, Liechtenstein, Norway, Switzerland) as in the definition of the European Commission (2021).

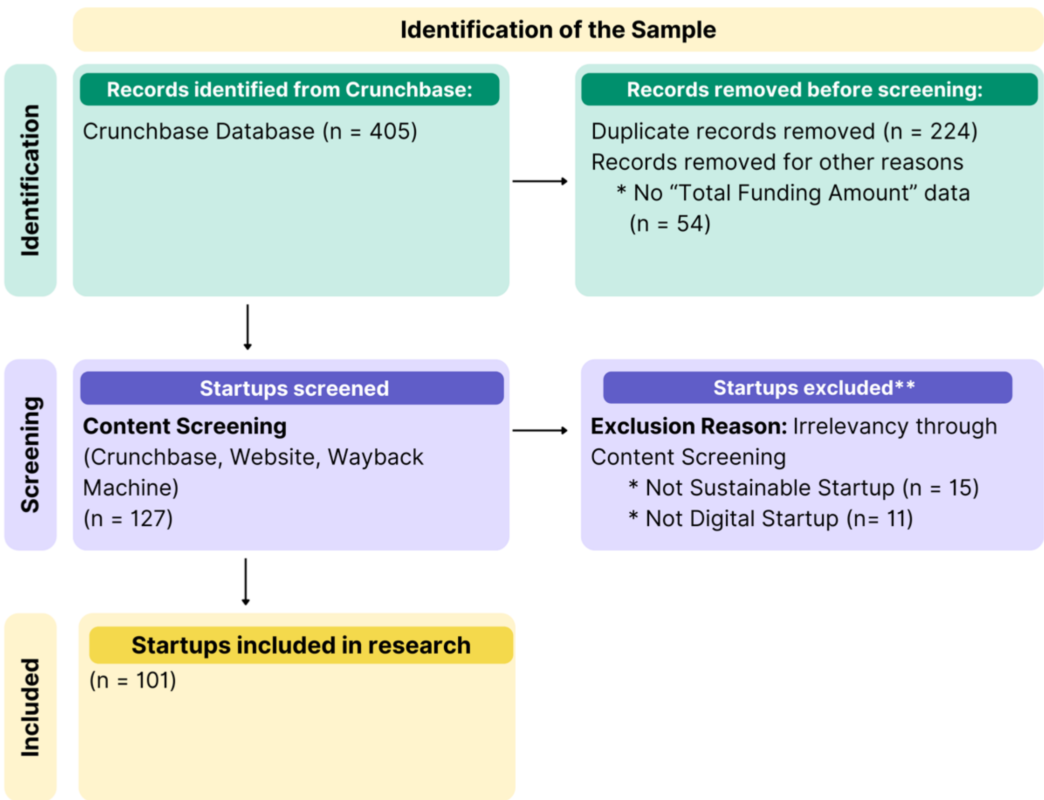

Figure 4.2 : Identification of the sample.

The Crunchbase database search provided 405 results.[10] In a further step, 127 results remain after removal of duplicates and the startups with no TFA data. To ensure (1)

[10] Data Retrieval Date: 3rd of November 2023.

direction of value propositions towards sustainability, rather than greenwashing (de Freitas Netto et al. 2020) or sustainability reporting (Beretta et al. 2025), and (2) the employment of DTs by the sample startups; (1) the organizational definition on Crunchbase database, and (2) the website of each individual startup is manually screened, and observed that 15 startups do not deliver value propositions directed to sustainability, and 11 startups do not employ DTs as represented in Figure 4.3. Consequently, the acquired data enable 101 observations with TFA data, 42 results with money raised data, and 17 results with pre-money valuation data within the European-based DSSs. Finally, considering a pragmatic lens, this research considers to operationalize the organizational-level TFA data as the dependent variable, in order to keep the sample size higher.

In this respect, the extracted Crunchbase data also includes two separate columns in regard to TFA data, which includes (1) the original TFA in its transaction currency (e.g., EUR, USD), and (2) the TFA converted into USD. In this respect, the prevailing spot exchange rates on the date of the reported funding round are defined to be used within the conversion process as defined by Crunchbase.[11] Consequently, this research operationalizes the TFA converted into USD data which is represented in the TFA currency (in USD) column within the Crunchbase data.

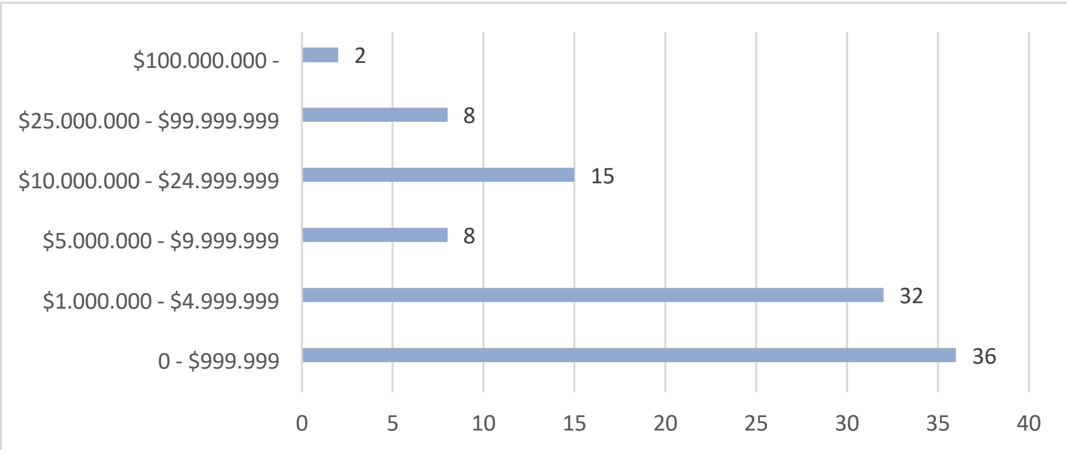

Figure 4.3 : Number of European DSSs by TFA.

In this respect, the TFA data is collected at a ratio level, as the acquired Crunchbase data represents continuous numerical US Dollars (USD) values as the standard unit of measurement (e.g., $10.000, $100.000), which also includes a true zero point.

[11] https://news.crunchbase.com/methodology/

Within the sampled observations, 36 DSSs are identified to acquire less than \$1.000.000 TFA as represented in Figure 4.3. Also, 32 DSSs are observed to hold TFAs between \$1.000.00 and \$4.999.999. Moreover, the TFA of 8 DSSs remain between \$5.000.000 and \$9.999.999, and 15 European DSSs acquire a TFA between \$10.000.000 and \$24.999.999. Further, eight European DSSs hold TFAs between \$25.000.000 and \$99.999.999. On the other hand, it is also observed that two DSSs which acquire a TFA of higher than \$100.000.000.

4.3.2 SDG-orientation

Second, as a systematic process in analysing the presence and/or frequency of specific keywords or keyword phrases within textual documents (Sabharwal et al. 2018), the conceptual content analysis is conducted on the organizational texts to identify the SDG-orientation of the sampled European DSSs. In this respect, SDG-specific search queries of Scival, Elsevier Data Repository (Jayabalasingham et al. 2019) are borrowed and downloaded,[12] which are built and augmented with a machine learning (ML) model by Elsevier's data science teams. On the other hand, SDG-specific search queries of Scival does not include SDG-specific search query for SDG17 (Partnerships for the Goals), which results in a limitation to our research to exclude SDG17 (Partnerships for the Goals). Further, each SDG-specific search query is split into keywords or keyword phrases considering "AND"," "OR," and "AND NOT" operators, and "*" and "?" wildcards, which will be hereinafter referred to as "keywords." In this step, "*" wildcards were removed, and keywords with "?" wildcards are edited with applicable versions to support the characteristics of the Google Sheets "find" command (Table 4.4).

Table 4.4 : Formulation of wildcards of SDG-specific search queries.

SDGs	Operator	Editions		
SDG2	? Operator	Original	Edited	Edited
		fertili?er	fertilizer	fertiliser
	* operator	malnourish*, undernourish*		
SDG3	* operator	health*, disease*, illness*, medicine*, polio*, vaccin*, cancer*, diabet*, sucid*		
SDG5	* operator	girl*		
SDG6	* operator	contamina*, sanit*, sewer*		

[12] https://elsevier.digitalcommonsdata.com/datasets/87txkw7khs/1

Table 4.4 (continued) : Formulation of wildcards of SDG-specific search queries.

SDGs	Operator	Editions		
SDG7	* operator	renewable*		
SDG8	* operator	microfinanc*, micro-financ*, micro-credit*, microcredit*, microenterprise*, micro-enterprise*		
SDG9	* operator	microenterprise*, micro-enterprise*		
SDG10	? Operator	Original	Edited	Edited
		economic marginali?ation	economic marginalization	economic marginalisation
	* operator	discriminatory law*		
SDG11	? Operator	Original	Edited	Edited
		urbani?ation	urbanization	urbanisation
	* operator	metropoli*, town*, municipal*, slum*, pollutant*		
SDG13	* operator	hazard*, island*, megacit*, atmospher*, emission*		
SDG14	* operator	coast*, eutrophicat*		
SDG15	* operator	biodivers*, bioeconom*, bio-econom*, deforest*, desertif*, ecosystem*, poach*, wetland*, mountain*, dryland*		
SDG16	? Operator	Original	Edited	Edited
		democrati?ation	democratization	democratisation
	* operator	genocid*, homicid*, murder*, refugee*, terroris*		

In the further step, Google Sheets software, as the equivalent to Microsoft Excel is employed to conduct the conceptual content analysis. In this respect, organizational-level textual data is collected from (1) mission and/or vision statements, “about us” sections, product and service pages, and other relevant pages as Tunçalp and Yıldırım (2022), and (2) Crunchbase website which includes (a) organizational description, (b) organizational industries, (c) products and (d) organizational specialties (which will be hereinafter referred to as “organizational text”), is collected and also placed into Google Sheets software. Further, the software is formuated to analyze the frequency of the keyword-occurences for each SDG at an organizational-level of analysis. This model will also be hereinafter referred to as “the conceptual content analysis model.” Lastly, the software is also formulated to identify the primary sustainability orientation by assigning a single SDGs which corresponds to the highest frequency of keyword occurences within each organizaitonal text at the nominal level, as each DSS is assigned only one SDG without any inherent order or quantitative differences, and which are coded by distinct categories from SDG1 to SDG16 (e.g., label “SDG14” indicates a primary focus on Life Below Water) (Figure 4.4).

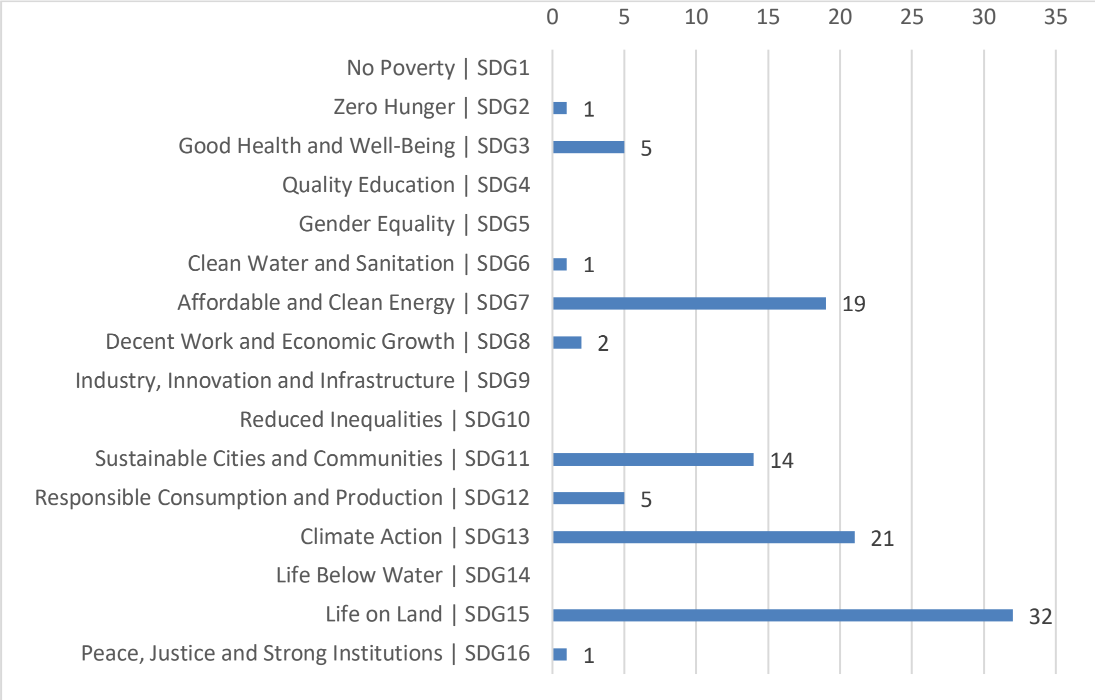

Figure 4.4 : Number of European DSSs by SDG-orientation.

In this respect, majority of the European DSSs concentrate on environmental goals which include SDG15 (Life on Land) with 32 DSS, followed by SDG13 (Climate Action) with 21 DSSs, and SDG7 (Affordable and Clean Energy) with 19 DSSs. A substantial number of European DSSs also orient towards SDG11 (Sustainable Cities and Communities) (14 DSSs), while SDG3 (Good Health and Well-being) attracts moderate attention. Also observed that none of the European DSSs prioritize SDG1 (No Poverty), SDG4 (Quality Education), SDG5 (Gender Equality), SDG9 (Industry, Innovation and Infrastructure), SDG10 (Reduced Inequalities), and SDG14 (Life Below Water). SDG1 (No Poverty), SDG4 (Quality Education, SDG5 (Gender Equality), SDG9 (Industry, Innovation and Economic Growth), SDG10 (Reduced Inequalities), SDG14 (Life Below Water) are not represented by European DSSs.

4.3.3 Digital technology (DT) adoption

Third, the conceptual content analysis model is also conducted on organizational texts to indetify the DT preferences of sampled DSSs. For this, (1) a manual keyword analysis is conducted on the organizational texts of the sampled DSSs. In this step, each organizational text is read and each identified DT-related keyword is noted, and clustered into, as presented on Table 4.5, which also enables the employment of an inductive approach. Further, (2) a copy of the Google Sheets document which was employed within the conceptual content analysis on SDG-orientation. Following, (3) the SDG-related keywords are replaced with DT-related keywords as represented in Table 4.5, which formulates the Google Sheets to analyze the DT-related keyword-occurences within each organizational text.

Table 4.5 : DT-related keywords in organizational texts.

Code	DT Cluster	DT-related Keywords	DSSs
1	AI	AI, A.I., artificial Intelligence, AI agents, generative AI, generative Adversarial Networks, machine learning, ML, m.l., computer vision	37
2	Cloud Computing / Infrastructure	Cloud, cloud-based big data tools, cloud computing, cloud services	9
3	Data & Analytics	Data, data analytic, data analytics, data science, database, databases, open data, predict	24
4	IoT	IoT, I.o.T., connected objects, sensor, remote sensing, agronomic modeling, satellite	12
5	Software Engineering / DevOps / Digital Platforms & Apps	Software, platform, digital platform, web app, mobile, mobile app, cybersecurity, API	68
6	3D Printing	3D printing	1
7	Robotics & Automation	Robot, robotics, automation, autonomous, autonomous navigation	6
8	Blockchain	Blockchain, digital assets, tokenisation, digital ledger technology, web3	6

In a further step, the binary (dichotomous) coded document is prepared which denotes the presence or absence (0 for absence, 1 for presence) of DT adoptation wihtin the sampled DSSs at an organizational-level of analysis. As a result, 163 DT adoptions are observed within 101 DSSs which result in an average of 1,6 DT adoption by each European DSS. Additionally, the thematic clustering also is operationalized, to consolidate and streamline the DT clusters within the semantically related DTs (keywords), which results in identification of eight DT clusters from the identified 46 DT-related keywords, which are represented in Table 4.5.

In this respect, each DTs are assigned as numeric codes at the nominal level, as each DT is treated as a distinct category without inherent order or quantitative difference. Consequently, “Software Engineering / DevOps / Digital Platforms & Apps” cluster is observed to be employed by 42% of the DSSs, which is followed by AI adaptation (23%). On the other hand, 3d printing is the least preferred DT, which is only employed by a-single EU-based DSS as represented in Table 4.5.

4.3.4 Innovation type (IT) adoption

Fourth, the manual inductive content coding is conducted on the organizational texts of the European DSSs to systematically identify the innovation types, as in the research of Singler (2023). In this respect, organizational texts which are operationalized as in the data preperation process of SDG-orientation, and DT preferences, and the innovation definitions on the fourth edition of Oslo Manual (OECD, 2018) are revisited to enable the manual assessment. Considering the definition of the fourth edition of Oslo Manual (OECD, 2018), which considers innovation types as the addressed common usage, in terms of "object" or "purpose" (e.g., delivery system innovations). In this respect, two main innovation categories with eight sub-categories (Table 4.6) are considered as represented in Table 4.6. Accordingly, organizational-level IT adaptation data is coded using a binary scheme (0 for absence, 1 for presence), based on the manual inductive content coding on the organizational texts.

Table 4.6 : Innovation taxonomy of Oslo Manual (OECD, 2018).

Innovation Types	Factor		DSSs
Product Innovation	1	Goods	10
	2	Services	12
Business Process Innovation	3	Production of Goods and Services	5
	4	Distribution and Logistics	0
	5	Marketing and Sales	5
	6	Information and Communmication Systems	63
	7	Administration and Management	0
	8	Product and Business Process Development	6

The distribution of the adopted ITs is at the nominal level, as each IT represents a distinct category without inherent order or quantitative difference. In this respect, each IT is also assigned as a numeric code (Table 4.6), which represents a significant variation between product innovations and business process innovations as 79% of European DSS adopt to business process innovations. On the other hand, 62% of the European DSSs are observed to adopt to information and communication systems innovation. Further, both distribution and logistics, and administration and management innovations are not adopted by the European DSSs.

4.3.5 Regional GDP

Fifth, a multi-source data collection is conducted to enable the NUTS-2 level regional GDP data. In this respect, the headquarter locations are considered as the geographical locations of the sampled DSSs, as in the research of Färber & Klein, (2021). For this, Crunchbase data which includes the geographical location of the headquarters, is also employed.

Second, the NUTS-2 level territorial codes which correspond to the geographical location of the sampled European DSSs are matched in accordance with NUTS-2 level EU maps[13] and with ITL2 level United Kingdom maps.[14]

Third, NUTS-2 level regional GDP data for the EU,[15] and ITL2 level regional GDP data for the UK[16] are downloaded[17] from related databases. Fourth, the GDP data for each European DSS is integrated by matching the NUTS-2 level regional codes. Fifth, the ITL-2 level data which considers GBP currency is converted into EUR currency, considering the currency conversion rate of the last day of 2021 (0,84028), which is represented by the European Central Bank.[18]

Consequently, the GDP data is identified to cover 101 results for 2021, 95 results for 2022 (which excludes Norway with six results), and 87 results for 2021 (which excludes Norway with six results and Switzerland with eight results).[19] Also, contacted with the Federal Statistical Office of Switzerland[20] and with Statistics Norway[21] but no progress is achieved. Consequently, the 2021 data is operationalized to enable a higher sample size within a pragmatic lens. On the other hand,

[13] https://ec.europa.eu/eurostat/web/nuts/maps#expand-de-20696703
[14] https://geoportal.statistics.gov.uk/datasets/e6d779438abd44dca2d283241bc673e9_0/explore
[15] https://ec.europa.eu/eurostat/databrowser/view/tgs00003/default/table?lang=en
[16]https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductallnutslevelregions
[17] Data Retrieval Date: 6th of November 2025.
[18]https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-gbp.en.html
[19] Data Retrieval Date: 6th of November 2025.
[20] https://www.bfs.admin.ch/bfs/de/home.html
[21] https://www.ssb.no/en/klass/klassifikasjoner/508

transformation of the location data into the NUTS2 level GDP data, also reflects a spatial data enrichment within this research.

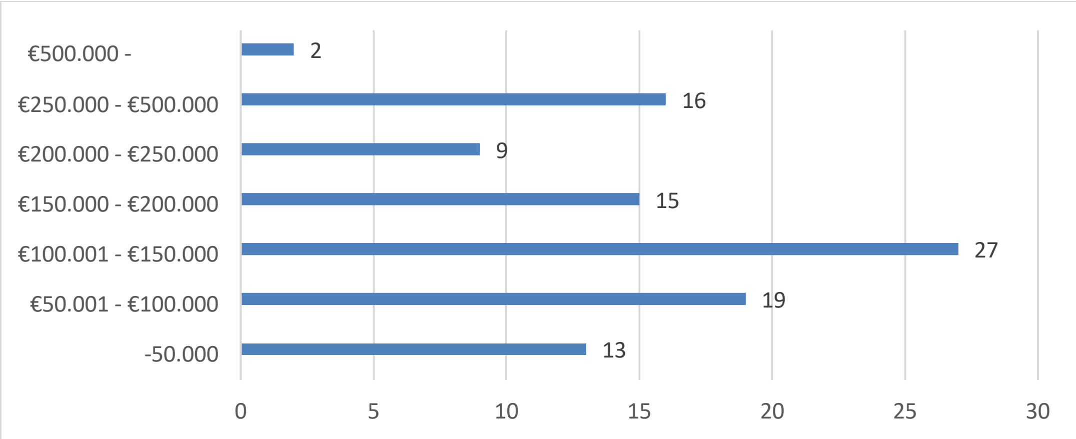

Figure 4.5 : Number of European DSSs by NUTS-2 level regional GDP.

NUTS-2 level Regional GDP data is collected at the ratio level, as the data represents continuous numeric values with a meaningful zero and equal intervals (e.g., €10.000, €100.000). In this respect, our sample includes European DSSs from 54 different NUTS2-level regions. Further, 13 of the European DSSs are observed to locate in regions with GDP levels below €50.000, and 19 DSSs are based in territories which hold GDP levels between €50.000-€100.000. Moreover, 27 of the sampled DSSs are located in the regions with GDP levels between €100,000 and €150,000, and 15 DSSs are based in regions with €150,000–€200,000 GDP levels. The sample also includes nine European DSSs within €200,000–€250,000 GDP levels, and 16 European DSSs within €250,000–€500,000 GDP levels. Our sample also includes two European DSSs which are located in the highest-income geographic locations with GDP levels exceeding €500,000, which are both located in France.

4.4 Measures

Multiple procedures are operationalized to enable the measures within the constructs of this research. In this respect, Table 4.7 represents the organizational-level operationalization of the measures.

Table 4.7 : Operationalization of constructs.

Variable	Construct	Scale	Operationalization
Dependent	Total Funding Amount	Ratio	Continuous (Log-transformed)
Independent	SDG-orientation	Nominal	Continuous (Standardized)

Table 4.7 (continued) : Operationalization of constructs.

Variable	Construct	Scale	Operationalization
Mediator	Digital Technologies	Nominal	Continuous (Standardized)
Mediator	Innovation Types	Nominal	Continuous (Standardized)
Moderator	NUTS-2 Level GDP	Ratio	Continuous (Log-transformed)

To enhance the explanatory power, new variables are consutructed from the binary coded SDG, and DT, and IT data by conducting the Principal Component Analysis (PCA) in IBM SPSS Statistics software, performing the factor rotation with the Varimax method without Kaiser normalization.

In this respect, operationalizing the dimension reduction procedure, SDG data are transformed into factor scores by calculating the standardized latent variable scores. The procedure resulted in extraction of 10 SDG clusters from the 16 operationalized SDGs. In this respect, the rotation converged in nine iterations, which indicates the achievement of a stable and interpretable factor solution. Further, the extracted ten SDG-orientation classes are represented in Table 4.9, which include SOWEJ, BICW, HECLIR, SUINRC, HAREC, ECOGE, SEQINC, HECLE, FSSI, and LWCS as measures.

Table 4.8 : SDG-orientation factor groups and abbrevations.

Factor	Measures	Included SDGs	Factor Theme
1	SOWEJ	1, 2, 3, 4, 5, 10, 16	Social Well-being and Justice — poverty, hunger, education, equality, institutions
2	BICW	6, 14, 15	Biosphere Integrity and Clean Water — water, life on land, life below water
3	HECLIR	3, 13, 15	Health and Climate Resilience — health, climate action, ecosystems
4	SUINRC	9, 12	Sustainable Industries and Responsible Consumption
5	HAREC	3, 11	Health and Resilient Cities
6	ECOGE	8	Economic Growth and Employment
7	SEQINC	5, 10	Social Equality and Inclusion — gender and income equality
8	HECLE	3, 7	Health and Clean Energy
9	FSSI	2, 9	Food Security and Sustainable Industries
10	LWC	6, 12, 15	Land, Water, and Consumption Systems

Operationalizing the same procedure, DT and IT adaptation data, which are also integrated to reduce the number of variables and convert binary coded data into continuous variables, are also transformed into factor scores by calculating the standardized latent variable scores, which results in 6 DT and IT contructs, which are obtained from the binary coded DT, and IT data. In this respect, the rotation converged in 26 iterations, as the post-rotation values (Rotation Suns ıf Squared Loadings) points to a balanced distribution of variance across components, with a factor which explains 13,72% of the total variance. Moreover, the cumulative variance (%71.63) also enables a satisfactory level of explanatory power for the underlying data structure.

Table 4.9 : PCA results of DT and IT adoption data.

Factor	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.788	14.897	14.897	1.646	13.719	13.719
2	1.658	13.820	28.717	1.620	13.504	27.223
3	1.504	12.532	41.249	1.540	12.837	40.060
4	1.370	11.418	52.667	1.352	11.266	51.326
5	1.188	9.900	62.566	1.250	10.418	61.744
6	1.087	9.061	71.627	1.186	9.883	71.627

In this respect, the extracted six DT and IT factors are represented in Table 4.11, which include SPDS, SICT, PGSI3D, AIPP, DMBA, and MSI measures.

Table 4.10 : DT and IT adoption factor groups and abbrevations.

Factor	Measures	Included DTs and ITs	Factor Theme
1	SPDS	DT_4 (IoT) DT_5 (Software / Digital Platforms) IT_1 (Goods)	Smart Products & Digital Solutions
2	SICT	IT_2 (Services) IT_6 (Information & Communication Systems)	Services & ICT Innovation
3	PGSI3D	DT_6 (3D Printing) IT_3 (Production of Goods & Services) IT_8 (Business Process & Product Development)	Production of Goods and Services Innovation & 3D Technologies
4	AIPP	DT_1 (AI) IT_8 (Business Process & Product Development)	AI-driven IT_ovative Processes & Products
5	DMBA	DT_2 (Cloud Computing) DT_8 (Blockchain)	Digital Marketing & Blockchain Applications
6	MSI	IT_5 (Marketing & Sales)	Marketing and Sales Innovation

Employing SPSS, log-transformation procedures are also applied to the ratio-scale dependent variable (TFA) and to the moderator variable (GDP), to address the linearity assumptions by mitigating the influence of extreme outliers and stabilize the executed variance, and potential skewness to enable the normality of the distribution, and enhance the statistical vailidity of the results. In this respect, SDG, and DT and IT data are operationalized as standardized Z-scores (mean = 0, SD = 1) which also ensures the scale uniformity within different cluster dimensions. Figure 4.6 represents the measurement model of the thesis research, which analyzes direct, moderating and mediating paths within the constructs.

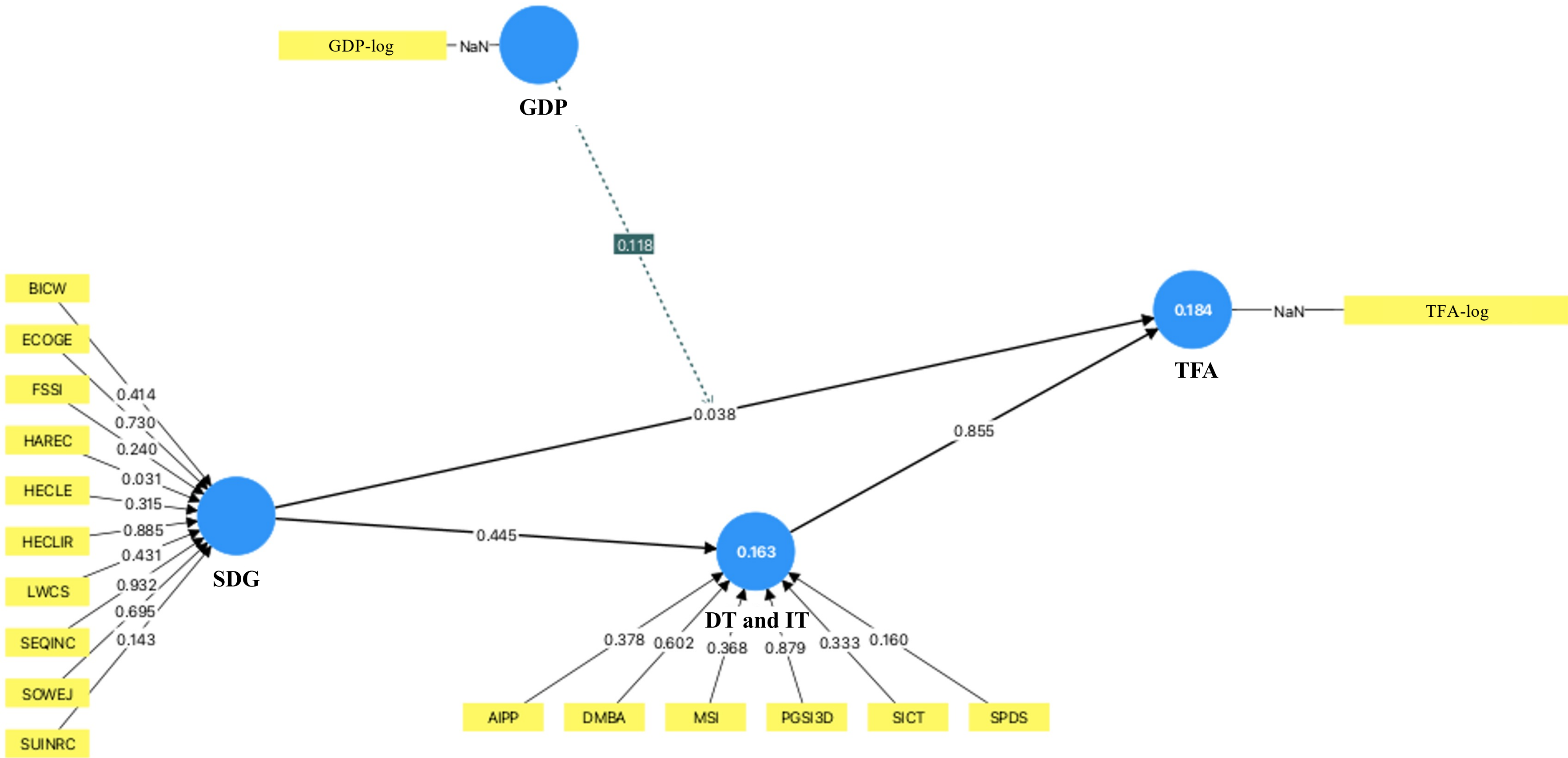

Figure 4.6 : Model 1 - measurement model and structural model.

4.5 Methodology and Analytical Strategy

Evaluating candidate approaches such as multiple regression, structural-equation modelling (SEM), and partial least squares structural-equation modeling (PLS-SEM), this research employs PLS-SEM method (Ringle et al. 2024), and operationalizes in SmartPLS 4 software, to enable (1) simultaneous analysis capabilities within direct, indirect, mediating, and moderating influences, (2) analysis on complex formative and reflective relationships (3) analysis capabilities relatively on smaller sample sizes. In this respect, even our sample size meets the "10-times" rule, which points to the sample size to be at least ten times the maximum number of structural paths which is directed to a particular latent construct (Kock & Hadaya, 2018), the sample size is also observed to be sufficient for detecting "medium effect" sizes within the post hoc power analysis with a statistical power of 0.90 at a 0.10 significance level, which meets the required sensitivity to illustrate meaningful structural relationships as identified by Cohen, (1992).

Given the prediction-oriented nature of PLS-SEM and the exploratory character of our model, bootstrapping confidence intervals were set at 90%, which is also identified as acceptable in explanatory and prediction-oriented PLS-SEM applications (Hair et al. 2019; 2022). Following the standard PLS-SEM bootstrapping procedure, percentile CI values are employed, which are considered as acceptable in PLS-SEM applications (Hair et al. 2019). Aligning with the predictive nature of PLS-SEM and explanatory character of our model, bootstrapping CI is set to 90%, which is also considered as acceptable in explanatory and prediction-oriented PLS-SEM applications (Hair et al. 2019).

5. PLS-SEM ANALYSIS AND HYPOTHESIS TESTING

This section includes the analysis and the results of the PLS-SEM testing of the main (Model 1) formative research model, which analyzes the effects of the strategic orientation towards SDGs on TFA of the European DSSs. Considering the same dataset, this thesis study also tests three different models. In this respect, the second research model examines the same relationships, adopting to a reflective measurement model. The third model investigates the effect of Regional GDP on the TFA of the European DSSs, adopting to a formative measurement model. The fourth model analyses the influence of the Regional GDP on the TFA of the European DSSs, adopting to a reflective measurement model as represented in Table 5.1.

Table 5.1 : Structural model overview.

Model	Measurement Type	Independent Variable	Moderator Variable	Medaitor Variable	Dependent Variable
Model 1	Formative	SDG	GDP	DT and IT	TFA
Model 2	Reflective	SDG	GDP	DT and IT	TFA
Model 3	Formative	GDP	-	SDG, DT and IT	TFA
Model 4	Reflective	GDP	-	SDG, DT and IT	TFA

Further, the descriptive statistics are represented in Table 5.2, which include mean, standart deviation, excess kurtosis, and skewness values within the observed 101 European DSSs (n = 101). In this respect, the indicators for SDG-orientation, and DT and IT, represent mean values of zero (0), as they represent factor scores. Also, the natural logarithm transformation was applied within the GDP and TFA variables.

Table 5.2 : Descriptive statistics.

	M	SD	Min.	Max.	n	Excess Kurtosis	Skewness
SDG							
BICW	0	0,995	-0,974	9,333	101	77,547	8,314
ECOGE	0	0,995	-1,079	5,482	101	13,838	3,527
FSSI	0	0,995	-2,355	5,199	101	9,048	2,110
HAREC	0	0,995	-1,297	6,150	101	13,899	2,916
HECLE	0	0,995	-2,617	2,654	101	0,618	0,481
HECLIR	0	0,995	-1,776	2,499	101	-0,774	0,163

Table 5.2 (continued) : Descriptive statistics.

	M	SD	Min.	Max.	n	Excess Kurtosis	Skewness
LWCS	0	0,995	-6,905	1,847	101	22,346	-3,566
SEQINC	0	0,995	-4,569	4,307	101	8,941	0,662
SOWEJ	0	0,995	-0,489	9,251	101	75,185	8,280
SUINRC	0	0,995	-1,458	3,460	101	2,746	1,590
DT and IT							
AIPP	0	0,995	-1,163	3,992	101	4,079	1,767
DMBA	0	0,995	-3,546	2,067	101	5,731	-1,952
MSI	0	0,995	-3,609	1,615	101	5,969	-2,070
PGSI3D	0	0,995	-0,548	8,153	101	45,939	6,270
SICT	0	0,995	-1,412	2,292	101	0,209	1,113
SPDS	0	0,995	-0,795	3,351	101	2,702	1,811
GDP_log	5,096	0,336	3,969	5,872	101	1,049	-0,766
TFA-log	6,254	0,931	3,532	8,329	101	-0,085	-0,310

Additionally, the descriptive statistics also indicate that several variables exhibit substantial skewness and excess kurtosis levels (BICW: Skewness 8.314, Excess Kurtosis 77.547; SOWEJ: Skewness 8.280, Excess Kurtosis 75.185; PGSI3D: Skewness 6.270, Excess Kurtosis 45.939), which deviate from normal distribution assumptions. In this respect, partial least squares structural equation modeling (PLS-SEM) is employed, which does not require multivariate normalty, and which is robust within non-normal data distribution (Hair et al. 2019). On the other hand, GDP_log and TFA-log reflect relatively more balanced distributions and lower skewness and kurtosis values, which point to a more suitable distibution structure for our analysis.

5.1 Assessment of the Measurement Model

This research considers SDG, and DT and IT as formative constructs. In this respect, indicators are considered as independent components which form the latent variable. Consequently, high correlation is not expected within the statistical findings. Further, as a result of the employment of the formative model, traditional convergent validity criteria such as indicator loadings, reflective convergent validity (AVE), and internal consistency measures such as cronbach’s alpha, or composite reliability could not be directly analysed (Hair et al. 2019). Instead, the assessment focuses on collinearity (VIF), and the significance and relevance of indicator weights (Hair et al. 2019).

Consequently, the analysis on the formative measurement model is conducted by employing three separate criteria of Hair et al. (2019) which include (1) collinearity statistics (VIF), (2) and significance and relevance of outer weights, and (3) outer loadings which is operationalized as a supportive analysis to outer weights.

5.1.1 Outer model collinearity assessment (VIF)

In advance, we employed Principal Component Analysis (PCA) with Varimax rotation to derive the indicators factor scores within the latent variables (SDG-orientation, and DT and IT), which also resulted in the perfect lack of multicollinearity within the indicators. Even, PCA ensures that the components are independent by design, we followed the criteria of Hair et al. (2019), and analysed the potential collinearity issues within the indicators by employing the Variance Inflation Factor (VIF) test. In this respect, it is observed that VIF values of all indicators are below the threshold values of 3.3 or 5 (Hair & Alamer, 2022), ranging from 1.032 to 1.262 as represented in Table 5.3, which reflects the absence of multicollinearity, and the contribution of each SDG, and DT and IT indicator to hold a unique information, which do not overlap with the others.

Table 5.3 : Collinearity statistics (VIF) outer model.

	VIF
SDG	
BICW	1,144
ECOGE	1,089
FSSI	1,115
HAREC	1,105
HECLE	1,084
HECLIR	1,101
LWCS	1,109
SEQINC	1,251
SOWEJ	1,262
SUINRC	1,131
DT and IT	
AIPP	1,050
DMBA	1,059
MSI	1,035
PGSI3D	1,032
SICT	1,046
SPDS	1,035
GDP	
GDP_log	1,000
GDP x SDG	1,000
TFA-log	1,000

5.1.2 Indicator relevance and outer weights

Further, the second criterion is applied, which refers to the analysiss of the significance and relevance of outer weights (Hair et al. 2019), that represents each indicator's relative contribution in forming the related construct. The results indicate that only HAREC provides a strong and significant contribution in forming the SDG construct (β = 0.817, t = 2.155, p = 0.031) (Hair et al. 2019). Further, the outer weights of the remaining SDG indicators are not statistically significant. Similarly, none of the indicators within the DT and IT construct exhibit statistical significance within outer weights, indicating that this construct operates as a composite formed by the joint contribution of its indicators (Hair et al. 2019). On the other hand, CI values within all indicators include zero (0), which also includes HAREC, which cannot be considered as robust. On the other hand, the single-item constructs (GDP, and TFA) display weights of 1.000 as a result of non-applicable significance tests, which is methodologically expected (Hair et al. 2019).

Table 5.4 : Outer weights results.

SDG					
BICW -> SDG	-0,253	0,817	0,414	-0,604	0,450
ECOGE -> SDG	-0,067	0,345	0,730	-0,334	0,287
FSSI -> SDG	0,232	1,174	0,240	-0,134	0,503
HAREC -> SDG	0,817	2,155	0,031	-0,400	0,900
HECLE -> SDG	-0,247	1,005	0,315	-0,603	0,193
HECLIR -> SDG	-0,029	0,145	0,885	-0,276	0,379
LWCS -> SDG	0,116	0,788	0,431	-0,119	0,361
SEQINC -> SDG	-0,020	0,086	0,932	-0,260	0,489
SOWEJ -> SDG	-0,072	0,392	0,695	-0,246	0,361
SUINRC -> SDG	0,359	1,465	0,143	-0,150	0,673
DT and IT					
AIPP -> DT and IT	0,309	0,881	0,378	-0,510	0,632
DMBA -> DT and IT	0,180	0,521	0,602	-0,483	0,655
MSI -> DT and IT	-0,500	0,900	0,368	-0,795	0,862
PGSI3D -> DT and IT	-0,036	0,152	0,879	-0,295	0,495
SICT -> DT and IT	0,331	0,969	0,333	-0,505	0,643
SPDS -> DT and IT	-0,716	1,405	0,160	-0,800	0,908
GDP					
GDP_log <- GDP	1,000	n/a	n/a	1,000	1,000
GDP x SDG -> GDP x SDG	1,000	n/a	n/a	1,000	1,000
TFA-log <- TFA	1,000	n/a	n/a	1,000	1,000

5.1.3 Assessment of outer loadings (supportive analysis)

Outer loadings are also examined, as a supplementary assessment, as in the definition of Hair et al. (2019). In this respect, HAREC (β = 0.817, t = 2.194, p = 0.028) also significantly exceeds the given threshold (0.500), which also confirms its role in defining the SDG construct. However, all of the other indicators within SDG, and DT and IT constructs represent loadings below the threshold value (Hair et al. 2019). Further, the CI values of all indicators include zero (0). In this respect, the formative indicators can also be portrayed to jointly define the construct, but provide relative and statistically insignificant individual contributions.

Table 5.5 : Outer loadings results (supporting analysis).

	β	*t*-value	*p*-value	5.0%	95.0%
SDG					
BICW -> SDG	-0,253	0,725	0,468	-0,639	0,497
ECOGE -> SDG	-0,067	0,345	0,730	-0,338	0,287
FSSI -> SDG	0,232	1,230	0,219	-0,126	0,488
HAREC -> SDG	0,817	2,194	0,028	-0,396	0,882
HECLE -> SDG	-0,247	0,978	0,328	-0,619	0,200
HECLIR -> SDG	-0,029	0,144	0,885	-0,281	0,378
LWCS -> SDG	0,116	0,750	0,453	-0,156	0,353
SEQINC -> SDG	-0,020	0,106	0,916	-0,241	0,366
SOWEJ -> SDG	-0,072	0,540	0,589	-0,208	0,226
SUINRC -> SDG	0,359	1,397	0,162	-0,180	0,692
DT and IT					
AIPP -> DT and IT	0,309	0,867	0,386	-0,504	0,651
DMBA -> DT and IT	0,180	0,522	0,602	-0,471	0,662
MSI -> DT and IT	-0,500	0,904	0,366	-0,790	0,857
PGSI3D -> DT and IT	-0,036	0,147	0,884	-0,298	0,530
SICT -> DT and IT	0,331	0,959	0,338	-0,518	0,644
SPDS -> DT and IT	-0,716	1,406	0,160	-0,791	0,903
GDP					
GDP x SDG -> GDP x SDG	1,000	n/a	n/a	1,000	1,000
GDP_log <- GDP	1,000	n/a	n/a	1,000	1,000
TFA-log <- TFA	1,000	n/a	n/a	1,000	1,000

Accordingly, the standard practice often suggests removal of the indicators with low loadings to improve the model, but removal of an indicator also results in essential changes in the definition of the construct and the definition of the indicator itself within the formative measurement model. In this respect, given the heterogeneity of our sample, the low loadings reflect different levels of contributions within different observations, which can still be theoretically necessary to cover the scope of the research framework. In this respect, all indicators are kept in the model based on the theoretical considerations within the preservation of the conceptual completeness of each construct, as in the definition of Hair et al. (2019).

5.2 Assessment of the Structural Model

After validating the measurement model, and following the procedure of Hair et al. (2019), the assessment is conducted on the structural model to test the hypothesized relationships among the constructs within the research framework. In this respect, potential multicollinearity issues, predictive capabilities, and effect sizes within the inner model are tested.

5.2.1 Inner model collinearity assessment (inner VIF)

Inner collinearity within the constructs are identified to ensure that multicollinearity does not bias the estimation of path coefficients within the constructs. In this respect, VIF values are calculated for each of the endogeneous construct, considering the threshold values (lower than 3.3, or 5), which reflects the absence of critical multicollinearity issues (Hair et al. 2019). In this respect, excluding the relationship between SDG, and DT and IT, VIF values are observed to be low, ranging from 1.000 to 1.245, which are below the mentioned conservative thereshold values (Hair et al. 2019). In this respect, we can confim that there are no collinearity issues within our independent variables.

Table 5.6 : Collinearity statistics (VIF) inner model results.

	VIF
SDG -> TFA	1,245
SDG -> DT and IT	1,000
DT and IT -> TFA	1,216
Regional GDP -> TFA	1,038
Regional GDP x SDG -> TFA	1,020

5.2.2 Hypothesis testing

To assess the validity of the relationships within our research model, a bootstrapping analysis is conducted in SmartPLS software with 50.000 subsamples to ensure the the stability of the estimates. In this respect, the path coefficients, significance levels and confidence intervals are represented in Table 5.7. Suporting the main focus of our research, the results indicate that strategic orientation towards SDGs has a positive and statistically significant effect on TFA (β = 0.385, t = 2.076, p = 0.038) (Cohen, 1988), and CI values of this path also does not include zero [0.021, 0.609], which confirms the reliability of this effect. As a result, H_1 hypothesis is accepted, which points to the strategic orientation towards SDGs significantly facilitates access to funding finance for the European DSSs. On the other hand, none of the other tested relationships within this research model is observed to be statistically significant. Further, SDG is observed to represent a negative effect on DT and IT, which is also insignificant (β = -0.404, t = 0.763, p = 0.455). Also, the influence of DT and IT on TFA is not significant (β = 0.032, t = 0.183, p = 0.855), as the direct influence of GDP on TFA (β = 0.024, t = 0.277, p = 0.782), and the moderating effect of GDP within the relationship between SDG and TFA, which is not also statistically significant (β = 0. 203, t = 1.564, p = 0. 118).

Table 5.7 : Hypothesis testing results.

	β	SD	*t*-values	*p*-values	5.0%	95.0%
SDG -> TFA	**0,385**	**0,186**	**2,076**	**0,038**	**0,021**	**0,609**
SDG -> DT and IT	-0,404	0,529	0,763	0,445	-0,643	0,664
DT and IT -> TFA	0,032	0,177	0,183	0,855	-0,299	0,279
GDP -> TFA	0,024	0,086	0,277	0,782	-0,099	0,185
GDP x SDG -> TFA	0,203	0,130	1,564	0,118	-0,069	0,349

5.2.3 Conditional direct effects

Our results indicate that, effect of SDG on TFA is contingent to GDP levels. In this respect, it is observed that the effect of SDG is significant at high GDP level (+1 SD: β = 0.588, t = 2.420, p = 0.016), and at mean GDP level (Mean: β = 0.385, t = 2.076, p = 0.038). On the other hand, it is also observed that the positive effect is insignificant at low GDP level (-1 SD: β = 0.183, t = 0.875, p = 0.381) as described by Hair et al. (2019).

Table 5.8 : Conditional direct effects (moderation) results.

	β	*t*-value	*p*-value	5.0%	95.0%
SDG -> TFA GDP at +1 SD	**0,588**	**2,420**	**0,016**	**0,055**	**0,810**
SDG -> TFA GDP at Mean	**0,385**	**2,076**	**0,038**	**0,021**	**0,609**
SDG -> TFA GDP at -1 SD	0,183	0,875	0,381	-0,127	0,560

5.2.4 Coefficient of determination (R^2 and adjusted R^2)

R^2 and adjusted R^2 values are employed to assess the explanatory power of the structural model. In this respect, it is observed that 18.4% of the variances in TFA, and 16.3% of the variance in DT and IT, which points to weak proportions of explanation within the variances of the endogenous constructs, as described by Hair et al. (2019) (weak ≈ 0.25, moderate ≈ 0.50, substantial/strong ≈ 0.75), which is represented in Figure 5.9. Also, adjusted R^2 values of TFA (adj. $R^2 \approx 0.150$), and DT and IT (adj. $R^2 \approx$ and 0.155) are observed to indicate weak explanatory power within the model as in the definition of Hair et al. (2019). Further, no inflation is observed by the inclusion of both constructs, as a result of the small differences between R^2 and adjusted R^2 values, which also points to the stable explanatory power of the structural model (Hair et al. 2019).

Table 5.9 : R-square and adjusted R-square results.

	R^2	Adj. R^2
TFA	0,184	0,150
DT and IT	0,163	0,155

5.2.5 Effect size (f^2)

As a complementary to R^2 findings, we also assessed f^2 values to identify the relative contribution of each construct towards the dependent constructs, as represented within five paths, as in Table 5.10. In this respect, the path from SDG to TFA reflects a small effect effect size ($f^2 \approx 0.146$), which nearly reaches the medium threshold (0.15) as identified by the guidelines of Cohen (1988) (small ≈ 0.02, medium ≈ 0.15, large ≈ 0.35). Further, a medium effect size is identified within the path from SDG to DT and IT ($f^2 \approx 0.195$). Further, the influence of GDP within the relationship between SDG and TFA reclects a small effect size (0.039). Moreover, both the effect sizes of DT and IT, and GDP on TFA are observed to be negligible ($f^2 \approx 0.001$).

Table 5.10 : Effect sizes of constructs (f²).

	f²
SDG -> TFA	0,146
SDG -> DT and IT	0,195
DT and IT -> TFA	0,001
GDP -> TFA	0,001
GDP x SDG -> TFA	0,039

5.2.6 Specific indirect effects, total indirect effects, and total effects

Analysing the relationship between the constructs in our model, the path analysis, which evaluates the strength and significance within the constructs, reveals a clear distinction between SDG and the other variables. In this respect, the total effect of SDG on TFA remains positive and significant (β = 0.372, t = 2.293, p = 0.022), which suggests that orientation towards SDGs contribute to TFA in the European DSS context. On the other hand, none of the other paths within total effects, specific indirect effects, and total indirect effects are statistically significant. Consequently, the results suggest that strategic orientation towards SDGs has a direct and statistically significant effect on TFA, but indirect paths and mediation effects do not meaningfully contribute.

Table 5.11 : Specific indirect, total indirect, and total effects results.

	β	*t*-value	*p*-value	5.0%	95.0%
Specific Indirect Effects					
SDG -> DT and IT -> TFA	-0,013	0,138	0,890	-0,164	0,144
Total Indirect Effects					
SDG -> TFA	-0,013	0,138	0,890	-0,164	0,144
Total Effects					
SDG -> TFA	**0,372**	**2,293**	**0,022**	**0,068**	**0,574**
SDG -> DT and IT	-0,404	0,763	0,445	-0,643	0,664
DT and IT -> TFA	0,032	0,183	0,855	-0,299	0,279
GDP -> TFA	0,024	0,277	0,782	-0,099	0,185
GDP x SDG -> TFA	0,203	1,564	0,118	-0,069	0,349

5.3 Model Fit Assessment

Model fit is also examined using SRMR, d_ULS, and d_G values, to identify the significance of both the estimated, and the saturated models. In this respect, SRMR values of the estimated model (0.060) and the saturated model (0.060) are below the threshold value (0.08) as identified by Hair and Alamer (2022). Further, SRMR value of the estimated model (0.060) is below the 95% (0.074) and 99% (0.080) bootstrap upper thresholds, as SRMR values of the saturated model (0.060), which is also below the 95% (0.073) and 99% (0.080) bootstrap upper threshold values, as identified by (Henseler et al. 2015). Moreover, the d_ULS and d_G values are also observed to be below the 95%, and 99% bootstrap upper thresholds, which points to a good level of model fit within both the estimated and the saturated models (as defined by Hair et al. (2019) (good < 0.08, acceptable < 0.10).

Table 5.12 : Model fit indicies.

	SRMR	95%	99%	d_ULS	95%	99%	d_G	95%	99%
Estimated Model	0,060	0,074	0,080	0,608	0,929	1,094	0,132	0,257	0,312
Saturated Model	0,060	0,073	0,080	0,608	0,921	1,085	0,132	0,253	0,309

On the other hand, PLSpredict results are not reported, which also reveal limited out-of-sample predictive power within all models, which also reflects the exloplorative nature of our research, rather than predictive.

6. CONCLUSIOSN AND RECOMMENDATIONS

The primary goal of this research is to examine the main research problem "what are the factors that impact the economic performance of European DSSs?" Theoretically, discussing the concept of DSSs as a combination of sustainability, innovation, digital technologies and entrepreneurship (Gregori & Holzmann, 2020; Xu et al. 2022), our main research model (Model 1) examines the direct and indirect influences of strategic orientation towards SDGs on total funding amount (TFA) of the European DSSs, at an organizational level-of analysis, which also tests the moderating effect of NUTS2 level regional GDP, and the mediating effects of digital technology preferences (DT) and innovation types (IT). Adopting to the formative measurement model, in which latent constructs (SDG, DT and IT) are defined as a composite of its indicators, this research employs PLS-SEM as the primary analytical technique within the analysis and testing processes, adopting to the procedure of Hair et al. (2019).

Within the main research model of this thesis study (Model 1), which operationalizes SDG as the independent variable, and considers SDG, and DT and IT as formative constructs, no multicollinearity issues are observed within the inner and outer values, as in the other models which are also discussed within this thesis research. In this respect, HAREC is appears to be the only statistically significant indicator within both outer weights and outer loadings results. On the other hand, this indicator's confidence interval values also include zero (0) as the other indicators within both SDG, and DT and IT constructs, which was also discussed to reflect different levels of contributions within different observations, and theoretically necessary to cover the scope of the research framework within the formative models. Further, even the formative indicator weights and loadings are insignificant, the main hypothesis of this research is supported at the construct-level, which reflects the positive and significant effect of SDG on TFA. Further, the effect of SDG on TFA is also observed to be contingent to higher GDP levels. Even reflecting low to medium effect sizes, this model also explains weak potion of variance in TFA, which indicates a limited overall explanatory power, despite significant contribution of SDG at the construct-level (Hair et al. 2019). Further, Model 1 also represents a good level of fit.

On the other hand, within the results of Model 2, which operationalizes SDG as the independent variable, and considers SDG, and DT and IT as reflective constructs, HAREC also appears to be the only statistically significant indicator within outer loadings results, but its confidence interval values also include zero, as all the other indicators within SDG, and DT and IT constructs, which also reveals the limitations within the results of Model 2, as a result of the reflective measurement model. On the other hand, even this model reflects low convergent validity, and acceptable level of discriminant validity at the construct-level, the influence of SDG on TFA is not observed to be statistically significant, as the other direct, conditional, or indirect paths within this reflective model. Further, the effect sizes of the direct paths are observed to be negligible, and the explained variances are weak within the model, which indicates that the reflective specification does not meaningfully explain the dependent construct. Further, the model fit assessment indicates to a marginal level of fit. Consequently, this reflective model fails to provide empirical support within the proposed relationships, which indicates that the reflective measurement model does not structurally capture the dynamics underlying the dependent variable.

Further, the results of Model 3, which operationalizes GDP as the independent variable, and considers SDG, and DT and IT as formative constructs, HAREC and SUINRC indicators are observed to reflect signficaint and positive contribution within the formation of SDG construct. Further, at the indicator-level, the direct effects of both SDG, and GDP on TFA are observed to be positive and statistically significant. On the other hand, it is also observed that only a weak portion of total variance in TFA is explained. On the other hand, only the path from SDG to TFA appears to represent a meaningful effect size. Further, specific mediating effect of SDG construct, and total effects of SDG, and GDP constructs are also observed to be positive and statistically significant. On the other hand, Model 3 represents acceptable level of fit. Overall, the results indicate that the explanatory power of this model is driven predominantly by SDG construct, within its mediating and direct effects on TFA, while indirect effect of GDP on TFA is also observed to be statistically significant.

The results of Model 4, which operationalizes GDP as the independent variable, and considers SDG, and DT and IT as reflective constructs, point that SUINRC and HAREC indicators positively and significantly reflect the underlying construct. On the other hand, even the model points to positive and significant influences within both paths from SDG, and GDP towards TFA, this model also reflects low convergent validity, low internal consistency, and partial levels of discriminant validity at the construct-level. Further, the model is also observed to explain weak potion of variance within TFA, and only SDG is observed to represent medium the effect size, as GDP and DT and IT reflect small or negligible effect sizes. On the other hand, the specific indirect effect of SDG within the path from GDP to TFA, and the total effect of GDP on SDG are observed to be statistically significant. On the other hand, this model reflects an acceptable but not optimal fit.

Focusing on the different research frameworks, the results within the framework which considers SDG as the independent variable (Model 1, and Model 2), both formative and reflective models do not represent significance within any of SDG, or DT and IT indicators. Further, only one direct path (from SDG to TFA) is observed to be statistically significant within the formative model (Model 1), and the total effect of this path is also observed to be significant within both formative and reflective models. Further, the influence of SDG is also observed to be contingent to higher GDP levels in both models, while formative model (Model 1) also reflects significance within the moderating effect of GDP ad the mean level. Reflecting weak explanatory power, both models also represent small to medium effect sizes. On the other hand, the formative model (Model 1) is observed to present good model fit, and fit within the reflective model (Model 2) is at an acceptable level. On the other hand, focusing on the research framework which considers GDP as the independent variable, SUINRC and HAREC indicators are observed to be significant within both models (Model 3, and Model 4). Further, both models also represent significance within the direct paths from SDG to TFA, and GDP to TFA. Also, total effects of SDG on TFA, and total effects of GDP on TFA are observed to be significant for both models within this research framework. Also reflecting weak explanatory power as in the results of the other research framework, both models are also observed to represent small to medium effect sizes. On the other hand, the formative model (Model 3) is observed to present good model fit, and fit within the reflective model

(Model 4) is at an acceptable level, as in the results of the other research framework. Consequently, the research framework which considers GDP as the independent variable is observed to perform better (Model 3, and Model 4), which represents statistically significant indicator (SUINRC, and HAREC) and path (SDG to TFA, and GDP to TFA) scores, and similarity is observed within the observed effect sizes, and explanatory power of the model.

Comparing the performance of the results which adopt to formative and reflective measurement models, and focusing on the research framework which operationalizes SDG as the independent variable, the formative model (Model 1) outperforms the reflective model (Model 2), which reflects the significance direct effect of SDG on TFA. Further, the influence of SDG on TFA is also observed to be moderated by GDP at high level, and even at mean level. Even reflecting similarities within effect sizes and explanatory power, the formative model (Model 1) represents good model fit, as the fit is at an acceptable level within the reflective model (Model 2). On the other hand, focusing on the research framework which operationalizes GDP as the independent variable (Model 3, and Model 4), Model 3 which adopts to formative measurement model also outperforms the reflective model, as a result of formative model's indicator validity and collinearity values, and reflective model's reliability and validity test results. Further, Model 3 is also observed to exhibit better model fit than the reflective model, as in the other measurement model-based comparison.

Within the scope of our research, Model 3 is observed to represent the strongest overall statistical performance. In this respect, at the indicator-level, SUINRC (Sustainable Industries and Responsible Consumption) which covers SDG9 (Industry, Innovation and Infrastructure) and SDG12 (Responsible Consumption and Production), and HAREC which covers SDG3 (Good Health and Well-being) and SDG11 (Sustainable Cities and Communities) are observed to be statistically significant indicators of SDG construct. Considering the positive and significant effect of these indicators, our findings suggest that increased orientation towards SUINRC and HAREC results in higher SDG levels, while higher SDG levels are associated with higher TFA. In this respect, at the indicator-level, SUINRC is also observed to slightly outperform HAREC. In this respect, two SDGs (SDG9 Industry, Innovation and Infrastructure) and SDG3 (Good Health and Well-being) from the economic pillar (Kostoska & Kocarev, 2019) are observed to positively influence

SDG levels, which in turn influences TFA of the European DSSs. Also, SDG12 (Responsible Consumption and Production) within the environmental pillar, and SDG11 (Sustainable Cities and Communities) within the social pillar are observed to influence the SDG levels.

Further, at the contruct-level, even the results of Model 3 indicate significance within direct effect and mediating effect of SDG, and direct effect and indirect effect of GDP on TFA with medium effect sizes, the findings demonstrate weak explanatory power, and represents restricted explanatory scope, with limited indicator contribution, but structural stability and good model fit, which are consistent with the results of the prior research of Mann et al. (2024) that points to the relationship between SDG-orientation and economic performance of social entreprises, and defines the adaptation towards a narrow set of SDGs to result in increased productivity. Other researches also point to correlations between strategic orientation towards SDGs and economic performance of organizations, such as the research of Khan et al. (2022) which indicates that orientation towards environmental SDGs, positively influence the economic performance, which also points to the negative correlation within social SDGs. Further, a positive correlation is observed between environmental performance and economic performance by researches of Ducassy (2013), and King and Lenox (2002). On the other hand, the research of Lassala et al. (2021) identifies a negative relationship between strategic alignment towards SDGs and return on equity in the publicly-listed Spanish company context.

On the other hand, our findings do not point to any significant relationship within DT and IT construct, even at the indicator-level, even the research of Ndei and Ngugi (2022) points to a positive correlation between DT adoption and economic performance of DSs, and the research of Shah et al. (2024) points to a positive and significant influence of digital capability, digital orientation and digital transformation on economic performance of DSs. In this respect, the researches of Bai et al. (2024), and Pham et al. (2025) also point to a positive relation between DT adoption and economic performance of startups, and the research of Mabenge et al. (2020) also points to a correlation between DT adoption and economic performance of SMEs (Mabenge et al. 2020), but as mentioned, our findings do not point to any significant paths within DT and IT construct. In our words, the lack of the indicator level, and construct level insignificance of the DT and IT construct, may be a result of the sample size limitations.

6.1 Theoretical Implications

While DSSs are accepted as critical figures for sustianability, research is limited within the field. Further, we believe that the influence of strategical orientation towards SDGs on economic performance of DSSs is a ciritical point to be illuminated. In that respect, our findings aim to enrich the academic discourse by adressing valuable research questions which require a complex analytical framework. Strategic orientation towards SDGs, as a competitive advantage, which relates to access to funding within the European DSSs context. Further, our research also offers insights into the theoretical intersections of digital technological innovation, sustainability, entrepreneurship, and digital sustainable entrepreneurship. Our approach not only identifies the existing knowledge but also discovers the gaps, empowering further theoretical advancements and interdisciplinary studies within the field of research.

6.2 Practical Implications

From the practical perspective, our findings bring actionable insights valuable guidance for policymakers, entrepreneurs, and other actors and stakeholders within the field of DSE, which enables stakeholders with clues and recommendations that foster the concept and the practice of DSE through environmental, social, and economic sustainability and the SDGs.

Moreover, this research also serves as a map for the entrepreneurs who aim to deliver value propositions directed towards the SDGs. Additionally, our empirical analysis provides an overview of influential research and emerging trends within the field of DSE, which also enables practitioners to leverage the most impactful knowledge resources.

6.3 Policy Analysis

This thesis research directly aligns with the SDGs, and with the TT Agenda as it focuses directly on digital sustainable startups which intersect the orientation towards sustainability, innovation capabilities, and employment of digital technologies, which also enables both green and digital dimensions. In this respect, our analysis examines the influence of strategic orientation towards SDGs, digital technology and innovation type adoption, and the regional economic context (NUTS2-level GDP), on the economic performance as total funding amount (TFA) of European DSSs. In this respect, our results illuminate how sustainability-oriented entrepreneurial strategies result in financial outcomes, within the European DSSs context, which are identified as a key-actors throughout the achievement of the sustainability objectives.

In this respect, among the ten operationalized SDG factor clusters, SUINRC (Sustainable Industries and Responsible Consumption) which covers SDG9 (Industry, Innovation and Infrastructure) and SDG12 (Responsible Consumption and Production), and HAREC which covers SDG3 (Good Health and Well-being) and SDG11 (Sustainable Cities and Communities) is observed to demonstrate statistical significance, even considering the limited sample size. Reflecting the entrepreneurial focus on (1) sustainable industrial transformation and resource efficiency, the European DSSs which strategically orient towards SDG9 (Industry and Infrastructure), or SDG12 (Responsible Consumption and Production) (SUINRC), and (2) European DSSs which direct value propositions towards social welfare, quality of life and urban resilience, and strategically orient towards SDG3 (Good Health and Well-being) and SDG11 (Sustainable Cities and Communities) (HAREC). From the policy perspective, our findings suggest that DSSs which promote social, industrial, and community-level impact, and strategically align with realization of sustainable industrial transformation, or resource efficiency, or sustainable urbanization, or public health-oriented value propositions, and direct value propositions towards SDG3, SDG9, SDG11 or SDG12, should be recognized as long-term strategic assets, and should be integrated into policy initiatives, and funding mechanisms. In this respect, it is alos observed that, two SDGs from the economic pillar (SDG3, and SDG9), one SDG from the environmental pillar (SDG12), and one SDG from the social pillar (SDG11) are observed to be policy-relevant, as they provide a stronger translation into organizational-level funding-related outcomes within the context of European DSSs.

On the other hand, NUTS2-level regional GDP conditions, is also observed to influence the extent to which SDG-oriented strategies translate into funding outcomes within the European DSSs context, as the influence of SDG on TFA is moderated at high level, and even at mean level GDP. Enabling a spatial data dimension to our analysis on digital sustainable entrepreneurship, this result also points that the regions with stronger economic GDP levels, are better positioned at providing complementary assets, such as access to funding finance. From a policy perspective, this also highlights the risk of spatially uniform entrepreneurship and sustainability policies which are regional, rather than national or EU-level. In this respect, Consequently, our findings suggest that EU-based sustainability-oriented digital startups also require regional, and differentiated policy approaches, while regional sustainability and innovation ecosystems should also be strengthened together with funding mechanisms, to support entrepreneurial conditions of European DSSs.

Consequently, our results indicate that, achievement of the SDGs and the objectives of the TT Agenda, requires a shift towards an SDG-based or SDG-cluster-based governance, which are embedded within regional policy design.

6.4 Limitations

The relatively limited sample size may have resulted in the statistical power of this research, On the other hand, conducting comprehensive research on available datasources, we consider the employed organizational-level dataset as the most accurate and comprehensive representation of the target population, which also provides the largest sample size.

Aiming to analyze the influence of the ecosystems effect, no aggarated organizational-level data is found. Consequently, in our definition the entrepreneurial ecosystems effect variable can only be included within a sponsor or a technology development association (such as KOSGEB), which may also narrow the focus of the research. Consequently, our research operationalizes NUTS2-level GDP data as a reflection of this effect.

Also, SDG17 is (Partnership for Goals) is excluded from our analysis, as the SDG-specific search queries of Scival, Elsevier Data Repository (Jayabalasingham et al. 2019) does not cover SDG-specific search query for SDG17 (Partnerships for the Goals).

Some aspects of the available data and measurement within this study should be considered when interpreting the results. In this respect, descriptive statistics reveals extreme values within skewness and kurtosis for several indicators (BICW, SOWEJ, PGSI3D). Further, PLS-SEM as a non-parametric method, which does not require normalty, these extreme points may have influenced the precision of some path estimates. As mentioned, the reflective models (Model 2 and Model 4) result in insignificant indicators, and the distinction between SDG and DT and IT is less clear as a result of HTMT results, while explained variance within TFA indicates that other factors also influence explanation of the variance.

6.5 Future Research

The thesis also introduces a main research framework which connects strategic orientation towards SDGs, digital technology and innovation type adoption, and regional GDP, with TFA that represents the economic outcome definition of Cohen et al. (2008) in the European DSS context, which was not previously explored. This unique positioning underscores the originality of our study and its capacity to serve as a foundation for future research and practice in the rapidly evolving field of digital sustainable entrepreneurship.

Future research may conduct the relational content analysis on DSSs, and within the research on DSE, to determine the patterns and intersections within the orientation towards SDGs, and DT adoption within the sampled observations, rather than the conceptual content analysis. Moreover, a relational content analysis within SE research and practice can be conducted, to identify the differences and similarities within the field of DSE. As in the other suggestions which consider the main research model.

Further, research can also address the given data limitations, by operationalizing larger, and/or more diverse samples, which may also address the lack of out-of-sample predictive power, and increase the generalizability of the research.

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APPENDICES

Appendix A. Model 2 - PLS-SEM Results

Appendix B. Model 3 - PLS-SEM Results

Appendix C. Model 4 - PLS-SEM Results

Appendix D. Rotated Component Matrix of SDG, and DT and IT Constructs

Appendix E. Correlation Matrix

Appendix F. SDG-orientation Comparison Between European DSSs, DSE Research, and Whole SDG-related Literature

Appendix G. Pillar-orientation Comparison Between European DSSs, DSS Research, and Whole SDG-related Literature

Appendix H. Digital Technology Preferences Comparison Between of European DSSs and DSS Research Geographical Distribution Comparison within European DSSs and Research on DSS.

Appendix I. Geographical Distribution Comparison within European DSSs and Research on DSS.

APPENDIX A: Model 2 - PLS-SEM Results

This section includes the analysis and the results of the PLS-SEM testing within the second model (Model 2) of this thesis study, which is reflective, and which considers SDG-orientation as the independent variable, GDP as the moderating variable, DT and IT adoption as mediating variables, and TFA as dependent variable as represented in Figure A.1, considering the same dataset. In this respect, this analysis proposes a change in the TFA of the European DSSs in parallel to their SDG-orientation. Considering SDG, and DT and IT as reflective constructs, this research model also uses a 90% CI and bootstrapping procedure with 50.000 subsamples to ensure the robustness of the results, and also follows the guidelines of Hair et al. (2019).

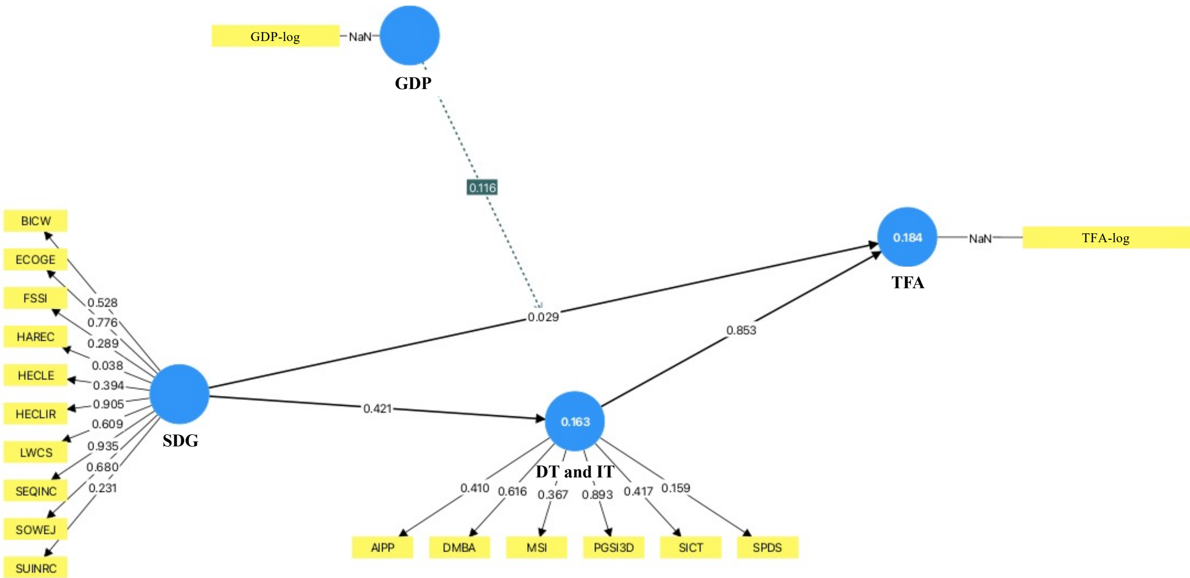

Figure A.1 : Model 2 - measurement model and structural model.

Assessment of the measurement model

Outer loadings results are used to test the indicator reliability within the reflective model. In this respect, HAREC ($\beta = 0.817$, $t = 2.076$, $p = 0.038$) appears to be the only indicator which significantly explains SDG construct as represent in Table A.1. Further, none of the indicators significantly reflectt DT and IT construct. On the other hand, CI values of all indicators, which also cover HAREC, are observed to include zero (0). Additionally, the fixed results within GDP (1.000) and TFA (1.000) are not subject to statistical testing, as these constructs are specified as single-indicator constructs (Hair et al. 2019). Consequently, outer loading results suggests that indicator-level support is absent, and indicator reliability is not achieved within Model 2 (Hair et al. 2019). In this respect, the standard practice suggests removal of the indicators with low loadings to improve the model. On the other hand, removal of insignificant indicators, eliminate all of the indicators within SDG and DT and IT constructs, and make the reflective model untenable. Consequently, we acknowledge the limited adequacy of the model, but the analysis is continued to enable comparative assessment with the other models.

Table A.1 : Outer loadings results.

	β	*t*-value	*p*-value	5.0%	95.0%
SDG					
BICW -> SDG	-0,253	0,631	0,528	-0,625	0,652
ECOGE -> SDG	-0,067	0,285	0,776	-0,393	0,370
FSSI -> SDG	0,232	1,061	0,289	-0,188	0,534
HAREC -> SDG	0,817	2,076	0,038	-0,532	0,867
HECLE -> SDG	-0,247	0,853	0,394	-0,655	0,291
HECLIR -> SDG	-0,029	0,120	0,905	-0,354	0,444
LWCS -> SDG	0,116	0,512	0,609	-0,328	0,435
SEQINC -> SDG	-0,020	0,082	0,935	-0,383	0,411
SOWEJ -> SDG	-0,072	0,412	0,680	-0,275	0,316
SUINRC -> SDG	0,359	1,198	0,231	-0,269	0,742
DT and IT					
AIPP -> DT and IT	0,309	0,824	0,410	-0,540	0,672
DMBA -> DT and IT	0,180	0,502	0,616	-0,497	0,690
MSI -> DT and IT	-0,500	0,902	0,367	-0,781	0,847
PGSI3D -> DT and IT	-0,036	0,134	0,893	-0,327	0,589
SICT -> DT and IT	0,331	0,811	0,417	-0,615	0,706
SPDS -> DT and IT	-0,716	1,410	0,159	-0,786	0,878
GDP					
GDP x SDG -> GDP x SDG	1,000	n/a	n/a	1,000	1,000
GDP_log <- GDP	1,000	n/a	n/a	1,000	1,000
TFA-log <- TFA	1,000	n/a	n/a	1,000	1,000

Further, Croncbach's alpha (α), rho_A (ρA), rho_C (ρC), and average variance extracted (AVE) results are employed to assess the internal reliability and convergent validity of the reflective constructs. In this respect, SDG (ρC = 0.072, AVE = 0.100), and DT and IT (ρC = 0.036, AVE = 0.167) constructs are observed to represent low composite reliability, and low convergent validity, which are below the expected thresholds as identified by Hair et al. (2019) (ρC: ≥ 0.70, AVE: ≥ 0.50). On the other hand, GDP and TFA, as single-indicator constructs, both reflect a perfect level of internal consistency (Cronbach's α = 1.000, ρA = 1.000, ρC = 1.000, AVE = 1.000), as a result of their model specifications. Consequently, the results indicate that convergent validity is weak, and internal consistency could not be established within the multi-item constructs in this model (Hair et al. 2019).

Table A.2 : Internal consistency and convergent validity results.

	Cronbach's α	ρA	ρC	AVE
GDP	1.000	1.000	1.000	1.000
TFA	1.000	1.000	1.000	1.000
SDG	n/a	n/a	0.072	0.100
DT and IT	n/a	n/a	0.036	0.167

On the other hand, heterotrait-monotrait ratio (HTMT) results point to establishment of discriminant validity within all paths, excluding the relationship between DT and IT and SDG, which represents a HTMT value (1,421) above the 0.85 conservative threshold, and CI values (5% = 1.041, 95% = 1.884) which include one (1), that points to a lack of discriminant validity, and substantial conceptual overlap between SDG, and DT and IT constructs. Overall, HTMT results indicate an acceptable discriminant validity within majority of the paths among the construct as identified by Henseler et al. (2015).

Table A.3 : Discriminant validity - HTMT ratios.

	HTMT	5.0%	95.0%
SDG <-> TFA	0,466	0,335	0,603
SDG <-> GDP	0,344	0,222	0,478
TFA <-> GDP	0,110	0,011	0,241
DT and IT <-> GDP	0,398	0,222	0,600
DT and IT <-> TFA	0,417	0,225	0,640
DT and IT <-> SDG	1,421	1,041	1,884

Assessment of the structural model

Inner VIF values, path coefficients, and effect sizes (f^2) are employed to assess the structural model. In this respect, no multicollinearity issues are observed as all VIF vales are lower than the threshold values of 3.3 or 5 (Hair et al. 2019) as represented in Table A.4.

Table A.4 : Collinearity statistics (VIF) inner model.

	VIF
SDG -> TFA	1,245
SDG -> DT and IT	1,000
GDP -> TFA	1,038
GDP x SDG -> TFA	1,020
DT and IT -> TFA	1,216

Further, the results of the path analysis indicate to a positive and significant effect of SDG on TFA (β = 0.385, t = 2.181, p = 0.029), but CI values of this path barely includes zero [-0.006, 0.563], which indicates to a marginal bur acceptable significance (Hair et al. 2019). On the other hand, none of the other paths are observed to be significant. In this respect, GDP (β = 0.024, t = 0.272, p = 0.785), and DT and IT (β = 0.032, t = 0.186, p = 0.853) reflect negligible direct effects on TFA, which are insignificant. Further, moderated by GDP, the path from SDG to TFA reflects positive effect, but this path is also insignificant (β = 0.203, t = 1.573, p = 0.116). Also, the negative effect of SDG on DT and IT is also observed to be insignificant (β = -0.404, t = 0.805, p = 0.421). Consequently, SDG to TFA is the only path which is marginally significant, which also reflects a limited direct effect.

Table A.5 : Structural model results.

	β	SD	*t*-value	*p*-value	5.0%	95.0%
GDP -> TFA	0,024	0,087	0,272	0,785	-0,094	0,193
GDP x SDG -> TFA	0,203	0,129	1,573	0,116	-0,073	0,343
SDG -> TFA	0,385	0,177	2,181	0,029	-0,006	0,563
SDG -> DT and IT	-0,404	0,502	0,805	0,421	-0,617	0,629
DT and IT -> TFA	0,032	0,174	0,186	0,853	-0,293	0,273

On the other hand, conditional direct effects results indicate that the positive effect of SDG on TFA is significant at high GDP level (+1 SD: β = 0.588, t = 2.467, p = 0.014). On the other hand, at mean GDP level, the effect also appears to be statistically significant (Mean: β = 0.385, t = 2.181, p = 0.029), but CI values [-0.006, 0.673] include zero (0). On the other hand, it is also observed that the positive effect of SDG on TFA is insignificant at low GDP level (-1 SD: β = 0.183, t = 0.926, p =

0.355). Consequently, our results indicate that, effect of SDG on TFA is contingent to GDP levels, as in Model 1, but the conditional direct effects of GDP is statistically significant only at high GDP level.

Table A.6 : Conditional direct effects results.

	β	SD	*t*-value	*p*-value	5.0%	95.0%
SDG -> TFA GDP at +1 SD	**0,588**	**0,238**	**2,467**	**0,014**	**0,020**	**0,774**
SDG -> TFA GDP at Mean	0,385	0,177	2,181	0,029	-0,006	0,563
SDG -> TFA GDP at -1 SD	0,183	0,197	0,926	0,355	-0,139	0,508

Effect sizes (f^2) of Model 2 indicate that SDG has a marginally medium effect on TFA (f^2 = 0.146), and medium effect on DT and IT (f^2 = 0.195) (Cohen, 1988), which confirms the contribution of SDG in explaining the variance within these constructs. On the other hand, the effect sizes of GDP (f^2 = 0.001), and DT and IT (f^2 = 0.001) on TFA are observed to be negligible. Further, a small effect size is identified within the moderation effect of GDP on the path from SDG to TFA (f^2 = 0.039). Overall, a medium effect size is observed, and SDG is observed as the primary construct in terms of effect sizes (Cohen, 1988).

Table A.7 : Effect sizes (f^2) results.

	f^2
SDG -> TFA	0,146
SDG -> DT and IT	0,195
GDP -> TFA	0,001
GDP x SDG -> TFA	0,039
DT and IT -> TFA	0,001

R^2 and adjusted R^2 values are employed to assess the explanatory power of the structural model. In this respect, our findings show that the model explains a weak proportion of variance (Hair et al. 2019), within the endogenous constructs which include TFA (R^2 = 0.184), and DT and IT (R^2 = 0.163). Further, the explanatory power of TFA (Adj. R^2 = 0.150), and DT and IT (Adj. R^2 = 0.155) is observed to be weak (Hair et al. 2019). Also, no inflation is observed by the inclusion of the constructs (TFA, and DT and IT), as a result of the small differences between R^2 and adjusted R^2 values, which points to the stable explanatory power within the structural model (Hair et al. 2019).

Table A.8 : Coefficient of determination (R^2 and Adj. R^2) results.

	R^2	Adj. R^2
TFA	0,184	0,150
DT and IT	0,163	0,155

Also, specific indirect effects, total indirect effects, and total effects results are employed. The results indicate that specific indirect effect of SDG on TFA within the mediating effect of DT and IT is insignificant (β = -0.013, t = 0.151, p = 0.880), which suggests that DT and IT does not mediate the relationship between SDG and TFA. Further, total indirect effect of SDG on TFA is also insignificant (β = -0.013, t = 0.151, p = 0.880). On the other hand, the total effect of SDG on TFA is observed to be positive and significant (β = 0.372, t = 2.323, p = 0.020), which indicates that SDG exhibits a meaningful overall impact on TFA. Further, the moderating effect of GDP within the path from SDG to TFA, and all the other paths within this model are observed to be insignificant.

Table A.9 : Specific indirect, total indirect, and total effects results.

	β	SD	*t*-value	*p*-value	5.0%	95.0%
Specific Indirect Effects						
SDG -> DT and IT -> TFA	-0,013	0,087	0,151	0,880	-0,145	0,139
Total indirect effects						
SDG -> TFA	-0,013	0,087	0,151	0,880	-0,145	0,139
Total effects						
SDG -> TFA	**0,372**	**0,160**	**2,323**	**0,020**	**0,054**	**0,543**
SDG -> DT and IT	-0,404	0,502	0,805	0,421	-0,617	0,629
DT and IT -> TFA	0,032	0,174	0,186	0,853	-0,293	0,273
GDP -> TFA	0,024	0,087	0,272	0,785	-0,094	0,193
GDP x SDG -> TFA	0,203	0,129	1,573	0,116	-0,073	0,343

Model fit assessment

Considering the reflective nature of this research model, both SRMR, d_ULS, and d_G values are tested within the assessment of the model fit for both estimated and saturated models. In this respect, SRMR values both for estimated model (0.084) and saturated model (0.084) are observed to be below 95% and 99% bootstrap thresholds, which also remain below the threshold value of 0.10, as identified by Hair et al. (2019). Further, d_ULS, and d_G values within the estimated model (1.198, 0.231) and saturated model (1.198, 0.231) are also observed to be lower than the 95% and

99% bootstrap thresholds within both estimated and saturated models. Consequently, this reflective model demonstrates an acceptable level of model fit, but the result should be interpreted with caution as a result of the previously identified measurement-related limitations (Hair et al. 2019).

Table A.10 : PLS-SEM model fit results.

	SRMR	95%	99%	d_ULS	95%	99%	d_G	95%	99%
Estimated model	0,084	0,115	0,122	1,198	2,254	2,564	0,231	0,609	0,728
Saturated model	0,084	0,114	0,122	1,198	2,238	2,545	0,231	0,606	0,722

APPENDIX B: Model 3 - PLS-SEM Results

This section includes the analysis and the results of the PLS-SEM testing of Model 3, which considers NUTS-2 level regional GDP within the headquarters of the European DSS's as the independent variable, SDG, and DT and IT as mediating variables, and TFA as the dependent variable, as represented in Figure B.1, considering the same dataset. In this respect, this analysis proposes a change in the TFA of the European DSSs in parallel to the NUTS-2 level regional GDP. Considering SDG and DT and IT as formative constructs, this analysis also uses a 90% CI and bootstrapping procedure with 50.000 subsamples to ensure the robustness of the results, and also follows the guidelines of Hair et al. (2019), and adopts to the identical analysis approach with Model 1.

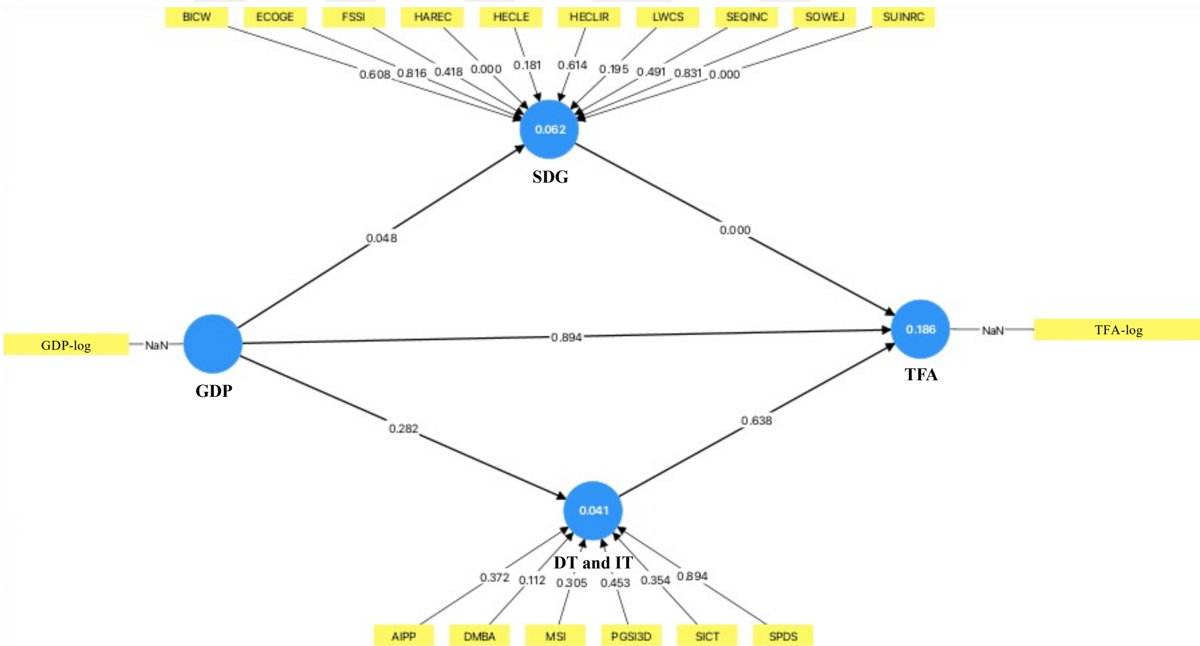

Figure B.1 : Model 3 - measurement model and structural model.

Assessment of the measurement model

VIF values within all indicators are below the threshold values of 3.3 or 5 (Hair & Alamer, 2022), ranging from 1.032 to 1.262 as represented in Table B.1, which reflects the absence of multicollinearity, and the contribution of each SDG, and DT and IT indicator to hold a unique information, which do not overlap with the others.

Table B.1 : Collinearity statistics (VIF) outer model - list.

	VIF
SDG	
BICW	1,144
ECOGE	1,089
FSSI	1,115
HAREC	1,105
HECLE	1,084
HECLIR	1,101
LWCS	1,109
SEQINC	1,251
SOWEJ	1,262
SUINRC	1,131
DT and IT	
AIPP	1,050
DMBA	1,059
MSI	1,035
PGSI3D	1,032
SICT	1,046
SPDS	1,035
GDP	
GDP_log	1,000
GDP x SDG	1,000
TFA-log	1,000

Observing the indicator relevance and outer weights, SUINRC ($\beta = 0.678$) and HAREC ($\beta = 0.608$) indicators within SDG construct, and DMBA (β = 0. 711) indicator within DT and IT construct, appear to reflect significant relative contribution in forming these constructs. On the other hand, only SUINRC (t = 3.868, $p < 0.001$) and HAREC (t = 3.755, $p < 0.001$) indicators represent significance, as their CI values do not include zero (0).

Table B.2 : Outer weights results.

	β	*t*-value	*p*-value	5.0%	95.0%
SDG					
BICW -> SDG	-0,081	0,513	0,608	-0,367	0,169
ECOGE -> SDG	-0,036	0,233	0,816	-0,289	0,225
FSSI -> SDG	0,153	0,810	0,418	-0,172	0,450

Table B.2 (continued) : Outer weights results.

	β	*t*-value	*p*-value	5.0%	95.0%
HAREC -> SDG	**0,608**	**3,755**	**0,001**	**0,292**	**0,794**
HECLE -> SDG	-0,250	1,338	0,181	-0,524	0,074
HECLIR -> SDG	0,094	0,504	0,614	-0,233	0,380
LWCS -> SDG	0,218	1,295	0,195	-0,113	0,438
SEQINC -> SDG	0,141	0,688	0,491	-0,197	0,469
SOWEJ -> SDG	0,038	0,213	0,831	-0,145	0,438
SUINRC -> SDG	**0,678**	**3,868**	**0,001**	**0,304**	**0,830**
DT and IT					
AIPP -> DT and IT	0,305	0,893	0,372	-0,439	0,694
DMBA -> DT and IT	0,711	1,589	0,112	-0,565	0,870
MSI -> DT and IT	0,483	1,026	0,305	-0,573	0,882
PGSI3D -> DT and IT	0,208	0,750	0,453	-0,305	0,625
SICT -> DT and IT	-0,352	0,927	0,354	-0,614	0,640
SPDS -> DT and IT	0,038	0,133	0,894	-0,400	0,532
GDP_log <- GDP	1,000	n/a	n/a	1,000	1,000
TFA-log <- TFA	1,000	n/a	n/a	1,000	1,000

Further, as a supportive analysis, the results of the outer loadings are analyzed, as represented as in Table B.3. In this respect, only SUINRC (β = 0.678, t = 4.186, p < 0.001) and HAREC (β = 0.608, t = 3.631, p < 0.001) indicators are observed to be statistically significant within the outer loadings results, which are also observed to be significant within the results of outer weights. Considering DT and IT construct, only DMBA indicator is observed to be marginally significant (β = 0.711, t = 1.619, p = 0.112) as in the outer weights results (Hair et al. 2019). On the other hand, CI values of all indicators include zero (0), excluding SUINRC (0.304, 0.830), and HAREC (0.289, 0.225), which results in insignificance within the relative contribution of the majority of the indicators in forming the construct. On the other hand, the single-item constructs (GDP, and TFA) display weights of 1.000 with non-applicable significance tests, which is methodologically expected (Hair et al. 2019).

Table B.3 : Outer loadings results.

	β	*t*-value	*p*-value	5.0%	95.0%
SDG					
BICW -> SDG	-0,081	0,526	0,599	-0,215	0,284
ECOGE -> SDG	-0,036	0,214	0,830	-0,309	0,252
FSSI -> SDG	0,153	0,835	0,403	-0,174	0,427
HAREC -> SDG	**0,608**	**3,631**	**0,001**	**0,266**	**0,785**
HECLE -> SDG	-0,250	1,268	0,205	-0,535	0,103

Table B.3 (continued) : Outer loadings results.

	β	*t*-value	*p*-value	5.0%	95.0%
HECLIR -> SDG	0,094	0,499	0,618	-0,232	0,388
LWCS -> SDG	0,218	1,278	0,201	-0,114	0,445
SEQINC -> SDG	0,141	0,889	0,374	-0,149	0,370
SOWEJ -> SDG	0,038	0,363	0,716	-0,080	0,246
SUINRC -> SDG	**0,678**	**4,186**	**0,001**	**0,319**	**0,800**
DT and IT					
AIPP -> DT and IT	0,305	0,900	0,368	-0,428	0,693
DMBA -> DT and IT	0,711	1,619	0,105	-0,558	0,855
MSI -> DT and IT	0,483	1,029	0,304	-0,571	0,875
PGSI3D -> DT and IT	0,208	0,726	0,468	-0,295	0,662
SICT -> DT and IT	-0,352	0,941	0,347	-0,602	0,633
SPDS -> DT and IT	0,038	0,133	0,894	-0,400	0,532
GDP_log <- GDP	1,000	n/a	n/a	1,000	1,000
TFA-log <- TFA	1,000	n/a	n/a	1,000	1,000

As mentioned within the definition of Model 1, removal of an indicator also results in essential changes in the definition of the construct and the definition of the indicator itself, as a result of the formative measurement model. Consequently, all indicators are kept in the model, as they can still be theoretically necessary to cover the scope of the research framework, which is also required to preserve the conceptual completeness of each construct, as in the definition of Hair et al. (2019).

Assessment of the structural model

The structural model results of the third model, which is formative, indicate that all inner VIF values are below the threshold values of 3.3 or 5 (Hair & Alamer, 2022), ranging from 1. 000 to 1.067 as represented in Table B.4, which reflects that multicollinearity does not bias the estimation of path coefficients within the constructs.

Table B.4 : Inner VIF results.

	VIF (Inner)
SDG -> TFA	1,067
GDP -> TFA	1,106
GDP -> SDG	1,000
GDP -> DT and IT	1,000
DT and IT -> TFA	1,043

Within the hypothesis testing results, the direct effect of SDG is observed to represent a positive and statistically significant effect on TFA (β = 0.425, t = 3.946, p < 0.001). Further, GDP is also observed to reflect a positive and statistically significant effect on TFA (β = 0.249, t = 1.975, p = 0.048). On the other hand, none of the other paths are observed to be statistically significant within Model 3.

Table B.5 : Path analysis and collinearity statistics (VIF).

	β	t-value	p-value	5.0%	95.0%
SDG -> TFA	**0,425**	**3,946**	**0,001**	**0,294**	**0,602**
GDP -> TFA	0,012	0,134	0,894	-0,172	0,13
GDP -> SDG	**0,249**	**1,975**	**0,048**	**0,074**	**0,46**
GDP -> DT and IT	0,202	1,075	0,282	-0,214	0,407
DT and IT -> TFA	-0,099	0,47	0,638	-0,337	0,314

R^2 and adjusted R^2 values are also employed to assess the explanatory power of the structural model. In this respect, 18.6% of the variance in TFA is observed to be explained, which points to a weak explanatory power within this model (Hair et al. 2019). On the other hand, limited levels of variance is observed to be explained within SDG (%6.2), and DT and IT (%4.1) constructs. Further, the explanatory power of TFA is also observed to be weak (Adj. R^2 = 0.161), while the explanatory power of SDG (Adj. R^2 = 0.053), and DT and IT (Adj. R^2 = 0.031) are limited, as in the definition of Hair et al. (2019). Also, no inflation is observed by the inclusion of the constructs (TFA, SDG, and DT and IT), as a result of the small differences between R^2 and adjusted R^2 values, which also pointw to the stable explanatory power of the structural model (Hair et al. 2019).

Table B.6 : Explained variance of endogenous constructs.

	R^2	Adj. R^2
TFA	**0.186**	**0.161**
SDG	0.062	0.053
DT and IT	0.041	0.031

We also assessed effect sizes (f^2) as a complementary to R^2 findings to identify the relative contribution of each construct towards the dependent constructs, as in Model 1. In this respect, medium effect size is observed within the path from SDG to TFA (Cohen, 1988), which is marginally significant (β = 0.208, t = 1,576, p = 0.115). On the other hand, none of the other paths, which also covers the path from GDP to

TFA, are observed to be statistically significant. Further, the effect size of GDP on TFA is practically observed as zero (β = 0), which suggests no meaningful explanatory contribution within this path(Hair et al. 2019), as represented in Table B.7.

Table B.7 : Effect sizes (f^2) results.

	β	*t*-value	*p*-value
GDP -> TFA	0,001	0,011	0,991
GDP -> SDG	0,066	0,792	0,429
GDP -> DT and IT	0,043	0,629	0,529
SDG -> TFA	0,208	1,576	0,115
DT and IT -> TFA	0,012	0,187	0,852

Analyzing the specific indirect, total, and total indirect effects, the mediating effect of SDG within the path from GDP to TFA is observed to be positive and significant (β = 0.106, t =1.758, p = 0.079). Also, the total effect of GDP on SDG is observed to be positive and significant (β = 0.249, t =1.975, p = 0.048), as the total effect within the path from SDG towards TFA (β = 0.425, t = 3.946, p < 0.001). On the other hand, none of the other paths are observed to be statistically significant. Consequently, SDG is observed to act as the primary influencer within Model 3.

Table B.8 : Specific indirect, total indirect, and total effects results.

	β	*t*-value	*p*-value	5.0%	95.0%
Specific Indirect Effects					
GDP -> DT and IT -> TFA	-0,020	0,474	0,635	-0,077	0,058
GDP -> SDG -> TFA	**0,106**	**1,758**	**0,079**	**0,033**	**0,226**
Total Indirect Effects					
GDP -> TFA	0,086	1,152	0,249	-0,001	0,239
Total Effects					
GDP -> TFA	0,098	1,137	0,255	-0,043	0,242
GDP -> SDG	**0,249**	**1,975**	**0,048**	**0,074**	**0,460**
GDP -> DT and IT	0,202	1,075	0,282	-0,214	0,407
SDG -> TFA	**0,425**	**3,946**	**0,001**	**0,294**	**0,602**
DT and IT -> TFA	-0,099	0,470	0,638	-0,337	0,314

Model fit assessment

SRMR results of the estimated model (0.063), and the saturated model (0.063) are both observed to be below the threshold value (0.08) (Hair & Alamer, 2022). Further, SRMR value within the estimated model (0.063) is also below the 95% (0.077) and 99% (0.083) bootstrap upper thresholds. Similarly, SRMR value within the saturated model (0.063) is also below the 95% (0.076) and 99% (0.083) bootstrap upper thresholds as identified by Henseler et al. (2015). Further, d_ULS and d_G values are also observed to be below the 95%, and 99% bootstrap upper thresholds, within both estimated model and saturated model results, which point to a good level of model fit (Hair et al. 2019).

Table B.9 : Model fit indices.

	SRMR	95%	99%	d_ULS	95%	99%	d_G	95%	99%
Estimated model	0,063	0,077	0,083	0,683	1,016	1,189	0,149	0,327	0,401
Saturated model	0,063	0,076	0,083	0,682	0,993	1,165	0,149	0,321	0,393

APPENDIX C: Model 4 - PLS-SEM Results

This section includes the analysis and the results of the PLS-SEM testing within the Model 4, which adopts to the reflective measurement model, and considers GDP as independent variable, SDG, and DT and IT adoption as mediating variables, and TFA as dependent variable as represented in Figure C.1, considering the same dataset. In this respect, this analysis proposes a change in the TFA of the European DSSs in parallel to observed NUTS2-level regional GDP values. Considering SDG, and DT and IT as reflective constructs, this research model also uses a 90% CI and bootstrapping procedure with 50.000 subsamples to ensure the robustness of the results, and also follows the guidelines of Hair et al. (2019), and conducts the identical analysis approach with Model 2.

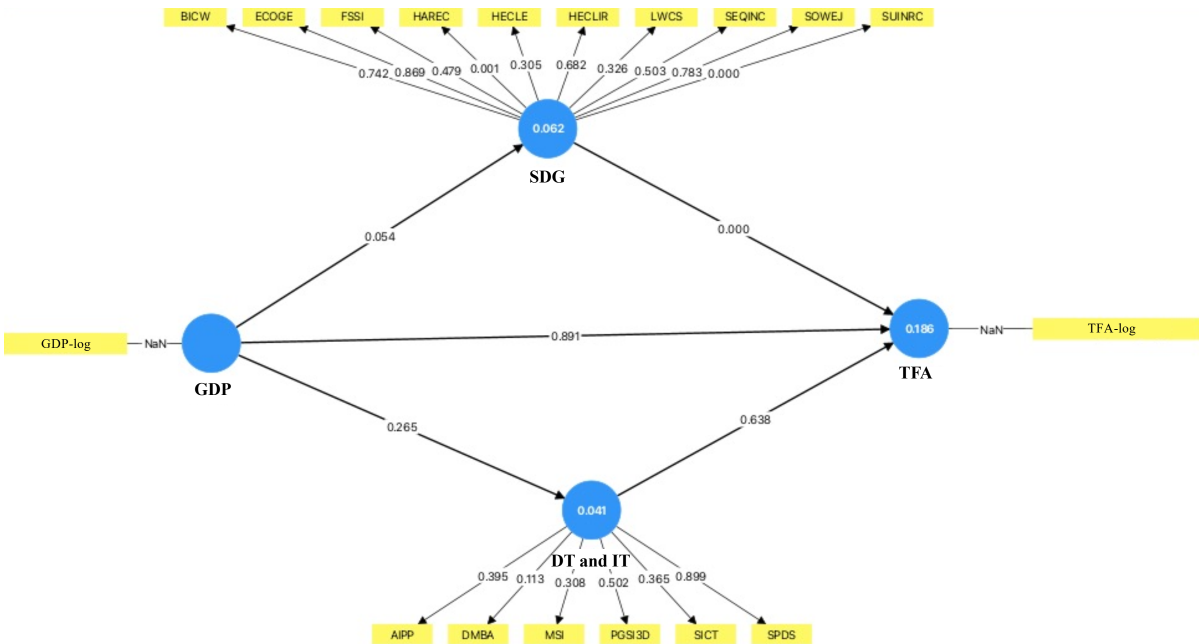

Figure C.1 : Model 4 - Measurement model and structural model.

Assessment of the measurement model

Outer loadings results are employed to test the indicator reliability. Consequently, SUINRC (β = 0.678, t = 3.498, $p < 0.001$), and HAREC (β = 0.608, t = 3.207, p = 0.001) are observed to significantly reflect SDG construct, as represented in Table C.1. Further, none of the indicators are observed to significantly explain DT and IT construct. On the other hand, excluding SUINRC and HAREC, CI values of all indicators include zero (0). Additionally, the fixed result (1.000) within the GDP and TFA are not subject to statistical testing, as these constructs are specified as single-indicator constructs (Hair et al. 2019). The results of the outer loadings indicate that SDG construct reflects limited indicator reliability as only SUINRC and HAREC indicators present statistically significant outer loadings. Consequently, majority of the indicators significantly do not explain their target constructs, which suggests limited indicator-level support, and limited indicator reliability within the model (Hair et al. 2019). In this respect, the standard practice suggests removal of the indicators with low loadings to improve the model. On the other hand, removal of insignificant indicators, eliminate majority of the indicators within SDG and DT and IT constructs, and make the reflective model untenable. Consequently, we acknowledge the limited adequacy of the model, but the analysis is continued to enable comparative assessment with the other models.

Table C.1 : Outer loadings results.

	β	*t*-value	*p*-value	5.0%	95.0%
SDG					
BICW -> SDG	-0,081	0,329	0,742	-0,273	0,512
ECOGE -> SDG	-0,036	0,164	0,869	-0,381	0,355
FSSI -> SDG	0,153	0,709	0,479	-0,219	0,486
HAREC -> SDG	**0,608**	**3,207**	**0,001**	**0,205**	**0,792**
HECLE -> SDG	-0,250	1,026	0,305	-0,590	0,213
HECLIR -> SDG	0,094	0,410	0,682	-0,303	0,447
LWCS -> SDG	0,218	0,982	0,326	-0,221	0,503
SEQINC -> SDG	0,141	0,670	0,503	-0,266	0,420
SOWEJ -> SDG	0,038	0,275	0,783	-0,131	0,312
SUINRC -> SDG	**0,678**	**3,498**	**0,001**	**0,247**	**0,809**
DT and IT					
AIPP -> DT and IT	0,305	0,850	0,395	-0,465	0,708
DMBA -> DT and IT	0,711	1,585	0,113	-0,579	0,857
MSI -> DT and IT	0,483	1,020	0,308	-0,574	0,875

Table C.1 (continued) : Outer loadings results.

	β	*t*-value	*p*-value	5.0%	95.0%
PGSI3D -> DT and IT	0,208	0,672	0,502	-0,304	0,702
SICT -> DT and IT	-0,352	0,906	0,365	-0,624	0,648
SPDS -> DT and IT	0,038	0,127	0,899	-0,430	0,554
GDP_log <- GDP	1,000	n/a	n/a	1,000	1,000
TFA-log <- TFA	1,000	n/a	n/a	1,000	1,000

Further, Croncbach's alpha (α), rho_A (ρA), rho_C (ρC), and average variance extracted (AVE) results are employed to assess the internal reliability and convergent validity of the reflective constructs, as in Model 2. In this respect, SDG (ρC = 0.214, AVE = 0.100), and DT and IT (ρC = 0.279, AVE = 0.167) constructs represent low composite reliability, and low convergent validity, which are below the expected thresholds (Hair et al. 2019). On the other hand, GDP and TFA, as single-indicator constructs, both reflect the highest level of internal consistency (Cronbach's α = 1.000, ρA = 1.000, ρC = 1.000, AVE = 1.000) as a result of their model specifications. Consequently, the results indicate that convergent validity is weak, and internal consistency could not be established within the multi-item constructs within Model 4 (Hair et al. 2019), as in Model 2 which also adopts to the reflective measurement model.

Table C.2 : Internal consistency and convergent validity results.

	Cronbach's α	ρA	ρC	AVE
GDP	1,000	1,000	1,000	1,000
TFA	1,000	1,000	1,000	1,000
SDG	n/a	n/a	0,214	0,100
DT and IT	n/a	n/a	0,279	0,167

HTMT results also point to the establishment of discriminant validity within all paths, excluding the relationship between DT and IT and SDG, which represents HTMT value (1,421) above the 0.85 conservative threshold, and CI values [1.041, 1.884] which include one (1), which point to a lack of discriminant validity, and substantial conceptual overlap between DT and IT and SDG constructs. On the other hand, the overall HTMT results indicate an acceptable discriminant validity within majority of the paths among the construct as identified by Henseler et al. (2015).

Table C.3 : Discriminant validity - HTMT ratios results.

	HTMT	5.0%	95.0%
TFA <-> GDP	0,110	0,011	0,241
SDG <-> GDP	0,344	0,222	0,478
SDG <-> TFA	0,466	0,335	0,603
DT and IT <-> GDP	0,398	0,222	0,600
DT and IT <-> TFA	0,417	0,225	0,640
DT and IT <-> SDG	1,421	1,041	1,884

Assessment of the structural model

Inner VIF values, path coefficients, and effect sizes (f^2) are employed to assess the structural model. In this respect, all the VIF values are observed to be below the threshold values of 3.3 or 5, as represented in Table C.4 (Hair et al. 2019), which indicates that no multicollinearity issues are valid within the structural model.

Table C.4 : Collinearity statistics (VIF) inner model results.

	VIF
SDG -> TFA	1,067
GDP -> TFA	1,106
GDP -> SDG	1,000
GDP -> DT and IT	1,000
DT and IT -> TFA	1,043

Further, the results of the path analysis also indicate that SDG construct represents a positive and significant effect on TFA ($\beta = 0.425$, $t = 4.044$, $p < 0.001$) (Hair et al. 2019). Further, GDP construct also represents a marginally significant influence on SDG ($\beta = 0.249$, $t = 1.930$, $p = 0.054$) (Hair et al. 2019). On the other hand, the influence of GDP on TFA ($\beta = 0.012$, $t = 0.136$, $p = 0.891$), and on DT and IT ($\beta = 0.202$, $t = 1.114$, $p = 0.265$) is observed to be insignificant. Further, the path from DT and IT to TFA does not also represent statistical significance ($\beta = -0.099$, $t = 0.471$, $p = 0.638$). Consequently, limited overall contribution is observed within the direct paths within Model 4 (Hair et al. 2019).

Table C.5 : Structural model results.

	β	SD	*t*- value	*p*- value	5.0%	95.0%
SDG -> TFA	**0,425**	**0,105**	**4,044**	**0.001**	**0,278**	**0,571**
GDP -> TFA	0,012	0,091	0,136	0,891	-0,150	0,145
GDP -> SDG	**0,249**	**0,129**	**1,930**	**0,054**	**0,045**	**0,436**

Table C.5 (continued) : Structural Model results.

	β	SD	*t*- value	*p*- value	5.0%	95.0%
GDP -> DT and IT	0,202	0,181	1,114	0,265	-0,192	0,395
DT and IT -> TFA	-0,099	0,210	0,471	0,638	-0,336	0,312

Considering the effect sizes (f^2), SDG is observed to represent medium effect size ($f^2 = 0.208$) on TFA (Cohen, 1988). Further, GDP also reflects small effect sizes both on SDG ($f^2 = 0.066$), and on DT and IT ($f^2 = 0.043$). On the other hand, the path from DT and IT to TFA represents negligible effect size ($f^2 = 0.012$), while the path from GDP to TFA shows no effect size ($f^2 = 0.000$). Consequently, Model 4 is observed to reflect a small medium overall effect size (Cohen, 1988).

Table C.6 : Effect sizes (f^2) results.

	f^2
SDG -> TFA	0,208
GDP -> TFA	0,000
GDP -> SDG	0,066
GDP -> DT and IT	0,043
DT and IT -> TFA	0,012

Further, R^2 and adjusted R^2 values are also employed to assess the explanatory power of the structural model. In this respect, 18,6% of total variance in TFA, 6.2% of total variance in SDG, and 4.1% of variance is observed to be explained within TFA construct, which represents a weak proportion of explanation within the variance of the endogenous constructs as represented in Table C7. On the other hand, adjusted R^2 values (0.161, 0.053, 0.031) also point to a weak or limited explanatory power within this model as in the definition of Hair et al. (2019). Also, no inflation is observed by the inclusion of the constructs (TFA, SDG, and DT and IT), as a result of the small differences between R^2 and adjusted R^2 values, which also points to the stable explanatory power within the structural model (Hair et al. 2019).

Table C.7 : Explained variance of endogenous constructs (R^2 and adj. R^2).

	R^2	Adj. R^2
TFA	0,186	0,161
SDG	0,062	0,053
DT and IT	0,041	0,031

Testing the specific indirect, total indirect, and total effects, positive specific indirect effect of GDP is observed to be positive and significant within the path from SDG to TFA (β = 0.106, *t* = 1.846, *p* = 0.065). Further, the positive total effect of GDP on SDG (β = 0.249, *t* = 1.930, *p* = 0.054), and the positive total effect of SDG on TFA (β = -0.020, *t* = 4.044, *p* = 0.001) are observed to be significant. On the other hand, the negative specific indirect effect of DT and IT within the path from GDP to TFA is also observed to be insignificant (β = -0.020, *t* = 0.486, *p* = 0.627), which suggests that DT and IT does not mediate this relationship. Also, none of the other paths within total indirect and total effects are observed to be significant. Consequently, SDG is observed to be central construct within the indirect and total effects within Model 4.

Table C.8 : Specific indirect, total indirect, and total effects results.

	β	SD	*t*-value	*p*-value	5.0%	95.0%
Specific Indirect Effects						
GDP -> DT and IT -> TFA	-0,020	0,041	0,486	0,627	-0,078	0,053
GDP -> SDG -> TFA	**0,106**	**0,057**	**1,846**	**0,065**	**0,020**	**0,206**
Total Indirect Effects						
GDP -> TFA	0,086	0,070	1,223	0,222	-0,011	0,214
Total Effects						
GDP -> TFA	0,098	0,087	1,133	0,257	-0,045	0,241
GDP -> SDG	**0,249**	**0,129**	**1,930**	**0,054**	**0,045**	**0,436**
GDP -> DT and IT	0,202	0,181	1,114	0,265	-0,192	0,395
SDG -> TFA	**0,425**	**0,105**	**4,044**	**0,001**	**0,278**	**0,571**
DT and IT -> TFA	-0,099	0,210	0,471	0,638	-0,336	0,312

Model fit assessment

SRMR value of the estimated model (0.088) is observed to be below 95% (0.117) and 99% (0.127) bootstrap upper threshold values. Further, SRMR value of the saturated model (0.088) is also observed to be below 95% (0.116) and 99% (0.126) bootstrap upper threshold values. Further, SMRM both values of the estimated and the saturated models are also observed to be below the threshold (0.10) as defined by Henseler et al. (2015), as represented in Table C.9. Also, d_ULS and d_G values also fall below the 95% and 99% bootstrap upper thresholds, within both estimated and saturated models, which points to an acceptable overall model fit (Hair et al. 2019).

Table C.9 : Model fit indicies.

	SRMR	95%	99%	d_ULS	95%	99%	d_G	95%	99%
Estimated model	0,088	0,117	0,127	1,338	2,337	2,738	0,260	0,639	0,764
Saturated model	0,088	0,116	0,126	1,337	2,313	2,722	0,260	0,637	0,762

APPENDIX D: Rotated Component Matrix of DT and IT, and SDG Constructs

Table D.1 : Rotated component matrix (PCA – Varimax Rotation) of DT and IT construct.

	1	2	3	4	5	6
Tech_4	0,777					
Inn_1	0,712					
Tech_5	-0,625				0,453	
Inn_6		-0,842				
Inn_2		0,806				
Inn_3			0,859			
Tech_6			0,819			
Inn_8				0,788		
Tech_1				-0,657		
Tech_8					-0,841	
Tech_2					0,476	
Inn_5						0,816

Table D.2 : Rotated component matrix (PCA - Varimax Rotation) of SDG construct.

	1	2	3	4	5	6	7	8	9	10
SDG4_Unique_Keywords	0,931									
SDG4_Total_Keywords	0,931									
SDG4	0,898									
SDG4_Any_Keywords	0,898									
SDG1_Unique_Keywords	0,735	0,321	0,324	0,222					-0,229	
SDG1_Keywords	0,734	0,54								
SDG2_Total_Keywords	0,669	0,544						0,329		
SDG3_Total_Keywords	0,653	0,63								
SDG1	0,638		0,527	0,25					-0,22	
SDG1_Any_Keywords	0,638		0,527	0,25					-0,22	
SDG2_Unique_Keywords	0,609	0,292						0,586		
SDG5_Unique_Keywords	0,436	0,818								
SDG10_Unique_Keywords	0,228	0,783	0,251		0,205					
SDG10_Total_Keywords	0,518	0,773								
SDG5		0,742								
SDG5_Any_Keywords		0,742								
SDG5_Total_Keywords	0,6	0,737								
SDG10_Any_Keywords		0,697	0,344		0,208					
SDG10		0,697	0,344		0,208					
SDG16_Unique_Keywords	0,538	0,570		0,403						
SDG16_Total_Keywords	0,543	0,556		0,408						
SDG14_Unique_Keywords			0,942							
SDG14_Total_Keywords			0,940							
SDG15_Unique_Keywords			0,927							
SDG6_Unique_Keywords			0,775						0,585	
SDG15_Total_Keywords			0,570	0,318					0,222	0,2
SDG16_Any_Keywords		0,303		0,764						
SDG16		0,303		0,764						
SDG3				0,690	0,214		-0,339		0,22	
SDG3_Any_Keywords				0,690	0,214		-0,339		0,22	
SDG13_Any_Keywords				0,586		0,487		0,247		
SDG13				0,586		0,487		0,247		
SDG3_Unique_Keywords				0,571			-0,293		0,323	0,26
SDG13_Unique_Keywords			0,265	0,564	0,259	0,472		0,318		
SDG13_Total_Keywords				0,468				0,386		
SDG12_Unique_Keywords				0,295	0,788					
SDG12				0,342	0,756		0,228			
SDG12_Any_Keywords				0,342	0,756		0,228			
SDG9_Total_Keywords		0,219			0,699			0,202		
SDG9_Unique_Keywords					0,696			0,293		0,266
SDG9		0,266			0,692			0,35		0,261
SDG9_Any_Keywords		0,266			0,692			0,35		0,261
SDG12_Total_Keywords					0,620					
SDG7_Unique_Keywords						0,841				
SDG7_Any_Keywords						0,827				
SDG7						0,827				
SDG7_Total_Keywords						0,723				
SDG8_Unique_Keywords							0,925			
SDG8_Any_Keywords							0,897			
SDG8							0,897			
SDG8_Total_Keywords							0,875			
SDG2	0,233							0,815		
SDG2_Any_Keywords	0,233							0,815		
SDG14_Any_Keywords		0,415	0,438					0,453		
SDG14		0,415	0,438					0,453		
SDG6			0,245	0,22					0,832	
SDG6_Any_Keywords			0,245	0,22					0,832	
SDG6_Total_Keywords			0,478						0,563	
SDG11_Total_Keywords		0,23				0,334			0,532	0,381
SDG11_Unique_Keywords		0,213				0,339			0,523	0,44
SDG15										0,854
SDG15_Any_Keywords										0,854
SDG11				0,265	0,206	0,473				0,504
SDG11_Any_Keywords				0,265	0,206	0,473				0,504

APPENDIX E: Correlation Matrix

Table E.1 : Correlation matrix.

	GDP	TFA	SDG_1	SDG_2	SDG_3	SDG_4	SDG_5	SDG_6	SDG_7	SDG_8	SDG_9	SDG_10	DT and IT_1	DT and IT_2	DT and IT_3	DT and IT_4	DT and IT_5	DT and IT_6
GDP	1,000	0,047	-0,039	0,001	-0,057	-0,056	0,234	-0,075	-0,086	-0,023	0,034	0,152	-0,032	-0,082	-0,010	0,019	0,118	-0,148
TFA	0,047	1,000	-0,089	0,243	-0,095	-0,009	0,084	0,164	-0,029	-0,081	0,101	0,218	-0,039	-0,005	-0,064	0,031	-0,238	-0,071
SDG_1	-0,039	-0,089	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,104	-0,117	-0,023	0,021	0,027	0,023
SDG_2	0,001	0,243	0,000	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,040	0,050	-0,038	-0,056	0,037	-0,037
SDG_3	-0,057	-0,095	0,000	0,000	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,035	-0,020	-0,022	0,036	0,030	0,306
SDG_4	-0,056	-0,009	0,000	0,000	0,000	1,000	0,000	0,000	0,000	0,000	0,000	0,000	-0,130	-0,026	-0,152	0,023	0,009	-0,006
SDG_5	0,234	0,084	0,000	0,000	0,000	0,000	1,000	0,000	0,000	0,000	0,000	0,000	-0,111	-0,171	-0,032	-0,065	-0,008	-0,136
SDG_6	-0,075	0,164	0,000	0,000	0,000	0,000	0,000	1,000	0,000	0,000	0,000	0,000	0,129	0,073	0,027	0,215	0,087	-0,019
SDG_7	-0,086	-0,029	0,000	0,000	0,000	0,000	0,000	0,000	1,000	0,000	0,000	0,000	-0,146	0,059	-0,057	0,031	-0,154	0,057
SDG_8	-0,023	-0,081	0,000	0,000	0,000	0,000	0,000	0,000	0,000	1,000	0,000	0,000	0,030	0,150	0,045	-0,007	0,037	-0,085
SDG_9	0,034	0,101	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	1,000	0,000	0,178	-0,088	-0,068	0,010	0,091	0,005
SDG_10	0,152	0,218	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	1,000	0,195	-0,088	0,057	-0,116	-0,063	-0,077
DT and IT_1	-0,032	-0,039	-0,104	-0,040	-0,035	-0,130	-0,111	0,129	-0,146	0,030	0,178	0,195	1,000	0,000	0,000	0,000	0,000	0,000
DT and IT_2	-0,082	-0,005	-0,117	0,050	-0,020	-0,026	-0,171	0,073	0,059	0,150	-0,088	-0,088	0,000	1,000	0,000	0,000	0,000	0,000
DT and IT_3	-0,010	-0,064	-0,023	-0,038	-0,022	-0,152	-0,032	0,027	-0,057	0,045	-0,068	0,057	0,000	0,000	1,000	0,000	0,000	0,000
DT and IT_4	0,019	0,031	0,021	-0,056	0,036	0,023	-0,065	0,215	0,031	-0,007	0,010	-0,116	0,000	0,000	0,000	1,000	0,000	0,000
DT and IT_5	0,118	-0,238	0,027	0,037	0,030	0,009	-0,008	0,087	-0,154	0,037	0,091	-0,063	0,000	0,000	0,000	0,000	1,000	0,000
DT and IT_6	-0,148	-0,071	0,023	-0,037	0,306	-0,006	-0,136	-0,019	0,057	-0,085	0,005	-0,077	0,000	0,000	0,000	0,000	0,000	1,000

APPENDIX F: SDG-orientation Comparison Between European DSSs, DSE Research, and Whole SDG-related Literature

Considering the results of the bibliometric research (Demirel & Yıldırım, 2025), there are similarities and differences are observed within the SDG-orientation of (1) academic research on DSSs, (2) whole SDG-related literature, and (3) the European DSSs as represented in Figure F.1. In this respect, DSS literature represents the most balanced distribution within SDG-orientation. Further orentation towards SDG3 (Good Health and Well-Being) dominates both the DSS literature (12.88%) and the whole SDG-related literature (73.64%), while only the 4.95% of the European DSSs engage with SDG3 (Good Health and Well-Being). Conversely, SDG15 (Life on Land), SDG13 (Climate Action), and SDG7 (Affordable and Clean Energy), which are moderately represented within the DSS literature and the whole SDG-related literature, respectively dominate the practice within the context of the European DSSs, which also highlights the gap between the conceptual emphasis and the practice. On the other hand, all SDGs are represented by the DSS literature, and by the whole SDG-related literature, but six separate SDGs are not observed to be presented by the European DSSs.

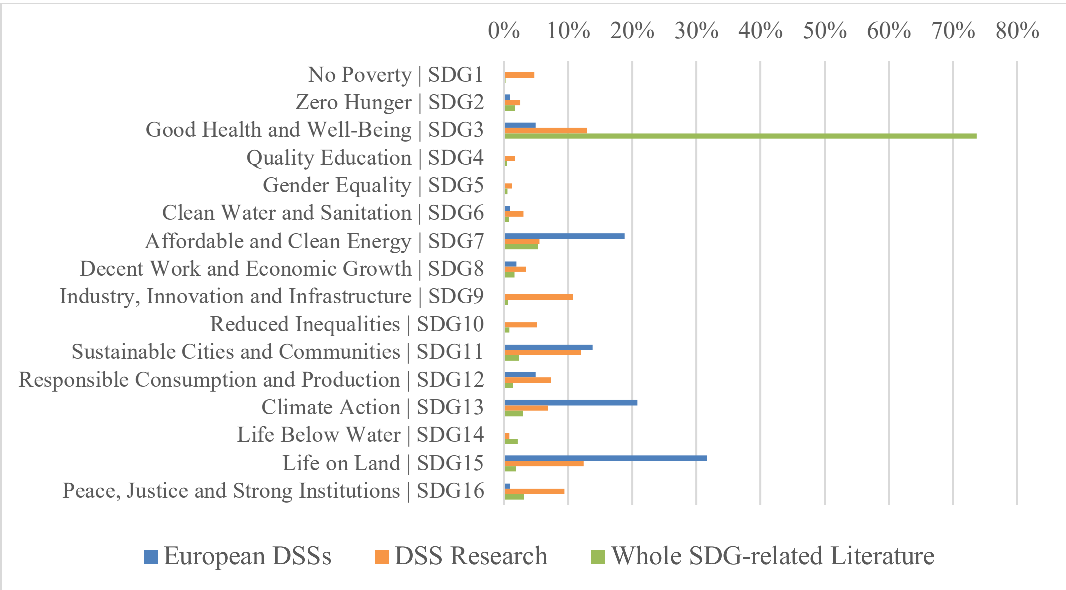

Figure F.1 : SDG-orientation comparison.

APPENDIX G: Pillar-orientation Comparison Between European DSSs, DSS Research, and Whole SDG-related Literature

Moreover, Figure G.1 represents the distribution within the SDG-orientation of the European DSSs, the research on DSS, and the whole SDG-related literature, within the environmental, social and economic pillars. In this respect, environmental pillar is the highest represented pillar by the European DSSs (77%), and by the DSS research (36%). In this respect, the strategic orientation is observed to prioritize the environmental pillar over economic and social pillars within the European DSSs context. Further, European DSSs leastly orient towards SDGs from the economic pillar (8%). On the other hand, social pillar is the least represented pillar across the DSS research (30%), and the whole SDG-related literature (7%), which represents an overall lower tendency of the academic research towards SDGs from the social pillar.

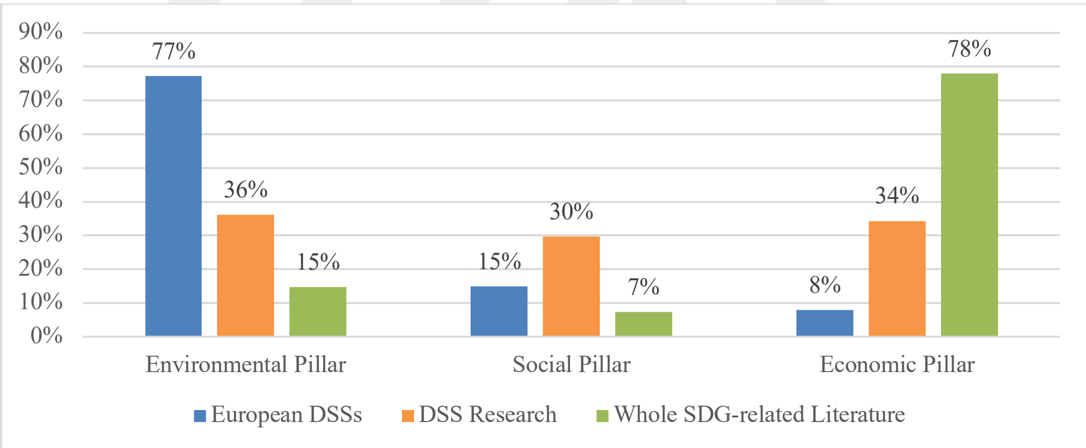

Figure G.1 : Pillar-orientation comparison.

APPENDIX H: Digital Technology Preferences Comparison Between of European DSSs and DSS Research

On the other hand, considering the results of the conceptual content analysis which is conducted by the bibliometric analysis on DSS research (Demirel & Yıldırım, 2025), Figure H.1 represents the similar patterns between DT adoption of the European DSSs and the academic research on DSSs. In this respect, “software engineering, digital platforms, and apps” dominate both the practice and the research, which points to the value of these DTs within the context of DSSs (European DSSs: 42%; DSS research: 41%). Further, artificial intelligence (AI) is observed to be the second most widely adopted DT within both European DSSs (23%, and the research on DSS (16%), which also points to a higher adoption by the practice. On the other hand, none of the sampled DSSs are observed to adopt to extended reality (XR), which covers virtual reality (VR) and augmented reality (AR), and which is represented by 6% of the studies within the field of DSS research.

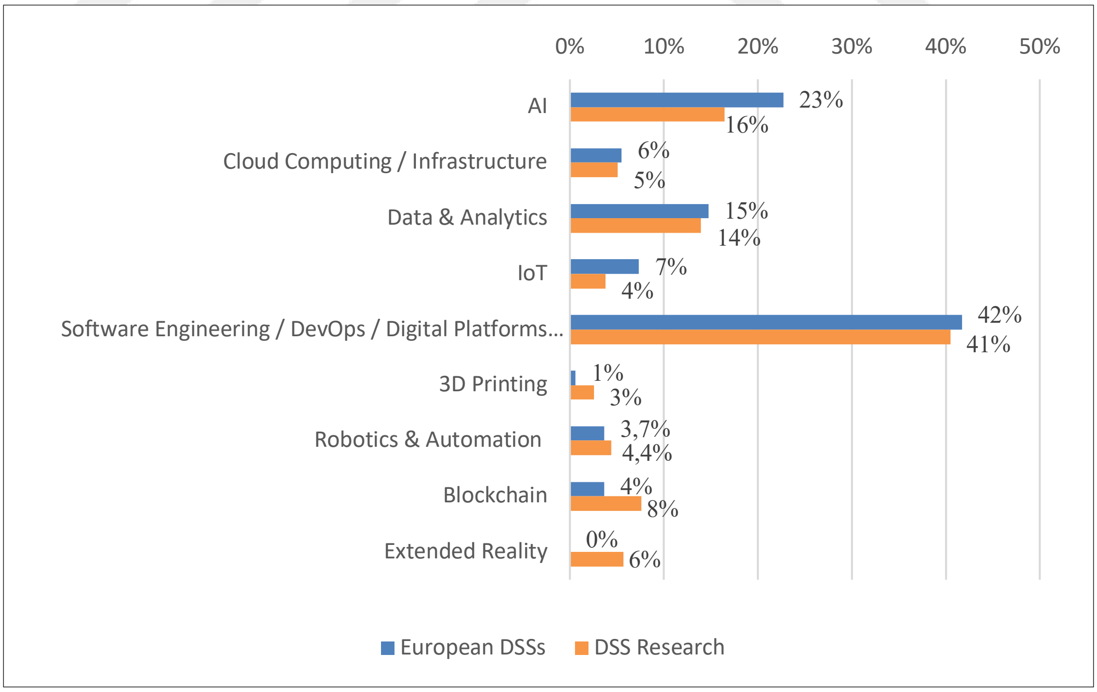

Figure H.1 : Digital technology adoption comparison.

APPENDIX I: Geographical Distribution Comparison within European DSSs and Research on DSS

Considering the bibliometric research of Demirel and Yıldırım (2025) on DSS research, the comparison of locations within the “headquarter” of the European DSSs and the “source” of the DSSs research papers is represented in Figure I.1. In this respect, headquarter location data is collected for the European DSSs, and the contact addresses of corresponding authors data is collected to enable the country-based location comparison between the practice and the academic research. In this respect, 41% of the global DSE publications originate from 12 different European countries, while excluding the other 10 countries to enable a comparison.

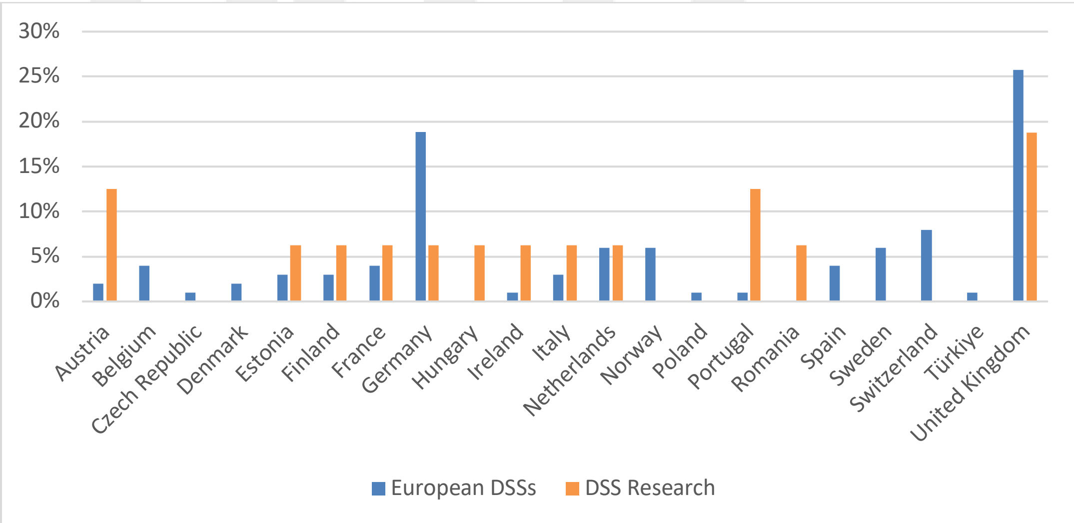

Figure I.1 : Geographical distribution comparison.

In this respect, United Kingdom is observed to host the highest number of DSSs and the highest number of academic researches within the field of DSS. Excluding this similarity, the geographical distribution of the European DSSs, and the sources of DSS publications, represents a clear mismatch between the practice and the academic research. As represented in Figure I.1, nine European countries which host headquarters of DSSs, produced no academic research on the concept of DSE. Further, two European countries which source DSE publications, are observed to host none of the sampled DSSs.

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