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Country-level analysis of the relationships between sustainability and the textile–clothing–leather–footwear industries

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Abstract

The current study aims to investigate the relationships between sustainability and the textile–clothing–leather–footwear (TCLF) industries in four countries, France, Germany, Italy, and Spain. The quantitative approach involved using the linear regression model for data from 2010 to 2020 related to three independent variables of TCLF configurations and six dependent variables of sustainability. Our findings show significant positive relationships between the trade balance values of agricultural raw materials (TB of ARM), footwear (TB of FOOT), and textiles and clothing (TB of TEXT), which were recognized as the key variables of the TCLF industries with overall sustainability and an emerging circular economy in the study areas. Among the four countries, the strongest correlations between TCLF industries and sustainability belonged to Italy. The novelty of this research lies in identifying the relevant variables from the World Integrated Trade Solution (WITS) and Eurostat databases to evaluate the TCLF industries–sustainability relationships at the country level.

KEYWORDS
circular economy, environmental changes, European countries, fashion industry, sustainability, textile–clothing–leather–footwear (TCLF)

1 | INTRODUCTION

Globally, the textile and clothing industries are considered to be a significant economic sector, with over 300 million people employed across the world's value chain (Ellen MacArthur Foundation, 2017). These industries also play a significant role in European manufacturing, accounting for around 1.7 million employees and generating revenues of approximately 166 billion euros (European Commission, 2022). The textile–clothing–leather–footwear (TCLF) industries (as mentioned by Belghazi & Berbich, 2019) are affected by the "fast-fashion" phenomenon, leading to the excessive generation of textile waste and consequent pressure on the environment (Shou & Domenech, 2022). Nowadays, environmental challenges, such as climate change, influence raw materials, natural systems, water, biodiversity, and livelihoods directly (Bherwani et al., 2022; Nair et al., 2021).

From the environmental viewpoint, all stakeholders need to implement circular economy principles to slow down the

Abbreviations: ARM, agricultural raw materials; CMUR, circular material use rate; EPR, extended producer responsibility; EU, European Union; FOOT, footwear; RRPW, recycling rate of packaging waste; SDGs, Sustainable Development Goals; SMF, sustainable material footprint; SRE, share of renewable energy; TB, trade balance; TCLF, textile–clothing–leather–footwear; TEXT, textiles and clothing; TGGE, total greenhouse gas emissions; TRRM, trade in recyclable raw materials; WFD, Waste Framework Directive; WITS, World Integrated Trade Solution.

environmental changes, enabling the TCLF industries to reach sustainable circular economy objectives (Bherwani et al., 2022). Hence, sustainability and zero-waste approaches in these industries are essential for reducing environmental pollution. In this regard, sustainability and its emerging circular economy, business models of sustainable product design, product life extension, and circular supply chain models promise to increase the sustainability performance in these industries (Peter John & Mishra, 2023). As the impacts of the textile industry on the environment are evident, the need for circular approaches is more urgent than ever (Tsironis et al., 2022). The TCLF industries is not usually viewed as exemplars of sustainable development and the circular economy due to the linear fashion of their products, with little recycling of the finished goods (Wiegand & Wynn, 2023).

From the social and economic viewpoints, there has been growing interest in the circular economy and how it can affect sustainability and economic development by replacing the existing linear model of the TCLF industries. It is necessary to enhance our understanding of how to foster growth for a sustainable and thriving fashion industry given the following points. (1) Circular fashion research is very limited, impeding the implementation of circular economy practices in the fashion industry (Ki et al., 2021). (2) The sustainable circular economy could map avenues for creating fashion closed loops, replacing the linear system. In country-level reviews, the entire fashion industry has not yet fully embraced the sustainable circular economy for its trading and processing (Arribas-Ibar et al., 2022). (3) A change in the demand for circular raw materials due to environmental challenges, for example, climate change, is apparent (Bherwani et al., 2022). Thus, the scarcity of studies exploring the interconnection of sustainability and the emerging circular economy in the TCLF industries can be considered a relevant research gap.

This study addresses the following research question: What are the relevant TCLF industries key variables influencing country-level sustainability? For this purpose, we assessed the effects of the TCLF industries in enhancing or reducing sustainable and renewable resources at the country level. Hence, the present paper aimed to investigate the relationships between the TCLF industries and sustainability in the four European countries—Italy, Spain, Germany, and France—that have the most relevant role in the TCLF global industries in manufacturing and exports. An important consideration in comparing these four countries is their position in different supply chain tiers. For instance, when it comes to leather production, Italy stands as the industry leader, while Spain follows. To establish a strong global presence in the luxury sector, beside the primary market, it can provide secondary-quality products suitable for mass production (Karaosman et al., 2020). Italy is involved in textiles, leather, and fabric manufacturing, importing the yarn from abroad (Brun & Lideo, 2021). While Italy may not focus on mass production, its suppliers should still embrace sustainable practices.

This study can support the development of sustainability and circularity in the TCLF industries at the country level. For instance, it provides empirical evidence on circularity solutions in the TCLF industries, completing previous research streams (e.g., Dragomir & Dumitru, 2022). This research is particularly relevant, especially in Europe, given several directives and regulations that call for a higher level of circularity. Among them, the Waste Framework Directive (WFD) proposal (European Commission, 2023), which includes legislation on extended producer responsibility (EPR), has the objective of reducing the number of textile products that, at their end of life, end up directly in landfill, incinerated, or exported to less regulated countries outside the EU.

2 | RESEARCH BACKGROUND

2.1 | TCLF and the sustainable circular economy

The sustainable circular economy is one of the ways of achieving the United Nations' sustainable development goals (SDGs) (Gabriel & Luque, 2020). It also offers an alternative to a traditional economy by keeping resources in a loop and promoting the continuous circulation of resources to maintain their value while generating new products at the end of utilization. It is estimated that waste from the TCLF industries will increase by 60% of the total production from 2015 to 2030 (Sandvik & Stubbs, 2019). However, less than 20% of all TCLF waste is recycled, and the rest is landfilled or incinerated (Koszewska, 2018). This indicates a significant gap between the amount of waste items and that being recycled.

Awareness of the TCLF industries' impacts has encouraged commitment and action toward achieving a more sustainable TCLF sector (Shou & Domenech, 2022), resulting in increased attention from the scientific community. As a research gap, the environmental sustainability of the TCLF industries has become a growing concern for consumers and policymakers in recent years. This fact calls scholars to investigate the transition to a sustainable textile and clothing economy, in which TCLF products are designed and produced with maximal uses and minimal environmental pressure generated from production to disposal (European Environmental Agency, 2020).

Concerns about the environmental impacts caused by clothing production and trading have contributed to a growing discourse on sustainable TCLF in which EU countries are increasingly engaged (e.g., Ellen MacArthur Foundation, 2017; European Commission, 2020; European Environmental Agency, 2022). There are few leading European manufacturing and exporting countries in the TCLF industries. In this regard, four countries—namely, Italy, Spain, Germany, and France—are the most relevant in the TCLF industries, accounting for three-quarters of the EU production in this sector (European Commission, 2023). Italy exported 10 billion euros worth of clothing to non-EU member states in 2020, representing 33% of total extra-EU clothing exports by value. After Italy come Germany (with 5 billion euros, 17%), Spain (with 4 billion euros, 14%), and France (almost 4 billion euros, 13%) (Fashion United, 2020). These four countries have the largest economies in the EU, contributing a total of >63% to the EU's GDP in 2020 (Germany: 25.1%, France: 17.3%, Italy: 12.4%, and Spain: 8.4%) (World Bank, 2023).

TABLE 1 Descriptions, units, and sources of the research variables.

Variable's code		Variable's name	Description	Unit	Source
Variables to define the TCLF index	TB of ARM	Trade balance of agricultural raw materials	Adaptive values of agricultural raw materials based on export product share minus import product share	%	WITS (2023)
	TB of FOOT	Trade balance of footwear	Footwear contribution to the traded products of import & export share	%	
	TB of TEXT	Trade balance of textiles and clothing	Textiles and clothing contribution to the traded products of import & export share	%	
Variables to define the sustainability index	CMUR	Circular material use rate	Circular material use rate based on the recovered and fed back of total material uses into the economy	%	Eurostat (2023)
	RRPW	Recycling rate of packaging waste	Recycling rate of packaging waste from all generated plastic packaging waste in the economy	%	
	SRE	Share of renewable energy (% of energy consumption)	Share of renewable energy based on the gross final energy consumption from total consumption	%	
	SMF	Sustainable material footprint (100/t)	Sustainable material footprint based on the demands for material extractions, e.g., biomass, triggered by business	100/t	
	TGGE	Total greenhouse gas emissions (million tonnes)	Decrease of total greenhouse gas emissions annually based on the minus yearly data from 2010 data	Million tonnes	
	TRRM	Trade in recyclable raw materials (million tonnes)	Trade in recyclable raw materials based on the selected waste categories and by-products, e.g., plastic & paper	Million tonnes	

Abbreviations: CMUR, circular material use rate; RRPW, recycling rate of packaging waste; SMF, sustainable material footprint; SRE, share of renewable energy; TCLF, textile–clothing–leather–footwear; TGGE, total greenhouse gas emissions; TRRM, trade in recyclable raw material.

2.2 | TCLF and sustainability variables

The TCLF variables were obtained from the World Integrated Trade Solution (WITS) database (https://wits.worldbank.org/Default.aspx?lang=en; WITS, 2023), and the sustainable circular economy variables were acquired from the Eurostat database (https://ec.europa.eu/eurostat/web/main/data/database; Eurostat, 2023). The variables are shown in Tables 1 and 2. All the variables were selected as relevant and available datasets, recognized in the World Trade Organization's publications (Bacchetta et al., 2019) and systematic literature reviews (e.g., Karaosman et al., 2017). In this research, an empirical model was constructed to examine the relationships between the three variables of the TCLF industries (Trade Balance of Textiles and Clothing, Trade Balance of footwear, and Trade Balance of Agricultural Raw Materials) and six variables of sustainability (circular material use rate [CMUR], recycling rate of packaging waste [RRPW], share of renewable energy [SRE], sustainable material footprint [SMF], decrease of total greenhouse gas emissions, and trade in recyclable raw material [TRRM]) for the four countries mentioned above (2010–2020).

The time intervals and their fitting data can be influenced by external factors, such as COVID-19's effects from 2020 to 2021 and the effects of the Russian–Ukrainian War from 2022 to 2023. However, this paper's authors decided to retain the time series from 2010 to 2020. We focused our study on these variables and countries because they have the only available data in relation to sustainability, circularity, and TCLF in the WITS and Eurostat databases. Other countries do not have registered membership of the mentioned databases. The selected variables can be defined as follows:

Variable number [1] is the Trade Balance of Textiles and Clothing (TB of TEXT) (% of import and export product share), including both intermediate and final products based on the export product share minus the import product share.

Variable number [2] is the Trade Balance of Footwear (TB of Foot) (% of import and export product share), including both intermediate and final products contributing to the share of products traded in both imports and exports. The production shares of textiles and clothing, in addition to footwear, are measured based on the traded products and are computed for the traded shares of imports from the world to the selected countries and exports from the selected countries to the world.

Variable number [3] is the Trade Balance of Agricultural Raw Materials (TB of ARM) (% of import and export product share), which is considered as input in the textiles and clothing industries, predominantly including cotton, wool, and silk, which are essential textile raw materials. In recent years, the use of fibers, filaments, and synthetic textile raw materials has grown, but the industries' attraction to nature and ecological agriculture has focused on cotton production (WITS, 2023). In our study, we considered the trade balance for all the TCLF variables simply using the following equation:

A = (Dexp-Dimp), where A is the adaptive values of agricultural raw materials as a percentage to assume its trade balance level, Dexp is the export value (%), and Dimp is the import value (%) in each year from 2010 to 2020. Hence, the more significant the export increase, the lower the impact on sustainability at the country level.

The six variables related to sustainability are presented below:

Variable number [4] is the CMUR (%), which measures the share of material recovered and fed back into the economy in overall material use. A higher circular material use value means that more secondary materials substitute for primary raw materials, thus reducing the environmental impacts of extracting primary material. Variable

TABLE 2 The variables to define textile–clothing–leather–footwear (TCLF) and sustainability (Eurostat, 2023; WITS, 2023).

Variables		Country	Years										
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Variables to define the TCLF index	TB of ARM	France	−0.33	−0.60	−0.73	−0.70	−0.78	−0.72	−0.75	−0.74	−0.61	−0.71	−0.68
		Germany	0.35	0.30	0.16	0.11	0.01	0.05	0.04	0.00	−0.11	−0.29	−0.49
		Italy	1.78	1.90	1.62	2.00	2.06	1.95	1.73	1.05	1.15	1.00	0.77
		Spain	−0.83	−0.70	−1.03	−0.95	−1.04	−0.68	−0.75	−0.91	−0.96	−0.96	−0.98
	TB of FOOT	France	0.95	0.82	0.79	0.84	0.95	1.01	1.01	0.95	0.86	0.82	0.79
		Germany	0.66	0.64	0.71	0.74	0.83	0.98	0.96	0.86	0.73	0.73	0.71
		Italy	−1.71	−1.74	−1.68	−1.75	−1.62	−1.47	−1.42	−1.46	−1.44	−1.54	−1.36
		Spain	−0.21	−0.29	−0.22	−0.27	−0.33	−0.06	0.04	0.00	−0.04	0.12	0.11
	TB of TEXT	France	0.62	0.55	0.49	0.55	0.67	0.83	0.80	0.68	0.63	0.62	1.41
		Germany	0.72	0.74	0.69	0.75	0.83	0.96	1.02	0.84	0.65	0.61	0.98
		Italy	−2.00	−1.84	−1.88	−1.81	−1.62	−1.46	−1.41	−1.49	−1.58	−1.60	−0.82
		Spain	0.08	0.00	−0.08	−0.13	0.01	0.18	0.34	−0.08	−0.11	−0.03	0.70
Variables to define the sustainability index	CMUR	France	0.87	0.70	0.72	0.82	0.94	1.16	1.33	1.19	1.41	1.48	1.29
		Germany	−0.62	−0.76	−0.66	−0.64	−0.64	−0.47	−0.42	−0.52	−0.37	−0.25	−0.25
		Italy	−0.59	−0.57	−0.01	0.51	0.53	0.80	0.94	1.09	1.19	1.36	1.63
		Spain	−0.86	−1.00	−1.00	−1.22	−1.52	−1.57	−1.39	−1.25	−1.20	−1.05	−1.13
	RRPW	France	−1.94	−1.87	−0.73	−0.25	−0.63	−0.54	−0.38	0.29	−1.17	−0.50	−2.19
		Germany	1.75	1.47	1.31	1.47	1.34	0.67	1.12	0.86	0.42	−1.27	0.29
		Italy	−0.89	−0.85	−0.19	−0.15	−0.57	−0.12	−0.09	−0.03	0.35	0.77	1.79
		Spain	−1.68	−1.05	−0.54	−0.19	0.48	0.39	0.99	0.42	0.51	0.77	0.35
	SRE	France	−1.32	−2.12	−1.07	−0.79	−0.58	−0.39	−0.11	0.06	0.29	0.64	1.47
		Germany	−1.75	−1.40	−0.94	−0.85	−0.57	−0.35	−0.36	−0.10	0.41	0.67	1.46
		Italy	−1.16	−1.22	−0.12	0.45	0.60	0.79	0.74	1.11	0.90	1.07	2.01
		Spain	−0.83	−1.10	−0.64	−0.27	0.07	0.22	0.57	0.61	0.57	0.93	2.39
	SMF	France	−0.58	−0.65	−0.47	−0.47	−0.47	−0.16	−0.09	−0.58	−0.54	−0.47	0.72
		Germany	−0.97	−1.41	−1.17	−1.13	−1.16	−0.96	−1.10	−1.20	−1.16	−1.09	−0.89
		Italy	−0.96	−0.88	0.02	0.60	0.69	0.67	0.71	0.57	0.37	0.71	1.36
		Spain	−0.59	−0.04	1.31	1.95	2.13	1.53	1.51	1.33	0.66	1.08	1.31
	TGGE	France	0.14	0.22	0.20	0.20	0.37	0.34	0.34	0.32	0.40	0.44	0.63
		Germany	−1.92	−1.77	−1.83	−1.92	−1.71	−1.73	−1.75	−1.66	−1.52	−1.26	−0.97
		Italy	0.09	0.15	0.24	0.40	0.50	0.44	0.46	0.49	0.51	0.56	0.75
		Spain	0.76	0.76	0.79	0.93	0.93	0.88	0.93	0.85	0.88	0.97	1.16
	TRRM	France	0.14	0.14	−0.55	−0.29	−0.13	−0.93	−0.82	−0.77	0.08	−0.41	−0.72
		Germany	0.71	0.71	0.07	0.21	0.16	0.45	0.31	−0.03	−0.39	−0.53	−0.61
		Italy	−1.78	−1.78	−1.32	−0.98	−0.76	−0.90	−0.70	−0.77	−0.93	−1.23	−0.39
		Spain	0.71	0.71	0.59	1.10	2.23	1.41	1.95	1.14	1.94	0.90	2.07
Overall SUST		France	−0.45	−0.60	−0.31	−0.13	−0.08	−0.08	0.04	0.08	0.08	0.20	0.20
		Germany	−0.47	−0.53	−0.54	−0.48	−0.43	−0.40	−0.37	−0.44	−0.43	−0.62	−0.16
		Italy	−0.88	−0.86	−0.23	0.14	0.16	0.28	0.34	0.41	0.40	0.54	1.19
		Spain	−0.42	−0.29	0.09	0.38	0.72	0.48	0.76	0.51	0.56	0.60	1.03

Abbreviations: CMUR, circular material use rate; RRPW, recycling rate of packaging waste; SMF, sustainable material footprint; SRE, share of renewable energy; TGGE, total greenhouse gas emissions; TRRM, trade in recyclable raw material.

number [5] is the RRPW (%), which indicates the proportion of recycled plastic packaging waste relative to the total plastic packaging waste, including materials used for containment, protection, handling, delivery, and presentation of goods throughout the life cycle from raw materials to processed goods and from the producer to the user or consumer.

In addition, variable number [6] is the SRE (% of energy consumption), which measures the gross final energy consumption, that is, the energy used by end-consumers plus grid losses and self-consumption of power plants, according to the renewable energy directive. Variable number [7] is the SMF (100/t), which quantifies the demand for material extraction (biomass, metal ores, nonmetallic minerals, and fossil energy materials/carriers) triggered by consumption and business investment (Eurostat, 2023).

Moreover, variable number [8] is the reduction in total greenhouse gas emissions (TGGE) (million tonnes of CO_2 equivalent), which encompasses various sources, including biomass burning along with all anthropogenic sources of CH4, N2O, and F-gases. In our study, we considered a decrease in TGGE, that is, an annual reduction of emissions versus the baseline value (2010 as the default), in line with the following equation: DT = |(Db-Dy)|, where DT is the absolute value of the decrease in TGGE in million tonnes to assume sustainability level, Db is the baseline value of TGGE in 2010, and Dy is the data for each year from 2010 to 2020.

Finally, variable number [9] is TRRM (million tonnes), which measures the quantities of selected waste categories and by-products, including plastic, paper, and metal, which are shipped between the EU countries and across the EU borders.

2.3 | Hypothesis development

The main goal of a sustainable and circular form of the TCLF industries is to shift from making profits through the sale of products and artifacts to making profits through the flow of resources, materials, and products, including reusing goods and recycling resources (Linder & Williander, 2017). Hence, our research framework should define the value creation by finding a model for achieving circularity and sustainability, as proposed in the literature (e.g., Frishammar & Parida, 2019; Lüdeke-Freund et al., 2019; Reim et al., 2021). Dissanayake and Weerasinghe (2022) stated that the resource sustainability and efficiency of textile and clothing products can be achieved along three main paths: using renewable and sustainable raw materials, reducing resource consumption, and minimizing waste.

However, as defined by the Ellen MacArthur Foundation (2021), the TCLF industries can improve their sustainability and circularity by utilizing innovative circular business models. In this regard, the raw material supply chain and trading values are the integrated issue in the enhancement of sustainability in fashion production (Karaosman et al., 2020). Overall, our study attempts to extract the TCLF variables as the key variables influencing country-level sustainability. On this basis, we present the hypotheses below:

Hypothesis 1. A higher level of "TB of ARM" can lead to a higher level of sustainability at the country level.

Hypothesis 2. A higher level of "TB of FOOT" can lead to a higher level of sustainability at the country level.

Hypothesis 3. A higher level of "TB of TEXT" can lead to a higher level of sustainability at the country level.

The research framework is reported in Figure 1.

3 | RESULTS AND DISCUSSION

3.1 | Results of the analysis

This research adopted a linear regression model for investigating the relations between the concepts discussed above at the macro-level or

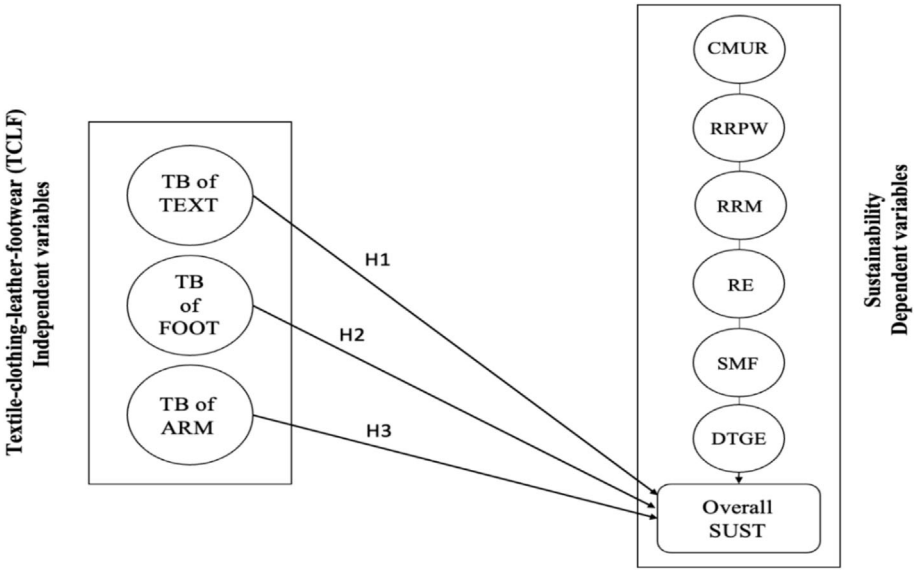

FIGURE 1 The research framework.

Relationships	Coefficient	Std. error	R-squared	*F*-test
TB of ARM → overall SUST	0.3685	(0.0938)*	0.4655	0.0000
TB of FOOT → overall SUST	0.9111	(0.2415)*	0.4655	0.0000
TB of TEXT → overall SUST	0.5005	(0.2578)***	0.4655	0.0000

*Coefficients (Std. Error):$p < 0.01$/.**$p < 0.05$/.***$p < 0.1$/ □$p > 0$.

TABLE 3 The correlation coefficients between overall sustainability (SUST) and textile–clothing–leather–footwear (TCLF) variables (2010–2020) (no. of observations = 44).

TABLE 4 The relations between overall sustainability (SUST) and textile–clothing–leather–footwear (TCLF) variables in the four selected countries (2010–2020) (no. of observations = 11).

		Overall SUST			
Variables	Test	France	Germany	Italy	Spain
TB of ARM	R^2	0.2681	0.2171	0.4058	0.1281
	F-test	0.1028	0.1486	0.0350	0.2798
TB of FOOT	R^2	0.0033	0.0657	0.6627	0.3655
	F-test	0.8662	0.4466	0.0023	0.0488
TB of TEXT	R^2	0.2676	0.6050	0.7476	0.2126
	F-test	0.1032	0.0048	0.0006	0.1535

country level for selected European countries during 11 time intervals from 2010 to 2020 using Stata 12. As Table 3 indicates, the causal relationships between the TCLF variables (i.e., TB of ARM, TB of FOOT, and TB of TEXT) and sustainability ranged from 0.3685 to 0.9111 (R-squared: 0.4655), exposing the positive effects of each TCLF variable on sustainability. In addition, the causal relationships between the three TCLF variables and the sustainability index in each selected country did not move similarly, as shown in Table 4. On this basis, the key variable of the TCLF industries, influencing the overall sustainability index, was recognized as the trade balance of textiles and clothing (TB of TEXT), typical in all the countries with R-squared values ranging from 0.2126 to 0.7476, revealing the positive and accelerative effects of this variable on the increasing values of sustainability in the study areas, especially Germany and Italy.

Moreover, the relationship between the trade balance of agricultural raw materials (TB of ARM) and the sustainability index resulted in significant and positive coefficients, with the R-squared ranging from 0.1281 to 0.4058, revealing the influential role of TB of ARM on the sustainability of the study areas. Similarly, the trade balance of footwear (TB of FOOT) had a close relationship with sustainability (ranging from 0.0033 to 0.6627) (Figure 2). Such a strong relationship could be explained by the fact that the management of TCLF trading (especially TB of TEXT) in Italy must conform to strong regulations on sustainability aspects.

For the time dimension, we added an extra correlation analysis based on the 11 time intervals from 2010 to 2020. The results in Table 5 reveal that the overall correlations (R^2 coefficients) have increased over time. However, the weakest relationships were observed in 2012, perhaps due to the global economic and social instability influencing the European countries. The trend of the relationships mentioned above is shown in Figure 3.

3.2 | Discussion

The present study investigated the relationships between the TCLF industries and sustainability for four selected EU countries. Our main results are as follows:

1. Hypothesis. 1, Hypothesis. 2, and Hypothesis. 3 were supported. This demonstrates the significant relationship between the TCLF industries and overall sustainability and circularity at the national level. Hence, a higher trade balance of the TCLF variables can lead to an improving status of sustainability variables, namely, the CMUR, RRPW, SRE, SMF, TGGE, and TRRM, in the study areas, especially Italy. It seems that the TCLF industries and trade in Italy have the lowest adverse effects on environmental sustainability (e.g., greenhouse gas emissions). However, to mitigate the environmental impact, it would be beneficial for EU countries, such as Italy, to focus on achieving a higher level of sustainability by increasing their leather goods exports and achieving higher trade balance values. In this regard, we need incentive regulations to select suitable raw materials, supporting biological cycles (Altenbuchner et al., 2018; Dissanayake & Weerasinghe, 2022).
2. The overall sustainability index is positively affected since there are higher exports than imports. These findings are confirmed by previous studies addressing sustainable and circular solutions to decrease TCLF waste and reduce energy use and unsustainable material footprints (e.g., Sandin & Peters, 2018; Shirvanimoghaddam et al., 2020). Zero-waste technology is implemented by assuming the decrease of greenhouse gas emissions and converting the waste and scrap pieces in the TCLF industries into valuable products, like fashion dresses, carpets, cloth bags, and pillows (Peter John & Mishra, 2023). Conversely, by extending the average life of clothing, which is currently around 3 years, the carbon and water footprint and waste generation can be reduced by 5%–10% (Shirvanimoghaddam et al., 2020). In this regard, the role of digital technologies in support of sustainability and the transition to circularity in the TCLF industries can be explored using digital technologies (Wiegand & Wynn, 2023). Digital technologies are bringing about greater efficiency, improved processes, and better data management, which are supporting and enabling the achievement of sustainability objectives and the potential transition to the circular economy in each industry (Wynn & Jones, 2022).
3. To answer the research question, we assumed a constant correlation between the TCLF industries and sustainability. The positive relationships highlight that we can assume that higher values of

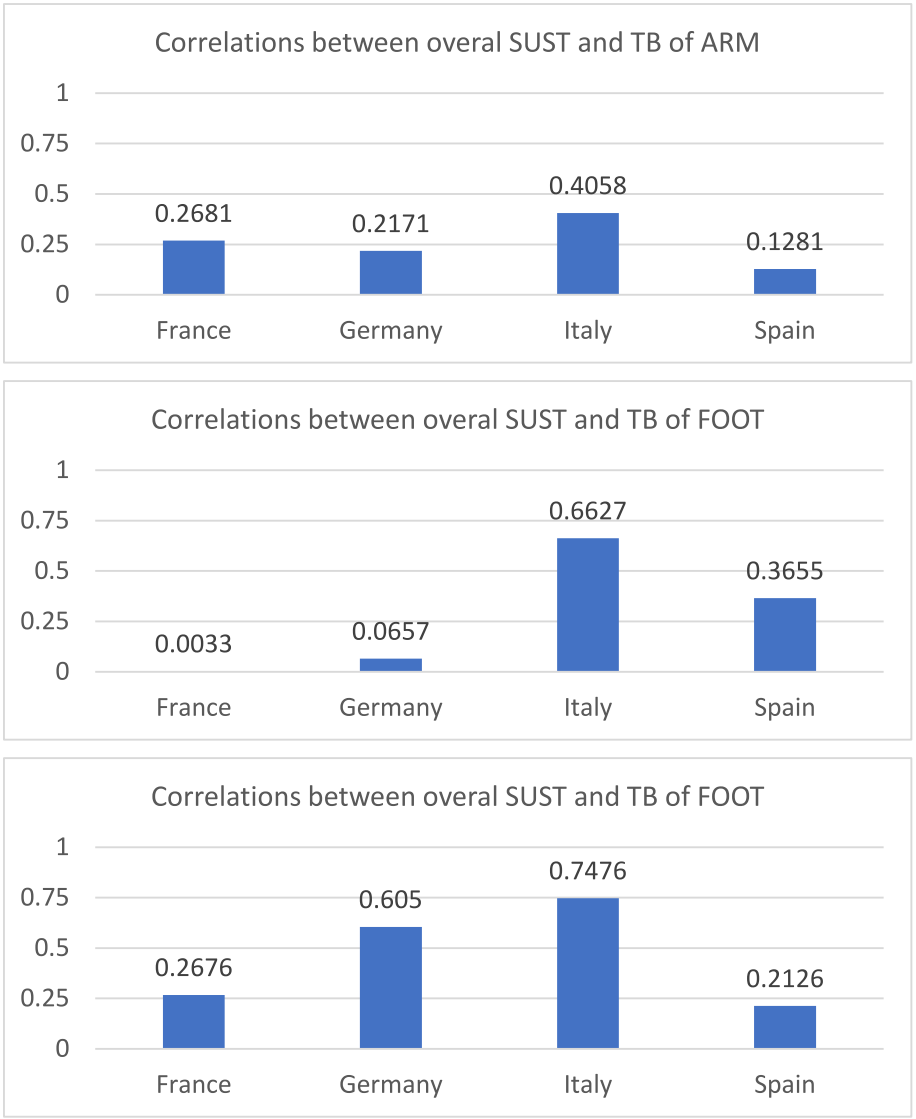

FIGURE 2 Variation of correlation results between research variables among four European countries.

TABLE 5 The relations between overall sustainability (SUST) and textile–clothing–leather–footwear (TCLF) based on the time intervals from 2010 to 2020 (no. of observations = 4).

		Overall SUST										
Variables	**Test**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
TB of ARM	R^2	0.8814	0.7170	0.1136	0.0009	0.0339	0.0231	0.0020	0.0003	0.0000	0.0148	0.1776
	F-test	0.0612	0.1533	0.6629	0.9708	0.8160	0.8481	0.9551	0.9835	0.9977	0.8782	0.5785
TB of FOOT	R^2	0.7695	0.2664	0.1689	0.3742	0.2781	0.4845	0.2959	0.4338	0.3861	0.3374	0.6846
	F-test	0.1228	0.4839	0.5891	0.3883	0.4727	0.3040	0.4560	0.3414	0.3786	0.4191	0.1726
TB of TEXT	R^2	0.9036	0.4386	0.1057	0.3278	0.1638	0.3899	0.2060	0.4893	0.3936	0.3642	0.5606
	F-test	0.0494	0.3377	0.6749	0.4275	0.5953	0.3756	0.5462	0.3005	0.3726	0.3965	0.2512

the trade balance of the TCLF industries (e.g., for TB of ARM) can increase the exports with a lower impact on sustainability at the country level because part of the impact will not be managed in the country. Still, it is transferred outside the country. However, the global impact would remain unchanged and should be considered as an integrated issue.

4. Hence, higher values of a positive trade balance (exports–imports) are the background strategy in EU countries to regulate the input materials and mitigate the import products, especially those from Asian countries (e.g., China). From the viewpoint of the integrated import/export share of TCLF products at the national level, we can observe a significant contribution of the TCLF industries to the

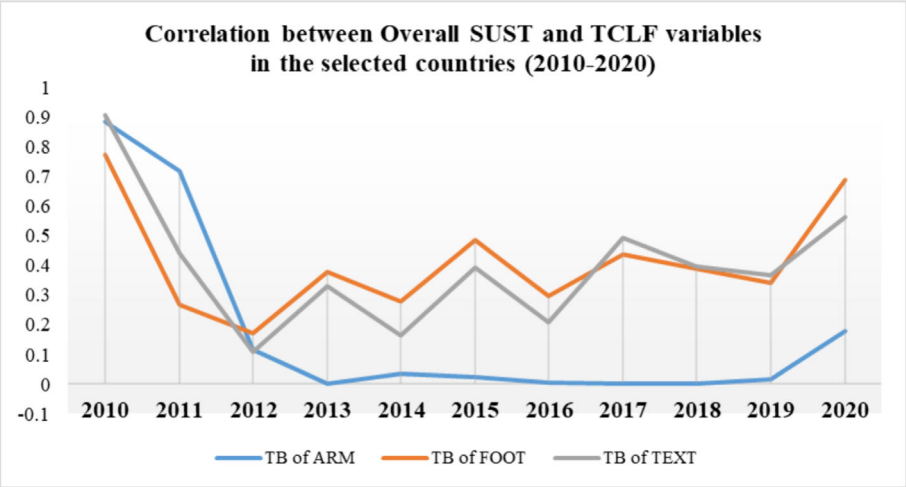

FIGURE 3 The correlation results based on the time intervals.

import share of trade between the mentioned four countries and China (15%–20%), which should be considered through the regulation of the SDGs in the TCLF sector (WITS, 2023).

In our study, we did not collect separate data for the premium/luxury fashion segment and the mass market for low-end production; for this reason, our results cannot be generalized to all types of segments in the selected countries. For instance, Italy does not have a large mass market segment, while the production is much stronger in the brand and fashion luxury segment (Brun et al., 2017; Karaosman et al., 2023). This point was also approved by Martino et al. (2017) for Italian fashion industries. In this regard, key actors in the luxury supply chain have had to respond to increasing levels of sustainability regulation (Caniato et al., 2012; Karaosman et al., 2020). As a consequence, the results for Italy are relevant to the high-end segment and cannot be extended to the mass market.

4 | CONCLUSIONS, IMPLICATIONS, AND LIMITATIONS

4.1 | Conclusions

The TCLF industries face complex challenges in transitioning to a sustainable circular economy, which is necessary to address environmental and social issues and maintain performance and profitability. Thus, the scarcity of studies exploring the interconnectedness of sustainability and the emerging circular economy in the TCLF industries is one of the main motivators for novel research. Hence, the present paper aimed to investigate the relationships between the TCLF industries and sustainability in four important European countries, specifically France, Germany, Italy, and Spain, which account for the lion's share of TCLF trading in the EU. The research time span was selected as the 11 years from 2010 to 2020.

Three independent variables were introduced to create indexes for the TCLF industries' overall activities. Simultaneously, six dependent variables were collected to develop a combined index for sustainability and the emerging circular economy concept. The correlation coefficients were calculated using Stata; the results highlighted that the overall TCLF variables positively influenced sustainability with correlation coefficients in the 0.3685–0.9111 range (R-squared: 0.4655). In this regard, all the trading balance values of agricultural raw materials (TB of ARM), footwear (TB of FOOT), and textiles and clothing (TB of TEXT) were recognized as the key variables of the TCLF industries, influencing the overall sustainability and the emerging circular economy in the study areas.

4.2 | Theoretical implications

The current study has contributed to a better understanding of the concept of circular fashion in different ways. Recently, scholars have focused on the concept of circularity in the fashion and textile industries (e.g., Arribas-Ibar et al., 2022; Dragomir & Dumitru, 2022; Karaosman et al., 2017; Peter John & Mishra, 2023; Shirvanimoghaddam et al., 2020; Shou & Domenech, 2022; Tsironis et al., 2022) and the concept of climate change in the fashion and textile industries (e.g., Bherwani et al., 2022; Provin et al., 2021). However, the different impacts of the TCLF industries on sustainability have not been analyzed simultaneously in prior research. The role of sustainability in the fashion and TCLF industries has not been considered adequately in previous research. For instance, Martino et al. (2017) noted that environmental sustainability has the lowest priority in the Italian fashion industries and is still considered the least important by TCLF managers.

Overall, in the literature, some preliminary results have been presented on how and to what extent TCLF companies implement sustainability and circularity practices along their supply chains (Caniato et al., 2012; Chi, 2011; De Brito et al., 2008; Resta et al., 2014), but a comprehensive analysis encompassing all the corporate environmental management areas is still lacking (Ciarapica et al., 2017). Dragomir and Dumitru (2022) revealed that some papers on the Italian fashion industry have attempted to show a connection between sustainability and the fashion industry but have not mentioned the circularity

elements (Da Giau et al., 2020; Grazzini et al., 2021). Hence, our results can complement the literature using a novel statistical correlation model between the TCLF industries trade balance variables and sustainability. In this way, we recognized the key variables of the TCLF industries, influencing the sustainability and circular economy at the country level.

4.3 | Implications for policymakers

The new requirements established in the WFD proposal will ensure that all European Member States collect textile waste separately from 2025, in line with the current WFD rules. The proposed directive would provide clarity on two key aspects: (i) defining what qualifies as waste, with specific criteria introduced to prevent the mislabelling of waste as "used goods"; and (ii) establishing clear guidelines for what constitutes reusable textiles to prevent the exporting of waste.

Textile producers must appoint an authorized producer responsibility organization to fulfill their EPR obligations. EPR fees will be calculated based on non-EU countries. These complement the proposed regulation on waste shipments, which will strive to ensure that textile waste is exported only when there are firm assurances that it will be managed in an environmentally responsible manner. With the implementation of the textile EPR system, producers will be obliged to take financial and operational responsibility for the full life cycle of textile products, meaning that they will cover the costs or other forms of treatment and recovery processes for products in their end-of-life phase. Furthermore, the textile EPR system will encompass outlays related to data collection and mandatory reporting while also supporting research and development endeavors to refine sorting and recycling methodologies. Online platforms enabling distance contracts between consumers and textile producers must also acquire relevant information from producers and ensure compliance with EPR requirements.

Consistently with the WFD proposal and with the results of this study, there is a need to collect more data at the country level to manage textile waste in a better way, which can be considered a global issue and opportunity.

4.4 | Limitations and further research

The current research has three main limitations. The first limitation concerns the data sampling and data availability of research datasets within the restricted study areas, which obliged us to select four countries. More encompassing research would require more data about sustainability and circularity. Meanwhile, our research was timely, and it could be expanded to include up-to-date data. The second limitation involves data availability, which is limited in terms of the level of detail in yearly data at the national level. Future studies should be undertaken using more countries, regions, or provinces for extended periods (e.g., from 2000 to 2020). In addition, the research methodology had a third limitation related to the interaction of the relationships in the model. Further research could provide standardized aspects to measure and model the impacts of the key sustainability factors on the TCLF trading values. Finally, future research could consider all types of products to identify clusters of countries.

Regarding the increasing role of digital technologies in supporting sustainability and the transition to circularity in the TCLF industries, further research should take advantage of the abilities of digitalization in enhancing the circularity progress of the TCLF industries through the EU's strategy for sustainable and circular textiles (Wiegand & Wynn, 2023). The EU's interconnected production processes of TCLF have wider implications for both humans and the environment. Hence, the TCLF industries can be followed by a research point of the EU's Industrial Strategy for Europe and the European Circular Economy Action Plan (European Commission, 2020).

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Current paper dedicated to my supervisor, Professor Alessandro Brun, who is not between us now. I will cherish all his memories of him forever. He will always remain alive in our prayers. Wishing you care. We will miss him deeply. Open access publishing facilitated by Universita Bocconi, as part of the Wiley - CRUI-CARE agreement.

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