

REVIEW

Twenty-Five Years of Self-Determination Theory Research: A Bibliometric Perspective

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ABSTRACT

This study presents a comprehensive bibliometric analysis of self-determination theory (SDT) research over 25 years of scholarly work (1998–2023) published in the Scopus database and comprising over 3706 publications. Using VOSviewer and Bibliometrix, this analysis identified the trends in SDT research covering core trending topics, authors, and institutional networks, as well as emerging themes, among others. The study highlights the theory's evolution from a focus on intrinsic motivation to its broader application today, covering both intrinsic and extrinsic motivation and extended organisational outcomes such as well-being and engagement. Key findings reveal that with the rise in the digital work environment, there has been a surge in publication post-2018, and attention has diversified in terms of adapting SDT to meet the evolving psychological needs of employees in the contemporary work environment. Additionally, SWOT analysis uncovers SDT's strengths in its foundational emphasis on three basic psychological needs (autonomy, competence, and relatedness) and its adaptability across diverse fields. The findings reveal the potential for cross-disciplinary integration between diverse areas in human resource management and organisational behaviour. Nonetheless, the study also reveals key limitations in operationalising SDT in high-pressure work environments and cross-cultural adaptability. As such, the study suggests future directions for research in exploring the theory's role in the digital work setting and its potential in supporting the psychological well-being of employees by addressing the evolving workplace, changing workplace dynamics, and addressing the evolving psychological needs of employees.

1 | Introduction

Self-determination theory (SDT) by Deci and Ryan is one of the most influential theoretical frameworks for understanding human motivation, well-being, and performance across various domains. SDT is an extensively applied theory in the context of motivation and wellness as well. The theory that began with a myopic focus on intrinsic motivation today has evolved with the inclusion of both intrinsic and extrinsic motivation and has procreated a new perspective on an individual's well-being, life goals, the concept of relationship quality, vitality, and

eudaimonia, among other emerging topics (Ryan et al. 2006; Ryan and Deci 2019, 2020).

The theory posits that human behaviour is primarily driven by three core psychological needs, including autonomy (the need to experience a sense of control and self-governance), competence (the need to feel capable and efficient), and relatedness (the need for meaningful connections). Much of the research grounded in SDT has also investigated the role of environmental factors that can challenge individual self-motivation, social functioning, and individual well-being. Even though many specific adverse

outcomes have been explored, it is also found that these adverse outcomes can be explained in terms of suppressing basic psychological needs. Thus, as argued by Ryan and Deci (2000), the theory is concerned with the definite nature of the positive changes in an individual's behaviour and suggests that social environmental factors can be antagonistic towards these developments. When these psychological needs are met, the theory proposes that individuals experience a higher level of intrinsic motivation, leading to a higher level of commitment, persistence, engagement, and well-being.

Nonetheless, while the theory's conceptual rigour and practical relevance have gained wide acceptance in diverse domains, its broader application also prompts questions on how SDT can sufficiently account for changes in human behaviour in a complex and dynamic work environment (Ryan and Deci 2000). With the evolution in the work environment and employee expectations, examining the research on SDT is vital for understanding its evolution and relevance in today's complex and fast-changing business environment. Reviewing the body of literature will allow the researchers to evaluate how the theory has been adapted and can be adapted to the new workplace context, uncover gaps in understanding and application of the theory, and refine the theory to address emerging needs and challenges (Vansteenkiste et al. 2020).

Bibliometric analysis has been used in this study to examine the trends in the 25 years of research on SDT. It is a widespread and rigorous method for exploring and analysing a larger volume of published data to uncover the evolutionary nuances of specific areas of interest (Donthu et al. 2021). The analysis helps identify trends, patterns, and the level of impact within a particular field. Academics employ bibliometric analysis for many other purposes, including uncovering emerging trends in journals and articles, collaboration patterns, and identification of knowledge gaps that pave the way for generating original research hypotheses and potential expected outcomes and contributions that can be made in the field (Donthu et al. 2021). Given the rise of digital work models and psychological well-being discourse post-2018, we expected a surge in SDT-related publications reflecting evolving workplace dynamics. In this context, this study can offer actionable insights for researchers by outlining future research avenues. The study intends to:

- Identify the current and future trends related to self-determination theory
- Map collaboration network among authors, nations and institutions
- Explore the key conceptual structures and keyword clusters within SDT research
- Highlight underexplored areas and propose future research directions using a SWOT-based analysis

By examining the evolution of research on the theory, this study offers a unique perspective on the progression of research on the theory. By employing extensive visual data and quantitative analysis of the trends and patterns, this study offers a visual interpretation of the research conducted over the past 25 years (1998–2023). The study provides a quick overview of the growing

corpus of works and demonstrates how the research trends have evolved. The study also employs various analysis techniques to identify the strengths and weaknesses in the current literature and future research potential through opportunities, as well as address the threats. Overall, the study offers a systematic view of SDT-centered research and opens the scope of extended research in its application in diverse areas.

2 | Methods

Scopus database and Web of Science are widely used for conducting bibliometric analysis. Considering the quality of research papers, this study's data have been extracted from the Scopus database. Additionally, the single database usage ensured consistency in indexing practices and the algorithm used for citation counting. After applying the keyword search, a total of 29,705 articles were identified. Further restricted to Articles only, in 1998–2023, 3706 articles were identified for the bibliometric analysis and extracted from Scopus. [TITLE-ABS-KEY ('Self-determination theory' 'SDT' 'PSYCHOLOGICAL NEEDS') AND PUBYEAR > 1998 AND PUBYEAR <= 2023 AND (LIMIT-TO (DOCTYPE, 'ar')) AND (LIMIT-TO (EXACT-KEYWORD, 'Self-determination Theory')) AND (LIMIT-TO (LANGUAGE, 'English'))].

The search was restricted to English-language publications to ensure indexing and citation metrics consistency. However, future research could benefit from multilingual inclusion, especially if researchers possess relevant language expertise. This search followed PRISMA guidelines (Page et al. 2021). The PRISMA flowchart for the search methodology has been depicted below (Figure 1).

To ensure methodological rigour, name duplications were resolved using the manual verification of inconsistencies. The keywords for search were standardised using synonym matching and stopword removal to enhance thematic search accuracy. This bibliometric analysis involved various analysis methods, including authors, documents, production, collaborations, and network visualisation. To analyse the data collected about the SDT, we have used the R programme 'Bibliometrix-Biblioshiny' and VOSviewer software. VOSviewer and Bibliometrix (R) were selected for their robust capabilities in visualising co-authorship networks, keyword clusters, and thematic evolution. VOSviewer excels in density and overlay visualisation, while Bibliometrix offers advanced statistical summaries and thematic mapping. Thresholds for various analyses were established based on the minimum citation counts, keyword occurrences, and network visualisation parameters to ensure meaningful data representation.

3 | Results

This section provides the results of the objectives briefed in the introduction. The results include an illustration and a discussion of the information regarding publications, countries, authors, keywords, sources, trending topics, and collaboration networks.

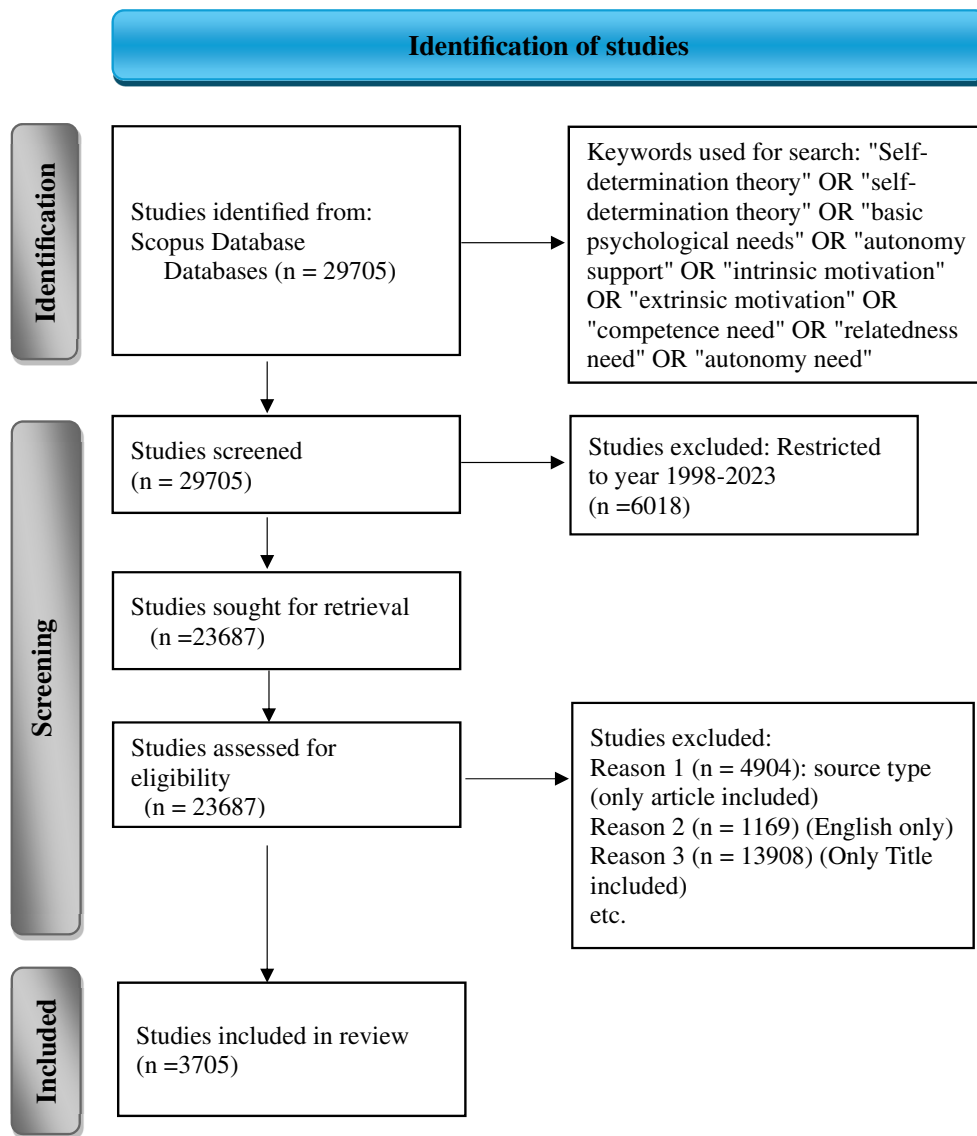


FIGURE 1 | PRISMA-based identification of studies.

3.1 | Sources Information

This source analysis focuses on analysing data to identify the most relevant sources, year-wise growth patterns in a publication, Bradford's law, sources' local impact, the total number of articles, etc. The outcomes of the data are listed in Table 1.

Table 1 demonstrates that the data were collected between 1998 and 2023. Only 3706 documents were selected for the study, including 1286 sources such as journals and books, with over 9079 authors. The total number of 4348 Keywords Plus (ID) and 7274 authors' keywords has been identified.

Although the full dataset spans 1998–2023, Table 2 focuses on the recent 10 years. As is evident, over 531 articles were published in 2023 focusing on SDT. This is followed by 2022, having $n = 458$ articles published on the SDT theory. At the comprehensive level, Figure 2 reflects the overall 25 years of publication trends from 1998 to 2023 for more visual clarity. The 12% annual increase

TABLE 1 | Primary information about the data.

Description	Results
Timespan	1998:2023
Sources (journals, books, etc.)	1286
Documents	3706
Keywords plus (ID)	4348
Author's keywords (DE)	7274
Authors	9079

Source: Biblioshiny.

refers to the period post-2014, where a consistent upward trajectory was observed. The figure highlights a notable increase in the publication trend, especially post-2018. This surge might correspond to the evolving workplace dynamics, including the rise in the hybrid work and remote work models that emphasise autonomy, competence, and relatedness as key factors in employee motivation.

Table 3 exhibits the names of the top 10 sources of publications on the SDT over 25 years. It is noted that *Frontiers in Psychology* has published the highest number of articles (n 155), followed by *Motivation and Emotion* (n 104). Then, there is the *Psychology of Sport and Exercise* (n 84), *International Journal of Environmental Research and Public Health* (n 68), *Journal of Sport and Exercise Psychology* (n 55), *Learning and Individual Differences* (n 42), etc.

Table 4 shows the leading sources of local impact. Local impact refers to the influence of a source within the SDT dataset, measured by h-index and total citations. It reflects both productivity and citation strength within the field. As is evident, *Psychology of Sport and Exercise* ranks first with an h-index of 42, followed by *Motivation and Emotion* with an h-index of 39, and *Journal of Sport and Exercise Psychology* has an h-index of 34. Interestingly, the table reveals that the overview is contrasting in terms of total

publications and total citations. For instance, while *Psychology of Sport and Exercise* has the highest h-index, it has a citation of 5015 with 84 publications. *Motivation and Emotion*, ranked 2nd in the h-index, has the highest total citations of 7879 and the second highest publication of 104 articles. While the *Journal of Educational Psychology* has an index of 24, it has published only 30 articles but garnered a total citation of 6219, the 2nd highest citation, measuring the local impact.

Bradford's Law is one of the fundamental laws in bibliometric analysis. It indicates the scattering of the articles into three distinct categories, comprising articles following common patterns and devotion to the subject matter. Figure 3 illustrates that journals like *Frontiers of Psychology*, *Motivation and Emotion*, *Psychology of Sport and Exercise*, *International Journal of Environmental Research and Public Health*, *Journal of Sport and Exercise*

TABLE 2 | Analysis of annual scientific production.

Year	Total no. of articles
2023	531
2022	458
2021	431
2020	390
2019	341
2018	265
2017	230
2016	204
2015	177
2014	153

Source: Biblioshiny.

TABLE 3 | Top 10 relevant sources.

Sources	Articles
Frontiers in Psychology	155
Motivation and Emotion	104
Psychology of Sport and Exercise	84
International Journal of Environmental Research and Public Health	68
Journal of Sport and Exercise Psychology	55
Learning and Individual Differences	42
Sustainability (Switzerland)	41
Computers in Human Behaviour	37
Journal of Happiness Studies	36
Personality and Individual Differences	32

Source: Biblioshiny.

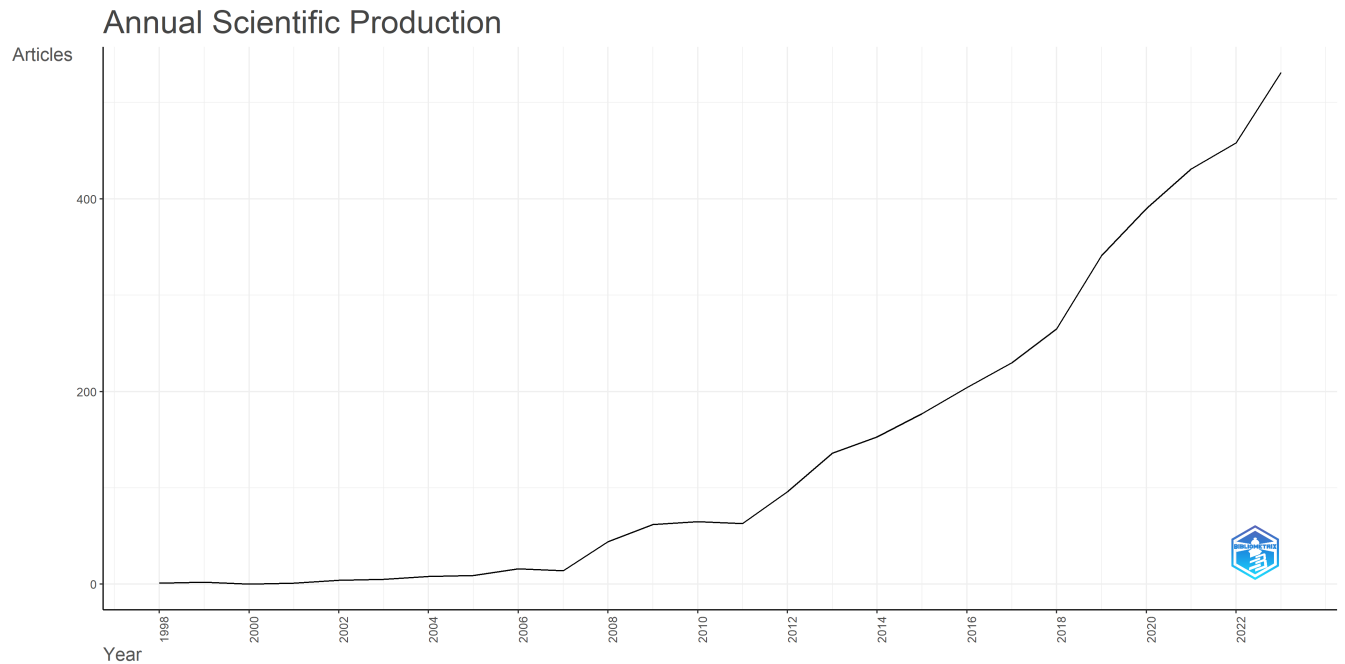


FIGURE 2 | Scientific productions on self-determination theory (Source: Biblioshiny).

TABLE 4 | Leading source's local impact.

Source	h_index	TC	NP	PY_start
Psychology of Sport and Exercise	42	5015	84	2002
Motivation and Emotion	39	7879	104	2003
Journal of Sport and Exercise Psychology	34	5417	55	2004
Computers in Human Behaviour	29	4839	37	2010
Frontiers in Psychology	25	2680	155	2014
Personality and Social Psychology Bulletin	25	2794	28	2003
Journal of Educational Psychology	24	6219	30	2005
Learning and Individual Differences	24	1661	42	2009
Contemporary Educational Psychology	19	2458	24	2005
Journal of Happiness Studies	19	2529	36	2008

Abbreviations: NP, number of publications; PY, publication year; TC, total citations.
Source: Biblioshiny.

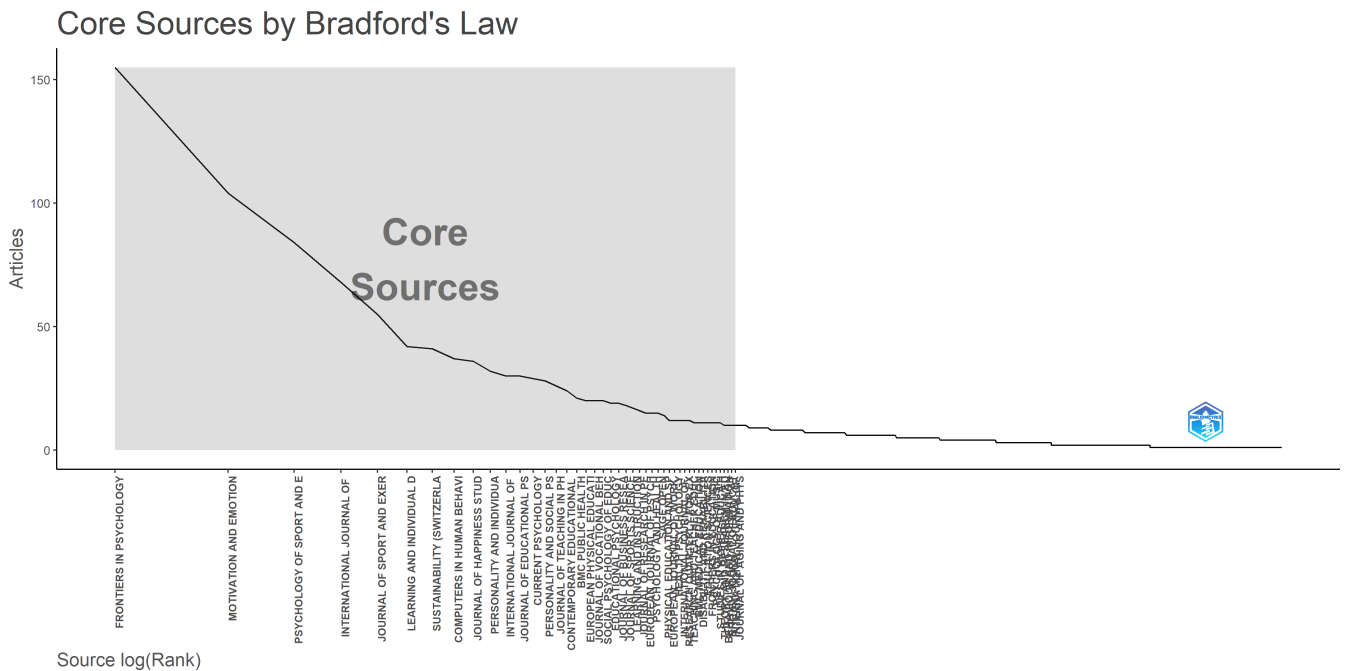


FIGURE 3 | Bradford law-based evaluation of the sources (Source: Biblioshiny).

Psychology, Learning and Individual Differences, Sustainability, and Journal of Happiness Studies fall under the Zone 1 core journals, Journal of Child and Family Studies, Journal of Positive Psychology, Measurement in Physical Education and Exercise Science, and Journal of Applied Psychology fall under the Zone 2, and journals like Applied Psychology, Asian Social Science, Australian Psychologists, and BMJ Open fall under the Zone 3, primarily indicating secondary sources of information. This classification helps understand that primary sources of theoretical and foundational discussions on the theory are published in Zone 1, whilst Zone 2 is focused on interdisciplinary applications, followed by Zone 3, which focuses on emerging discussions on the theory. The findings suggest that the theory research expands to other fields like education, workplace motivation, and sports. This distribution of zones reflects the evolving nature of SDT from being a foundational theory to a more diversely applied theoretical framework.

Table 5 offers the most locally cited sources and reveals that the Journal of Educational Psychology and the Journal of Psychotherapy Integration are the top-ranked journals publishing over 366 and 289 local citations, respectively. This is followed by the Journal of Sport and Exercise Psychology with 271 citations and Theory and Research in Education with 193 local citations.

3.2 | Author's Analysis

This section offers the analysis of information on the top authors using Lotka's analysis, the local impact of the authors' co-citation network, the top relevant affiliations, the country of Table 6 shows the names of the top relevant authors who have published articles on the self-determination theory. Vansteenkiste M. has published more frequently (n 114), followed by Ryan R.M. (n 73), and Soenens B. (n 69), etc. Aelterman N. and Koestner R.

TABLE 5 | Most local cited sources.

Sources	Local citations
Journal of Educational Psychology	366
Journal of Psychotherapy Integration	289
Journal of Sport and Exercise Psychology	271
Theory and Research in Education	193
Pers Soc Psychol Bull	187
Journal of Management	160
Learning and Instruction	96

Note: Scientific production and the most cited countries.

Source: Biblioshiny.

TABLE 6 | Top 10 relevant authors.

Authors	Articles	Articles fractionalized
Vansteenkiste M.	114	25.52
Ryan R.M.	73	19.46
Soenens B.	69	14.39
Ntoumanis N.	52	12.67
Hagger M.S.	45	12.78
Haerens L.	39	7.29
Reeve J.	32	9.74
Weinstein N.	32	9.49
Aelterman N.	31	5.9
Koestner R.	31	6.7

Source: Biblioshiny.

have taken the 9th and 10th positions on the list, with 31 articles related to self-determination theory. Lotka's Law 1926 explains the frequency of publications by authors in any given field, indicating the correlation between the authors and the number of articles published by them in any given field. Figure 4 illustrates the authors' productivity using Lotka's Law. While the X axis represents the documents the authors wrote, the Y axis shows the percentage of authors.

Table 7 demonstrates the analysis of the Lotka law's result, as evident in Figure 4, wherein one document was written by 7251 authors, with the proportion of authors being 0.799. One thousand and thirty three authors wrote two papers, with 0.114 authors in total, and so forth. Only 11 authors have authored 10 papers.

TABLE 7 | Analysis of the author's productivity through Lotka's law.

No of authors	Documents written	Proportion of authors
7251	1	0.799
1033	2	0.114
353	3	0.039
134	4	0.015
83	5	0.009
62	6	0.007
30	7	0.003
20	8	0.002
20	9	0.002
11	10	0.001

Source: Biblioshiny.

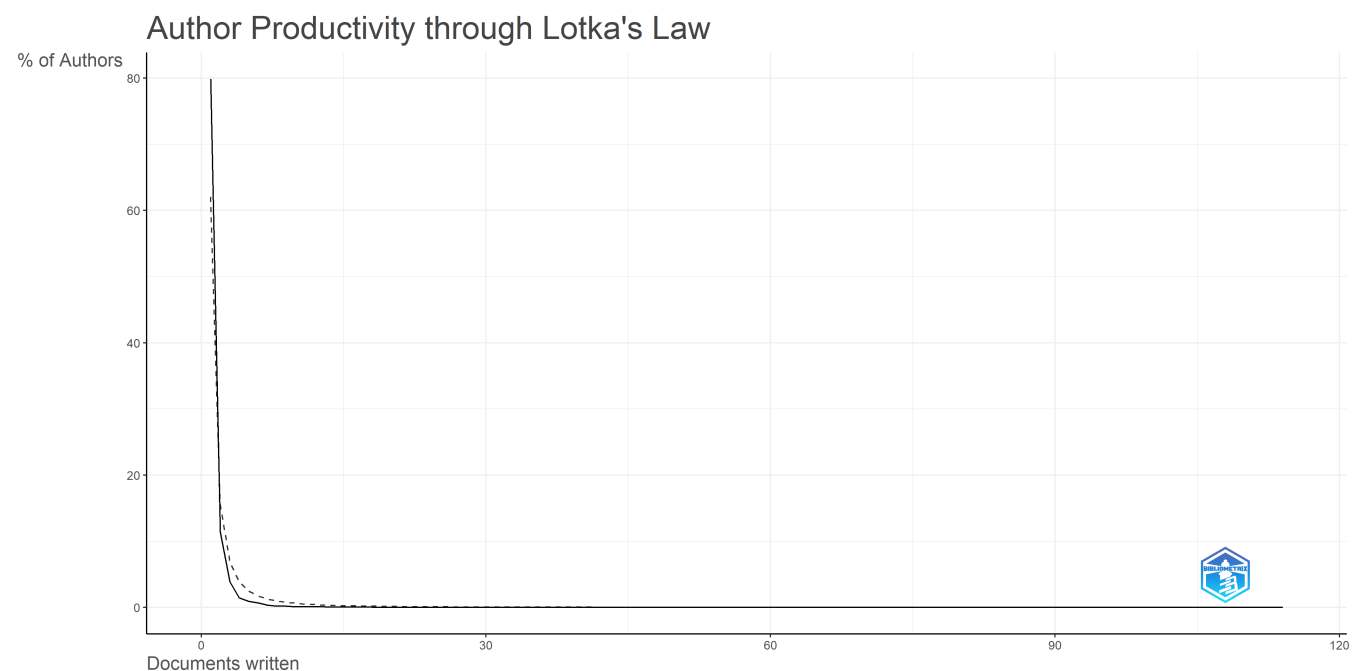
**FIGURE 4** | Authors' evaluation using Lotka's law (Source: Biblioshiny).

Table 8 illustrates the top 10 authors based on local impact. The results conclude that Vansteenkiste M. ranks first regarding the h-index score of 53, followed by Ryan R.M. with an h-index score of 51. Reeve J has scored the lowest h-index of 20. In terms of the total citations, Vansteenkiste M. (TC 11132) and Ryan R.M. (TC 16982) are among the highest-cited authors. Hagger M.S. has received the lowest TC 2089 yet is listed among the top 5 owing to the h-index and number of publications. In the context of several publications, Vansteenkiste M. (TP 114), Ryan R.M. (TP 73), and Soenens B. (TP 69) are the top three authors.

Figure 5 displays the authors' co-citation analysis network. As can be seen, the analysis reflects four clusters. Cluster 1 includes authors like Ryan R.M., Cohen J., Hayes R.F., Deci E.L., Gagne M., and Vansteenkiste M., belonging to Cluster 2. While Fornell C. and Baumeister R.F. belong to cluster 3, cluster 4 includes authors like Bandura A. and Tabachnick B.G. Interestingly, Deci

E.L. and Ryan R.M. have been part of each cluster. The cluster thematic analysis suggests that whilst the Cluster 1 authors primarily focused on applying the theory in the context of motivation and psychological needs, Cluster 2 authors attempted to establish a link between SDT and organisational behaviour and leadership. Lastly, Clusters 3 and 4 have attempted to apply theory to broader behavioural sciences.

Table 9 shows the leading affiliations publishing articles on self-determination theory. Ghent University has published most frequently with 413 articles, followed by Curtin University ($n = 190$), University of Rochester ($n = 146$), McGill University ($n = 141$), and University of Ottawa ($n = 127$), among others.

Table 10 denotes the top countries based on scientific production on self-determination theory. The United States of America tops the list with 2802 publications, followed by Canada ($n 1256$), Australia ($n 1024$), the United Kingdom ($n 851$), and China ($n 843$) as the top by affiliation.

TABLE 8 | Top 10 authors' local impact.

Authors	h_index	TC	NP	PY_start
Vansteenkiste M.	53	11,132	114	2004
Ryan R.M.	51	16,982	73	1998
Soenens B.	35	5599	69	2004
Ntoumanis N.	29	4765	52	2001
Hagger M.S.	26	2089	45	2005
Deci E.L.	25	6599	28	1998
Haerens L.	24	2585	39	2010
Aelterman N.	23	2252	31	2012
Gagné M.	22	4815	28	2002
Reeve J.	20	4594	32	2009

Abbreviations: NP, number of publications; PY, publication year; TC, total citations.
Source: Biblioshiny.

TABLE 9 | Leading 10 relevant affiliations.

Affiliation	Articles
Ghent University	413
Curtin University	190
University of Rochester	146
McGill University	141
University of Ottawa	127
Australian Catholic University	122
University of Birmingham	90
Nanyang Technological University	84
Purdue University	78
University of Zaragoza	77

Source: Biblioshiny.

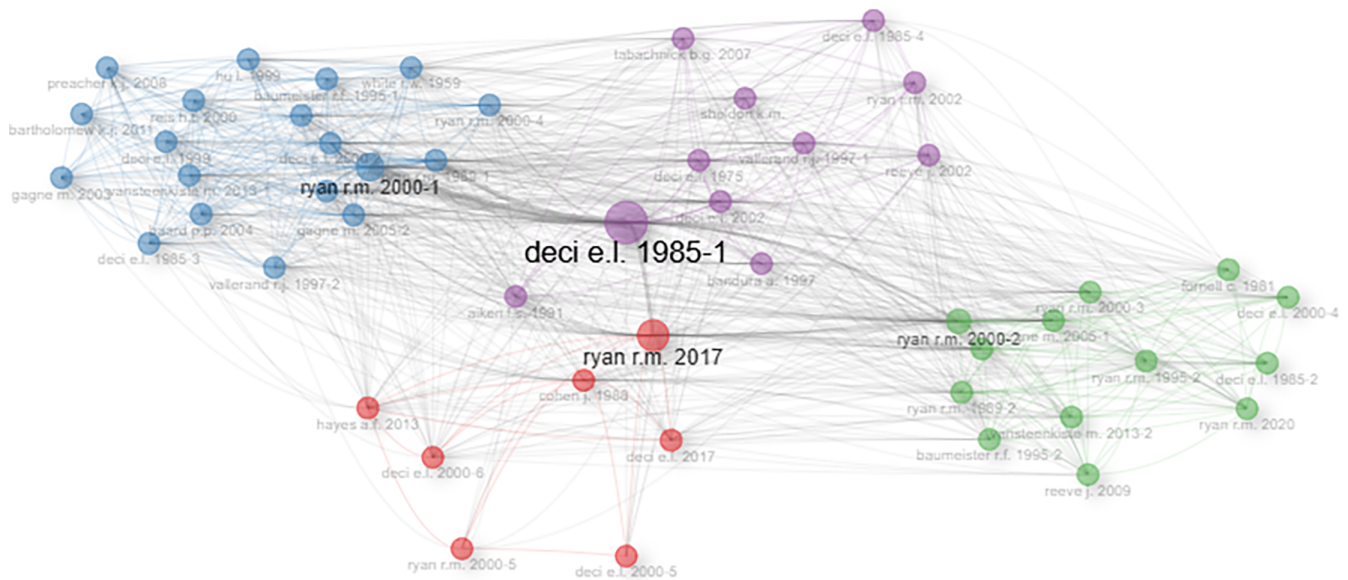


TABLE 10 | Countries' scientific production.

Country	Freq
USA	2802
Canada	1256
Australia	1024
UK	851
China	843
Belgium	790
Spain	603
Netherlands	579
Germany	527
France	295

Source: Biblioshiny.

TABLE 11 | Top cited nations.

Country	TC	Average article citations
USA	24,544	37.4
Canada	13,897	48.1
Belgium	10,548	74.8
United Kingdom	8956	42
Australia	7730	33.2
Mainland China (China Hong Kong)	7498	30.4
Germany	4828	32.4
Korea	3831	81.5
Netherlands	3763	28.3

Note: As per the peer review, reviewers suggested the data from China and Hong Kong to be combined under Mainland China.

Source: Biblioshiny.

Table 11 demonstrates the 10 cited countries with total citations. The United States has over 24,544 citations, Canada has 13,897 total, and Belgium has 10,548 citations. Hong Kong ranks in 10th place with 2581 citations. Since Hong Kong is officially part of China now, we can say that Mainland China has 7498 citations.

3.3 | Conceptual Structure

This section shows the network approach, including a thematic map and factorial analysis.

Figure 6 exhibits a thematic map, identifying the cluster's co-occurrence network based on the Keywords Plus between 1998 and 2023. The entire thematic map is divided into four quadrants based on specific parameters. The first quadrant focuses on the motor themes, followed by the 2nd quadrant, focusing on the Niche themes, the 3rd quadrant on the basic themes, and the 4th quadrant on the emerging or declining themes involving the intersection of concepts covering studies from other fields. In Figure 5 and Table 12, centrality reflects the degree of keyword connectivity across themes, while density indicates internal

cohesion within a theme. Quadrants are derived from these metrics: motor themes (high centrality and density), Niche themes (high density, low centrality), basic themes (high centrality, low density), and emerging/declining themes (low centrality and low density).

Table 12 shows the topics categorised under these thematic quadrants. Quadrant 4 includes themes that are either under-developed or require more studies, considering their increasing relevance. Future works can be derived from Quadrant 4, which involves studies using self-determination theory, extrinsic motivation, and advanced data analytics like structural equation modelling.

Figure 7 represents the word map under the factorial analysis. Based on the author's keyword method, the parameter reflects on the cluster, the pink-shaded portion. Multiple correspondence methods with several 50 show the emergence of a single cluster involving keywords like 'Psychology', 'motivation', and 'female personal autonomy', among others.

Figure 8 shows the word cloud based on the KeyWords Plus method. As can be seen, the word 'motivation' is the most frequently used word (n 1316), followed by 'female' (n 1312) and then 'male' (n 1269), 'human' (n 1097) and so forth.

Figure 9 depicts the author's keywords network. As we can see, Self-determination theory has been the significant keyword with a frequency of 3694, followed by motivation (n 219), basic psychological needs (n 215), autonomy (n 209), and intrinsic motivation (n 178), etc.

Figure 10 illustrates the density representation of the author's keywords, with 'Self-determination theory' as the most prominent keyword, the most significant yellow density surrounded by motivation and satisfaction being the most prominent keywords associated with it. Figure 11 illustrates the density representation of the keywords based on the clusters using VOSviewer.

As can be seen, there are 11 clusters identified, with Cluster 1 having keywords like adherence, behaviour change, children, and qualitative research; Cluster 2 includes keywords like burnout, COVID-19, gender, and leadership; Cluster 3 has basic psychological needs, depression, satisfaction, and so on.

The complete keyword co-occurrence analysis has been displayed in Figure 12. The study draws attention to the key topics of scientific attention, with concepts primarily focusing on self-determination theory, motivation, and basic psychological needs. An aggregate of 10,431 keywords was found in the analysis, where major studies were broadly falling into three clusters: cluster 1 involved keywords from studies focusing on education and sports, Cluster 2 mainly derived keywords from workplace context, and Cluster 3 focused on keywords derived from studies focused on mental health and well-being. One thousand and one hundred and four have at least five occurrences, which have been set as the threshold criterion for the network analysis. 'Self-Determination Theory' is the most often used keyword from 1998 to 2023 and is closely associated with other keywords. The keywords have been segregated into seven clusters,

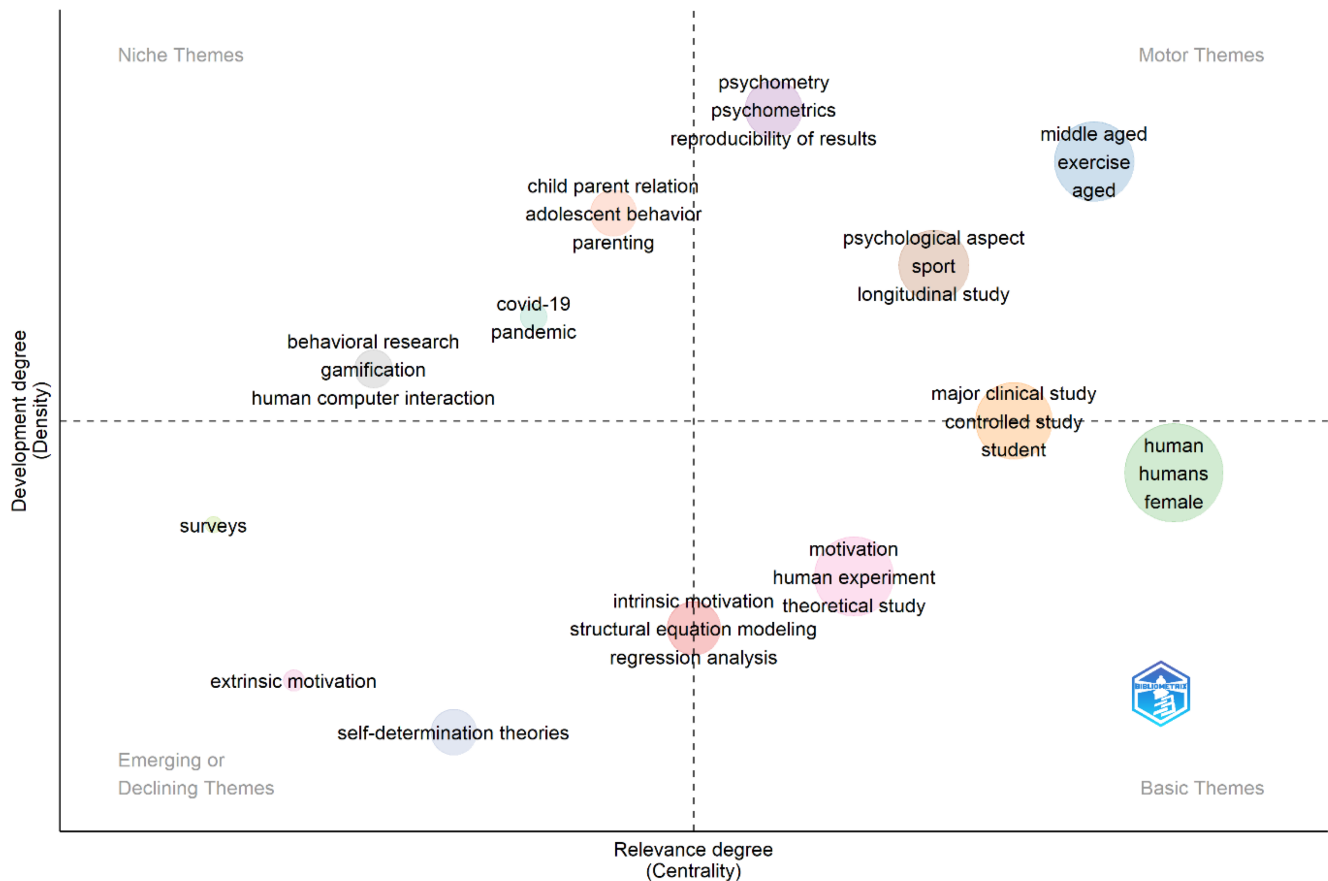


FIGURE 6 | Thematic map analysis (Source: Biblioshiny).

TABLE 12 | Thematic map quadrant-wise analysis.

Quadrant 1-motor themes	Quadrant 2-Niche themes	Quadrant 3-basic themes	Quadrant 4-emerging or declining themes
Aged	Child–parent relationship	Student	Self-determination theories
Middle-aged	Adolescent behaviour	Motivation	Surveys
Psychometry	Gamification	Human experiment	Extrinsic motivation
Psychological aspect	Covid-19 pandemic	Theoretical study	Structural equation modelling
Sports			Regression analysis

Source: Created by author.

each drawing attention toward the scope of future research in ‘Self-Determination Theory’.

3.4 | Social Structure

This section draws attention to the collaboration between different countries and institutions, the three field analyses, and the trending areas related to Self-Determination Theory. Figure 13 shows the collaboration between countries, and the same is summarised in Table 13.

The data reveals that the United States and Canada have the highest number of collaborations ($n = 84$), followed by collaboration between Australia and the United Kingdom with a frequency of 69, and the United States and China take third place with $n = 62$

and so forth. Interestingly, the United States, followed by Canada, has been among the top 2 originating countries for collaborations globally.

Figure 14 shows the collaboration network between various institutions in the field of self-determination theory. Overall, 13 clusters have been identified. Universities in Cluster 1 include Curtin University, the University of Birmingham, and the University of Tartu. Universities in Cluster 2 include Ghent University, the University of Rochester, Utrecht University, etc.

Figure 15 illustrates three field plots. Authors are displayed on the left field ($n = 10$), the nations of the authors are shown in the centre ($n = 10$), and the keywords are shown on the right field ($n = 10$). Ryan R.M., Koester R., Weinstein N., and other

FIGURE 7 | Word map under factorial analysis (*Source: Biblioshiny*).



FIGURE 8 | Word cloud (*Source*: Biblioshiny).

notable authors contributed to the SDT research. The top contributing nations include the United States, Canada, Australia, the United Kingdom, Belgium, and China. Top search terms include self-determination theory, motivation, physical activity, and basic psychological needs, among others.

Figure 16 shows trending topics from 2012 to 2023 based on KeyWords Plus. As we can see from 2015, many issues have gained researchers' attention. In the year 2015, topics related to sports (freq. 34) and psychological counselling (freq. 50) were trending; choices in 2016 included attitude to health (freq. 65) and longitudinal study (freq. 57); frameworks in 2017 included a focus

on adolescents (freq. 625) and middle-aged (freq. 401); the focus shifted to gender [male (freq. 1269) and female (freq. 805)] in 2018; 2019 focused on humans and motivation (freq. 1316), and 2020 involved the trending topics focusing on controlled and significant clinical study. In 2021, the focus was on theoretical study (freq. 189), self-determination (freq. 85), and mental health (freq. 80). 2022 witnessed increased study with freq. under the lens and the impact of COVID-19, and focus on intrinsic motivation (freq. 95). In 2023, in addition to AI (freq. 5), the focus is on emotional well-being (freq. 5). It is interesting to see that the usage of SDT theory has evolved, wherein the pre-pandemic period saw it to be primarily linked with motivation, whilst the post-pandemic shift is towards mental health and well-being.

4 | Discussion

Studies over the years demonstrate that research on SDT across the globe has been affected by various factors that can be categorised into internal (individualistic inspiration and interest) and external factors (environmental conditions). Internal factors are those within the researchers' control, while external factors, though beyond their direct influence, can still be strategically leveraged. This study identifies four components in the context of identifying the strengths, weaknesses, opportunities, and threats associated with the research conducted on the SDT theory over the years; the study employs SWOT analysis for examining the dataset.

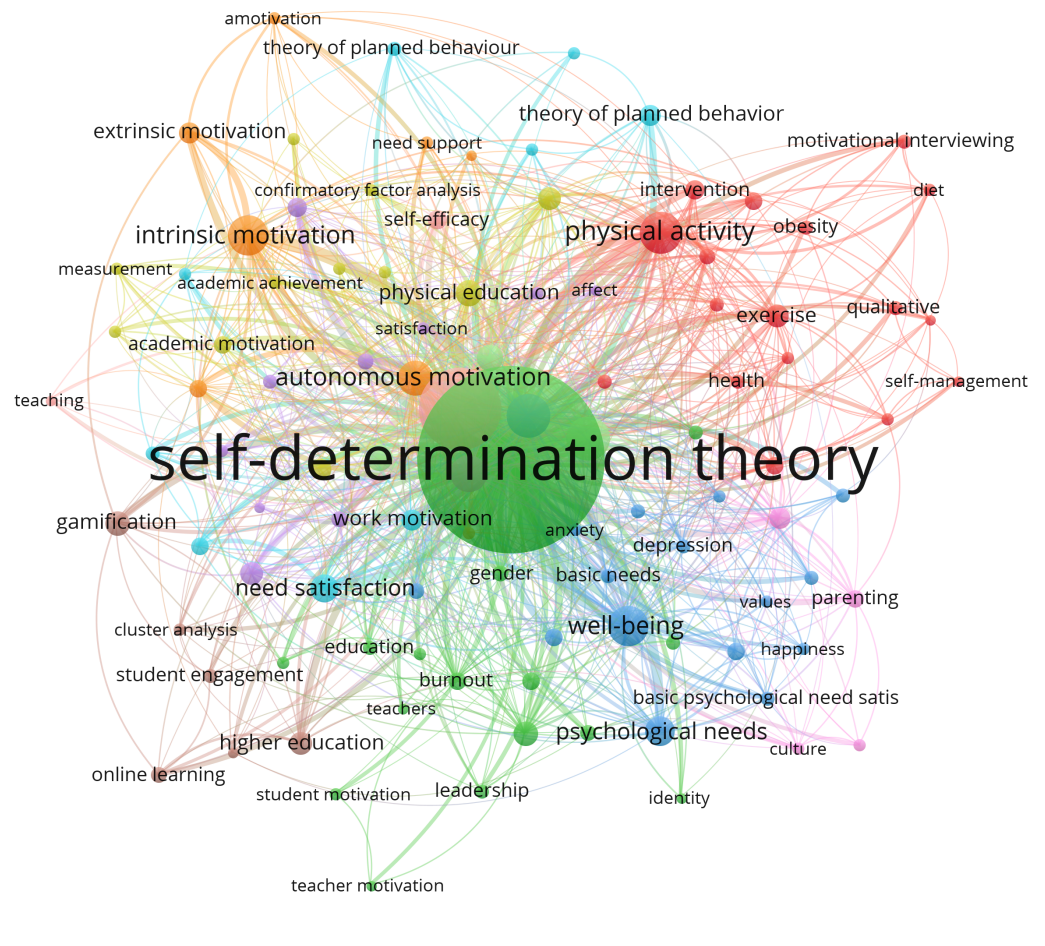


FIGURE 9 | Representation of the author's keywords (Source: VOSviewer).



FIGURE 10 | Density representation of author's keywords (Source: Biblioshiny).

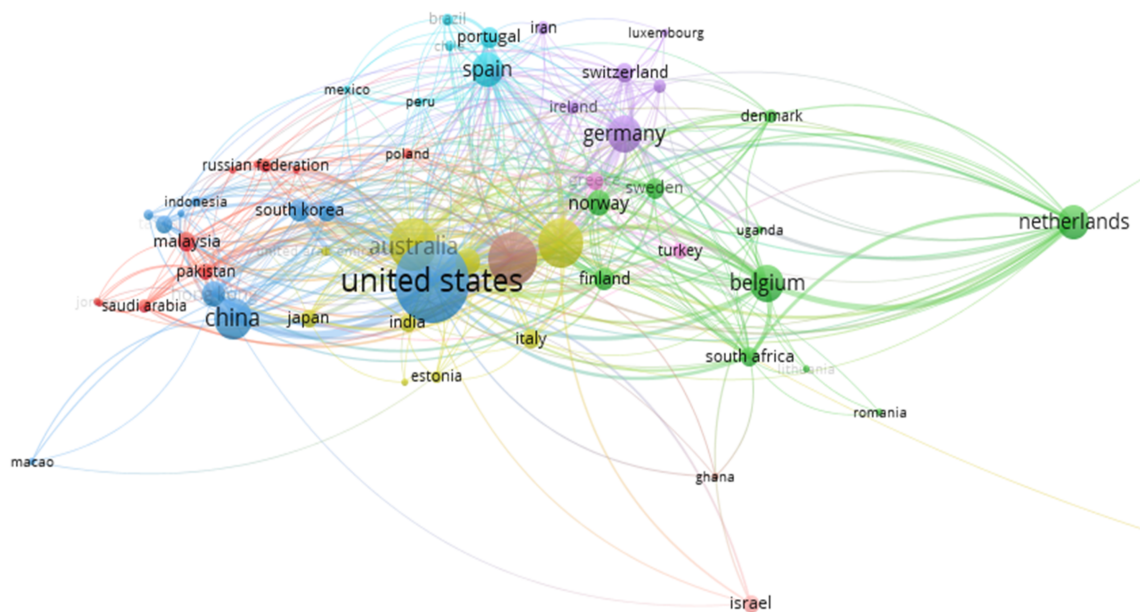


FIGURE 13 | Collaboration network of countries (Source: VOSviewer).

TABLE 13 | Analysis of countries' collaboration.

From	To	Frequency
USA	Canada	84
Australia	United Kingdom	69
USA	China	62
USA	Australia	53
USA	United Kingdom	46
Canada	Australia	43
Canada	France	36
Belgium	Netherlands	29
China	Hong Kong	23
USA	Korea	23

Source: Biblioshiny.

The bibliometric analysis of the SDT research highlights significant emerging trends and strengths, weaknesses, opportunities, and threats (SWOT) in applying self-determination theory, employee engagement, employee well-being, and motivation. While the descriptive trends help understand the scope of SDT's application, the interpretive value lies in recognising how this evolution reflects broader socio-cultural and technological shifts. For example, the dominance of SDT research in Western nations (Table 10) is not only a geographic trend; however, it reflects the theoretical alignment between SDT's emphasis on autonomy and the values of individualistic cultures. This has implications for adopting or resisting the theory in collectivist contexts, where the need for relatedness might be more culturally salient.

Further analysis reveals that internal and external factors influence the expansion of SDT research across multiple sectors, mainly focusing on the need for HR interventions and employee psychological needs. Although the term 'human resources' was

not explicitly coded, the presence of workplace-related keywords in Cluster 2 (Figure 11) and journals such as *Journal of Management* (Table 5) suggests an emerging interest in organisational applications of SDT. The data analysis shows the SDT research's strengths as a well-established theoretical framework, focusing on the psychological needs of autonomy, competence, and relatedness. Research by Flamant, Martinent, and Gaudreau (2023) and Reeve et al. (2023) confirms that these constructs remain key drivers for employee motivation, well-being, and engagement. The consistent validation of the SDT has been mainly in the educational setting, where student motivation was significantly improved through fulfilling psychological needs (André et al. 2023; Kaplan and Patrick 2016).

In addition, this theory's application in the corporate background offers valuable insight into the complex correlation between the basic psychological need for satisfaction and employee engagement, talent retention, and the need to boost productivity (Baard et al. 2004; Gagné and Deci 2005). Additionally, the adaptability of the theory across sectors underlines its importance. As demonstrated by Carraca et al. (2023), encouraging autonomy and competence among employees can increase job satisfaction and organisational commitment. Its alignment with other widely accepted models, such as the PERMA framework (Seligman 2011), further aids in connecting positive emotions, engagement, meaning, and achievement with psychological needs, thereby allowing SDT to offer a more comprehensive and holistic understanding of the concepts of employee well-being and its role in the development of sustainable HR practices (Sheldon et al. 2020).

An added strength of SDT lies in bringing out the role of transformational leadership style in improving employees' psychological need satisfaction and consequently improving the organisational outcomes (Reeve et al. 2023). Despite its strengths, SDT research has limitations, especially in scope and its application in high-pressure industries like healthcare and IT/ITES, where job

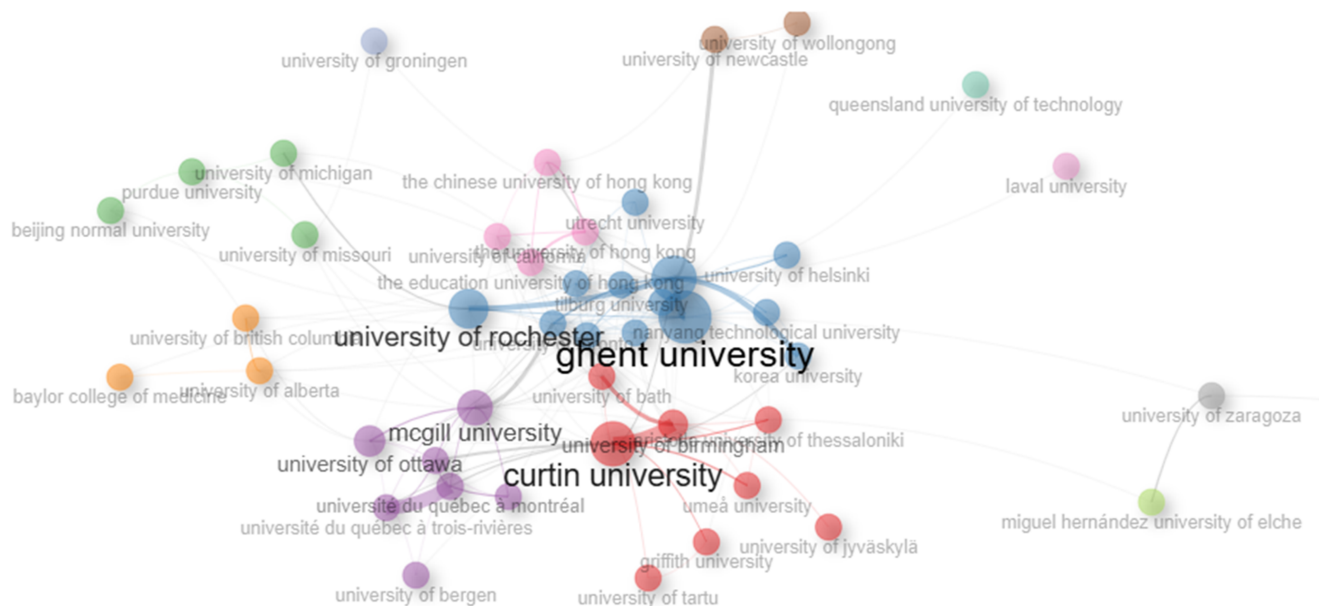


FIGURE 14 | Collaboration network of institutions (Source: Biblioshiny).

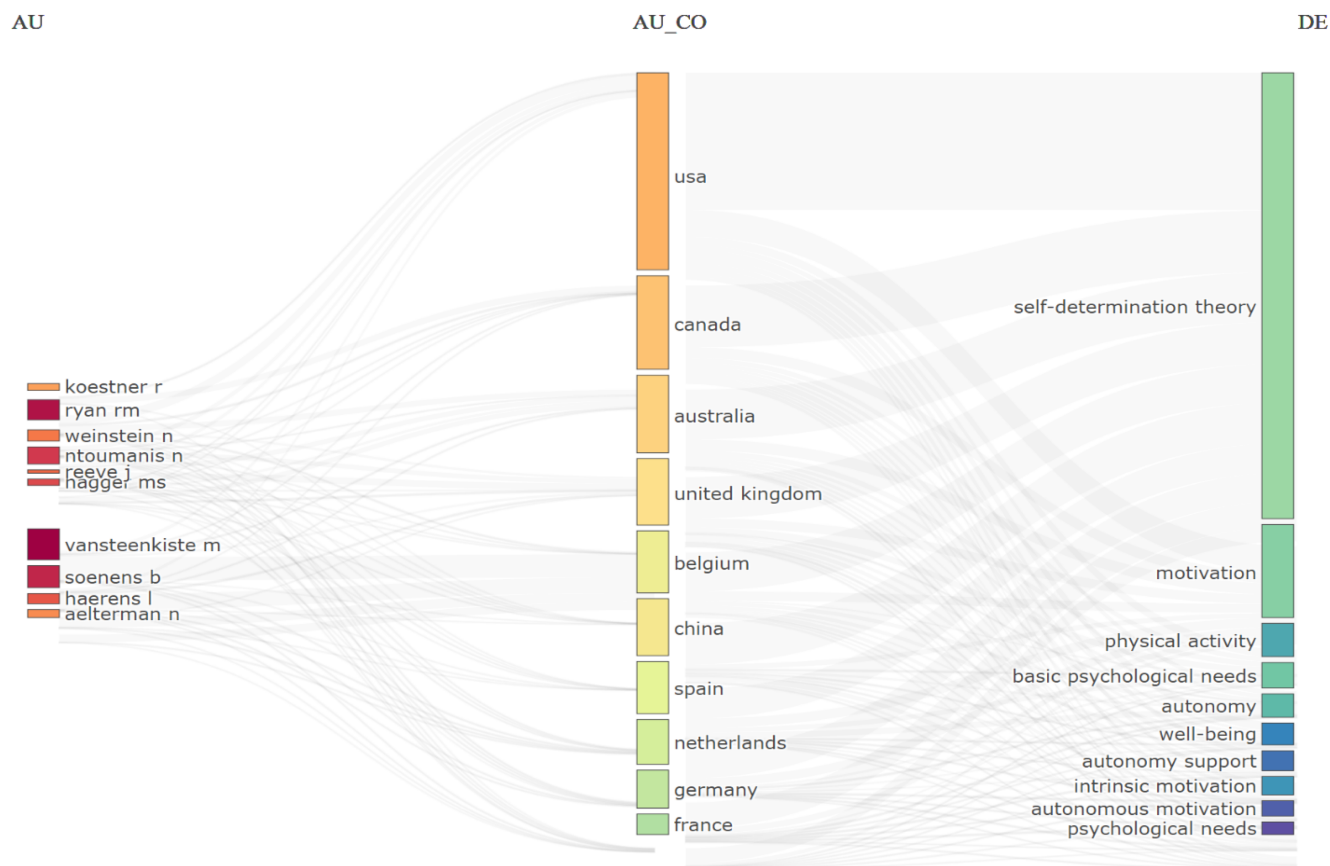


FIGURE 15 | Three-field plot analysis (*Source: Biblioshiny*).

intensification and role ambiguity are highly prevalent. In these work environments, addressing the psychological needs of the employees can be highly challenging. In the presence of burnout, workload, and disengagement, these unmet needs can get underexplored or unidentified.

This absence is reflected in the keyword co-occurrence and thematic map analysis, where terms like ‘burnout’, ‘technostress’, or ‘digital fatigue’ remain marginal. This suggests that SDT literature may be overly focused on positive outcomes, underemphasising its potential explanatory power in adverse

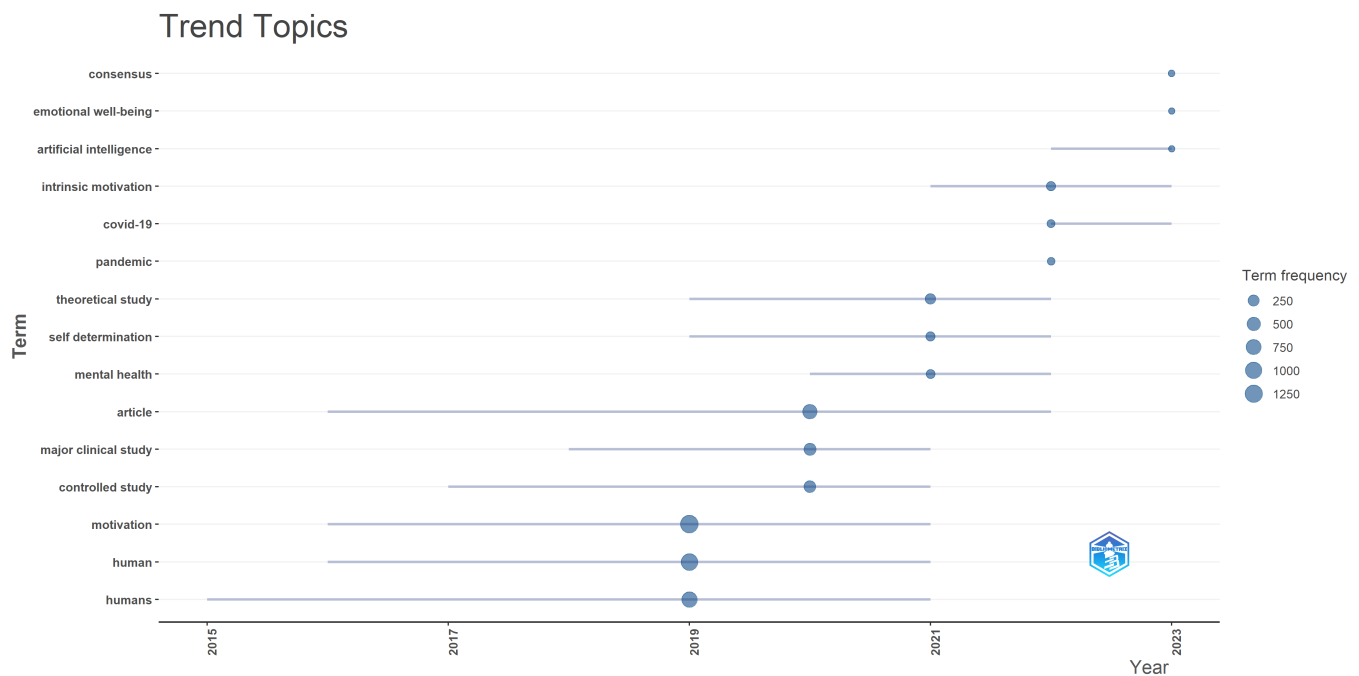


FIGURE 16 | Trending topics from 2015 and 2023 (Source: Biblioshiny).

work conditions- a limitation that weakens its practical utility in today's demanding workplaces.

Flamant, Fouquereau, et al. (2023) and Deslippe, Paquette, and Bergeron (2023) found that while autonomy has been a powerful motivator for employees, the intense and pressurising workload often undermines its benefits. Another weakness of the SDT research lies in the narrow focus on the psychological and educational domains, which limits its application in public policy and corporate settings. Carraça, Rodrigues, et al. (2023) stressed the need for more cross-disciplinary research adopting SDT dimensions. Similarly, Flamant, Martinent, and Gaudreau (2023) also suggested that the current body of literature often overlooks the broader applications and implications of SDT in environments that are synonymous with high work and performance pressure, and there is a need for viewing these dimensions from the perspective of the fulfillment of psychological needs. Also, SDT research often focuses on positive organizational outcomes like well-being, commitment, and engagement. In contrast, the adverse consequences are frequently overlooked and go unaddressed, such as stress, burnout, and disengagement. Jang et al. (2010) and Baard et al. (2004) call for more research examining how the lack of autonomy, competence, and relatedness can result in adverse psychological outcomes.

Beyond these thematic imbalances, the structural concentration of SDT research around a few prolific authors and institutions, particularly Ryan, Deci, Vansteenkiste, and universities such as Ghent and Rochester (Tables 8 and 9), suggests an intellectual centralisation that may contribute to theoretical consistency but also risks epistemic insularity. This pattern, evident in the co-citation and collaboration networks (Figure 5, Figure 14), implies that while SDT has grown quantitatively, its development is mainly driven by a narrow set of voices. Analytical depth is further constrained by the thematic redundancy in keyword clusters

(Figures 11–12), where core constructs like autonomy and motivation dominate without significant diversification. This signals a possible saturation of foundational themes, reinforcing the urgency to explore underdeveloped areas such as AI-driven work environments, cross-cultural interpretations of autonomy, and SDT's interface with emerging psychological models. Without such expansion, SDT risks conceptual stagnation, where the proliferation of studies adds breadth but not depth to the field. Recommendations for future research are based on the bibliometric trends identified in Figures 11–12, which show thematic saturation around autonomy and motivation. This signals the need to diversify SDT applications beyond foundational constructs.

While 'employee' was not a dominant keyword, the bibliometric data (Figure 16) show post-2018 trends in workplace-related terms such as 'engagement' and 'digital leadership', which indirectly reflect employee-focused research that is still under-theorised. These trends demand interpretive attention, especially in how SDT's constructs of autonomy and relatedness can be maintained in digital or hybrid work models.

Whilst there are weaknesses or gaps in the current body of literature on SDT, opportunities can be explored to enhance the quality of research across industries and sectors. The post-pandemic transformation of the work environment presents numerous opportunities for exploration and expansion of SDT research. The acceleration of the remote and hybrid work models raises critical concerns over how autonomy and relatedness can be maintained in digital workspaces. For example, a Reeve et al. (2023) study argues that employee engagement in virtual teams can be boosted through autonomy-supportive leadership, creating a venue for future research in digital work environments. Another opportunity lies in integrating SDT with sustainable HR practices, especially in organisations that focus on purpose-driven work environments and are concerned about

long-term employee well-being. Offering further exploration areas, Carraça, Rodrigues, et al. (2023) called for exploring the importance of inculcating a sense of relatedness to foster a collaborative workplace culture, and Flamant, Fouquereau, et al. (2023) focus on the need to examine how autonomy can empower employees in the fast-paced innovation-driven industries.

A promising area for future SDT development is cross-cultural research, considering the theory has been predominantly applied in Western individualistic societies where autonomy and competence are highly valued. However, using the theory in a collectivist culture, where relatedness is prioritised over autonomy, needs to be explored further, thereby creating avenues for the adaptability of SDT in different cultural settings. These cultural variations and exploration can offer a more nuanced understanding of how the core principles of the theory manifest across diverse cultural and organisational contexts. In collectivist societies, the need for relatedness might take precedence over autonomy, which can potentially influence the motivational dynamics of the employees. For example, in Asian culture, social harmony and group affiliations are prioritised, which could reshape how autonomy is perceived, not at an individual level, but acting in alignment with the group values. This highlights the cultural nuances that the theory in its traditional form might not have fully captured. Studies by Deslippe, Williams, and Murphy (2023) and Carraça, Rodrigues, et al. (2023) suggest adapting the theory to cultural context to enhance its relevance and applicability. This opens the possibility of refining SDT constructs from a culturally embedded perspective, perhaps redefining autonomy not as independence, but as harmony with collective values. Doing so would extend the theory's global relevance and make it more inclusive of non-Western motivational dynamics. Future studies should explore culturally sensitive exploration of SDT and possibly offer a new rebalanced approach to understanding the three basic needs from a cultural perspective.

Even though the study has identified avenues for extending future research on SDT, the research in this theory faces several threats that could limit its broader application. With the rapid development of information technology and the digitalisation of workplaces, especially in adopting artificial intelligence and automation, one can expect significant changes in employees' psychological needs, thereby creating concerns over how these needs can be met. As routine job tasks get automated, the traditional form of autonomy and competence might need to be redefined. Flamant, Fouquereau, et al. (2023) and Deslippe, Williams, and Murphy (2023) have expressed concerns over the risk of SDT becoming less relevant in industries where human decision-making becomes increasingly minimised. Furthermore, since SDT faces competition from other comprehensive models like the Job Demands–Resources (JD-R) model, there is a need for integrating the theories in a way that helps address the demands and resources that are available to the employees and offers a broader framework to address both positive and negative organisational outcomes. The Job Demands–Resources (JD-R) model offers a complementary framework to SDT by emphasizing how job demands (e.g., workload, emotional strain) and resources (e.g., autonomy, support) influence employee well-being and performance. Integrating SDT's psychological needs with JD-R's structural components can provide a broader lens to address both positive and negative organisational

outcomes. This integration allows for a more nuanced understanding of how internal motivation interacts with external job conditions. As such, SDT must be expanded to broaden its scope to include psychological outcomes that will remain relevant in both organisational psychology and management research (Reeve et al. 2023). Lastly, organisational resistance to change can significantly threaten the successful adoption and implementation of SDT-based interventions to address employees' psychological needs (Vansteenkiste et al. 2022). Overall, whilst there are gaps in the existing literature and threats to the application of SDT, leveraging the opportunities can significantly enhance its application across diverse industries and academic research areas.

As shown in Table 3, the prominence of sports psychology journals such as *Psychology of Sport and Exercise* and *Journal of Sport and Exercise Psychology* suggests a strong disciplinary focus. This trend indicates that SDT research has been particularly influential in sports contexts, which warrants deeper exploration in future studies.

Table 14 further summarises the SWOT analysis of SDT research from the identified dataset:

To further assess the research landscape of SDT, based on the findings of Table 14 and the review of the preceding analysis, each component of the SWOT analysis has been discussed, grounded in the bibliometric evidence presented earlier in the study.

4.1 | Strengths

The high volume of publications and the concentration of core keywords, such as motivation, autonomy, basic psychological needs, and engagement (Figures 8–11), underscore the conceptual strength of SDT and the consistently rising academic interest. The dual process model continues to receive strong empirical support (Matos et al. 2023; Wang and Deci 2022), and the theory's adaptability is reflected in the cross-sectoral use, particularly in leadership development and employee engagement studies (Vansteenkiste and Ryan 2021; Ryan and Deci 2019).

4.2 | Weaknesses

Several weaknesses emerge from the review of the studies. First, cross-cultural generalisation is a concern as most of the studies are originating from or focused on Western individualistic societies (Table 10), limiting the theory's applicability in collectivist cultures where relatedness takes priority over autonomy (Carraça, Silva, et al. 2023; Deslippe, Williams, and Murphy 2023). Secondly, the theory's practical application continues to be challenging, especially in high-pressure environments such as IT and healthcare. Theories around autonomy-supportive behaviours often face difficulties in these contexts, where burnout and workload are high (Flamant, Fouquereau, et al. 2023). Additionally, the review finds limited longitudinal and field-based studies in real-world settings (Walker and Smith 2022), which can enrich the understanding of the theory.

TABLE 14 | SWOT analysis of SDT research.

Dimension	Key points	In-text citation (authors)
Strengths	SDT provides a comprehensive framework for understanding motivation and well-being.	André et al. (2023), Carraça, Rodrigues, et al. (2023), Flamant, Martinent, and Gaudreau (2023), Reeve et al. (2023), Deslippe, Williams, and Murphy (2023)
	Strong empirical support for SDT's dual-process model.	Matos et al. (2023), Nguyen and Deci (2022), Walker and Smith (2022), Wang and Deci (2022), Smith and Williams (2021)
	Effective in promoting engagement across education, healthcare, and sports.	Brown et al. (2021), Zhang et al. (2021), Thompson et al. (2020), Patel and Sheldon et al. (2020), Chen et al. (2020)
	SDT is widely applicable in organisational settings and leadership development.	Martín-Albo et al. (2014), Deci et al. (2020), Ryan and Deci (2019), Sheldon et al. (2020), Vansteenkiste and Ryan (2021)
Weaknesses	Challenges in cross-cultural generalizability.	Carraça, Silva, et al. (2023), Deslippe, Williams, and Murphy (2023), Flamant, Martinent, and Gaudreau (2023), Brown et al. (2021), Zhang et al. (2021)
	Difficulty in operationalising autonomy-supportive behaviours.	Thompson et al. (2020), Patel and Sheldon et al. (2020), Chen et al. (2020) Smith and Williams (2021),
	Limited long-term research in organisational settings.	Reeve et al. (2023), Walker and Smith (2022), Nguyen and Deci (2022), Matos et al. (2023), Wang and Deci (2022)
	High reliance on self-report measures, raising validity concerns.	Martín-Albo et al. (2014), Deci et al. (2020), Ryan and Deci (2019), Vansteenkiste and Ryan (2021), Sheldon et al. (2020)
Opportunities	Expansion of SDT to digital and remote work environments.	André et al. (2023), Nguyen and Deci (2022), Walker and Smith (2022), Brown et al. (2021), Zhang et al. (2021)
	Applying SDT in healthcare, oncology, and sustainable behaviours.	Smith and Williams (2021), Thompson et al. (2020), Patel and Sheldon et al. (2020), Chen et al. (2020)
	Potential integration of SDT with other psychological theories.	Reeve et al. (2023), Matos et al. (2023), Wang and Deci (2022), Martín-Albo et al. (2014), Deci et al. (2020)
	Using SDT to promote policy changes in education and public health.	Ryan and Deci (2019), Sheldon et al. (2020), Vansteenkiste and Ryan (2021), Flamant, Martinent, and Gaudreau (2023), Walker and Smith (2022)
Threats	Competing theories challenge SDT's universality.	Flamant, Fouquereau, et al. (2023), Walker and Smith (2022), Matos et al. (2023), Reeve et al. (2023), Deslippe, Paquette, and Bergeron (2023)
	Over-reliance on self-report measures leads to biases.	Zhang et al. (2021), Brown et al. (2021), Smith and Williams (2021), Thompson et al. (2020), Patel and Sheldon et al. (2020)
	Rapid technological changes may alter motivational dynamics.	Chen et al. (2020), Wang and Deci (2022), André et al. (2023), Carraça, Silva, et al. (2023)
	Difficulty in applying SDT in highly structured corporate environments.	Martín-Albo et al. (2014), Deci et al. (2020), Ryan and Deci (2019), Vansteenkiste and Ryan (2021), Sheldon et al. (2020)

4.3 | Opportunities

Table 2 shows a sharp rise in SDT publications post-2018, which aligns with the increased focus on digital work environments and psychological well-being. This trend supports the relevance of SDT in addressing emerging workplace challenges. The surge in SDT-related research post-2018 (Table 2 and Figure 2) corresponds to the evolving work models like remote and hybrid settings, where autonomy and relatedness are challenging. Trending keywords in 2023, such as AI, emotional well-being, and digital platforms (Figure 16), point to underexplored areas for applying SDT. The theory has immense potential in its application and integration with other psychological theories. Organisational leaders can apply SDT principles to design autonomy-supportive environments, foster competence through meaningful feedback,

and enhance relatedness via inclusive practices. These strategies are particularly relevant in hybrid and remote work settings, where psychological need satisfaction can mitigate burnout and improve engagement.

4.4 | Threats

While SDT continues to thrive, several external challenges could limit its future applicability. Competing frameworks like the Job Demands-Resources (JD-R) model offer more context-specific explanations for motivation and burnout, potentially overshadowing SDT in applied organisational research (Flamant, Fouquereau, et al. 2023; Walker and Smith 2022). Additionally, rapid technological advances and AI-driven work environments

may alter the psychological dynamics that SDT traditionally addresses. As shown in the keyword and thematic maps (Figures 6 and 11), emerging terms like automation, technostress, or digital fatigue are absent, revealing a gap in the literature. Lastly, organisational resistance to change (Vansteenkiste et al. 2022) may be a barrier to implementing SDT-aligned practices, especially in bureaucratic or performance-driven settings.

Our research analysis of recent publications, including Ryan (2023), further adds depth to the need to explore SDT's application in a broader context, including its application in emerging fields like artificial intelligence and sustainability-focused HR practices. Research has extended the application of SDT to emerging workplace models, including remote work environments. The digital transformation of work necessitates re-evaluating the application of autonomy, competence, and relatedness in virtual spaces. This aligns with the identified trends showing a rise in the SDT-related publications post-2018, reflecting a growing interest in workplace adaptation.

Additionally, as suggested by Gagné et al. (2022), with the changing nature of work driven by technological changes, there is scope for applying the theory to understand its role in addressing the concerns over uncertainty and interdependence for driving employee motivation, well-being, and performance. Furthermore, the scoping review by Herchenroeder et al. (2024) further validates our findings that the foundational emphasis on autonomy, competence, and relatedness will continue to be highly relevant. However, our findings also highlight underexplored areas, including the application of SDT in high-pressure work environments, non-Western cultures, and digitally transforming work environments. This has been substantiated through the SWOT analysis, wherein the need for robust empirical frameworks considering the dynamics of workplaces has been identified. The findings affirm the need to extend the SDT's theoretical dimensions to address the demands of the contemporary workplace and cross-cultural validity.

5 | Research Gaps and Future Directions

The findings of this analysis provide important insights into the evolution of research on the SDT theory, highlighting key themes that are future areas of exploration. The consistent increase in the SDT-related publications post 2018 establishes a growing interest in understanding how the psychological needs shape workplace engagement, motivation, and well-being in digitalised and hybrid work environments. While this trend has been identified, a critical gap remains in systematically identifying how SDT can be operationalised in diverse work settings, especially in high-pressure sectors like IT, healthcare, and finance.

We recommend future research directions to focus on applying SDT principles to remote and hybrid work settings. For example, recent research by Reeve et al. (2023) and Flamant, Fouquereau, et al. (2023) has examined the integration of autonomy-supportive leadership in virtual teams to boost engagement and well-being. Future research examining the role of digital platforms in influencing the need for relatedness and competence can further refine the applicability of SDT in a technologically mediated environment. Another dimension to explore involves

understanding cross-cultural dynamics, considering the current findings that the studies predominantly focused on the Western context. Future studies should examine how relatedness needs, often prioritised in non-Western collectivist cultures, interact with the need for autonomy and competence to shape engagement and motivation. As such, comparative studies across cultures can offer a nuanced understanding of SDT's adaptability in a culturally diverse context. Another interesting area of future research could be the integration of sustainability into the purpose-driven work environment. The researcher should explore how constructs of SDT align with the PERMA framework and sustainable HR practices to foster employee well-being and commitment. Whilst our study has relied on bibliometric analysis to understand and explore the trends from the research conducted in the past 25 years, incorporating more advanced analytical methods, such as structural equation modelling and longitudinal designs, can strengthen the study's findings and offer deeper insights into the causal relationship between psychological needs and employee engagement. Integrating bibliometric analysis with systematic reviews can capture evolving trends in SDT research and mitigate the gaps identified in the prior studies as identified in the current research.

6 | Limitations

One of the key limitations of the study is that the bibliometric analysis was conducted based on the data derived from only the Scopus database, whilst there is a need to cover all the relevant literature from other databases, including Web of Science, PubMed, PsycINFO, and Google Scholar. These databases can be an excellent source of SDT-related research and offer additional insights. Future research should incorporate multiple databases to ensure a more representative bibliometric analysis of the SDT research. Additionally, while this study offers a comprehensive bibliometric analysis of the SDT research conducted over the past 25 years, it is identified that the existing body of literature remains predominantly focused on the western context. This reflects the need for broader trend analysis on SDT research where studies should emphasize the inclusion of studies from both eastern and western contexts. This is critical to address this area, considering the current study aligns more closely with individualistic cultures, limiting exploration of collectivist cultures. Although not central to our design, future studies could apply regression analysis to assess trend significance and conduct sensitivity analyses on keyword thresholds to validate robustness. This study did not differentiate between lead and co-authors in country-level analysis. Future research could incorporate author position to better understand leadership patterns in SDT scholarship. Addressing this gap will allow for extending the research to diverse cultural settings to enhance its cross-cultural validity.

7 | Conclusion

This comprehensive bibliometric analysis of the Self-Determination Theory (SDT) from 2018 to 2023 employing VOSviewer and Biblioshiny underscores the growing impact of the theory and its substantial influence on other fields such as psychology, education, organisational behaviour, and human resource management, among others, by examining over 3700

publications which more than 9000 contributors have authored. This research has identified clear trends in the rising academic interest in recent years. Key sources of publications such as *Frontiers in Psychology*, *Motivation and Emotion*, and *Psychology of Sport and Exercise* have been instrumental in advancing the research on SDT, with seminal contributions from authors including Deci and Ryan and Vansteenkiste.

The instrumental work done by these authors has advanced the application of the theory, extending beyond psychology and particularly applying it to education and workplace settings. Nonetheless, the finding reveals that despite robust foundational work, there is still limited application of the theory in specific domains. The findings establish the theory's potential and its relevance for application across diverse fields. However, to move beyond the descriptive accumulation of literature, the theory must be actively reinterpreted in light of modern work and cultural shifts. This means confronting how digital transformation, burnout, and cross-cultural differences shape employee motivation and psychological need satisfaction today.

Research has mainly focused on Western individualistic societies, limiting its generalisation to collectivist cultures where relatedness precedes autonomy and competence. Additionally, today's high-pressure work environments, such as healthcare and IT, also present challenges to the conventional constructs of SDT. For example, role ambiguity and job intensification can inhibit the practical utility value of autonomy and competence. They might require an extension of the theory by including more constructs in the specific work setting. Integrating SDT with contemporary frameworks such as the Job Demands–Resources model or applying it in sustainable HRM initiatives could enhance its practical value. Future research should also incorporate advanced methods like structural equation modelling, longitudinal designs, and cross-cultural comparative studies to strengthen empirical depth.

Addressing these outcomes presents an opportunity for further exploration of how SDT principles can be adapted to address the diverse psychological needs of employees in the current diverse and highly demanding work environment. In emerging work models like remote working or hybrid work, SDT's application can grow as the researcher needs to examine how the need for autonomy and relatedness can be maintained in such environments. Ultimately, advancing SDT research will require empirical innovation and theoretical reinterpretation, ensuring that it remains a vital tool for understanding and supporting human motivation across diverse and evolving contexts.

Integration of SDT with other frameworks, such as the Job Demands-Resources (JD-R) model, could potentially offer a more comprehensive understanding of the psychological needs and how their management can, through organisational resources, result in positive and negative organisational outcomes, such as engagement, burnout, etc. An expanded SDT should focus on examining positive outcomes for the organisations and how organisational resources can be efficiently employed to address the unmet psychological needs of the employees, thereby reinforcing the relevance of SDT in the contemporary work environment. Despite the positive, organisational resistance to change or adaptation can impede the adoption of SDT-based interventions for employees' psychological needs, thereby calling

for empirical research to advocate for the effectiveness of the SDT. SDT's emphasis on autonomy, competence, and relatedness offers valuable insights for public policy design and ethical AI deployment, especially in contexts involving digital autonomy and psychological well-being. In conclusion, through a rigorous and systematic examination of the SDT research, this study offers valuable insights for the researchers and practitioners who seek to advance the application of SDT across diverse fields in the contemporary environment.

Author Contributions

Evangelina Rekha Joseph: conceptualization, methodology, investigation, data curation, resources, visualization, formal analysis, writing original draft, review and editing. **Vinita Seshadri:** formal analysis, review and editing, supervision.

Ethics Statement

The authors have nothing to report.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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