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National characteristics and competitiveness in MOT research: A comparative analysis of ten specialty journals, 2000–2009

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ABSTRACT

This paper addresses how countries placed a different intellectual focus on the management of technology and innovation (MOT) research in ten leading MOT specialty journals published in 2000–2009. The result confirms that each country has quite diverse relative research interests and performances in MOT domains. Among the top seven leading countries in MOT research, the US has a comparative advantage in project management (PJM); the UK has one in social change (SCH); and Spain has one in intellectual property (IPR). The other four countries show much more dynamic observations. Netherlands has clearly a comparative advantage in technology policy (TPO), while Taiwan has one in technology analysis and forecast (TAF), Germany in entrepreneurship (ENT), and Italy in technology transfer and commercialization (TTC).

This paper contributes to the MOT community by providing much clearer evidence of how countries become differently positioned in the global MOT arena. These empirical findings demonstrate significant differences in the comparative competitiveness of countries involved in MOT research that were little known earlier.

1. Introduction

Each researcher has different areas and levels of intellectual interest in the domains of management of technology and innovation (MOT) studies. Some researchers examine a national innovation system, while others have an interest in university technology transfer. Each country may also have its own different research focus and a different competitive advantage and disadvantage. National advantage and disadvantage have been widely studied in many research fields using bibliometric methodologies (Franceschet and Costantini, 2011; Islam and Miyazaki, 2010; Laursen and Meliciani, 2010; Miyazaki and Islam, 2007; van Leeuwen, 2009). Although these bibliometric methodologies have been often used in MOT studies, recently just minimal research has concentrated on the national characteristics of MOT research.

These prior MOT bibliometric studies mainly concentrated on journal comparisons and rankings, researcher and institution rankings, and topical evolution and methodologies whether the studies were single journal or multiple journal analyses. The majority of these studies covered single journals, including Technovation, Technology Forecasting & Social Change (Biemans et al., 2007; Callon et al., 1999; Durisin et al., 2010; Guo, 2008; Junquera and Mitre, 2007; Linstone, 1999; Merino et al., 2006; Pilkington, 2008; Pilkington and Teichert, 2006). Their focus was mostly on the evolution of research topics and methodologies, identifying the most cited journals and authors and investigating basic theories and disciplines. A few multiple journal analyses were conducted by several authors (Cheng et al., 1999; Linton and Embrechts, 2007; Linton and Thongpapanl, 2004), and their attention was mainly on ranking journals and institutes and citation patterns.

Characteristics in MOT studies between different regions or between the developed countries and the developing countries in a collective manner were also conducted in a few prior studies. Among the single journal analysis research efforts, Pilkington and Teichert (2006) investigated the differences between regions. They argued that the major interests of North America, Europe, the UK, and the rest of the world are quite diverse. In spite of these interesting findings and achievements, their regional comparisons were based on single journal analysis, which may have used a different spectrum when compared to overall MOT research. In their multiple journal analyses, Cetindamar et al. (2009) and Beyhan and Cetindamar (2011) compared the MOT studies between developed and developing countries as a group. Their studies argued that the MOT literature generated in developing countries was dominated by the knowledge and theories created in the developed countries. Despite their meaningful discovery, those studies were still more focused on 'basis theories' and based on citation analysis rather than on actual national

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differences in light of a topical comparison. This situation was problematical because few of the prior studies clearly presented the different levels of interest and the strengths and the weaknesses of countries involved in global MOT research.

In this context, the present paper examines the relative advantage and disadvantage of different countries for MOT studies. Keyword frequency analysis and relative research advantage (RRA) profiling analyze here how countries focus differently on MOT research, so these countries can better understand their relative strengths and weaknesses at the national level. This study takes a step forward in that regard and investigates the relative competitiveness of different countries in the MOT domain over time, as grounded in the relative number of publications and polished classifications for MOT research. Recognizing the present position of a country in the MOT domain is a matter of fundamental importance since it can be a critical marker for researchers and policy-makers to use to advance their future national MOT research. Recognition of the different levels of interest in research topics between countries can produce additional insights and important implications for further advancement of national MOT research competitiveness. Therefore, this article presents a comprehensive overview of global MOT studies and a cross-national comparison analysis with that end purpose clearly in mind.

This paper is divided into four sections. The following Section 2 presents the detailed methodology employed for this paper, followed by Section 3 offering the results of the empirical study. The final Section 4 presents a summary, the conclusions, and useful future research agendas.

2. Data and the research method

2.1. Data collection

Base journal selection was cardinal to this investigation. Single journal selection provided a clear research scope, but it was not complete enough to represent overall MOT study because each journal has a different focus and scope. Prior studies of multi-journal analysis have included slightly different base journals over time—Cheng et al. (1999) analyzed five base journals based on the study by Liker (1996). After Cheng et al. (1999), ten MOT specialty journals were often used by several other studies (Beyhan and Cetindamar, 2011; Cetindamar et al., 2009; Linton and Embrechts, 2007; Linton and Thongpapanl, 2004). Although other studies did use slightly different base journals, for instance, Ball and Rigby (2006) analyzed eleven journals and one additional journal, the *European Journal of Innovation Management*, ten specialty journals are often considered to be a good representation of the journals for MOT.

The following ten MOT specialty journals were chosen as our base journals because these journals are repeatedly used in studies: *The Journal of Engineering and Technology Management* (JETM), *Journal of Product Innovation Management* (JPIM), *Research-Technology Management* (RTM), *Technology Analysis & Strategic Management* (TASM), *R & D Management* (R&DM), *IEEE Transactions On Engineering Management* (IEEE), *Technological Forecasting and Social Change* (TFSC), *Technovation* (TVN).

The bibliometric information for these ten journals for the period 2000–2009 was collected on 11 September 2010 from a renowned academic database, the ISI Web of Science (WoS) so as to secure full data homogeneity for the ten journals. The bibliometric data included titles, keywords, abstracts, authors, institutes, countries, and publication years. The initial search produced 7077 articles. To avoid possible nationality bias from this initial result, less research-focused articles were excluded, including editorials, book reviews, letters, and notices. Finally,

Table 1
Ten base MOT journals and their articles published from 2000 to 2009.

Journal Name	Number of papers	Publication share (%)
Journal of Engineering and Technology Management (JETM)	164	3.1
Journal of Product Innovation Management (JPIM)	286	5.5
Research-Technology Management (RTM)	340	6.5
Technology Analysis & Strategic Management (TASM)	340	6.5
R & D Management (R&DM)	359	6.9
IEEE Transactions On Engineering Management (IEEE)	417	8.0
Technological Forecasting and Social Change (TFSC)	618	11.8
Technovation (TVN)	818	15.6
International Journal of Technology Management (IJTM)	922	17.6
Research Policy (RP)	975	18.6
Total	**5239**	**100.0**

5239 research papers were distilled for the analysis for this study, as shown in Table 1.

Two additional journals—*The Journal of Technology Transfer* (JTT) and *the Asian Journal of Technology Innovation* (AJTI), newly included in the WoS database in 2009, can possibly be considered MOT specialty journals for future studies. However, since the WoS database for these two journals has only a few years of bibliometric recordings, we did not include these in the current analysis.

2.2. Classification of MOT research, and allocation of 5239 research papers

Classification of MOT research is presumed to achieve the objective of this study, namely, identifying the relative strengths and weaknesses of nations in MOT research. In light of the classification of MOT, due to the interdisciplinary characteristics and relative young history of MOT study, there is as yet no widely accepted classification. Some of the earlier studies have attempted to develop a significant MOT categorization, but at the conceptual level rather than for its sub-domains (Drejer, 1996; Pavitt, 2002; Phaal et al., 2004). Although more tangible classifications have been presented in other studies (Dodgson, 2000; Hidalgo and Albors, 2008; Khalil, 2000), their diversity in the classifications shows that there are no commonly used and accepted classifications in MOT.

In prior studies, multivariate techniques were broadly used to develop exploratory taxonomy or classifications (Choi et al., 2011; Kostoff et al., 2008; Law et al., 1998). Although it is evident that multivariate techniques are very useful tools for these functions, they also have a certain limitation when developing classifications. This limitation is grounded in the heterogeneous distribution of data, number of variables (words), the number of factors, and also the complexity found in the resultant interpretation (Hubbard and Allen, 1987; Short and Horn, 1984; Stewart, 1981). MOT has an interdisciplinary nature (Biemans et al., 2007; Liao, 2005; Yanez et al., 2010), and as Choi et al. (2011) point out, multivariate methods may include a certain level of exaggeration and incompleteness for the process of classification and its naming, particularly in terms of the multidisciplinary nature of research disciplines like MOT. Pilkington and Teichert (2006) also express the opinion that their multivariate techniques' analysis for the geographical concentrations of MOT research requires considerable subjective input in their interpretation. These limitations require more room still for any further development of existing MOT classifications that may have a different perspective.

To address these limitations, the present paper proposes an alternative approach, that of combining two methods from prior studies—a text mining-based keyword frequency analysis (Guo, 2008) and an experts-based journal description keyword analysis (Merino et al., 2006). Merino et al. analyzed 25 years of *Technovation* based on an MOT classification using central keywords in the journal description of *Technovation*, so similarly, we collected a total of 109 keywords from the descriptions of ten MOT journals as well as the call for papers for IAMOT 2010 to describe and categorize the MOT domains. Consultation meetings with a group of external MOT experts and a conference presentation to the Korean Society for Innovation Management & Economics (KOSIME) were also conducted to minimize any biased input from the authors of this paper. These 109 journal description keywords were then grouped into thirteen MOT domains. The thirteen MOT domains were quite comparable to prior classifications and thus considered to be an empirically polished version (Dodgson, 2000; Khalil, 2000; Merino et al., 2006). The thirteen MOT research domains are the followings: Technology innovation (TIN), technology strategy (TST), technology policy (TPO), technology analysis, forecast, and roadmap (TAF), research and development (RnD), technology transfer and commercialization (TTC), new product development (NPD), entrepreneurship (ENT), organization learning, culture and HRD (OHR), project management (PJM), knowledge management (KNM), intellectual property rights (IPR), social change (SCH), and no specific classification (OTH).

Keyword matching and keyword frequency analysis were then taken to assign the 5239 papers into the thirteen MOT domains. First, to develop a matching table between the MOT domains with 'paper keywords', a full set of 10,099 'paper keywords' were retrieved from the keywords for the bibliometric data of the 5239 papers. By excluding common keywords not related to one specific MOT domain (for example, case studies, Europe, survey, automobile industry, data mining, factor analysis), we refined the full 10,099 paper keywords into 2502 keywords that then represented the thirteen MOT domains. Then, keyword frequency analysis was applied to assign the 5239 papers into the designated thirteen MOT research domains. The suitability of these allocation procedures was subsequently then verified through two internal workshops to review the pilot results and update the drafted matching tables accordingly. Finally a set of 2393 paper keywords were selected that described the thirteen MOT domains for this study.

In the assigning process, SAS macrofunctions were developed to count the keyword frequency of each paper and allocate each paper into one of the thirteen MOT domains. The keyword frequency counting process was conducted using SAS structured query language (SQL) and information retrieval (IR) structure. This SAS program counts the keyword frequency for each paper for all thirteen domains and identifies the top-ranked domain that acquired the highest frequency of keywords. This keyword frequency allocation process uses each abstract as base bibliometric data. An abstract is commonly used in bibliometric studies, as there is little significant difference between analyzing the abstract and analyzing the full text of a paper, and the abstract outlines the purpose of the research, the methodology, the major results, and conclusions of each paper (Guo, 2008).

However, some papers did not have abstracts in the WoS database analyzed, or did produce more than two top domains with equal frequencies. In these cases, the title and then the keywords of each paper were used to allocate its MOT domains as a supplementary base of bibliometric data for the keyword frequency-based allocation. If a paper was not classified by all of the frequency counting scheme from all three datasets, namely, the abstract, title, and keywords, then those papers were automatically grouped into others (OTH), i.e., having no specific grouping. Part of the SAS programming is designed to avoid double counts of the same keywords in each paper for allocation (Gamber et al., 2008). For example, the phrase 'technology innovation' in a sentence can be double counted as 'innov+' and 'technology innov+'; in this case, the SAS macrofunctions counts the longest multi-keyword 'technology innov+' only once to prevent any over-counted-based bias. The thirteen MOT research domains and extracted sample keywords are exhibited in Table 2.

2.3. A cross-national comparison: the relative research advantage (RRA) profile

A *relative research advantage* (RRA) profile was developed and used to better visualize the comparative strengths and weaknesses of different countries. The RRA profile is inspired by a modified form of the concept called *revealed technology advantage* (RTA) profile as developed by Patel and Pavitt (1997). Patel and Pavitt argue that it is inappropriate to measure the technical competencies of large firms simply by a few fields of excellence and the proposed RTA to profile competencies having varying levels of commitment and competitive advantage in a range of technological fields. The RTA approach has been extensively used for many researchers in evaluating comparative advantage and innovation performances at company or national levels (Ahuja and Katila, 2001; Chen and Chen, 2010; Lee et al., 2009; Lundvall et al., 2002; McQueen, 2005).

The RTA approach can be equally used to assess research performance, as discussed by Islam and Miyazaki (2010). When

Table 2
MOT research domain classifications.

Domain	Examples of keywords
TIN	Technological innovation, innovation management, product innovation, radical innovation, open innovation, user innovation, innovation adoption, innovation diffusion
TST	Technology strategy, strategic alliances, competitive advantage, competition, strategic planning, strategic management, corporate strategy, competitive strategy, core competence
TPO	Technology policy, innovation policy, industrial policy, science policy, research policy, national innovation system, NIS, regional innovation system, RIS, cluster, governance
TAF	Technology analysis, technology forecasting, technology foresight, technology roadmap, roadmapping, technology planning, scenario planning
RnD	R&D, research and development, R&D management, real options, R&D cooperation, R&D investment, research management, R&D consortia, R&D intensity, cooperative R&D
TTC	Technology transfer, technology assessment, technology acquisition, licensing, commercialization, international technology transfer, university technology transfer
NPD	New product development, product design, manufacturing, quality management, lean production, concurrent engineering, advanced manufacturing technology
ENT	Entrepreneurship, technology entrepreneurship, spin-off, entrepreneurial university, venture capital, university entrepreneurship, entrepreneurial education
OHR	Organizational learning, organizational culture, organizational performance, organizational design, human resource management, human resource development, manpower, career choice
PJM	Project management, project selection, project evaluation, project performance, project risk management, project success, project teams, project-based firms, project risk management
KNM	Knowledge management, knowledge transfer, knowledge spillover, knowledge sharing, knowledge diffusion, knowledge flows, explicit knowledge, tacit knowledge
IPR	Intellectual property rights, IPR, IP management, intellectual management, patents, patent citations, patent value, patent statistics, patent strategy, university patenting, patent map
SCH	Economic development, economic growth, national culture, knowledge economy, technology change, globalization, social networks, change management
OTH	Others (those not allocated to the thirteen MOT domains above)

Table 3
Developed RRA profile based on the RTA profile.

Profile (author)	*Y*-axis value	*X*-axis value	Data and comments
RRA (this study)	National Share (%)=nation-domain/nation-total	Relative National Competence=(nation-domain/globe-domain)/(nation-total/globe-total)	Research papers: useful for visualizing firms/nations within one domain
RTA (Patel and Pavitt, 1997)	Patent Share (%)=firm-domain/globe-domain	Relative Firm Competence=(firm-domain/globe-domain)/(firm total/globe-total)	Patents: useful for comparing domains within one firm/nation

Table 4
Annual growth and publications of fifteen countries involved in MOT research.

Nation **Rank**	Global ■	Total ■	US **1**	UK **2**	NL **3**	TW **4**	DE **5**	IT **6**	ES **7**	CA **8**	JP **9**	FR **10**	SE **11**	CN **12**	AU **13**	KR **14**	FI **15**
2000	464	358	159	61	24	4	12	11	6	17	12	15	10	6	11	7	5
2001	459	358	143	45	22	6	18	19	5	13	14	19	12	16	10	8	9
2002	464	388	151	52	34	14	7	23	13	17	14	15	12	8	13	8	8
2003	498	423	158	67	21	11	25	15	18	17	29	12	12	9	11	9	10
2004	497	407	137	47	21	13	21	21	18	24	23	17	18	13	15	12	8
2005	544	441	125	59	37	39	28	19	17	15	19	18	17	11	11	12	14
2006	550	466	143	65	36	38	35	18	16	17	8	12	13	18	10	17	18
2007	556	479	140	78	41	32	34	18	33	14	14	12	16	14	10	16	9
2008	579	496	150	74	45	56	17	23	30	16	16	12	11	11	10	15	10
2009	628	525	153	73	46	44	27	25	36	27	17	14	10	12	17	12	11
Total	**5239**	**4341**	**1459**	**620**	**327**	**257**	**225**	**192**	**191**	**177**	**166**	**147**	**130**	**118**	**116**	**115**	**101**
Share (%)	*100.0*	*82.9*	*27.9*	*11.8*	*6.2*	*4.9*	*4.3*	*3.7*	*3.6*	*3.4*	*3.2*	*2.8*	*2.5*	*2.3*	*2.2*	*2.2*	*1.9*
CAGR (%)	*3.4*	*4.4*	*−0.4*	*1.9*	*7.4*	*30.6*	*9.9*	*10.3*	*22.2*	*5.5*	*4.4*	*−0.3*	*0.6*	*7.7*	*5.2*	*5.7*	*9.5*

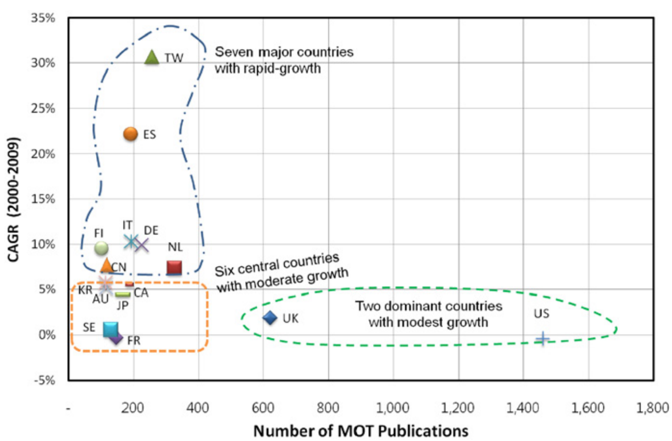

Fig. 1. MOT research forecast: a country-based analysis.

we used the RTA concept for relative cross-national comparison, we slightly modified the *Y*-axis value as shown in Table 3. The *Y*-axis value of the original RTA profile could represent the publication share of one country in each MOT domain, but it cannot visualize the relative ratio for each MOT domain within a nation—our major interest. Because we are interested in visualizing the relative ratio of each MOT domain, compared to its relative competence in each nation, we thus slightly modified the *Y*-axis value and named this adjusted method '*relative research advantage* (RRA)' profile. Although we note that the RRA profile has linear characteristics attributable to its formula, this adjustment can be useful for examining the relative research advantage of countries when considering variance for each domain.

Around 18% of the 5239 papers analyzed in this study were written by multi-national authors, and the ratios of multinational authorship are quite diverse in terms of countries and domains. Since different counting methods result in fairly different counting scores, the counting scheme for nationality should be cautiously selected (Gauffriau et al., 2008). Given that circumstance, we agree with Gauffriau and Larsen (2005) that the fractional counting method is more appropriate than the whole counting method to apply for the purpose of this study. In whole counting, all unique countries contributing to a paper receive one credit per country regardless of the number of authors; in fractional counting one credit is shared between the unique countries with equal fractions given to each author (Gauffriau et al., 2007). In this paper, the numbers of publications presented are calculated by applying fractional counting methods drawing on the downloaded database of 5239 papers from ISI WoS, and rounded off to the nearest whole number.

The following Section 3.1 provides the results of growth rate analysis for the fifteen countries and thirteen domains; then followed by Section 3.2 briefing a comparison of MOT research performance using thirteen domains. Section 3.3 presents a detailed relative research competence with RRA profiles of the top seven countries.

3. Results

3.1. Comparison of MOT research performance from 2000 to 2009

Table 4 shows that MOT research has gradually grown from 464 to 628 papers from 2000 to 2009 at an annual average rate of 3.4%. The top fifteen leading countries, comprising about 82.9% of the global MOT studies, were listed in Table 4: United States (US, 1459 papers), United Kingdom (UK, 620), Netherlands (NL, 327), Taiwan (TW, 257), Germany (DE, 225), Italy (IT, 192), Spain (ES, 191), Canada (CA, 177), Japan (JP, 166), France (FR, 147), Sweden (SE, 130), China (CN, including Hong Kong, 118), Australia (AU, 116), South Korea (KR, 115), Finland (DK, 101).

Fig. 1 illustrates the three different groupings of the top fifteen countries by comparing the CAGR with the number of publications in 2000–2009. The first group, the US and UK, is clearly dominating the global MOT studies in publications (39.7%), but their growth rates for the US (0.1%) and UK (3.8%) are similar to the global average. The other thirteen countries have similar number of publications, but they can be categorized into two groups by cumulative annual growth rates. The second group, consisting of six central countries in MOT studies, has moderate growth rate, around 5% or lower—Korea (5.7%), Canada (5.5%), Australia (5.2%), Japan (4.4%), Sweden (0.6%), and France (−0.3%). The third group has seven major countries, which demonstrates remarkably higher growth rate than the other two groups—Taiwan (30.6%), Spain (22.2%), Italy (10.3%), Germany (9.9%), Finland (9.5%), China (7.7%), and Netherlands (7.4%). The comparative positioning of this third group indicates that the seven countries are indeed influential contenders in MOT studies not only in growth rate, but also in total number of publications. Their total publications in 2009 were 201 papers, and this number is quite comparable to the sum of the US and UK publications in 2009, which was 226 papers.

3.2. Comparison of MOT research performance using thirteen domains

Keyword frequency analysis allocated the 5239 papers into thirteen MOT domains. Table 5 presents the domain distribution results. The highest number of papers was produced in TIN (797 papers), RnD (762), and TST (601), while the lowest number of papers was produced in ENT (98), TAF (143), and IPR (161).

Fig. 2 allocates the thirteen MOT domains, comparing their number of publications using CAGR for 2000–2009. This chart confirms that the four large fundamental pillars of MOT research are TIN, TST, RnD followed by SCH. The chart also reveals the five emerging small-medium-size fields: TAF, IPR, TTC, KNM, and ENT. The firm growth of the five emerging domains indicates that more research has been conducted and published in the MOT community in recent years, and therefore, the five domains have converged as major topics of MOT studies. In particular, TAF, IPR, and TTC are found yet to be small, but they are the three fastest emerging MOT fields. The reduction of the other PJM, NPD, and OHR studies in low areas can be interpreted as that these three fields, when compared to others, are likely not to converge much with MOT via other business and management disciplines. This result does not necessarily mean that the overall studies of the three domains are decreasing in general, but at least those studies would appear so for the ten MOT specialty journals.

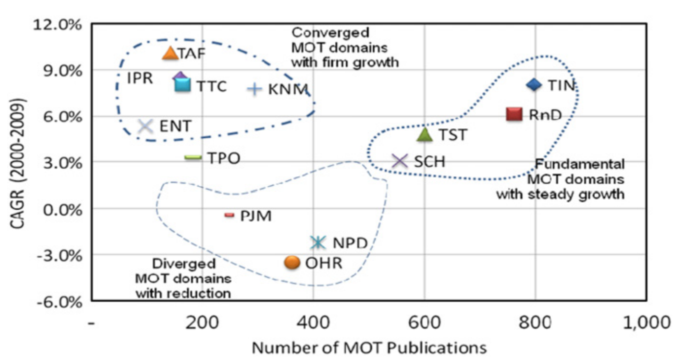

Fig. 2. MOT research forecast: a domain-based analysis.

Table 6 presents an in-depth analysis of top seven countries for the thirteen MOT domains. While the US and the UK showed a similar order of publications for the national total and each MOT domain, the other five countries did show diversity and competition in each MOT domain.

Although Netherlands ranks third in the national total, the other four countries have higher research performance in several specific MOT domains. For instance, Taiwan has produced more papers than the Netherlands in KNM (NL:12 papers vs. TW:27) and TAF (NL:6 vs. TW:12); Germany has produced more papers than the Netherlands in KNM (NL:12 vs. DE:18), IPR (NL:6 vs. DE:14), TAF (NL:6 vs. DE:8), ENT (NL:2 vs. DE:11); Italy has produced more papers than the Netherlands in KNM (NL:12 vs. IT:17), IPR (NL:6 vs. IT:11); Spain has produced more papers than the Netherlands in TTC (NL:5 papers vs. ES:8) and EN (NL:2 vs. ES:5).

This phenomenon indicates that the overall research competence of these five countries may vary in each MOT domain. Notably, some emerging countries like Taiwan already have surpassed the strong developed countries in certain MOT fields. Taiwan's overall MOT research performance has outdone many of the developed countries. The research competencies of countries in MOT can be better understood in terms of relative research share in the following section.

3.3. Relative research competence of MOT studies

To develop the RRA profile, the relative research share of the top seven countries for each MOT domain was calculated using a graphical bar chart in Fig. 3. The length of each bar in its cell is automatically calculated for each MOT domain and kept independent from the other domains. This calculation and the bar chart visibly display the relative strengths and weaknesses of each country in each specific MOT domain. Each country shows quite a diverse relative research competence for each MOT domain.

The distribution deviation for each domain and each country can be determined by a coefficient of variation (CV) based on a standard deviation divided by the average relative research share of each MOT domain. The CV is useful because the standard deviation of data should always be interpreted in the context of the mean of the ratio scale data. If the coefficient of variation of a

Table 5
Research performance for thirteen MOT domains.

Domain Rank	TIN 1	RnD 2	TST 3	SCH 4	NPD 5	OHR 6	KNM 7	PJM 8	TPO 9	TTC 10	IPR 11	TAF 12	ENT 13	OTH ■	Total ■
2000	57	57	42	48	44	58	24	26	15	12	14	8	5	54	**464**
2001	52	69	44	59	47	41	16	21	21	13	11	18	2	45	**459**
2002	54	74	63	47	48	27	23	22	16	15	9	11	6	49	**464**
2003	58	72	53	67	40	23	25	37	16	17	9	15	13	53	**498**
2004	61	87	60	46	49	38	19	23	14	15	10	19	9	47	**497**
2005	95	72	68	56	40	30	20	25	20	17	19	17	14	51	**544**
2006	103	81	61	53	38	28	53	21	21	22	14	13	6	36	**550**
2007	107	62	70	58	41	35	32	20	21	15	18	7	26	44	**556**
2008	96	91	76	59	26	39	35	23	20	15	28	16	9	46	**579**
2009	114	97	64	63	36	42	47	25	20	24	29	19	8	40	**628**
Total	**797**	**762**	**601**	**556**	**409**	**361**	**294**	**243**	**184**	**165**	**161**	**143**	**98**	**465**	**5239**
Share (%)	*15.2*	*14.5*	*11.5*	*10.6*	*7.8*	*6.9*	*5.6*	*4.6*	*3.5*	*3.1*	*3.1*	*2.7*	*1.9*	*8.9*	*100.0*
CAGR (%)	*8.0*	*6.1*	*4.8*	*3.1*	*−2.2*	*−3.5*	*7.8*	*−0.4*	*3.2*	*8.0*	*8.4*	*10.1*	*5.4*	*−3.3*	*3.4*

Table 6
Research performance of top seven countries for the thirteen MOT domains.

Domain Rank	TIN 1	RnD 2	TST 3	SCH 4	NPD 5	OHR 6	KNM 7	PJM 8	TPO 9	TTC 10	IPR 11	TAF 12	ENT 13	OTH ■	Total ■
US	188	220	163	155	133	116	75	90	30	45	42	33	24	188	**1459**
UK	101	85	64	82	40	46	34	32	27	22	16	15	13	101	**620**
NL	66	43	41	37	17	24	12	15	25	5	6	6	2	66	**327**
TW	45	40	38	17	12	15	27	5	12	6	7	12	3	45	**257**
DE	45	35	17	16	13	6	18	6	8	6	14	8	11	45	**225**
IT	24	31	28	24	14	8	17	4	6	5	11	3	2	24	**192**
ES	28	32	28	18	8	19	10	2	9	8	6	4	5	28	**191**

Country	UK	US	ES	NL	TW	IT	DE	*G.Average*	*CV*	*CV Rank*
RND	13.6%	15.1%	17.0%	13.3%	15.4%	16.3%	15.7%	*14.5%*	0.09	1
NPD	6.5%	9.1%	4.1%	5.1%	4.6%	7.4%	5.8%	*8.9%*	0.20	2
TIN	16.2%	12.9%	14.6%	20.1%	17.3%	12.3%	20.1%	*15.2%*	0.21	3
TST	10.4%	11.2%	14.7%	12.4%	14.6%	14.4%	7.5%	*7.8%*	0.24	4
SCH	13.3%	10.6%	9.6%	11.4%	6.7%	12.2%	7.0%	*11.5%*	0.24	5
IPR	3.6%	3.1%	4.3%	1.7%	2.1%	2.3%	2.6%	*10.6%*	0.26	6
OHR	7.4%	8.0%	9.7%	7.3%	5.7%	4.3%	2.8%	*3.1%*	0.30	7
PJM	5.2%	6.2%	1.1%	4.5%	2.0%	2.2%	2.8%	*6.9%*	0.33	8
KNM	5.6%	5.1%	5.1%	3.8%	10.5%	8.7%	7.8%	*4.6%*	0.35	9
TPO	4.4%	2.0%	4.7%	7.5%	4.7%	3.2%	3.6%	*2.7%*	0.37	10
TAF	2.4%	2.3%	1.9%	2.0%	4.8%	1.6%	3.5%	*5.6%*	0.37	11
TTC	2.6%	2.9%	3.1%	1.7%	2.5%	5.8%	6.3%	*3.5%*	0.55	12
ENT	2.1%	1.6%	2.6%	0.6%	1.2%	0.8%	5.1%	*3.1%*	0.56	13
OTH	6.9%	9.9%	7.3%	8.6%	7.8%	8.4%	9.4%	*1.9%*	0.58	■
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	■	■	■
CV	0.14	0.19	0.32	0.38	0.40	0.43	0.50	■	■	■
CV Rank	1	2	3	4	5	6	7	■	■	■

Fig. 3. Relative research share and the variation coefficient for the thirteen MOT domains.

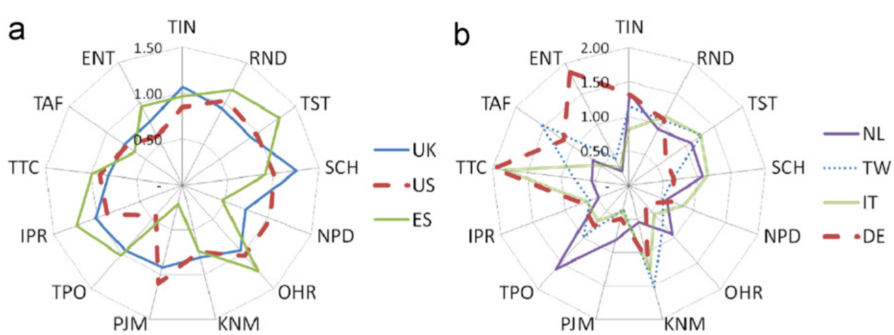

Fig. 4. Cross-national comparison of relative competitiveness for the thirteen MOT domains. (a) Three countries with low CV. (b) Four countries with high CV.

domain is higher, then that domain may have more diversity in terms of its level of relative research interest and competitiveness. The CV is calculated in the second to last column for the domain and the second to last row for country in Fig. 3. The data in Fig. 3 is sorted by the CV of the domains and countries in ascending order for value and in descending order for rank.

In light of the domain-based perspective, the four areas with the lowest coefficient of variation for comparative research level per country were RnD (0.09), NPD (0.20), TIN (0.21), and TST (0.24). Three of the four domains are the biggest fundamental pillars of MOT as described in the previous section. This variation signifies that those four topics are of common interest in most countries at an equivalent level. The four highest areas of CV were ENT (0.56), TTC (0.55), TAF (0.37), and TPO (0.37). These high variations indicate the considerably different levels of interest per country on ENT, TTC, TAF, and TPO.

When considering the county-based perspective, the three countries' positions with lower CV (coefficient variations) are UK (0.14), US (0.19), and Spain (0.32); the other four countries show the four higher coefficient variations—Netherlands (0.38), Taiwan (0.40), Italy (0.43), Germany (0.50). This country-based interpretation is translated into Fig. 4 with the thirteen MOT domains. Fig. 4 portrays the country perspective of relative competences in MOT research. The values are calculated as the ratio of relative research share of a country in an MOT domain to the global average relative research share of each domain. The higher diversity of relative research performances between the three low CV countries and the high CV countries is well contrasted in these two charts Fig. 4a and b.

Fig. 4a illustrates that the three countries with low CV, namely, the US, the UK, and Spain, are polygons with a rather round shape. Most of their values are quite close to the global average value

1.0. This investigation explains that the UK and the US show the most balanced research competitiveness, followed by Spain when compared to the global average of each domain. It also indicates that the UK has a comparative advantage in TIN and SCH, the US has advantage in PJM, and Spain has advantage in OHR, and disadvantage in PJM and NPD. To the contrary, the other four countries with higher CV are less similar to each other, and all indicate a clearly polygon-shaped or star-shaped result as shown in Fig. 4b. Netherlands shows a relative high competence in TPO, but low competence in IPR. Taiwan proves to be comparatively the most capable in TAF while being the least so in PJM. Italy shows a relative high competence in TTC and a low competence in PJM. Germany focuses more on TTC, and less on OHR.

3.4. RRA: relative research advantage profiling

The RRA profiles of eight MOT domains are displayed in Fig. 5. The eight RRA profiles deliver eight domains—four domains with the lowest CV (coefficient of variation) in Fig. 5a–d, and four with the highest CV in Fig. 5e–h. These RRA profiles visualize relative

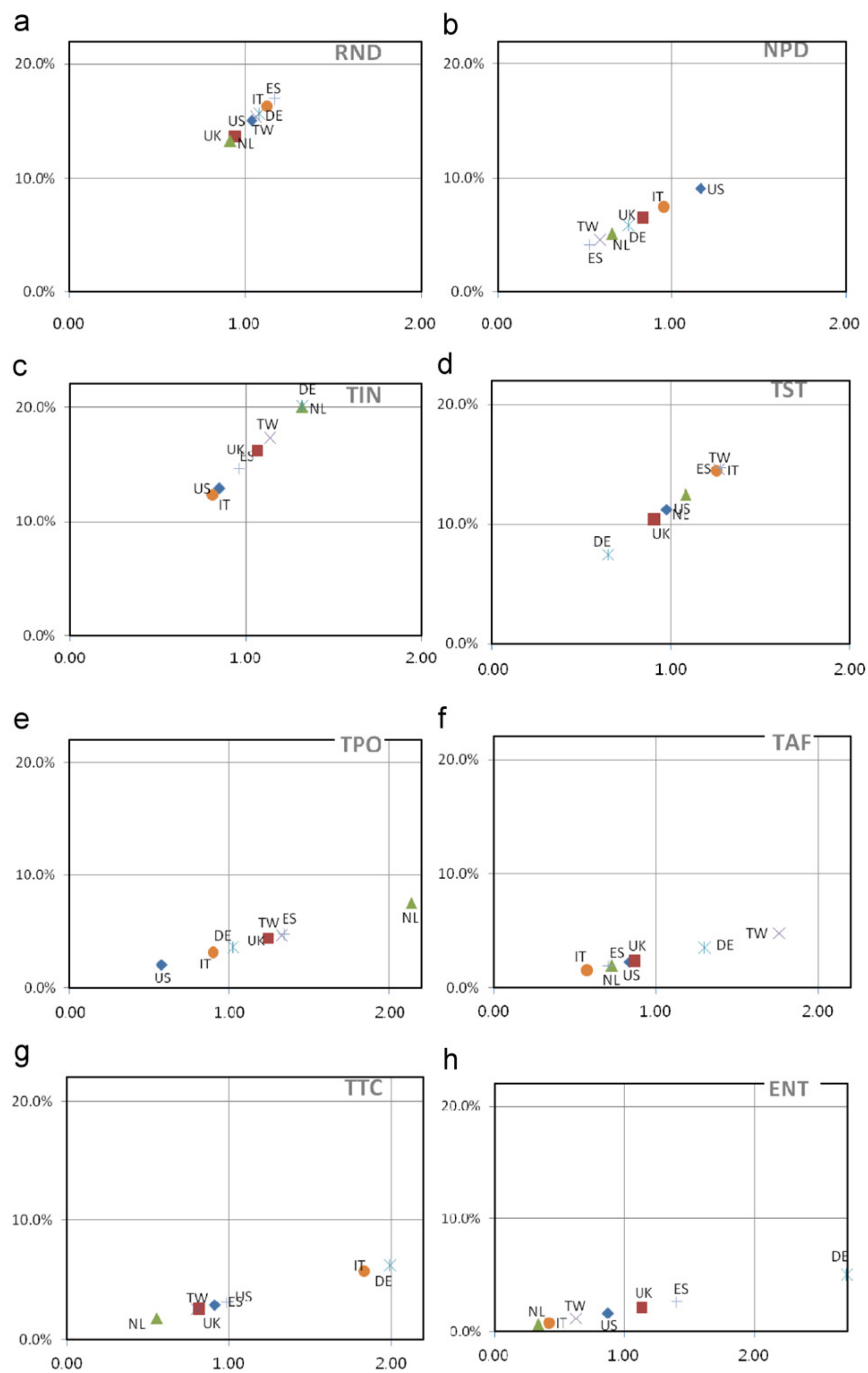

Fig. 5. Eight RRA Profiles: four lowest CV and four highest CV MOT Domains. (a) RND (1st CV: 0.09). (b) NPD (2nd CV: 0.20). (c) TIN (3rd CV:0.21). (d) TST (4th CV:0.24). (e) TPO (10th CV:0.37). (f) TAF (11th CV: 0.37). (g) TTC (12th CV: 0.55). (h) ENT (13th CV:0.56).

competitiveness and let us make a microscopic comparative analysis on the relative strengths and weaknesses of countries per MOT domain. As explained in Section 2.3, the *Y*-axis indicates the relative ratio in a domain, while the *X*-axis shows the relative research advantage value in the RRA profile charts.

The eight RRA profiles deliver the following four messages with their visualizations.

First, RRA profiles present the variation level of a domain in general. The gathering of values implies low variation, and the scattering of values implies high variation. The first four figures (Fig. 5a–d) clearly contrast with the last four figures (Fig. 5e–h) in the degree of dispersion. The first four domains visibly illustrate a low degree of dispersion, while the last four domains show a high degree of dispersion per country. The RnD and NPD domains show a clear grouping, while TTC and ENT are all loosely scattered.

Second, the RRA profiles visualize the relative research advantage of a country in a specific MOT domain. When a country is positioned on the right side in the chart compared to the other counties, that country has a comparative advantage in the particular domain. We can thereby visibly detect which countries are comparatively advantageous–Netherlands has a clear comparative advantage in TPO, but Spain and Taiwan have an obvious comparative disadvantage in NPD.

Third, the RRA profiles are showing whether an MOT domain is a major pillar or a minor pillar. The RRA profiles of the big pillars like RND and TIN have their value points in the upper side of the charts, while small pillars like TTC, TAF, and ENT appear on the lower side of the charts.

Fourth, the RRA profiles allow us to detect whether a country is comparatively well balanced or imbalanced in MOT research performance. The US and UK are mostly located in the central area where the *X*-value is around 1.0, while the other countries including Germany, Italy, and Taiwan are quite differently positioned per each domain.

The above four functions and findings, as derived from the RRA profiles, are all beneficial when we seek to understand the relative competitiveness of countries in specific MOT domains. The RRA profiles can deliver country specific characteristics in a collective manner as follows: the US and the UK are well balanced, and therefore, it is difficult to specify relative strengths or weaknesses. The US has a comparative advantage in NPD and PJM; the UK has one in SCH and TPO, and Spain in ENT and IPR. The other four countries show much more dynamic observations. Netherlands has a noticeably comparative advantage in TPO, while Taiwan has one in TAF; Germany has one in ENT; Italy has one in TTC. The comparative disadvantage of Germany is in TST, Italy in TAF, Taiwan in NPD, and Netherlands in TTC.

4. Discussion and conclusions

This paper differentiates from the existing MOT bibliometric research in terms of the kinds of data analyzed, the methodology chosen, and its major research objectives. This paper analyzes all 5239 research papers published in ten MOT journals during the years 2000–2009. Using an enhanced combination of keyword frequency competition analysis and experts-based journal description keyword analysis, this study developed and categorized these papers into thirteen MOT domains. Additionally, a *relative research advantage* (RRA) profile was developed to better compare the characteristics of the countries in each MOT domain. Identifying and comparing the different characteristics of top fifteen countries and an in-depth relative comparison analysis of top seven countries – US, UK, Netherlands, Taiwan, Germany, Italy, Spain – in MOT research was then conducted to discover the policy implications.

In summarizing these results, this study offers four major discoveries to add to the MOT community. First, the seven major countries, Taiwan, Spain, Italy, Germany, Finland, China, and Netherlands, show relatively rapid growth and will be promising contenders in MOT research. These seven countries will quickly narrow the gap with two dominant countries, the US and the UK in MOT research. Second, the comparison analysis for growth rate and publication share in thirteen MOT domains revealed that the four small and medium-sized MOT domains—TAF, IPR, TTC, KNM, are emerging as and converging into major topics of MOT study. Third, our investigation discloses that most countries show a similar level of interest in large fundamental MOT pillars for RND, NPD, TIN, but a quite different level of interest in MOT studies for TAF, TTC, and ENT. Finally, our discovery confirms that countries have quite diverse relative research performances in MOT domains. Among the top seven countries in MOT studies, the US and the UK show well-balanced research competiveness in overall MOT domains, whereas Spain, Italy, Netherlands, Canada, Taiwan, and Germany have a clearly different comparative superiority and inferiority in MOT research efforts and performance.

The practical findings of this study are quite meaningful because the RRA profiles demonstrate significant differences in characteristics and comparative competences for countries in MOT research, which has been little known before the current study. These empirical findings contribute to MOT studies by providing a much clearer picture of how MOT research has grown over the last decade per country and its per domain. Further, this research demonstrates how countries are differently positioned in their comparative competences in the global MOT arena with its example of in-depth analysis of top seven countries. This enhanced recognition of the current positions of these top seven countries is attributed to their comparative strengths and weaknesses and is decisive in planning the future direction of MOT research. This determination also can enable MOT researchers and policy-makers to better design future research at both the individual and the national level. In this vein, these policy-makers can facilitate further research on relatively weak MOT domains, where necessary, through related research funding and incentive programs.

Despite the contributions of this study, it does have certain limitations. First, in spite of the base data, this study did not fully consider that there are gaps between the studies of domestically published studies and those for international journals. Still the ten MOT journals can be considered as effective, peer-reviewed quality studies that do clearly represent an ongoing overall MOT study. Second, this study includes only the quantitative competences of countries and does not reflect on the qualitative aspects of the different MOT papers. Third, although this study retains an objectivity and reliability in methodology, there is still room for further stabilizing.

Future research should conduct more in-depth analysis to disclose the detailed differences of countries and topical evolution over time in each MOT domain, both for large fundamental MOT areas and small and medium-sized emerging areas. Such a thorough analysis of each specific domain is worthwhile for better capturing more specifically the exact diverse socio-economic and technological environments of countries, and how those different circumstances have triggered or motivated the diversity of MOT research in each country.

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