A Bibliometric Analysis of the Knowledge Exchange Patterns between Major Technology and Innovation Management Journals (1999-2013)

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Introduction

It is healthy, even vital, for a domain area to conduct periodic and critical self-evaluation of its impact and evolution. Over the years, disciplines like marketing have engaged in several such "state of the discipline" appraisals (e.g., Biggadike 1981; Day 1992; Day and Montgomery 1999; Varadarajan and Jayachandran 1999; Pieters and Baumgartner 2002; Reibstein et al. 2009 etc.).

In a recent evaluation, Clark et al (2014) analyzed aggregate levels of citation flows between the top four journals of major business disciplines to show that Marketing was a net importer of knowledge from other related business disciplines, and largely isolated. Similar analyses have also been conducted on the knowledge structures of a broadly classified innovation area (e.g., Shafiq 2013). However, aggregate level citation data do not provide us with the directionality or evolution of such trends over the years. To our knowledge, we are lacking a longitudinal perspective on the impact and evolution of knowledge exchange patterns in the Technology and Innovation Management (TIM) domain.

The purpose of this essay is to take a dynamic, longitudinal look at the citation flows between the top dedicated TIM journals, and its effect on their impact factors. Specifically, we take a year-by-year look at the following trends:

1) The level of self-citation by major TIM journals
2) The level of cross-citations between the major TIM journals
3) The effect of self-citation and citation of other major TIM journals on the impact factor of each journal.

Data

We extracted article-by-article citation data from 336 journals in major business disciplines from the Web of Science, from 1994 to 2013. This bibliometric database contained data on a total of 135,559 articles and 5,998,130 citations. However, some of the journals have a later start date, depending upon when they were incorporated in the database.

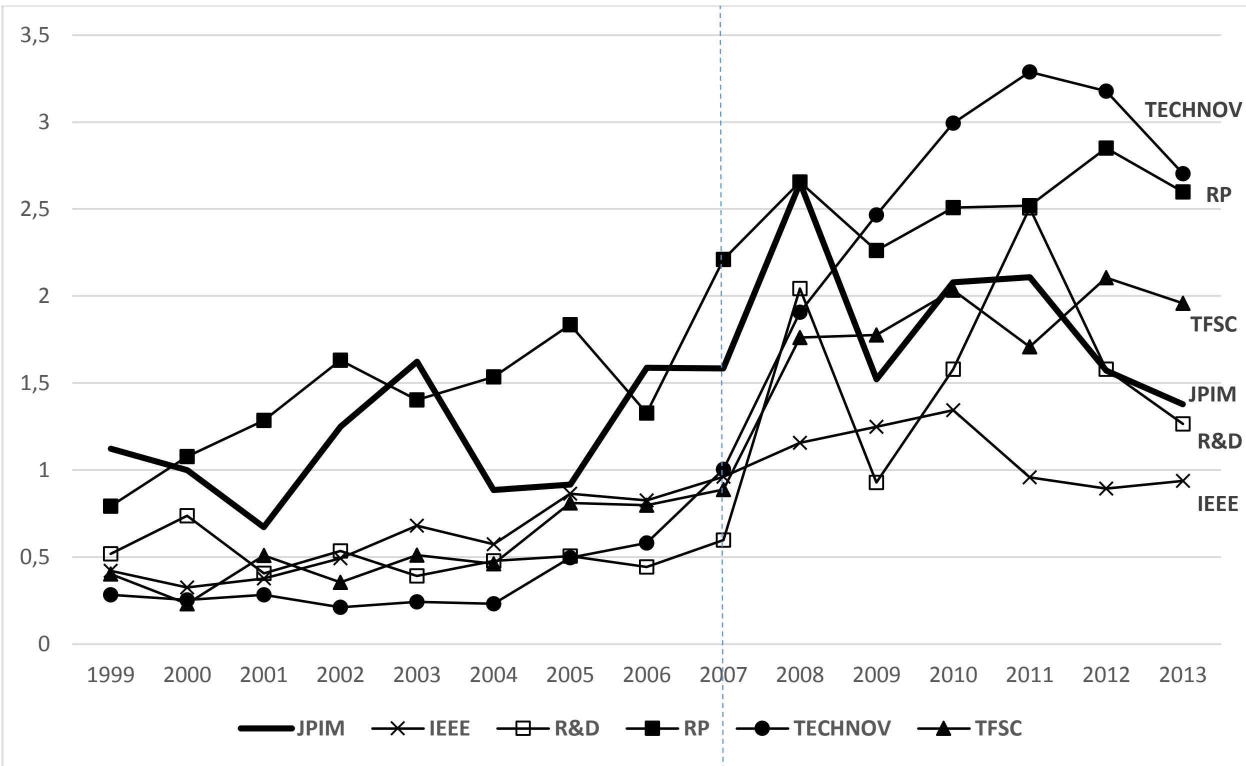
Starting with the dedicated TIM journals identified by Linton and Thongpapanl (2004), we focused on the top six (major) TIM journals based on average Impact Factor in order to keep the analyses and presentation manageable. Our final analysis was carried out on the following major dedicated TIM journals: *Journal of Product Innovation Management, Research Policy, R&D Management, IEEE Transactions on Engineering Management*, *Technovation*, and *Technological Forecasting and Social Change*. A full set of data for these journals in our consideration set were available only from 1999 – 2013. The final analyses for this essay were conducted on 29,776 citations from 4,171 articles published by these top six selected TIM journals.

In order to account for the differences in the number of articles published by each journal per year, and the number of references cited per article among different journals, we adopted the approach recommended by Di Benedetto et al (2018). All citation data were normalized and presented in terms of the percentage of all references cited in that journal, in that year as reported by Scimago Journal & Country Rank (http://www.scimagojr.com). The journal impact factors (IF) were extracted from Thomson Reuters database.

Findings

Figure 1 shows the evolution in the 2-year impact factor of journals under consideration from 1999 – 2013. It can be seen that most major dedicated TIM journals saw their 2-year impact factor rise significantly starting 2005-2007, to peak 2 to 5 years later, before starting to show some decline. An analysis of self-citation over this period could perhaps provide a tentative explanation of this general trend.

Figure 1: 2-Year Impact Factors of Major Dedicated TIM Journals (1999 – 2013)



Self-Citation Analysis of Major TIM Journals (1999 – 2013)

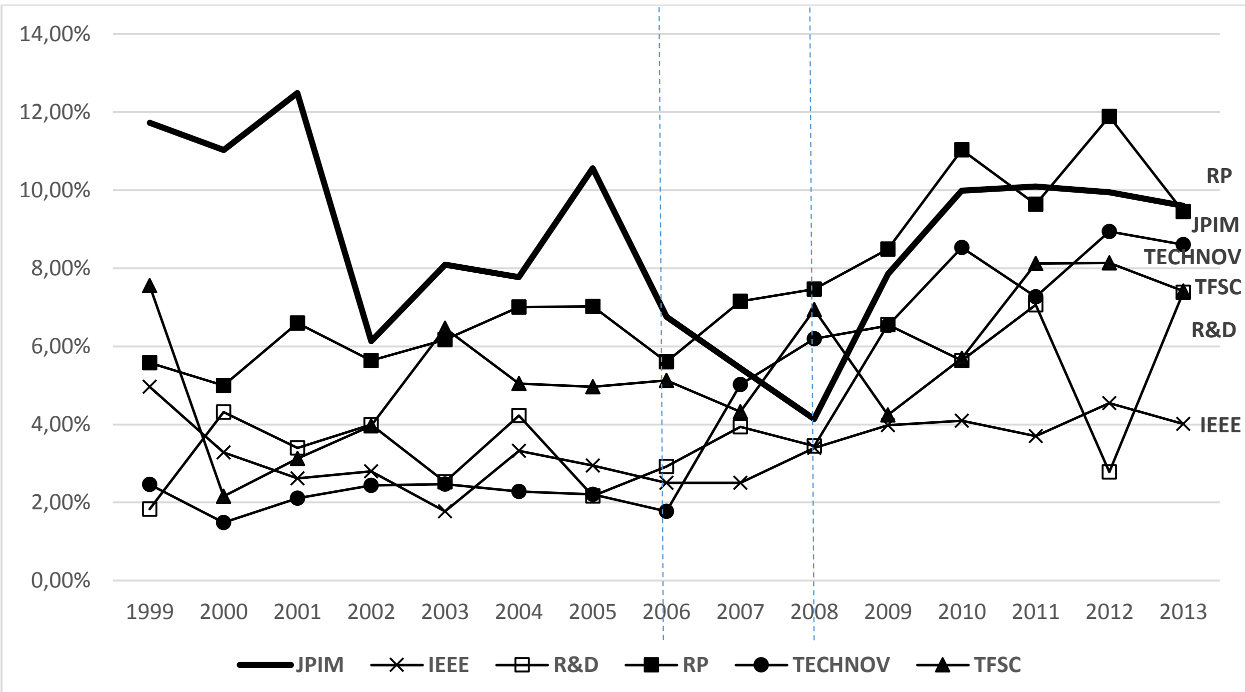
Figure 2 presents the rates of self-citation among the six major TIM journals over the 1999-2013 period. Patterns of self-citation by the major TIM journals suggest two distinct periods/phases, before 2006/2008 and after 2006/2008 (the transition year depends on the journals):

- The self-citation rates are rather steady before 2006/2008 for most journals except for *JPIM*. *JPIM* started out with the highest self-citation rates prior to 2005, but the rate decreased overall between 2005-2008, before climbing again. However, since 2008, the

JPIM self-citation rates have been more aligned with those of the other major TIM journals - though they still on the higher side in the consideration set;

- From 2006/2008 onwards, the self-citation rates increased for all major TIM journals, especially for *Research Policy*, *Technovation*, and *JPIM* (which hovered around 9% each in 2013).

Figure 2: Self-Citations Rates of Major Dedicated TIM Journals (1999 – 2013)



One possible explanation to this increase in self-citation is that over time, the body of knowledge in the major TIM journals has grown and matured; and these journals have published enough content to become a source of knowledge for their own articles. However, if we consider the evolution of the journals' impact factor as shown in Figure 1, a complementary explanation may be considered. It is possible that the emphasis on increasing impact factors (starting 2005-2007) has driven the increase in self-citation started in 2006/2008. As the journals in this domain area have gained in reputation, authors have felt more compelled to cite them.

Self-Citation vs. Cross-Citation of Major TIM Journals (1999 – 2013)

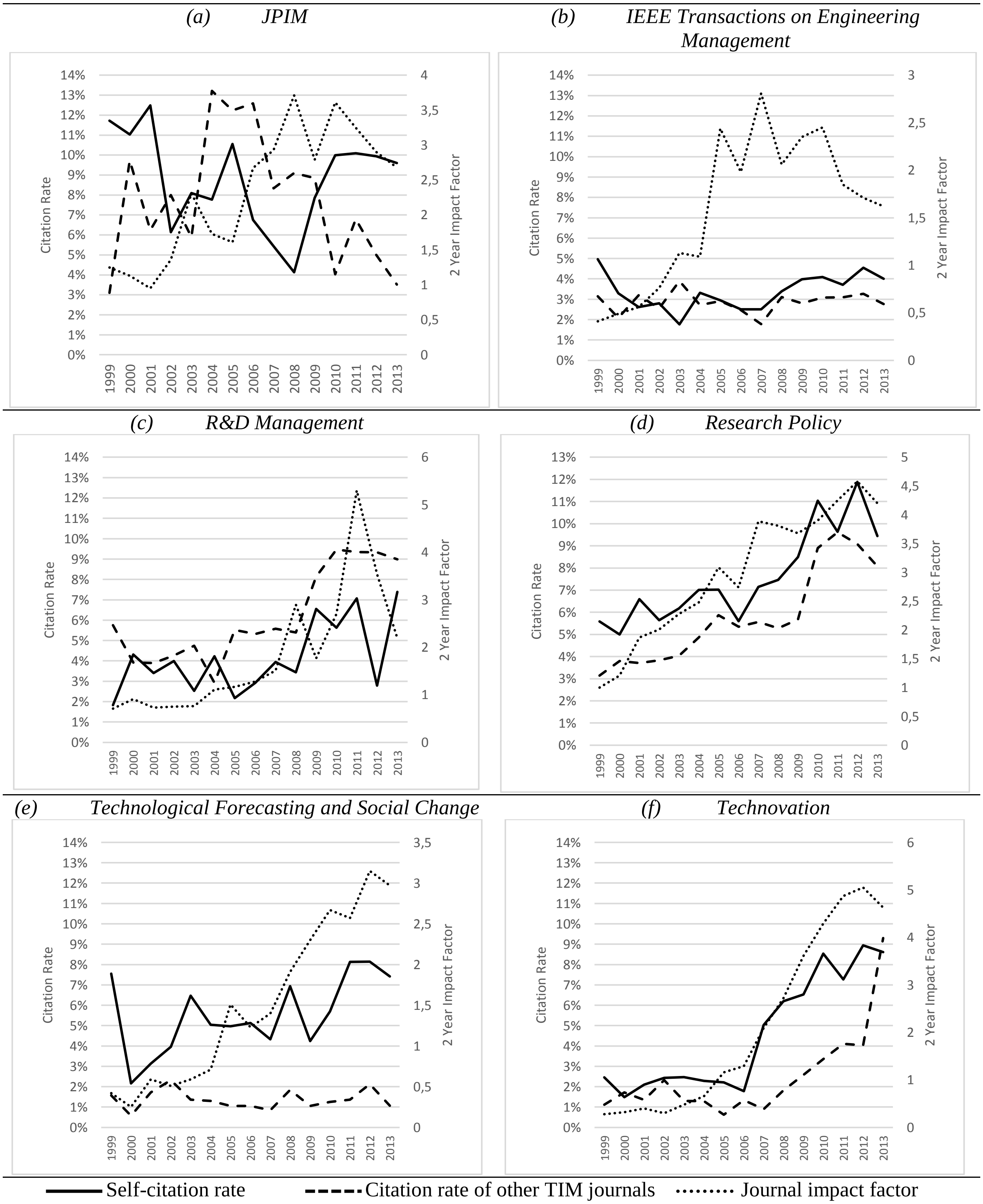
In order to complement our understanding of the journals' citation dynamics for each of the six major TIM journals, we analyzed a comparison of the evolution of their rates of self-citation and of cross-citation with the other five journals. Plots of these rates are presented in Figure 3.

Figure 3a shows that after peaking in 2004-2006, cross-citation rates of other major TIM journals in *JPIM* have steadily decreased over the years. *JPIM* went from being a major 'cross-citer' (12%-13% of total citations) to only about 3% of its citations coming from the five other major TIM journals by 2013.

On the other hand, *R&D Management*, *Research Policy*, and *Technovation* show the highest propensity to cite the knowledge created in major TIM journals in recent years (Figures 3c, 3d, and 3f). While historically low, since 2007 *Technovation* has shown an increasing tendency to cite the other TIM journals. Over the years, *TFSC* and *IEEE Transactions on Engineering Management* show the lowest propensity to cite knowledge from the other major TIM journals (1% – 3% of their references; Figures 3b and 3e). This tendency has remained fairly consistent. Interestingly, *IEEE Transactions on Engineering Management* also displays the lowest rates of self-citation in the set. Among the journals considered, *JPIM, TFSC*, and *IEEE Transactions on Engineering Management* tend to be most isolated in terms of knowledge imported from the other major TIM journals.

Overall *TFSC* and *JPIM* display some of the highest differentials between self-citation and cross-citations from the other major TIM journals. While *R&D Management*, *Research Policy*, *Technovation*, and *IEEE Transactions on Engineering Management* show the lowest gap between self-citation rates and citation rates of other major TIM journals.

Figure 3: Self-Citation vs. Cross-Citation Rates of Other Major TIM Journals (1999 – 2013)



Self-Citation Rates, Cross-Citation Rates, and Impact Factor

Next, we investigated the relationship between self-citation, cross-citation of other TIM journals, and the 2-year impact factor of the journals in our consideration set. Table 1 shows the descriptive statistics and the correlation matrix of our data. Self-citation and cross-citation of other TIM journals were significantly and positively correlated with the 2-year impact factor (.62 and .39 respectively).

Table 1: Descriptive Statistics and Correlation Matrix

		Mean	S.D.	Min	Max	Correlations		
						1	2	3
1	IF	1.26	0.8	0.21	3.28	1.00		
2	Self-citation	5.66	2.78	1.48	12.48	0.62^{***}	1.00	
3	Cross-citation	4.41	3.06	0.57	13.2	0.39^{***}	0.47^{***}	1.00

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We further examined the effect of self-citation and cross-citation of other major TIM journals on the 2-year impact factor, by estimating three regression models. In Model 1, we regressed the 2-year impact factors on the self- and cross-citation rates of all six major TIM journals. In Model 2, we ran the same regression on five major TIM journals excluding *JPIM*. Models 1 and 2 provide a good baseline for examining the effect of self- and cross-citation on the two-year impact factor knowing that we used fixed effects to control for the heterogeneity among journals. In Model 3, we focused exclusively on *JPIM* only. This way, we can compare the effects estimated for *JPIM* (Model 3) with those obtained for the five other journals (Model 2). The standardized regression results are presented in Table 2.

The estimation of Model 1 shows that as expected, both self-citation and cross-citation of TIM journals have a significant and positive effect on the 2-year impact factor of all major TIM journals at an aggregate level ($\beta = .56$, $p < .01$; $\beta = .11$, $p < .01$ respectively). In addition, self-citation rates have five times as strong an effect on impact factor compared to citation of other major TIM journals. These effects still hold once JPIM is taken out of the sample of the TIM journals (Table 2, Model 2). The effect of self-citation on impact factor becomes even stronger as compared to the overall sample; the effect of self-citation on impact factor is still over five times greater than the effect of cross-citation of other TIM journals ($\beta = .73$, $p < .01$ vs. $\beta = .13$, $p < .05$). These results seem to indicate that self-citation, and citation of the major journals in the TIM domain directly enhances a journal's impact and reputation in general.

Table 2: Effect of Self-Citation and Cross-Citation of Major TIM Journals on 2-Year Impact Factor (Standardized Regression Coefficients)

	All TIM journals	All TIM journals excluding JPIM	JPIM
Self-citation	0.56^{***}	0.73^{***}	-0.72^{***}
Cross-citation	0.11^{***}	0.13^{**}	-0.47^{**}
Observations	90	75	15
VIF	1.29	1.28	1.18
R^2	0.395	0.626	0.468
Adjusted R^2	0.343	0.593	0.379

One-tailed significance tests.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

However, when these relationships are examined for *JPIM* alone (Table 2, Model 3), we find that much to our surprise, *JPIM* bucks the trends displayed by the other journals in the TIM domain. Over the 1999-2013 period, both self-citation and cross-citation of other major TIM journals have a significant and *negative* effect on the impact factor of *JPIM* ($\beta = -.72$, $p < .01$; $\beta = -.47$, $p < .05$) with the self-citations having a stronger negative effect than the cross-citations. While seemingly counterintuitive, these results can perhaps be explained by the unique positioning of each journal within the larger TIM domain. Table 3 presents a summary of the self-described positioning of each journal from their own websites.

Table 3: Positioning of Major Dedicated TIM Journals

Journal	**Positioning *(Source)***
Journal of Product Innovation Management	An *interdisciplinary*, international journal that seeks to advance *theoretical* and *managerial knowledge* of *new product/service development*, and *innovation management* in an organization's external and internal environments. Publishes articles on *organizations of all sizes* (start-ups, small-medium enterprises, large), from the *consumer, business-to-business, and institutional domains*. ***(http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1540-5885/homepage/ProductInformation.html)***
IEEE Transactions on Engineering Management	Publishes articles on *management of technical functions* such as research, development, and engineering *in industry, government, university, and other settings*. Emphasis is on studies carried on within an organization *to help in decision-making or policy formation* for *research, development and engineering*. ***(http://ieeexplore.ieee.org/xpl/aboutJournal.jsp?punumber=17#AimsScope)***
R&D Management	Publishes articles of interest to *practicing managers and academic researchers* in R&D and innovation management. Covering the full *range of topics in research, development, design and innovation,* and related *strategic and human resource issues* - from *exploratory science to commercial exploitation* - and examining *social, economic and environmental implications.* ***(http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-9310/homepage/ProductInformation.html)***
Research Policy	A *multi-disciplinary* journal devoted to *analyzing, understanding and responding to the economic, policy, management, organizational, environmental and other challenges posed by innovation, technology, R&D and science* on the one hand, *and economic, social, political and organizational processes*, on the other. This includes a number of related activities concerned with the creation, diffusion, acquisition and exploitation of knowledge (in the form of new or improved products, processes or services). Findings *must have implications for policy or management.* ***(https://www.journals.elsevier.com/research-policy/)***
Technological Forecasting and Social Change	The journal offers a forum for those wishing to *deal with the methodology and practice of technological forecasting and future studies as planning tools* as they *interrelate social, environmental and technological factors*. ***(https://www.journals.elsevier.com/technological-forecasting-and-social-change/)***
Technovation	An *interdisciplinary* journal that encompasses *all facets of technological innovation*. Technological innovation is considered from both *process and product perspectives*, *social innovations*, and *conceptualization to commercialization* of a new technology-based products or processes in *all forms of enterprise, political and economic systems*. ***(https://www.journals.elsevier.com/technovation/)***

From Table 3 it can be seen that *JPIM* (along with *Research Policy, Technovation, and R&D Management*), has the broadest positioning statements of the journals under consideration. Over the years, while the other journals seemed to have anchored more strongly in the TIM literature (as indicated by their relatively higher rates of self- and cross-citations), *JPIM* seems to have broadened its appeal and knowledge base beyond the traditional TIM domain. In recent years, *JPIM* seems to be placing greater emphasis on theoretical grounding in core business disciplines (i.e., management, strategy, marketing, IS, operations) beyond the traditional TIM literature (including self-citations). This would result in an increase knowledge import from (and hopefully export to) the core businesses disciplines – as indicated by an increasing impact factor of *JPIM*, despite a significant negative relationship with both self-citation and cross-citation rates of other major TIM journals. It would be interesting to see the knowledge flows between *JPIM* and the major journals in the core business disciplines over this period to shed more light on this rather unusual finding.

Conclusions

The purpose of this essay was to examine the knowledge exchange patterns between the major TIM journals. In so doing, we examine 4,171 articles and 29,776 citations from the top six dedicated TIM journals from 1999 – 2013. The bibliometric analysis presented here gives us one of the most comprehensive and detailed year-by-year look at the intra-domain knowledge exchange over a 15-year period. Our analyses indicate that:

- All the major dedicated TIM journals included in the analysis showed significant increases in their impact factors beginning 2005-2007.
- The increase in the impact factors of the journals coincides with increasing self-citation by all the major TIM journals, starting 2006-2008. *Research Policy*, *Technovation*, *JPIM*, and *TFSC* exhibit the highest self-citation rates among the major dedicated TIM journals. This could be a sign of development and maturity of the TIM as a field of study – with domain-specific knowledge reaching critical mass and generating self-referencing.

- After exhibiting the highest self-citation rates in the set from 1999-2005, *JPIM* self-citation rates became more consistent with those of other major TIM journals starting 2007-2008.
- From 1999-2013 *R&D Management*, *Research Policy*, and lately *Technovation* have shown an increasing tendency to cite other major TIM journals in the consideration set, suggesting that they may be becoming more deeply rooted in the TIM literature.
- *JPIM*, *TFSC*, and *IEEE Transactions on Engineering Management* on the other hand, tend to cite the other major TIM journals the least. The tendencies displayed by *IEEE Transactions on Engineering Management* and *TFSC* might be explained by their very specific and specialized positioning within the TIM domain, which reduces overlap with other major TIM journals (see Table 3). The knowledge exchange patterns displayed by *JPIM* might be indicative of a broadening of *JPIM*'s appeal, and knowledge base beyond the traditional TIM domain.

Overall, our findings suggest that the major TIM journals seem to be bifurcating in how they exchange knowledge within the domain. Half of the journals considered (i.e., *R&D Management, Research Policy, Technovation)* seem to be becoming more firmly rooted in the domain, while the other half (i.e., *JPIM, TFSC, IEEE Transactions on Engineering Management*) seem to be becoming more insulated from the other TIM journals, for various reasons.

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