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# Disciplinary knowledge diffusion in business research

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ABSTRACT

Business research has established itself in largely six disciplines: Accounting, Marketing, Organizational Behavior and Management, Finance, Management Science and Operations Research, and Management Information Systems. The knowledge flows among these six disciplines and the factors that drive knowledge diffusion are important considerations. The quantitative analyses on a large dataset containing over 400,000 journal-to-journal citations for business journals published between 1997 and 2009 reveal important patterns of knowledge diffusion in business research. The cross-disciplinary knowledge diffusion is discipline-dependent and converging to a similar level in terms of the diversity. Aside from other factors such as articles published in the journal and the number of classifications, we find that journal quality, as measured by inclusion in the UT Dallas top journal list, has a significant effect on cross-disciplinary knowledge flows. We also offer some potential explanations for the effect of this formalized measure of quality.



## 1. Introduction

Business research has largely established itself in recent decades in six disciplines, namely Accounting, Marketing, Organizational Behavior and Management (OB/M), Finance, Management Science and Operations Research (MS/OR), and Management Information Systems (MIS). The status quo of the knowledge diffusion among the six disciplines is of interests to many researchers in business schools. Indeed, considerable research interests exist in the interdisciplinary scholarly exchange and academic knowledge diffusion (e.g., Biehl, Kim, & Wade, 2006; Linderman and Chandrasekaran, 2010). The current studies are limited in scope for the limited journals (e.g., Biehl et al., 2006) or disciplines (e.g., Linderman and Chandrasekaran, 2010). To get a full picture of the six disciplines, this study investigates the knowledge diffusion of the six disciplines of business research using a large dataset containing over 400,000 journal-to-journal citations for business journals published during 1997–2009. We first study discipline-level knowledge flow dynamics, such as dependency and diversity among the six business disciplines. We then study factors influencing knowledge exchange in these disciplines using econometric methods. Besides the contextual contributions in providing a more complete picture of the interdisciplinary knowledge diffusion in business research, this study also applies some state of the art econometric techniques to the citation networks of the six disciplines.

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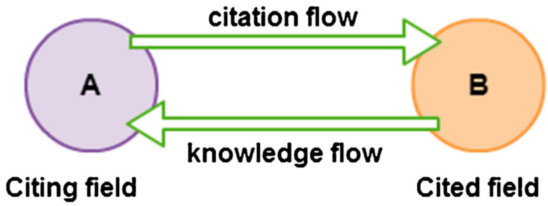


**Fig. 1.** Citation flow and knowledge flow.

The use of citations as a research instrument allows for a view of the impact of knowledge exchange on the dynamic formulation and development of the field of business. Despite the potential limitations in reproducing the intellectual connections of the citing and cited work,[1] citations are the most widely used measure of knowledge flows, due to the objectivity of the measurement, which is independent from personal perceptions (e.g., Lockett & McWilliams, 2005). According to Bhupatiraju, Nomaler, Triulzi, and Verspagen, (2012, p.1206), citations "are indications of intellectual influence (from the cited paper to the citing paper), and therefore can be used as 'paper trails' of the flow of ideas between and within" disciplines. Existing studies have used citations to reveal macro-level knowledge diffusion patterns among various science and social science domains (Yan, Ding, Cronin, & Leydesdorff, 2013; Yan & Yu, 2016; Yan, 2016) and it is among our goals to further this area of research by conducting analyses that examines several closely-related fields of business research. We use citation flows to quantitatively study knowledge exchange. Knowledge flows into a field via outgoing citation links and a field's own knowledge is disseminated via incoming citations links (Fig. 1).

In addition to the consideration of knowledge exchange, existing research has attempted to obtain an objective measure of disciplinarity and interdisciplinarity (Leydesdorff & Rafols, 2011; Rodriguez, 2017; Rafols & Meyer, 2010). Rafols and Meyer (2010) suggested the use of diversity and network coherence to evaluate interdisciplinarity. Rodriguez (2017) proposed a measure of disciplinarity based on entropy. Leydesdorff and Rafols (2011) considered three types of indicators in an attempt to identify a robust measure of interdisciplinarity. While they did not find a single measure, they found that Shannon entropy, as a measure of diversity, is a better measure than the Gini coefficient, despite its sensitivity to size. Our use of Shannon entropy is the first in studying interdisciplinarity and diversity among these six business disciplines. Our results reveal that pairs of disciplines vary greatly in their interdependency and diversity. The overall trend, however, seems to suggest that all disciplines are converging to similar diversity in their knowledge exchange based on the Shannon entropy.

To further understand the drivers of interdisciplinary knowledge flow, we study the journal level factors associated with knowledge diffusion in the six business disciplines. The journal level factors include the number of publications, number of journals inside and outside of the field, journal classification, and an indicator of journal status—top-tier designation by the University of Texas at Dallas. The UT Dallas Top 100 Business School Research Rankings[2] is a ranking list of top higher-education academic institutions, based on a widely-accepted list of "top-tier" business journals, created by UT Dallas. They also include a database of publications and institution rankings based on the number of publications in these journals by faculty at that institution. This list has become increasingly popular and is well-known throughout the business research community, especially in the United States.

This paper joins the stream of empirical studies examining factors associated with knowledge exchange in business research (e.g, Judge, Cable, Colbert, & Rynes, 2007; Mingers & Xu, 2010; Stremersch, Verniers, & Verhoef, 2007). Stremersch et al., (2007) used a sample of five journals in marketing to investigate article-level citations and found that the number of citations depends on the "who, what and how" elements of a particular article. Mingers and Xu (2010) investigated the drivers of citations in a small sample of management science journals and found that citations are related to the journal itself, status of the first author's institution, length of the paper and number of references. Judge et al. (2007) found that besides other article and author level factors, the single most important factor is the prestige of the journal as measured by the average citation rate. Our paper emphasizes the journal level factors in affecting citations and the findings enrich our understanding in this stream of research.

Moreover, by using the difference in difference identification strategy and the state of the art synthetic controls, we find that the quality proxy—the top-tier journal status, had little impact on infield citations but positively affected the outfield citations. This is likely due to the fact that the infield audience can more easily assess the quality of the cited work without referring to a formal journal ranking system, whereas outfield scholars have a harder time assessing the quality of a journal or article outside of their field and may rely more on the publicized journal list. The results of this research contribute to the conversations on the fundamental question of why scholars cite other publications. The seminal article by Baldi (1998) argued that scholars cite articles because of their relevance rather than a signal of their social status, which sparked a multitude of research and discussions in this field. Contrary to Baldi's observations, some argued that citing is not purely

[1] For example, it is common for scholars inside a discipline to translate ideas from outside the discipline, and then scholars within the discipline cite the translated work, rather than citing the original source of the idea.

[2] See the website http://jindal.utdallas.edu/the-utd-top-100-business-school-research-rankings/. We use UT Dallas ranking and UT Dallas top-tier designation interchangeably.

**Table 1**
Data statistics for the six areas of research.

| Citation window | No. of journals | No. of incoming citations | % of citations[a] |
|---|---|---|---|
| 1997/1999 | 352 | 34,611 | 0.76% |
| 2000/2002 | 382 | 44,059 | 0.77% |
| 2003/2005 | 441 | 64,805 | 0.87% |
| 2006/2008 | 500 | 103,346 | 1.23% |
| 2009/2011 | 490 | 147,427 | 1.56% |

[a] % of citations: this column shows the percentage of citations received by business journals over the total number of citations of all journals in the Scopus database.

based on intellectual relevance. For example, Podolny (2001) argued that "potential exchange partners would rather enter into an exchange relation with a high-status rather than a low-status producer if only because high status is a signal of quality (Podolny 2001; p. 41)." Other research suggests that by citing an article published in a high quality journal, the citing article could potentially be signaling the quality of their work. Our results support the notion that scholars cite articles not only based on intellectual relevance but also status-seeking or quality signaling (Podolny 2001), especially when citing an article outside of their own discipline, in which case the objective quality may be harder to assess.

The rest of the paper is organized as follows. Section 2 describes the data, metrics, and quantitative models for investigating knowledge flows. Section 3 presents the analytical results. Section 4 offers discussions and concludes the paper.

## 2. Data and methodology

### 2.1. Data

The data were obtained from the Elsevier Bibliometrics Research Program. The intermediary data file was a journal-to-journal citation matrix for all indexed journals and proceedings in Elsevier's Scopus database with a two-year citation window (cited/citing years: 1997/1999, 2000/2002, 2003/2005, 2006/2008, and 2009/2011). The total numbers of journal-to-journal citations are over 4 million. The journal-to-journal citation data were then aggregated at the discipline level according to Elsevier's All Science Journal Classification (ASJC) Codes. A journal is assigned into one or a few of the 307 minor subject areas. In this study, we focus on the analysis of the following six business related minor subject areas:

1. Accounting
2. Marketing
3. Organizational Behavior and Management (OB/M) [comprises (1) Organizational Behavior and Human Resource Management and (2) Strategy and Management]
4. Finance
5. Management Science and Operations Research (MS/OR)
6. Management Information Systems (MIS) [comprises Information Systems Management and Management Information Systems]

A journal may be classified in multiple subject areas or fields. In such situations, a journal's citations are counted in full in every subject field that it is assigned into. This counting method is consistent with the way we aggregate citations in our prior work (Yan et al., 2013; Yan, 2016). We count the citations as infield if the citing journal has the same classification as the cited one. For example, if the cited journal is classified as both MIS and Accounting, and the citing journal is either classified as an MIS or Accounting journal, then the citation is counted as an infield citation but not as an outfield citation.

The number of journals and subject level citations for each citation window are shown in Table 1. In general, the number of journals, the number of incoming citations and the percentage of citations among all subjects increase over the years. The number of journals dropped slightly in 2009, primarily due to modifications in the classifications of some journals.

### 2.2. Knowledge exchange interdependencies

To examine the dynamic aspect of interdependencies in business research, we study the citation links among the six business fields. Knowledge interdependence is defined as:

$$D_{k\leftrightarrow i} = D_{k\rightarrow i} = D_{i\rightarrow k} = \frac{G_{ik} + G_{ki}}{G_{ii} + G_{kk}},$$

where $G_{ik}$ is the citation flow from $i$ to $k$, $G_{ki}$ is the citation flow from $k$ to $i$, $G_{ii}$ and $G_{kk}$ are self-citations of fields $i$ and $k$. The slope of $D_{k\rightarrow i}$ is also calculated to reveal the interdependency dynamics.

### 2.3. Interdisciplinarity and diversity

Knowledge carriers vary greatly in their ability to export and import knowledge: some are more permeable while others are more self-dependent. In their research to obtain a numerical measure of interdisciplinarity, Leydesdorff and Rafols (2011) found that Shannon entropy is a valid measure of interdisciplinarity. They identify that the strength of the Shannon diversity measure stems from its ability to consider the reach of a journal. We use Shannon entropy (Lin, 1991; Leydesdorff & Rafols, 2011) to measure the knowledge diversity of the six business fields:

$$H_k = -\sum_{i=1}^{n} \frac{G_{ik} + G_{ki}}{\sum_{j=1}^{n} G_{jk} + \sum_{j=1}^{n} G_{kj}} \ln \frac{G_{ik} + G_{ki}}{\sum_{j=1}^{n} G_{jk} + \sum_{j=1}^{n} G_{kj}},$$

where $H_k$ is the Shannon entropy for field $k$, $G_{ik}$ is the citation flow from $i$ to $k$, $G_{ki}$ is the citation flow from $k$ to $i$, $\frac{G_{ik}+G_{ki}}{\sum_{j=1}^{n} G_{jk}+\sum_{j=1}^{n} G_{kj}}$ is the proportion of citations between $i$ and $k$ over the total incoming and outgoing citations of $k$, and $n$ is the number of knowledge carriers (6 in this case).

### 2.4. Driving factors of knowledge flows

#### 2.4.1. Model

The bibliometric knowledge exchange analyses were conducted at the discipline level. At the journal-level, we are interested in examining the factors (i.e., drivers) that contribute to the diffusion of knowledge. We consider the factors associated with total, within field (or in-field), and outside field citations. All citations are limited to the six business disciplines. We also highlight the impact of quality, as approximated by inclusion on the UT Dallas top-tier journal list. The drivers that we consider in our study include:

- Top-tier status[3]: This variable indicates whether the journal is listed on the UT Dallas top-tier journal list in a particular year. This variable is of particular interest in this research because it serves as a formal measure of quality, beginning with its publication in 2003. Appendix A includes a list of journals on the UT Dallas list. Using this measure, we are able to consider if citations increased after the publication of the top-tier journal list. In particular, we look at whether the total, outfield, and infield citations increase significantly when compared to other journals that are not listed as top-tier.
- Number of articles published in the same journal: Journals tend to have self-citations. This motivates us to consider the number of articles published in each of the sample journals. The more articles that are published in this journal, the more citations they may generate for the same journal.
- Number of journals within the same field: Journals tend to be cited by journals in the same field. Therefore, the more journals that are published in the same field, the more citations they may generate for the journals in the same field.
- Number of journals outside each field: Given that everything else the same, the more journals that exist outside of each field, the more citations they may generate.
- Number of classifications of the journal: Elsevier classifies some journals as belonging to a single discipline, and some as belonging to multiple disciplines. Journals classified as multidisciplinary journals may have more outside citations from other disciplines or fields. The number of classifications in the sample range from 1 to 4. Since there are very few journals that are classified to have more than two categories, we group the journals that have two or more categories as journals having multiple classifications.

Due to the panel data structure of the data, we use a fixed effect specification to study the impact of the aforementioned factors on citation changes. There are a few considerations of using fixed effect models. First, because fixed effect models use the within journal variations, which removes the time constant factors, the estimation will not be biased by any time invariant factors. Second, the effect of the top-tier journal list can be conveniently estimated using the fixed effect model in that it can suitably implement the difference in difference identification strategy (Wooldridge 2012). Finally, Hausman tests conducted on our sample suggest fixed effect models are preferred over random effect models. The fixed effect models are specified as follows:

$$Y_{\text{it}} = \beta_1\, quality_{it} + \boldsymbol{\beta}_2 \boldsymbol{X}_{it} + \gamma_i + \delta_t + u_{it},$$

where $Y_{\text{it}}$ is the log-citations (total, within field or outside field) for journal $i$ at time $t$; $quality_{it}$ is a quality indicator (i.e. UTD list status) variable for journal $i$ in year $t$; $\boldsymbol{X}_{it}$ represents a vector of the aforementioned factors; $\gamma_i$ is the journal-specific fixed effect which is allowed to be arbitrarily correlated with any of the factors $\boldsymbol{X}_{it}$ and $quality_{it}$; $\delta_t$ is the year fixed effect; and $u_{it}$

[3] Aside from the widely used UT Dallas list, an alternative list from Financial Times is also used in many business schools, especially international business schools. We did not include the analysis for the Financial Times list of journals because we only have 27 out of the 45 journals in our sample, while the UT Dallas list is near complete (23 out of 24). We also note that 21 out of the 23 journals on the UT Dallas list are also on the Financial Times list.

**Table 2**
Knowledge flows measured by knowledge interdependency.

| | $D_{k\leftrightarrow i}$ (2009/2011) |
|---|---|
| Accounting ↔ Finance | 0.73 |
| MS/OR ↔ MIS | 0.42 |
| OB/M ↔ MS/OR | 0.26 |
| Marketing ↔ OB/M | 0.20 |
| OB/M ↔ Finance | 0.17 |
| OB/M ↔ MIS | 0.17 |
| Marketing ↔ MIS | 0.11 |
| Accounting ↔ OB/M | 0.11 |
| Marketing ↔ MS/OR | 0.10 |
| Accounting ↔ MIS | 0.09 |
| Marketing ↔ Finance | 0.06 |
| Finance ↔ MIS | 0.06 |
| Finance ↔ MS/OR | 0.04 |
| Accounting ↔ MS/OR | 0.02 |
| Accounting ↔ Marketing | 0.02 |

is the error term. $quality_{it}$ equals 1 for top-tier journals by UTD after 2001[4] and all 0′s for other journal-years. Coefficient $\beta_1$ is the difference-in-difference estimate for the top-tier classification, $\boldsymbol{\beta}_2$ is the vector of coefficients for the other control variables. To remove the linear time trend, we also add the linear time effect (*time*) in the model. We use robust standard errors to account for possible within journal heteroskedasticity and autocorrelations.

## 3. Results

### 3.1. Knowledge exchange in business research

First, we examine knowledge exchange between pairs of disciplines over time. Table 2 reports the knowledge flows between pairs of business disciplines using the 2009/2011 citation data, with the most dependent pairs ranked first. Two pairs, Accounting and Finance, and MS/OR and MIS, lead in the dependence flows, followed by the pairs of OB/M and MS/OR, Marketing and OB/M, and OB/M and Finance. The table also shows that, among the six disciplines in business research, MS/OR is the least dependent on Finance and Accounting.

To visualize knowledge exchange among the disciplines, we decompose the two-way knowledge flows into two directions and represent the pairwise knowledge flows through a chord diagram (Fig. 2). The chord diagram is plotted with the combined data of all years, based on the observation that the knowledge exchange patterns are consistent across the years. The knowledge exchange is represented by an arc whose width is proportional to the volume of citations. Arcs are color-coded based on the direction of citations: arcs have the same color with the field from which they originate. Self-citations are also included in this diagram and are represented by the "U"-shaped arcs that originate from and end in the same discipline.

We see in Fig. 2 that finance and accounting have the strongest connection and the most knowledge exchange. These two fields are also the most established in terms of degree program offerings; for instance, each of the top 10 schools on the most current UT Dallas North American rankings list has a specific department for finance and accounting. Marketing is also a specific department in each of the 10 schools. The additional three disciplines (i.e., MIS, MS/OR and OB/M) under consideration vary departmentally from school-to-school. In addition, Marketing and OB/M are the most self-dependent because the two fields' knowledge flows are dominated by their self-citations (their self-citation rates within the six business disciplines are 0.56 and 0.63, respectively), while the self-citation rates for other disciplines are smaller than 0.5.

In Lockett and McWilliams' (2005) study, the authors found that management had a balance-of-trade deficit with economics, psychology, and sociology based on a journal citation analysis. In the current study, within the six business fields, we did not find a noticeable trade deficit of management (OB/M) with others, as the incoming and outgoing citations took similar shares on the circle (the ratio of incoming and outgoing citations within the six business disciplines is 0.97). It is also worth noting that there is no link between Accounting and Marketing or between MS/OR and Accounting in Fig. 2. This is the result of chord diagrams that omitted links with very small weight (the abovementioned two links made up less than 2% of the weight of the link between Accounting and Finance). The result suggests that even within the business research domain, some disciplines show a certain degree of distinctiveness and do not form strong ties with others in this umbrella domain.

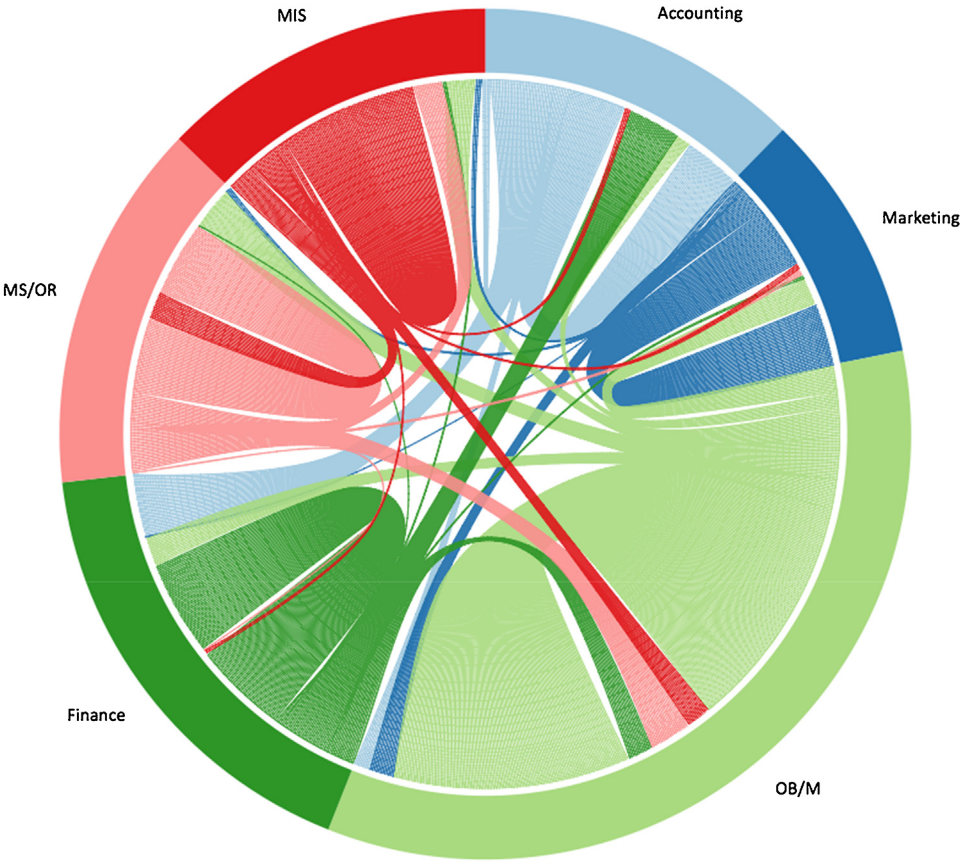


**Fig. 2.** A chord diagram representation of knowledge flows within the six business fields. Arcs are color-coded based on the direction of citations. Arcs have the same color with the field from which they originate.

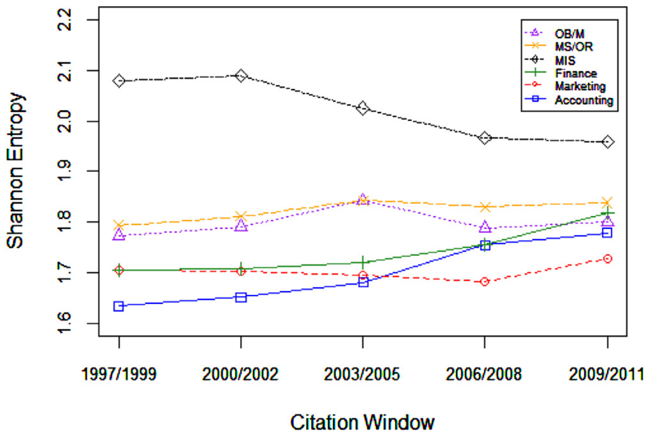


**Fig. 3.** Shannon entropy for the six business areas.

### 3.2. *Interdisciplinarity and diversity*

Diachronically, we use Fig. 3 to illustrate the Shannon entropy measure for disciplinary knowledge diversity. As shown in Fig. 3, all fields seem to converge to a similar diversity level. This is the result of a decrease in Shannon entropy in MIS and

[4] the citations of the articles published in the year of 2003 will be counted after 2003, which is after the UTD top-tier effect. Thus the 2003 year should be coded as 1′s for the top-tier journal observations.

**Table 3**
Summary statistics.

| Variables | Descriptions | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| logcitett | Log(Total Citations) | 1342 | 1.246 | 0.511 | 0.301 | 2.833 |
| Logciteout | Log(Outside Citations) | 1342 | 0.494 | 0.465 | 0 | 2.017 |
| logcitein | Log(In-field Citations) | 1342 | 1.170 | 0.520 | 0 | 2.809 |
| Utd | UT Dallas Top-Tier status | 1342 | 0.0402 | 0.197 | 0 | 1 |
| lnarticles | Log(Article published in this journal) | 1342 | 1.598 | 0.290 | 0 | 2.880 |
| lognjout | Log(Outside Journals) | 1342 | 2.483 | 0.103 | 2.021 | 2.663 |
| lognjin | Log(In-field Journals) | 1342 | 1.170 | 0.520 | 0 | 2.809 |
| class2 | Number of journal classifications | 1342 | 1.229 | 0.420 | 1 | 2 |

**Table 4**
Correlation matrix.

| | logcitett | logciteout | logcitein | utd | lnarticles | lognjout | lognjin | class2 |
|---|---|---|---|---|---|---|---|---|
| logcitett | 1 | | | | | | | |
| logciteout | 0.7163 | 1 | | | | | | |
| logcitein | 0.9778 | 0.5926 | 1 | | | | | |
| Utd | 0.3769 | 0.3512 | 0.3701 | 1 | | | | |
| lnarticles | 0.4989 | 0.3804 | 0.4777 | 0.1004 | 1 | | | |
| lognjout | 0.0686 | 0.2026 | 0.0361 | 0.0982 | 0.1002 | 1 | | |
| Lognjin | 0.1356 | −0.0277 | 0.1651 | 0.0214 | 0.0312 | −0.6043 | 1 | |
| class2 | 0.1627 | −0.0156 | 0.1851 | 0.0730 | 0.0597 | −0.4036 | 0.4310 | 1 |

a slight increase in all other fields. While this may suggest that all business fields are converging to be diverse in terms of cross-disciplinary knowledge exchange, it could also be the result of the "Google Scholar effect" (Serenko & Dumay, 2015). This effect suggests that scholars are increasingly dependent on Google Scholar to search for literature and as a keyword-based search engine, Google Scholar are likely to bring articles the match certain keywords from a variety of disciplines; thus reducing disciplinary boundaries. In the next section; we consider additional factors that may influence knowledge flows among the six business disciplines.

### *3.3. Factors impacting knowledge flows among disciplines*

Since we are interested in exploring knowledge diffusion within the six business disciplines, we excluded journal citations outside of the six disciplines. It is worth noting that new journals are added each year into the Scopus database. New journals typically have different citation patterns from the established ones, and thus we excluded those new journals and focus on the journals that were consistently published in the years from 1997 to 2009, resulting in a total of 281 business journals and 1342 journal-year observations (which accounted for close to 80% of all journal-year observations). Tables 3 and 4 give the names, descriptions, summary statistics and Pearson correlation matrix of the variables. We note that the citation number is added by 1, in case the citation number is zero to avoid taking the log of zeros. The results are robust if another small constant (0.1 for example) is added.

#### *3.3.1. Estimation results*

Three separate fixed effect models were utilized to estimate how each of the aforementioned factors affect the three dependent variables: log(total citations), log(outside citations), and log(infield citations). All log-transformations are 10 based. The estimation results are presented in column (1)–(3) of Table 5. In general, the logged number of publications within the same journal is highly correlated with all three types of citations.

To illustrate the effect of formalized journal quality (UT Dallas top-tier journal list) on knowledge flows, Fig. 4 presents the average citations of the top-tier journals and the non-top-tier journals before and after they were included on the UT Dallas journal list. There seems to be an increase in total, outside and in-field citations after the UT Dallas top-tier classification designation; however, this could be the effect of extraneous factors. As such, it is imperative to estimate the effect of top-tier classification on citation changes. To accomplish this, we adopt a difference-in-difference strategy. That is, we estimate the difference in the before-after effect in the treatment group (top-tier journals) with the control group (non-top-tier journals).

The estimation results in Table 5 suggest that the top-tier journal status is significantly positive for the outfield citations but not the infield citations, nor the total citations. The coefficient of 0.076 translates into about 20% more citations for top-tier journals within the first two years of publication after UT Dallas classification. This finding is consistent with the notion that scholars cite articles not only based on intellectual relevance but also based on status-seeking or quality signaling (Podolny 2001). This effect is evident in an interdisciplinary setting when citing an article outside of its own discipline, where the objective quality is harder to assess. Whereas infield audience can more easily assess the quality of the cited work without referring to a formal journal ranking system.

The organizational structure within business schools, grouping faculty by departments, may also help explain the above finding. Business research units are traditionally organized in departments of the same discipline, with some smaller

**Table 5**
Fixed effect model estimates.

| | Citations | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | log(Total) | log(Outside) | log(Infield) | log(Total) | log(Outside) | log(Infield) |
| utd | 0.005 | 0.076** | 0.014 | 0.005 | 0.075** | 0.014 |
| | (0.036) | (0.034) | (0.040) | (0.036) | (0.034) | (0.040) |
| lnarticles | 0.791*** | 0.538*** | 0.763*** | 0.791*** | 0.538*** | 0.763*** |
| | (0.079) | (0.064) | (0.084) | (0.079) | (0.064) | (0.084) |
| lognjout | 0.440 | 2.344 | 0.618 | 0.282 | 1.391 | 0.169 |
| | (2.313) | (2.286) | (2.476) | (0.764) | (0.930) | (0.839) |
| lognjin | −0.210 | 0.757 | −0.240 | −0.255 | 0.486 | −0.368 |
| | (0.814) | (0.772) | (0.888) | (0.397) | (0.426) | (0.460) |
| time | 0.018 | −0.019 | 0.015 | 0.023 | −0.008 | 0.024 |
| | (0.036) | (0.035) | (0.039) | (0.017) | (0.019) | (0.019) |
| utdpost1 | | | | −0.026 | −0.051* | −0.015 |
| | | | | (0.021) | (0.027) | (0.023) |
| utdpost2 | | | | −0.032 | 0.041 | −0.024 |
| | | | | (0.067) | (0.069) | (0.074) |
| Constant | −0.795 | −7.559 | −1.186 | −0.329 | −4.751* | 0.138 |
| | (7.013) | (6.766) | (7.524) | (2.273) | (2.562) | (2.549) |
| Observations | 1342 | 1342 | 1342 | 1342 | 1342 | 1342 |
| R-squared | 0.425 | 0.270 | 0.368 | 0.425 | 0.270 | 0.368 |
| Number of journals | 281 | 281 | 281 | 281 | 281 | 281 |
| Journal FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | NO | NO | NO |

Note: Robust standard errors in parentheses. All specifications fit a journal specific fixed effect model and R-squared is the within R squares. To remove the time trend, we fit a linear time trend (*time*) in the model. The variable utdpost1 and utdpost2 are two dummy variables for one and two period after the top-tier classifications respectively. The coefficients capture the post-classification trend.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

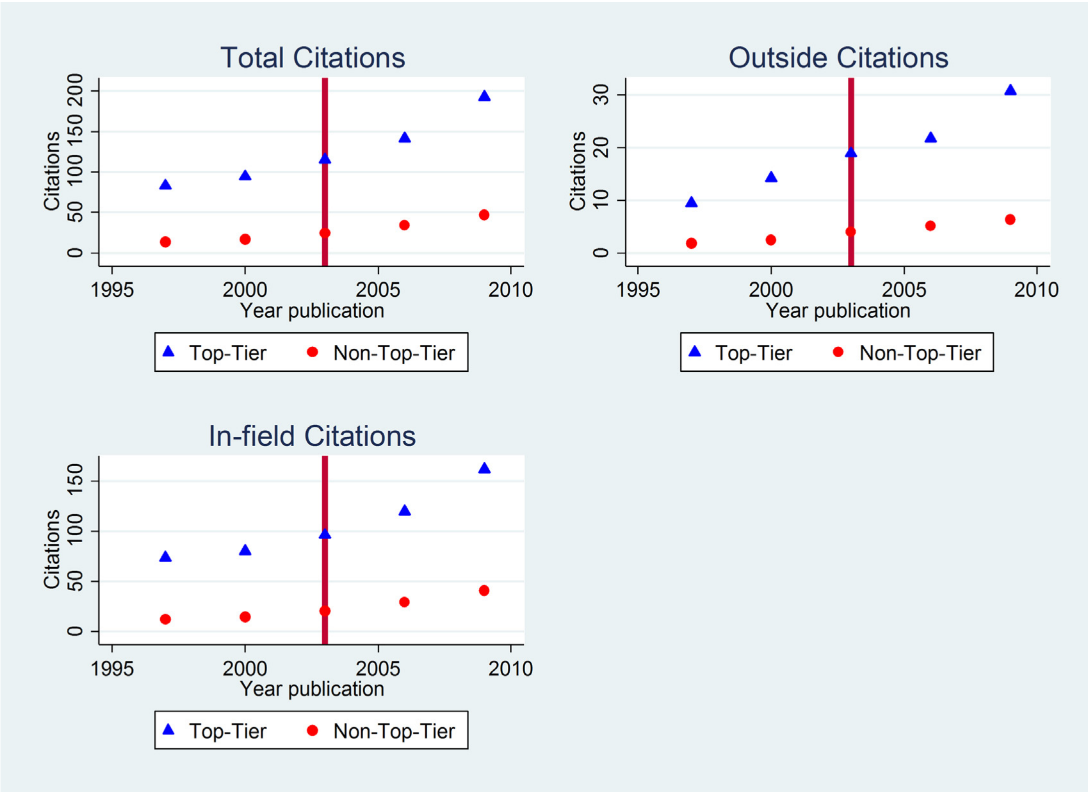


**Fig. 4.** Plot of average citations by top tier and non-top tier journals. The vertical line indicates the year of UT Dallas top-tier journal categorization.

**Table 6**
Random effect model estimates.

| | *Citations* | | |
|---|---|---|---|
| | log(Total) | log(Outside) | log(Infield) |
| class2 | 0.155*** | 0.006 | 0.173*** |
| | (0.060) | (0.054) | (0.060) |
| utd | 0.159*** | 0.217*** | 0.188*** |
| | (0.030) | (0.037) | (0.033) |
| lnarticles | 0.746*** | 0.524*** | 0.713*** |
| | (0.066) | (0.053) | (0.070) |
| lognjout | −0.761 | 0.609 | −0.687 |
| | (0.750) | (0.672) | (0.766) |
| time | 0.032*** | 0.009 | 0.030** |
| | (0.012) | (0.011) | (0.012) |
| Constant | 1.917 | −2.040 | 1.528 |
| | (2.308) | (2.040) | (2.355) |
| Observations | 1342 | 1342 | 1342 |
| Number of journals | 281 | 281 | 281 |
| Journal FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |

Note: Robust standard errors in parentheses. Again, to remove the time trend, we fit a linear time trend (*time*) in the model.
*$p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

disciplines grouped together. Different disciplines (and departments) may be uncertain how reputable the journals from other disciplines are. The UT Dallas top-tier designation may have signaled the quality of these journals to outside disciplines. Within each discipline, however, it is reasonable to believe that there should already be an informal understanding regarding journal quality in the academic community. This may explain why in-field citations do not change with this formal indicator of quality.

To investigate the possibility that a delay effect may exist in the quality signal, such that the positive effect on citations or knowledge flows will not manifest until a few years later, we present the post-classification trend effect for the top-tier classifications in column (4)–(6). The variable *utdpost1* and *utdpost2* are dummy variables for one and two periods after the top-tier classifications, respectively. The two coefficients capture the post-classification trend, which is not significant in our estimation. The coefficients are not significant at the conventional significance level, suggesting that there is no delay effect in top- tier classification.

### *3.3.2. Effect of multiple classifications*

The independent variable *class2* (number of journal classifications) is excluded from the fixed effect models because it is time invariant. To investigate if multiple classifications affect citations, we fit a random effect model that can incorporate a time invariant classification variable. Table 6 shows that the number of classifications is positively associated with both total citations and in-field citations, but not with outside citations. The results in the above random effect models are confirmed by a cross-sectional analysis, where each regression is conducted year-by-year for the cross sectional journal-year observations. Most of the coefficients are significant for total citations and in-field citations but not outside citations. Because we count the citations as infield if the citing journal has one common field as the cited one, the significant effect of top tier classification on outside citations in Table 6 may be biased downwards by this counting rule. The actual effect of top tier classification on outside citations may be larger than estimated in Table 5.

### *3.3.3. Robustness checks*

To check the robustness of the analyses, we have conducted several analyses. First, because that the difference-in-difference strategy suffers from parallel assumptions, as a robustness check, we use the state of the art synthetic controls. Due to the limit of pages and clarity of the presentation, we have relegated the approach and the results in the appendix (Appendix B). The results show qualitatively consistent results as the difference-in-difference approach. Second, to remove the leading factor of number of articles per journal, we scale the citations by the number of articles per journal. We then use a fixed effect model with average number of citations per article as the dependent variable (Appendix C). The results are still qualitatively similar. Finally, we include new journals in addition to established journals (Appendix D). Again, the results are qualitatively consistent. Notice that total and infield citations show significance at 10% level. This is due to the inclusion of newer journals which generally have lower citations. When compared to those newer journals, the top-tier journals effect is inflated as a result.

## 4. Conclusions and discussions

In this paper we studied journal citations among six business disciplines and reveal patterns of the knowledge flows, interdependencies and interdisciplinarity of these six disciplines. Biehl et al. (2006) documented the relationships among business disciplines using the *Financial Times* journal list and found that there is an increase in the integration of citation networks over time. By including a broader range of journals, we observed a converging degree of interdisciplinarity among the six disciplines over time based on the Shannon entropy measure. Based on the diversity measures, MIS is the most interdisciplinary. The results also suggest that even within the business research domain, some fields show a degree of distinctiveness and do not form strong interdisciplinary ties. Finance and Accounting share the closest tie among all pairs of disciplines. At the other extreme, the pairs of Accounting and Marketing or MS/OR and Accounting have the least knowledge exchange.

We also studied the factors impacting the overall knowledge flows, as well as intra- and inter-disciplinary knowledge flows. Besides the leading factors such as number of articles in the journal and the journal's number classifications, the quality proxy of UTD top-tier status seems to be significant in an interesting way. Formalized quality measures, such as the top-tier ranking creates a diffusion effect outside of its own disciplines, possibly by increasing the awareness of the journal quality. Within each discipline, it is reasonable to believe that there should already be an informal understanding regarding journal quality or the scholars within the discipline can easily judge the quality of articles of a journal; however, uncertainties may exist outside of the discipline. The journal top-tier status may serve to mitigate risks and uncertainties about quality, leading to the diffusion effect of high-quality journals outside of their own discipline. The diffusion effect is noticeably fast, as we did not observe any delay effect.

On the surface, our empirical findings that top-ranked, high-quality journals receive more outfield citations while infield citations remain the same seems to contradict the conclusions of Rafols, Leydesdorff, O'Hare, Nightingale, and Stirling (2012). They suggested that journal rankings may suppress interdisciplinary research, based on their findings from a comparison study of all publications from the researchers in three Innovation Studies units and three business school units in the U.K. The two findings are seemingly different but not necessarily contradictory. Rafols et al. (2012) documented less diversity in higher ranked journals list which is recognized by business schools, and they argue that the research assessment based on such a list may encourage more discipline focused research. Our message is that a top-ranked journal list signals their unambiguous quality to outfield scholars, who cite more of these journals after such ranking, possibly due to a status-seeking effect. In other words, our study does not make inferences on the diversity of top-ranked journals but states that increased citations to top-ranked journals may be partially due to their perceived status through such a ranking.

While their study is static in time, our study dynamically observes the change in journal status. Besides the time dimension, there are a few other factors that may also contribute to the differences. First, the approach of Rafols et al. (2012) is rather descriptive and no causal inference methods are used whereas our study implemented several identification strategies in studying the causal relationship of journal ranking effect. Second, the two studies vary significantly in the scope. Rafols et al. (2012) limited their focus to the comparisons of all publications from the researchers in three Innovation Studies units and three business school units in the U.K. Our study instead involved the entire business community by including all publications in all six business disciplines. Third, despite of overlaps in the disciplines, the two studies included different sets of disciplines. Rafols et al. (2012) included the disciplines that are most relevant to Innovation Studies while our study includes the six business disciplines. The former included journals in psychology and economics while the latter largely excluded those journals. Lastly, the UT Dallas list in our study mostly overlaps with the Rank 4* (World Elite) category in the ABS list used in Rafols et al. (2012). The larger list of Rank 4 (Top in Field) and other lower ranked journals are also computed in their outcome measures in Rafols et al. (2012), which may further contribute to the differences of the two studies.

While our research contributes to the discussions of why scholars cite other publications, future research would help us better understand this issue by investigating at a finer granular level, such as article level analyses. For example, Azoulay et al. (2013) used article level data and found that there is a status effect to the author of articles, namely there exists a boost to the citations of old articles by new Howard Hughes Medical Institute (HHMI) Investigator, when compared with similar scholars without this title. To further explore the event of UT Dallas top-tier journal designation, an article level data on citations can more definitively identify the journal status effect, as opposed to the scholar status effect in Azoulay et al. (2013).

Another area of future research is to build on our descriptive findings to make prescriptive claims about how specific business fields should exchange more knowledge. In particular, the findings in our paper reveal that there are pairs of disciplines scarcely exchange knowledge. For example, findings in Fig. 2 provide evidence for the claim that OB/M rarely draws knowledge from accounting discipline, based on the observation that the links between the two disciplines are relatively weak. It may be beneficial for scholars and practitioners alike to incorporate more insights from accounting to be able to calculate and financially justify proposed interventions relating to employees. It may also be valuable for accounting scholars and practitioners to borrow knowledge from OB/M, in order to adjust for human behaviors and the corresponding potential consequences that may not be reflected in accounting numbers. Similar arguments can be made for the pairs of Accounting and Marketing, and MS/OR and Accounting, both pairs shown in Fig. 2 with little links. This lack of knowledge exchange presents an area of silo and deficiency, but also an opportunity for scholars to conduct future interdisciplinary research to fill in these gaps.

Our findings related to disciplinary dependence serve as an initial step in identifying the need for an increase in disciplinary knowledge exchange in the six business disciplines. While it may take time for our prescriptive claims to be realized in practice, our research provides support for an already growing trend towards interdisciplinarity and cross-discipline knowledge diffusion.

## Author contributions

Conceived and designed the analysis: Chaojiang Wu; Erjia Yan.
Collected the data: Erjia Yan.
Contributed data or analysis tool: Chaojiang Wu; Chelsey Hill; Erjia Yan.
Performed the analysis: Chaojiang Wu; Chelsey Hill.
Wrote the paper: Chaojiang Wu; Chelsey Hill; Erjia Yan.
Other contribution: Chelsey Hill.

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## Appendix A. List of UT Dallas top-tier journals in our study.

| |
|---|
| MIS Quarterly: Management Information Systems |
| Information Systems Research |
| Review of Financial Studies |
| Journal of Finance |
| Journal of Operations Management |
| Academy of Management Journal |
| Academy of Management Review |
| Management Science |
| Manufacturing and Service Operations Management |
| Operations Research |
| Organization Science |
| Production and Operations Management |
| Journal of Consumer Research |
| Journal of Marketing |
| Journal of Marketing Research |
| Strategic Management Journal |
| Marketing Science |
| Journal of Financial Economics |
| Journal of International Business Studies |
| INFORMS Journal on Computing |
| Accounting Review |
| Journal of Accounting and Economics |
| Journal of Accounting Research |

Note: Administrative Science Quarterly is not available in our sample.

## Appendix B. Analyses using Synthetic Controls.

In Section 3.2, the difference-in-difference approach is only valid under the parallel assumption that both outcomes in the treated group and control group would follow the same trend in the absence of the event. One often uses the time trend before the intervention as a way to verify the parallel assumption. In Fig. 4, we can see a slight upward trend for the top-tier journals before the classification. To address this issue, we follow the pioneering work of Abadie and Gardeazabal (2003) and adopt a novel matching method called synthetic control method. Abadie and Gardeazabal (2003) used this method to estimate the effect of terrorist conflict in the Basque Country, by using a combination of other Spanish regions as a control group. The synthetic control method is very appealing because it provides a synthetic control group from a large pool of potential controls, even if a single one of them is not suited for a control because of systematic differences with the treated unit. Since its introduction, it has been used in estimating the effect of Proposition 99 or Tobacco control program in California (Abadie, Diamond, & Hainmueller, 2010), in estimating the effect of Arizona's 2007 Legal Arizona Workers Act on the proportion of the state's noncitizen Hispanics (Bohn, Lofstrom, & Raphael, 2014), among other applications.

**Table 7**
Fixed effect model estimates using citations per article.

| | Citations per article | | | | | |
|---|---|---|---|---|---|---|
| | Log(Total) | Log(Outside) | Log(Infield) | Log(Total) | Log(Outside) | Log(Infield) |
| utd | 0.030 | 0.023** | 0.028 | 0.030* | 0.023** | 0.029 |
| | (0.018) | (0.010) | (0.018) | (0.018) | (0.010) | (0.018) |
| lognjout | −0.245 | 0.189 | −0.368 | 0.134 | 0.115 | 0.046 |
| | (0.696) | (0.263) | (0.702) | (0.238) | (0.104) | (0.233) |
| lognjin | −0.086 | 0.116 | −0.139 | 0.021 | 0.095 | −0.021 |
| | (0.209) | (0.096) | (0.209) | (0.110) | (0.058) | (0.109) |
| time | 0.010 | −0.002 | 0.011 | 0.005 | −0.001 | 0.005 |
| | (0.010) | (0.004) | (0.011) | (0.005) | (0.002) | (0.005) |
| utdpost1 | | | | −0.009 | −0.005 | −0.006 |
| | | | | (0.007) | (0.003) | (0.007) |
| utdpost2 | | | | −0.001 | 0.005 | −0.003 |
| | | | | (0.020) | (0.008) | (0.019) |
| Constant | 0.909 | −0.651 | 1.288 | −0.208 | −0.432 | 0.066 |
| | (2.028) | (0.790) | (2.042) | (0.678) | (0.304) | (0.665) |
| Observations | 1342 | 1342 | 1342 | 1342 | 1342 | 1342 |
| R-squared | 0.160 | 0.104 | 0.129 | 0.160 | 0.104 | 0.129 |
| Number of journals | 281 | 281 | 281 | 281 | 281 | 281 |
| Journal FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | NO | NO | NO |

Note: Robust standard errors in parentheses. Again, to remove the time trend, we fit a linear time trend (*time*) in the model.
*** $p < 0.01$.
* $p < 0.1$.
** $p < 0.05$.

More specifically, we synthesize a control from a pool of candidate journals based on the yearly citations of the top-tier journals before the classification. Suppose there are J available control journals,[5] to construct a synthetic control sample for a top-tier journal, a vector of weights $W = \left(w_1, \ldots, w_J\right)'$, $w_j \geq 0$, $\sum w_j = 1, j = 1, \ldots, J$ is to be determined. The weights are chosen such that the synthetic top-tier journal would most closely resemble the actual top-tier journal before the top-tier classification. Let $X_1$ be a $K \times 1$ vector of predictors for top-tier log-citations before classification and $X_0$ be a $K \times J$ matrix each of which contains the values of the predictors for the J possible control journals, and let $V$ be a diagonal matrix with nonnegative elements each of which representing the importance of the different predictors. Then the vector of weights is chosen by solving the following constrained quadratic programming problem:

$$\text{Minimize } (X_1 - X_0 W)' V (X_1 - X_0 W)$$

$$s.t. \sum w_j = 1$$

$$w_j \geq 0$$

Once the weights are determined, then the synthetic control after-treatment values can be constructed. Suppose the $T \times J$ matrix of observed log-citations for the control group is $Y_0$, then the constructed log-citations for synthetic group is $Y_1^* = Y_0 W$. Also, suppose the treated group has $T \times 1$ years of observation $Y_1$, then a comparison of the difference of treatment group and the control group can be done before and after the event, $[(Y_1|post = 1) - (Y_1|post = 0)] - \left[Y_1^*|post = 1) - (Y_1^*|post = 0)\right]$ which is the difference in difference estimator,

One of the appealing features of this synthetic control method is that it not only can match the dependent variable but also can match any possible important variables in predicting the outcome variable. For example, in this setting, to account for the effect of multiple classifications (Table 7) on citation patterns, we also closely match the number of classifications for the control group. The following results are based on matching the log (per article citations) before the top-tier designation, and number of multiple classifications.

Fig. 5 summarizes the results for the synthetic control methods and the difference-in-difference estimates. The total citation and outside citations increased significantly after the top-tier classification, whereas the in-field citations did not. The coefficient of 0.11 for the total citation means 30% more citations for the top-tiers journals after classification when compared to non-top-tier journals. The coefficient of 0.05 for the outside citations means 12% more outside citations for the

[5] In our implementation, to construct a pool of candidate controls for a top tier journal, we use all non-top journals that belong to the same Elsevier classifications. The candidate pool would include all non-top tier journals in multiple disciplines, the same as the top-tier journal, should it be classified into multiple Elsevier classifications. For example, the journal of *Review of Financial Studies* belongs to two disciplines: finance and accounting. We use all non-top journals from finance and accounting as our pool of controls for *Review of Financial Studies*.

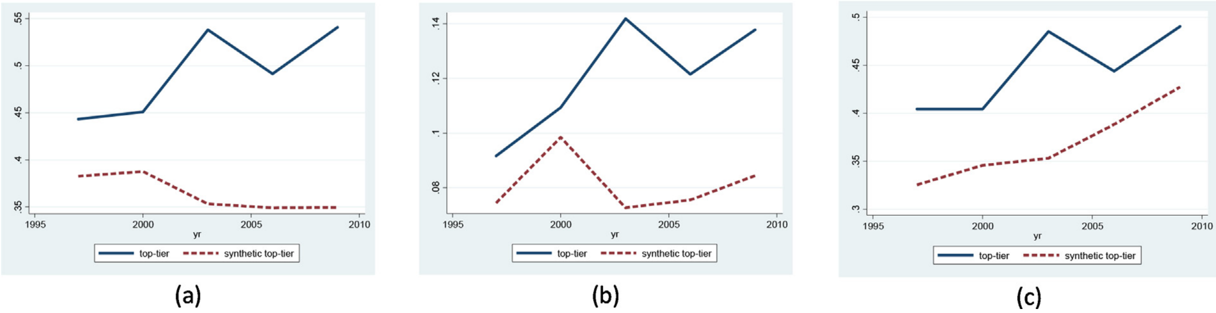


**Fig. 5.** Plot of average log (citations/article) for top-tier (solid line) journals and synthetic top-tier controls (dashed line). The year axis stands for the year in which the articles are published. 2003 is the year of UT Dallas top-tier journal classification. Therefore, citations per article on the year 2000 or 1997 are closely matched. As suggested by our empirical results, we also match closely the number of disciplinary classifications. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

**Table 8**
Fixed effect model estimates using all journal year observations.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| VARIABLES | Log(Total) | Log(Outside) | Log(Infield) | Log(Total) | Log(Outside) | Log(Infield) |
| utd | 0.033* | 0.021** | 0.033* | 0.034* | 0.021** | 0.033* |
| | (0.018) | (0.010) | (0.018) | (0.018) | (0.010) | (0.018) |
| lognjout | −0.849 | −0.018 | −0.865 | 0.006 | 0.065 | −0.056 |
| | (0.672) | (0.234) | (0.683) | (0.231) | (0.097) | (0.229) |
| lognjin | −0.217 | 0.059 | −0.241 | 0.030 | 0.083 | −0.006 |
| | (0.199) | (0.087) | (0.198) | (0.101) | (0.052) | (0.100) |
| time | 0.019* | 0.001 | 0.018* | 0.007 | −0.000 | 0.007 |
| | (0.010) | (0.004) | (0.010) | (0.005) | (0.002) | (0.005) |
| utdpost1 | | | | −0.012* | −0.005* | −0.009 |
| | | | | (0.007) | (0.003) | (0.007) |
| utdpost2 | | | | −0.014 | −0.001 | −0.014 |
| | | | | (0.019) | (0.008) | (0.018) |
| Constant | 2.592 | −0.048 | 2.660 | 0.062 | −0.293 | 0.267 |
| | (1.957) | (0.706) | (1.980) | (0.648) | (0.284) | (0.640) |
| Observations | 1724 | 1724 | 1724 | 1724 | 1724 | 1724 |
| R-squared | 0.148 | 0.088 | 0.120 | 0.146 | 0.088 | 0.118 |
| Number of journal | 442 | 442 | 442 | 442 | 442 | 442 |
| Journal FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | NO | NO | NO |

Robust standard errors in parentheses.
***$p < 0.01$.
* $p < 0.1$.
** $p < 0.05$.

top-tiers journals after classification when compared to non-top-tier journals. This finding is consistent with the diff-in-diff estimation for the outside citation patterns, but also in contrast with the findings in the diff-in-diff results in terms of the total citations.

## Appendix C. Robustness checks using citations per article.

Journals may increase the number of articles per issue or even increase the number of issues per year. Therefore, some may argue that the average number of citations per article is a better measure for measuring knowledge flow. We use the log-transformation of the number of citations per article as the dependent variable. Table 7 reports the regression results for the three types of knowledge flows: log(total citations per article), log(outside citations per article), and log(infield citations per article).

We observe qualitatively similar results. That is, the top-tier classification has a positive effect on the outside citations of the top journals. Compared to lower quality journals, these journals receive 5% more citations ($10^{0.023} = 1.05$) on average within the first two years after the publication of the UT Dallas journal list.

## Appendix D. Robustness checks using all journal year observations

In our analyses, we excluded new journals that appeared after 1997. As another robustness check, we included the full sample of journals, which resulted in an unbalanced panel with a total of 1724 journal-year observations. Results in Table 8 show qualitatively the same results. That is, the logged number of article publications within the same journal is highly correlated with all three types of citations. The top-tier classifications effect is present only for outside citations when controlling for other factors. Notice that total and infield citations show significance at 10% level. This is due to the inclusion of newer journals which generally have lower citations. When compared with those newer journals, the top-tier journals effect is inflated as a result.

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