

## A Review and Comprehensive Analysis of the Performance of University – Construction Industry Collaboration

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### Abstract

University–construction industry collaboration (UIC) has become an essential part of driving innovation and fostering construction industry growth. Measuring the performance of such collaboration is an emergent field of study that is scattered through the current literature. This study aims to identify the UIC performance indicators advocated by the top-cited references, and map UIC performance indicators in the context of the state of Qatar. The present research evaluated the literature related to measuring the performance of UIC, considering publications in selected scientific databases over the period of 2004 – 2020. The publications were obtained through a search of the Science Direct, Emerald Insight, Scopus, Web of Science, Springer Link, SAGE, Research Gate, and Taylor & Francis Online databases. Keywords used in searching for publications included university, construction industry, business, cooperation, collaboration, relation, performance, and measurement. The findings were discussed and confirmed in the context of Qatar's education and innovation ecosystem through semi-structured interviews with two renowned scholars who are involved in UIC. The study revealed that both universities and the construction industry are increasingly focused on measuring the performance of collaboration through specific performance indicators. The results show that both universities and the construction industry share some interests when it comes to four key performance indicators. These performance indicators are (1) the number of registered patents, (2) the number of patent applications, (3) the number of innovations (process/marketing/product/organisational), and (4) the number of publications. This study contributes to a general understanding of measuring UIC performance and defining trends in this research field. It also highlights research limitations and provides an arena for future research in the field.

**Keywords:** University; Construction, Industry; Business; Cooperation; Qatar; Collaboration; Relations.

### 1. Introduction

A key focus of transforming the construction industry is promoting a more innovative working environment through collaboration across the construction industry ecosystem. Such collaboration would have a vast effect on relationships between the construction industry and universities, among other partners [1]. Indeed, universities and the construction industry can cooperate in different ways. These include, but are not limited to, research and development, mobility of academics, mobility of students, commercialisation of research results, curriculum development, curriculum delivery, lifelong learning, spinoff and start-up formation, and university governance [2].

Likewise, types of university–construction industry cooperation that provides straight and measurable benefits have a tendency to be the most developed types of cooperation [3], such as research and development,

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commercialisation, and student mobility. Thus, university–construction industry collaboration (UIC) can take several forms and practices through various activities. Commonly, such collaborations fall under one of three main activities: (1) collaborative training and education, (2) collaborative consulting and services, and (3) collaborative research [3-5].

Indeed, the outcome of such collaborations is realised differently by universities and the construction industry. From a university perspective, such outcomes are realised through aspects related to an enhanced learning environment, increased rates of knowledge creation, and better serving society and regional economies. From the construction industry perspective, such outcomes are realised by aspects related to improved innovation rates, revenue, and access to resources [6, 7].

Accordingly, UIC is essential to establish and nurture innovation ecosystems that drive the national innovation agenda and sustain economic growth [8]. In the United States, the most notable programme driving UIC is sponsored by the Bayh–Dole Act (1980) [9]. The comparable programme in Europe is the Horizon 2020 [10]. In Qatar, UIC is driven mainly by initiatives of the Qatar National Research Fund [11]. However, the economic dynamic between the two major actors of the innovation ecosystem faces a dilemma. It consists of two distinguished economies: the knowledge economy and the commercial economy. The first is driven by a need for advanced fundamental research or social value through universities and research centres, while the second is driven by the requirements of the marketplace of business entities [12]. This dichotomy makes measuring UIC performance a challenge for universities and the construction industry alike.

Indeed, there is a vast body of literature on the topic of UIC. However, these studies have focused on aspects related to technology transfer [13], UIC governance [14], collaboration forms or activities [15], commercialisation [16], university entrepreneurship [8], and UIC as open innovation [10]. The subject of measuring the performance of university–construction industry relations is scattered throughout the current literature, and this gap provided a basis for this study. In Qatar, there is a lack of objective performance management process of university–construction industry relations. Such a process is key to assessing UIC partnerships' validity and credibility (Abduljawad, 2015). Also, it shall provide the basis for the legitimacy of co-creation of value in the construction industry [17] and improving trust between UIC partners [18].

Therefore, this research sought to fill this gap and review most relevant literature on measuring the performance of UIC. We also conducted semi-structured interviews in order to refine, align, and interpret the findings of the literature review in the context of the state of Qatar. Therefore, this research, on the one hand, contributes to systematic literature reviews focused on UIC performance. On the other hand, it sheds light on context-related matters relating to UIC performance in Qatar. In this sense, this research presents a future research agenda for measuring UIC performance. This study aims to identify the UIC performance matrices advocated by the top-cited references and refine the performance matrices of UIC in the context of the state of Qatar.

## 2. Research Methodology

A systematic review was carried out on the topic of UIC. The search for published papers was carried out in Science Direct, Emerald Insight, Scopus, Web of Science, Springer Link, SAGE, Research Gate, and Taylor & Francis Online. We used keywords in searching for articles including university, construction, industry, university, business, cooperation, collaboration, relation, performance, and measurement. We selected papers for this review from the past 17 years (i.e., articles published since 2004). This restriction was chosen to reveal the most recent trends in this emergent field of research. The time period was also in line with the coverage limits of the Scopus database, as it is currently limited to articles published since 1995 [10].

The literature research was performed between 10 February 2018 and 31 December 2020. The literature research followed six steps, as displayed in Figure 1 below. In parallel, the researcher reached out to two active scholars in UIC from Qatar University. The researcher conducted semi-structured interviews with both scholars in order to reveal country-specific concerns, challenges, and priorities in regard to measuring UIC performance. The interviews were conducted on 19 February 2018 and 7 January 2019. The semi-structured interview protocol is displayed in Figure 2 [19].

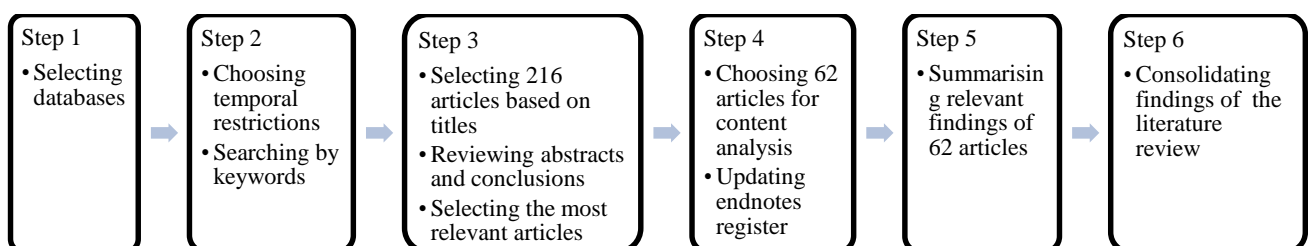


Figure 1. Steps Followed in the Literature Review

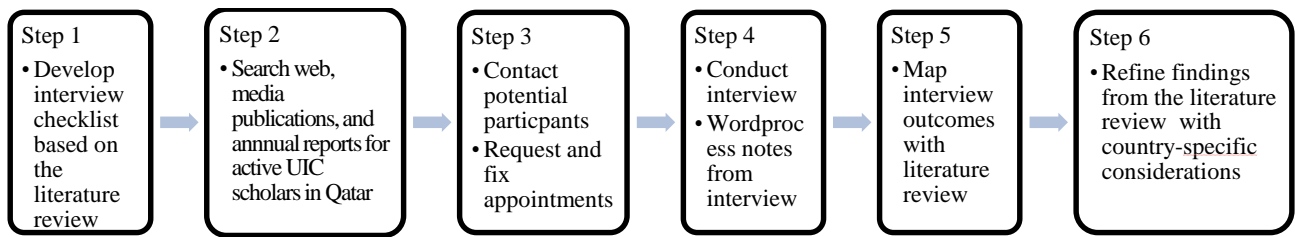


Figure 2. Steps Followed in Conducting Semi-Structured Interviews

### 3. Results

#### 3.1. Overview of Selected Publications for Content Analysis

In step 4 of the literature review, 62 published articles were selected for content analysis, which included papers from the last 17 years, with more focus on the most recent publications, as shown in Figure 3.

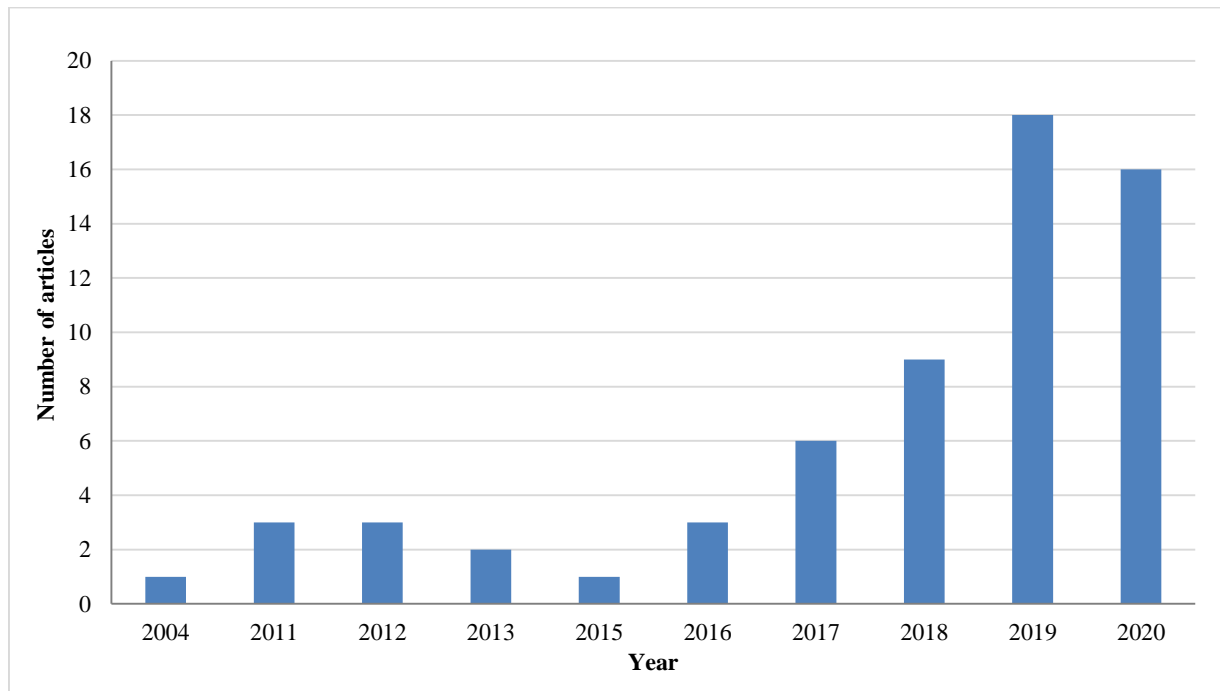


Figure 3. Number of Selected Papers for Content Analysis by Publication Year

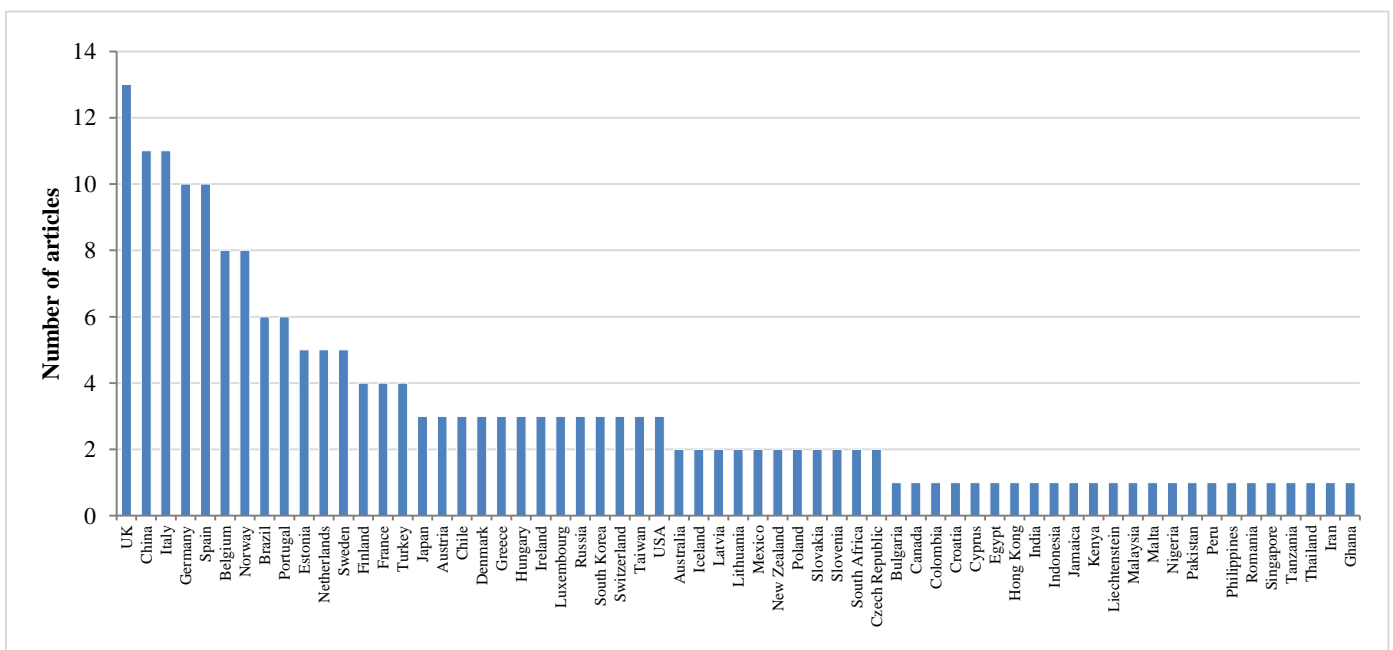


Figure 4. Context of Selected Papers for Content Analysis

From the context perspective, the selected papers covered 63 countries, with more papers published in the European context, as shown in Figure 4. A review of the literature published during the last 17 years showed the absence of research related to measuring UIC performance in Gulf Cooperation Council Countries, including Qatar. This issue provided a rationale for conducting interviews and refining the findings according to country-specific considerations.

### 3.2. UIC Performance Explained

University–construction industry relations influence all three institutional paradigms involved in the collaboration (i.e., university, construction industry, and cooperation or collaborative forms of organising). A study of the relationships between the competence factors of universities and UIC performance suggested the significant influence of university research capacity on driving performance of UIC in terms of providing full-time faculty members and the size of the technical licensing office [20]. Moreover, the performance in this study was mediated by government funding for research and development activities. Similarly, another study for the role of technology transfer offices (TTOs) in establishing successful university–construction industry partnerships suggested a positive influence of the university's social capital on setting research and development (R&D) contracts. Universities with larger social networks, both local and international, were more successful in attracting R&D contracts [21].

The technology parks' influence on university and construction industry performance differs depending on the university's involvement and its share in the park. For that reason, it was suggested to (distinguish four types of parks [22]. The first type, where the university is the major shareholder, is called a pure science park. The second type, where the university is the minority shareholder, is called a mixed park. The third type, where some university research facilities are located in the park, but the university holds no share, is called a technology park. The fourth type, where the university has no formal involvement, is called a pure technology park. The higher involvement of the university (i.e., the case of the pure science parks) was correlated with the best patenting performance among universities. Surprisingly, such involvement was correlated with the lowest product innovation levels measured by sales from new-to-market products. On the other side of the spectrum, it was suggested that the lowest university involvement (i.e., the case of pure technology parks) was correlated with the lowest patenting performance among universities. On the contrary, such involvement was correlated with the best product innovation levels measured by sales from new-to-market products. However, there is no evidence that the chance of cooperation between universities and the construction industry, in the case of research contracts, has influenced by the degree of university involvement in park shareholding. Therefore, a high level of patent applications and potentially published research, in the case of pure science parks, does not necessarily lead to increased product innovation. On the other hand, a high level of product innovation, in the case of pure technology parks, is not necessarily associated with a high level of patent applications or published papers. These findings illustrate the dilemma of different interests in university–construction industry relationships. As such, changes to the academic reward system may shift the academic focus from publishing and patenting to including commercialisation [22].

Indeed, with respect to the extent of UIC success in terms of the capability to attract funding for research activities, scholars suggested three important elements that can improve such capability. The first is previous experience with the business [23], which improves maturity and trust-building [24]. The second is the ability to produce a critical mass of research in a certain sector [23], which responds to institutional pressure to improve the performance of the university in research activities [25]. The third is proximity to industrial districts [23], which relates to different types of the distance between university and construction industry partners, including cognitive, geographical, organisational, and social distance [26].

The influence of publicly-funded UIC on R&D efforts by the construction industry provided interesting insights into the construction industry [27]. First, university–construction industry partnerships have a positive impact on the R&D expenditure per employee. Second, university–construction industry partnerships have a positive impact on the share of R&D employment. In fact, partnerships between the university and the construction industry enhance resource utilisation for the construction industry and encourage the construction industry to invest more in R&D activities. University–construction industry relationships are two-way relationships. Thus, evaluations of performance are realised on both sides of the relationship. This is a major break away from the traditional role of university knowledge transfer, namely a one-way relationship. The rise and adoption of the open innovation concept have contributed to a changing paradigm with respect to university–construction industry relations. In the context of UK universities, a recent study revealed that universities had become a central actor in open innovation ecosystems through acting as a reliable intermediary or an open innovation hub [28].

Similarly, studying how to improve the performance of academic innovation in UIC suggested a positive relationship between both formal management mechanisms and regulation implementation and academic innovation [29]. Both relationships were found to be moderated by the university's innovation climate [29]. In this context, the formal management mechanism for university–construction industry relationships are related to formal arrangements

to control and coordinate university–construction industry relationships in terms of the university. Regulation implementation is related to the implementation of specific regulations to foster R&D, as well as university–construction industry relations. Finally, the innovation atmosphere reflects the university’s support for entrepreneurial activities by faculty members, students, and administration staff.

Similarly, a recent study, conducted in Europe, found a positive relationship between four management mechanisms and seven key activities of university-business collaboration [4]. The mechanisms were top management support, communication, incentives, and support structures. The seven key collaboration activities were joint curriculum design and delivery, lifelong learning, student mobility, professional mobility, joint R&D, entrepreneurship, and commercialisation of joint R&D results.

The role of academic engagement in sustaining university–construction industry relationships was investigated by Perkmann studies [16]. Academic engagement refers to knowledge-related collaboration activities by researchers with the construction industry and non-academic organisations. The determinants that lead to academic commercialisation are distinguished from the determinants of academic engagement. Commercialisation refers to the use of knowledge created by the university through patenting, licensing of inventions, and business entrepreneurship. Their findings suggest a positive relationship between some individual determinants and academic engagement [16]. These determinants include gender (male), seniority, previous government grant experience, previous construction industry contract experience, and scientific productivity.

Moreover, the recent studies revealed that some other organisational and institutional determinants positively moderate the relationship between individual determinants and academic engagements. These include the university’s focus on applied disciplines. Surprisingly, the quality of the university or department concerned has a negative influence on academic engagement. This finding may be justified by the fact that lower-quality departments often have fewer resources and more reasons to seek engagements and collaborations with the construction industry [16].

In addition, Perkmann the previous studies showed that commercialisation has a positive relationship with individual determinants, which include gender (male), previous commercialisation experience, and scientific productivity [16]. Similarly, some other institutional determinants positively moderated the relationship between individual determinants and academic commercialisation. These include the quality of the university or department concerned, organisational support, organisational commercialisation experience, peer effects, the university’s focus on applied disciplines, and country-specific regulatory policies. Likewise, it was argued that academic commercialisation often leads to increased secrecy and scientific productivity among academics. Finally, academic engagement often leads to improved collaborative behaviour [30]. Moreover, non-academic work experience positively influences external interaction activities among academics [31].

To acquire and share knowledge is vital for both universities and the construction industry, especially in regard to patenting and licensing new technologies [32, 33]. Indeed, university–construction industry relationships influence the performance and outcomes of both institutional paradigms. From the university side, the intended outcomes include attracting third-party funds for employees, research, and operational expenses; research papers published; conferences; presentations; and increased reputation among the scientific community. From the construction industry side, the intended outcomes include new inventions for products, services and processes; new licenses; and new patents.

However, there are control factors to examine the impact of knowledge sharing on achieving the objectives of UIC [33]. These control factors include obligations to get external research funding [34], professors’ attitudes towards UIC [35], the degree of applied research [36], the number of employees under professors’ supervision, professors’ years of experience, size of the partner organisation, and the type of partner organisation (i.e., whether it is a private company, a public organisation, or a not-for-profit organisation).

### 3.3. Summary of Key UIC Performance Indicators

Definitions of all performance indicators identified in the content analysis were reviewed, refined, and grouped in order to provide a list of distinct indicators, avoiding duplications. Moreover, measuring UIC performance can take place from the university’s or the construction industry’s perspective. Therefore, the performance indicators from each perspective were grouped into two separate lists.

From university perspective, the literature review revealed performance indicators of UIC. Indeed, the most frequent UIC performance indicators were (1) number of publications [16, 29, 31, 34, 37-51], (2) number of registered patents [3, 7, 16, 20, 29, 37, 40, 48, 50-58], (3) number of occurrences for each UIC activity (consulting and services, research, and training and education) [6, 21, 33, 37, 47, 50, 59-63], (4) number of generated start-ups and spinoffs [16, 37, 40, 48, 50, 53-55, 64-66], (5) amount of external funds to research projects [23, 33, 40, 41, 48, 55, 63, 67], (6) income from intellectual property (IP) sales [20, 37, 48, 50, 51, 54, 65, 68], (7) citation index [16, 31, 39, 44, 50, 69], (8) number of patent applications [37, 50, 52, 54, 70, 71, 78], (9) number of IP licenses [3, 37, 47, 48, 54, 65], and (10) number of innovations (process/marketing/product/organisational) [47, 52, 68].



From the construction industry's perspective, the literature review revealed performance indicators of UIC. The most frequent UIC performance indicators were (1) number of innovations (process/marketing/product/organisational) [2, 33, 37, 52, 59, 62, 68, 72-79], (2) number of registered patents [33, 54, 56-58, 73, 75, 80, 81], (3) income from innovations (process/marketing/product/organisational) [22, 73-75, 78, 82], (4) number of patent applications [2, 22, 54, 75, 78], and (5) number of publications [37, 73, 83, 84].

The above results show the different focus of the university and construction industry when measuring UIC performance. These findings are in line with the initial discussion stating that universities and industries often operate in different institutional paradigms [28, 85]. However, these results show that both universities and the construction industry share some interests when it comes to four key performance indicators. These performance indicators are (1) the number of registered patents, (2) the number of patent applications, (3) the number of innovations (process/marketing/product/organisational), and (4) the number of publications. These findings suggest that the core of mutual benefit foreseen from university–construction industry relationships are driven by the innovation agenda, represented by patenting activities and being a pioneer in creating knowledge [86].

### 3.4. UIC Performance Indicators and Context-Specific Considerations

The two semi-structured interviews conducted with scholars revealed interesting findings with respect to measuring UIC performance from the perspective of Qatar University. In order of significance, both interviews highlighted key indicators for measuring UIC performance, including (1) the number of publications, (2) the number of citations (local and international), (3) the number of registered patents, (4) the number of patent applications, (5) the number of training programs provided (to faculty and students), and (6) the number of innovations (process/marketing/product/organisational).

These findings, at least from the interviewees' perspective, provide some key context-specific considerations. On the one hand, the number of publications and patent registrations and applications are the top UIC performance indicators, which are in line with previous research findings [32]. On the other hand, the number of citations is also related to previous indicators obtained from the literature [32, 71]. Moreover, the indicator of the number of innovations was also indicated by previous studies [52, 68]. However, the high importance of this indicator, from the interviewees' perspective, may be related to the direction of the Qatar National Research Strategy (QNRS) [10] that aims to put Qatar on the world map as a research and innovation hub [87].

Another interesting finding is the indicator of the number of training programmes provided. From both the university and construction industry perspectives, this indicator is related to the number of occurrences for each UIC activity [21, 33]. The UIC activity, in this case, is collaborative training and education [5].

Historically, university–construction industry relationships have been viewed as a means of transferring knowledge from the knowledge economy (i.e., universities) to the commercial economy (i.e., construction industry and business) [12]. As a result, the latter indicator (number of training programmes provided) may suggest that the interviewees also look to construction industry relationships as a means to transfer knowledge and technology back from the construction industry to university members [8].

In fact, none of the UIC performance indicators obtained from the interviews related to commercialisation and revenue generation. The latter insight is not in line with the top UIC performance indicators obtained from the literature, such as the number of generated start-ups and spinoffs [40], the number of and income from IP sales [65], and the amount of external funds to research projects [21]. Therefore, a deeper look into the motives and drivers of the QNRS [11] is worth further investigation.

## 4. Conclusions

First, this study revealed that universities are increasingly focused on measuring the performance of their collaborations with the construction industry. The results revealed a number of UIC performance indicators used in previous research, including (1) the number of publications, (2) the number of registered patents, (3) the number of occurrences for each UIC activity (consulting and services, research, and training and education), (4) the number of generated start-ups and spinoffs, (5) amount of external funds to research projects, (6) income from IP sales, (7) citation index, (8) the number of patent applications, (9) the number of IP licenses, and (10) the number of innovations (process/marketing/product/organisational).

Second, this study revealed that the construction industry is increasingly focused on measuring the performance of its collaboration with universities. The results presented a number of UIC performance indicators used in previous research, including (1) the number of innovations (process/marketing/product/organisational), (2) the number of registered patents, (3) income from innovations (process/marketing/product/organisational), (4) the number of patent applications, and (5) the number of publications.

Third, universities and the construction industry share common interests when it comes to driving innovations as a key motive for UIC. This proposition is supported by the common indicators used for measuring UIC performance, namely (1) the number of registered patents, (2) the number of innovations (process/marketing/product/organisational), and (3) the number of patent applications.

Fourth, this study contributes to a general understanding of how universities and the construction industry measure UIC performance. It also highlights Qatar's country-specific considerations for measuring UIC performance considerations. In this context, the key UIC performance indicators mentioned by the interviewees include (1) the number of publications, (2) the number of citations (local and international), (3) the number of registered patents, (4) the number of patent applications, (5) the number of training programmes provided (to faculty and students), and (6) the number of innovations (process/marketing/product/organisational).

Finally, considering the research limitations, there is also a need for more research examining a wider range of performance indicators and the impact of research strategies and policies on UIC performance. In Qatar, in particular, there is a lack of empirical studies concerning the effects of the QNRS [11] on what indicators are chosen to monitor UIC performance.

In conclusion, despite numerous studies conducted on measuring the performance of UIC, there is still a great deal of research yet to be conducted in order to model, theorise, and empirically test the indicators used to measure UIC performance in general and in the context of the state of Qatar, in particular.

#### 4.1. Limitations and Future Research

While noting the important contributions made by this paper, we recognise a number of limitations. This study is limited to a 17-year period of time and the specific publication databases used for searching for papers. The keywords used in this research provided another limitation regarding the number of papers revealed in the selected publication databases. Thus, it is recommended for future research to consider a wider literature search in terms of time span, publication databases, and keywords.

In addition, only two interviews were conducted with active scholars in UIC. The objective of conducting interviews was to map and refine the findings of the literature review with country-specific considerations. Furthermore, both interviews were conducted with scholars from Qatar University. None of the interviewees came from the construction industry or business. Therefore, mapping and refining the indicators and country-specific considerations from the construction industry perspective was not possible. Consequently, it is recommended to future researchers to consider a wider representation of scholars and business leaders engaged in university–construction industry relations in Qatar, or another context of interest, to get insights that further enable the refinement and mapping of the findings from the literature.

Indeed, this research was mainly a literature review, and country-specific considerations were obtained from a limited number of interviews. Therefore, the results are yet to be confirmed empirically in the context of Qatar. Comparative analysis of UIC performance indicators used across countries is another attractive field for future research.

### 5. Declarations

#### 5.1. Author Contributions

Conceptualization, Z.A., A.A.S. and M.E.Y.; writing—original draft preparation, Z.A., A.A.S. and M.E.Y.; writing—review and editing, Z.A., A.A.S. and M.E.Y. All authors have read and agreed to the published version of the manuscript.

#### 5.2. Conflicts of Interest

The authors declare no conflict of interest.

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