Dynamics of the Impact of the Coronavirus Disease on Scientific Production, Fund Attraction, and Project Delay for Engineering and Other Disciplinary Areas

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Abstract

This study aims to identify the dynamics among scientific production, fund attraction, and delayed projects during quarantine periods during coronavirus disease (COVID-19) based on the perceptions of researcher professors surveyed. The survey response rate was 47%, corresponding to 118 research professors from a private university. Additionally, we explored articles by area on the period 1996–2023 at the institution and international levels indexed in the Scival database to elucidate trends in research production and, with this, verify if the perception of the research professors surveyed is correct. The research is expo-facto correlational, using statistical methods analysis like chi-squared tests to show statistically significant associations and polynomial models to project the expected research trends. The results indicated that for engineering research areas, developing projects with external funding and whose activities were delayed due to the pandemic was dependent on and highly correlated with the lack of access to laboratories, the inability to travel, and face-to-face meetings. The study found significant associations between the pandemic effect on the professors and the amount of external funding they attract. Although the majority considered themselves affected by the pandemic, all schools expected to produce more articles compared with those in previous years. At the international level, the booming number of publications has surpassed projections from 2020 to 2023, indicating the positive effect of the pandemic on the number of medical publications during the quarantine periods of 2020–2023. Finally, a verification conducted in Scival enabled the study to conclude that the expected increase in the scientific production of professors is agreed upon in 2020–2023 for many academic areas at the institution.

Keywords: Scientific publication; Impact on research; COVID-19; Higher education, educational innovation; professional education.

1. Introduction

As of March 9, 2024, the reference [1] has identified more than 700 million cases of the coronavirus disease (COVID-19) and more than 6 million related deaths globally. The COVID-19 pandemic has significantly altered economies worldwide. Measures, such as social distancing

and quarantin e, ceased the majority of economic and social activities in 2020 [2]. This situation made evident the unprecedented impact of the pandemic on the majority of economic sectors.

The physical facilities of universities had to be closed, and educational institutions had to quickly adapt to virtual environments with technological support to continue education and learning [3]. After the long periods of confinement, the conduct of research in universities had to be modified as well. A number of research laboratories had been closed entirely, and analysis and research had been halted. Scholars who could continue conducting social or clinical research continued to write articles; one can even infer that production increased. However, a method for identifying the implications of these changes on research output is required.

Campuses for universities in which research is conducted were also closed. However, academic activities were resumed remotely (online) since March 2020 and continued online during the August–December 2020 semester and the summer 2020 and winter 2021 periods. Community health care was always a priority. Relevant education departments formulated new distance learning models, which they enriched with additional programs to support the emotional health of students and teachers.

The pandemic was accompanied by significant changes in the research production of professors and students in institutions worldwide. The closure of campuses ceased or changed research plans. Physical laboratories were also closed or required minimal attendance due to the restrictions on the presence of university students on campuses. Thus, the current study posed the following question: how did confinement influence the research production of researchers at institutions? Funders partially or fully decreased financial support, which was expected to exert a negative impact on the perception of researchers.

At the international level, we observe that a significant number of publishing houses, such as Springer, Elsevier, Taylor and Francis, and Karger, among others, allowed open access to articles related to COVID-19 to support researchers during this period of confinement. However, a few of them only did so temporarily [4]. The goal was to increase access to new research to produce knowledge and solve problems. Thus, scientific communication and publishing systems and their elements (e.g., journals, reviewers, databases, and repositories) began to rapidly generate a large amount of knowledge. This initiative helped in preventing the decrease in the production of articles and other issues.

In addition, preprints acted as a fast-paced data-feed channel for researchers to quickly access information [5]. Preprint servers that did not exist a decade previously published a torrent of data on a daily basis. These data are dissected on platforms, such as Slack, Twitter, and other social media long before peer review begins. As such, publication related to COVID-19 is continually emerging worldwide [6].

One can observe that journal staff work overtime to process manuscripts for review, editing, and publishing in record time. In this regard, COVID-19 has changed the manner in which researchers collaborate and share findings [5]. The speed of publication increased in 2020, [7]. The New England Journal of Medicine published an article on COVID-19 in 48 h. Results were previously shared in preprints and social networks [5].

Intense communication has catalyzed an extraordinary level of collaboration among scientists. The slow pace of scientific communication before the pandemic has always been a problem. As such, COVID-19 broke the mold. Sharing information at high speed has created a new research culture under the crisis [5], which has prevented, along with other issues, scientific production from decreasing as would have been predicted.

A trend exists that research should be evaluated on its merits based on different metrics instead of using only the journal as an indicator of quality. This possibility has been led to the consideration of preprints as research evaluation frameworks to provide proof of productivity regardless of the place of publication [6]. Thus, an interesting aspect would be to follow the evolution of research evaluation frameworks to witness the adoption of other funders and institutions of policies that support preprints.

We observe that several studies [8] [9] [10]mention the significant increase and greater visibility of scientific production on COVID-19 issues.

Reference [8] analyzed records in the Scopus database in the period from 2019 to 2020 and selected 655 open-access articles with three main research focus groups, descriptions of COVID-19, clinical studies, and proposed treatments, among others. The author pointed out that the publication has many citations and great visibility on social networks during the pandemic. Moreover, [9] reported an exponential growth of publication in various databases in terms of scientific production related to the COVID-19 pandemic. The author examined Scopus and Web of Science and analyzed articles according to author, area, and country, among others. Reference [10] discussed studies that examined the relationship between COVID-19 and physical activity. From April to June 2020, scientific production significantly increased by 76%, and the country of origin of such production is mainly the United States. Thus, scholars inferred that scientific production demonstrated the concern of the scientific community about solving the increase in physical inactivity generated by the COVID-19 pandemic.

Thus, the need emerges to elucidate how the activity and production of scientific research will continue within a private university in Mexico. For this reason, we surveyed professors to determine their perception of research production and to implement a strategy for supporting these professors in their academic activities. This study is relevant, because (1) the study determines the perception of professors about the short-term impacts of COVID-19 on scientific production, including positive and negative consequences on research production, fund attraction, and delayed projects, (2) the work identified support at the local level for research at risk, and (3) the study presents the worldwide research trends by area.

This article analyzes the perceptions of researchers regarding research productivity using a survey on quarantine periods during COVID-19. The study analyzes scientific production using Scopus to identify the trends in scientific production in the university and internationally to identify some behavior that corresponds to the perceptions the researchers gave us about their research production during quarantine times.

2. Method:

The research used an expo-facto quantitative methodology with a descriptive–correlational statistical analysis and chi-squared tests to determine the dynamics of scientific production, fund attraction, and project delay. To verify the perceptions of the respondents about scientific production and to determine whether or not such tendencies or growth rates were consistent with the perceptions of the participants, we used the polynomial model and records from the Scopus database.

Sample

The target population was 250 research professors. We received a total of 118 responses (response rate: 47%). Using the formula of [11] for finite or small populations, a sample of 118 individuals from a population of 250 individuals depicts a reliability of 90% and an estimation error of 5.5%. A total of 49% of professors belonged to the Engineering and Sciences school followed by the business school (13.6%), the medicine and health sciences school (11.9%), the humanities and education school (11%), the school of architecture, art, and design (7.6%), and the school of social sciences and government (6.8%).

Instrument

The study formulated an instrument for measuring the impact of the pandemic on the scientific production of the professors of the institution. The survey was composed of eight questions. Four questions were dichotomous; the other four were in multiple-choice format with six, five, four, and three options, respectively. Three professors with experience in validating item content and form validated the questionnaire items by reaching inter-rater agreement. Accordingly, the study made revisions as per the recommendation of the judges, and the contents of all solicited information were validated. The judges evaluated the performance criteria of each item according to content (uniqueness), relevance (items most closely related to the topic), and clarity (easily understandable and simple statements). The reliability of the evaluations of the expert was estimated according to the formula of [12]: reliability = total number of agreements/total number of coded units. Inter-rater reliability was considered acceptable at 0.85 and above.

The survey was uploaded to the portal of the institution. The survey aimed to determine the effect of confinement on research production, including the number of scientific publication and funds attracted for research development. We also intended to identify whether or not any potential delay is related to access to laboratories, inability to travel, and the inability to meet. Moreover, we verified whether or not the cancellation of funds influences research production. We also aimed to examine if professors need institutional support to continue research development and if any research project was linked to an institutional program that could impact them.

In the second stage, we conducted a comparative analysis between the perceptions of impact on the scientific production of the professors and the Scival records at the institutional and international levels after confinement. The institutional level refers to all types of publication in the educational institution in which the survey is conducted, while the international level equally refers to all types of publication in the Benchmarking module of Scival [13].

From the institutional and international levels, we downloaded data from the [13]homepage on January 02, 2024. The path used in Scival was "Benchmarking > Select subject classification > ASJC" (ASJC by Scival is the classification of all scientific journals). In the option "countries, regions, and groups," we selected the option "World" to extract articles at the international level. Similarly, at the institutional level, in the option for institutions and groups, we selected the institution in which the survey was conducted.

According to [13], Scival provides access to the research output of thousands of institutions and their associated researchers from 231 countries. Scival has used information from Scopus since 1996, which makes more than 50 million records on research performance available across institutions, countries, and the world. It offers quick and easy access to statistics and visualization of research trends. However, considering that Scival typically lags behind Scopus due in terms of processing time by one or two weeks [13].

Statistical analysis

First, we coded the answers and created dummy variables for the categories of questions 1, 3, and 8 (see the Appendix). We conducted descriptive and correlational analyses to show some general statistics and trends. We conducted χ^2 tests to demonstrate dependency relationships and significant associations with at least a 5% statistical significance. These tests enable the study to conclude whether or not the categorical variables are dependent on one another [14]. In accordance with [15] the null hypothesis considers that marginal probabilities determine joint probabilities. In this case, a hypothesis rejection indicates statistical evidence for refuting the independence between pairs of variables.

Using Scival Benchmarking, we extracted the number of scientific articles written from 1996 to 2023 in Arts and Humanities, engineering, medicine, social sciences, and business, management, and accounting. We selected these areas, because they are the most similar ones considered in the survey applied to the institution. The concept is to determine whether or not the perceptions reported in the survey are consistent with those registered in Scival. Toward this end, we adjusted polynomial models using information from 1996 to 2019 to project the expected research trends from 2020 to 2023. We then compared this projection with the actual result.

Considering the datasets comprising survey responses and Scival data, this study employed Python programming and Excel to conduct exploration, experimentation, analysis, and visualization, as elaborated in subsequent sections. The Python software tools and libraries utilized included the Pandas library [16] for data processing and the SciPy library [17] for conducting statistical tests.

3. Results:

Analysis of the survey to research professors

Figure 1 presents the perceptions of the respondents regarding the pandemic by area. The engineering and science school stands out, because 84.5% of professors reported that the

pandemic affected them. This result differs from those of other schools, in which opinion was divided between 50% and 67%.

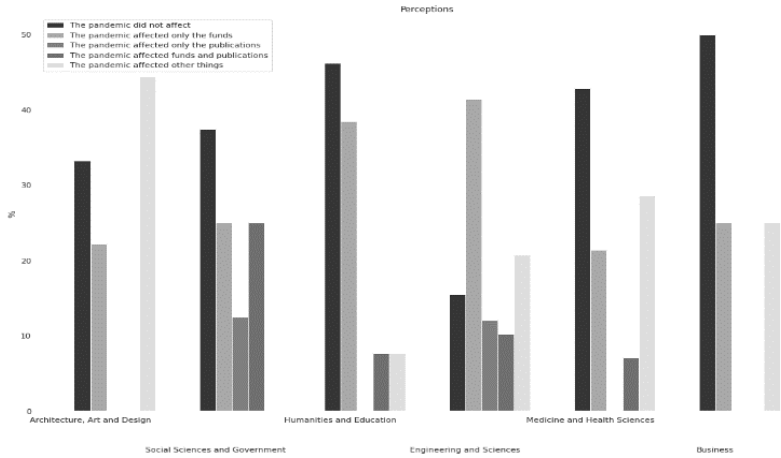

Figure 1. Perceptions According to School (September 2020 to June 2021)

Regarding the impact of the pandemic on external funding, the business school, architecture, art, and design school, and the school of medicine and health sciences revealed a percentage impact of less than or equal to 29%. Once again, the engineering and science school stood out, because approximately 50% mentioned problems with funds—similarly, social science and government school, and humanities and education school. The business school and the architecture, art, and design school thought the pandemic do not affect publications. The rest of the schools required help with publication and funds.

Except for the social science and government school, all schools mentioned that they experienced additional problems due to the pandemic. In an open-ended question, they mentioned family problems and health or emotional health problems, among others.

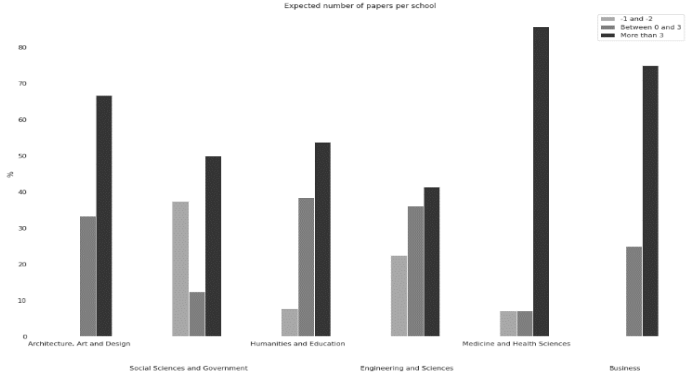

Figure 2. Estimated Items by School (September 2020 to June 2021)

Figure 2 presents the expected number of scientific articles by area. In all schools, including engineering and science, the bar corresponding to the production of four or more scientific articles stands out (dark gray). We note that, in all areas, the expected number of scientific articles that teachers plan to produce is higher than the previous year. In the "Verification of Scientific Production in Scopus" section, we will verify the perceptions of the respondents.

Professors who pursued projects funded by external sources experienced delays in their planned activities, and/or deliverables were delayed due to the pandemic. Across various academic departments, the percentages of delayed projects were as follows: 50% in the social science and government school, 36.2% in the engineering and science school, 14.3% in the school of medicine and health sciences, 12.5% in the business school, and 11.1% in the architecture, art, and design school.

The reasons for the delays were fund cancellation for the architecture, art, and design school, whereas inability to travel, impossibility of face-to-face meetings, and fund cancellation were the reasons cited by the social science and government school. Moreover, project delays in the school of medicine and health science were due to inaccessible laboratories. Lastly, these delays were due to fund cancellation and inability to travel for professors in the business school.

Professors in the engineering and science school commented that delay was due to inaccessible laboratories (72.7%), the impossibility of travel (40.9%), and the impossibility of face-to-face meetings, fund cancellation, and other reasons (13.6%).

Correlations and χ^2 test

Table 1 presents the correlations in absolute values more than 0.3 and associations in the chi-square tests. As previously mentioned, we conducted tests to illustrate only dependency relationships with at least a 5% level of significance.

Table 1 Results of correlation and χ^2 tests

Projects with external financing whose activities were delayed due to the pandemic (2)				
	Correlation	p-Value	χ^2	p-Value
3-a	0.67	7.5e−17***	49.16	2.4e−12***
3-b	0.60	5.2e−13***	38.55	5.4e−10***
3-c	0.32	3.9e−04***	8.41	3.7e−03***
3-d	0.40	8.8e−06***	14.63	1.0e−02**
3-e	0.32	4.0e−04***	8.41	3.7e−03**
4	0.32	4.0e−04***	8.41	3.7e−03***
requiring some support to request or negotiate a formal extension of the project (question 4)				
	Correlation	p-Value	χ^2	p-Value
3-b	0.38	1.9e−05**	11.19	8.2e−04***
How will the pandemic affect you: It does not affect me (1-c)				
	Correlation	p-value	χ^2	p-value
1-b	−0.56	5.8e−11***	34.16	5.1e−09***
5	−0.34	2.0e−04***	11.87	5.7e−04***
6	0.31	5.4e−04***	17.31	2.7e−02**

Note: **p < 0.05, ***p < 0.01.

We found that developing a project with external financing whose activities were delayed due to the pandemic (2) was dependent on the lack of access to laboratories (3-a), inability to travel (3-b), impossibility of face-to-face meetings (3-c), fund cancellation (3-d), and support required to request or negotiate formal extensions to projects (4). Requiring support for requesting or negotiating a formal extension of the project (question 4) depended on the inability to travel (3-b).

Additionally, the impact of the pandemic on the respondents involves the amount of external funds attracted (1-b), whether or not the professor observed a change in their productivity in scientific articles registered under Scopus compared with that of the previous year (5), and the number of items that the professors expected to produce (6).

Notably, when a professor had a scientific production, the pandemic did not exert an effect; thus, when the number of articles increased, the impact of the pandemic decreased. Similarly, regarding fund attraction, the pandemic did not affect teachers if it did not affect the attraction of funds.

Verification of scientific production in Scopus

This section analyzes the scientific production recorded in Scival to verify the perceptions of the respondents. Through Scival Benchmarking, we extracted the number of scientific articles posted from 1996 to 2023 for the following areas: “Arts and Humanities,” “Engineering,” “Medicine,” “Social Sciences,” and “Business, Management, and Accounting.” We selected these areas because they are the most similar to those considered in the survey analyzed in the last section. It is essential to mention that we are not comparing the investigation at the institutional level with the national or international level. We are checking if the institutional patterns are like the international patterns. The final objective is to verify if the perception of the research-professors survey in articles is according to the institutional level or international level.

The objective of this section is to illustrate areas that experienced growth in the number of scientific papers published during the pandemic. To achieve this goal, polynomial models were employed, utilizing data from 1996 to 2019 to project expected outputs for 2020 and 2023. These projections were then compared with the actual results. Figure 3 displays the number of articles published in Scopus for Medicine at institutional and international levels, alongside projections for institutional and international scientific production. The dotted line represents the projection adjusted using polynomial models. The figures also include the polynomial equations utilized for the predictions.

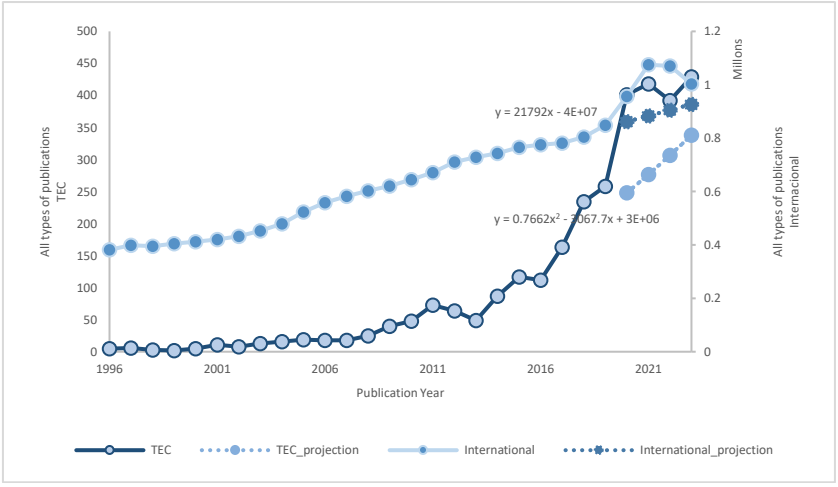

Figure 3. Scientific Production in Medicine

For the institutional and international levels, the actual count between 2020 and 2023 exceeds the projection (Figure 3). Given the actual numbers, an increase of 62% was observed for 2020 compared with the projection at the institutional level. Also, in 2021, 2022, and 2023, the increase was 51%, 28%, and 27% compared with the projection. A similar result was noted at the international level. In 2020, the increase reached 11% and 22% in 2021. By 2022, the increase was 18%, and in 2023, of 8%. This finding may indicate that the COVID-19 pandemic led to a research boom in medicine, which continues to exceed expectations but has stopped increasing with the same intensity as that in 2020.

Like medicine, Figure 4 illustrates the number of articles published in Scopus in the social sciences at both the institutional and international levels. At the international level, we observe a steady increase without abrupt changes. However, at the institutional level, a clear upward trend is evident from 2019 to 2023, surpassing both previous years and projections. In 2020, this increase reached 44%, and 68% in 2021 compared with the projections. The trend continued with increases of 63% in 2022 and a striking 111% in 2023. Although the pandemic could have accelerated this growth in the institution, we lack sufficient evidence to confirm this assertion because it also seems like something particular to the institution.

In engineering at the institutional level, the actual numbers of publications in 2020 and 2023 surpass the projection (Figure 5). The increase reached 52% in 2020 compared to the projection, while in 2021, 2022, and 2023, the increases were 49%, 37%, and 38%, respectively. This stands in contrast to the situation at the international level, where research production in engineering aligns with the projection for 2020 and 2021. Hence, the pandemic may not have significantly impacted the engineering field at the international level during those years, with an increase of 9% in 2022 and 8% in 2023. However, upon closer examination of the numbers and patterns at the international level, they follow natural patterns within this domain. Conversely, there is a

noticeable rise in the number of articles at the institutional level, but it cannot be conclusively assumed that the pandemic led to these increases.

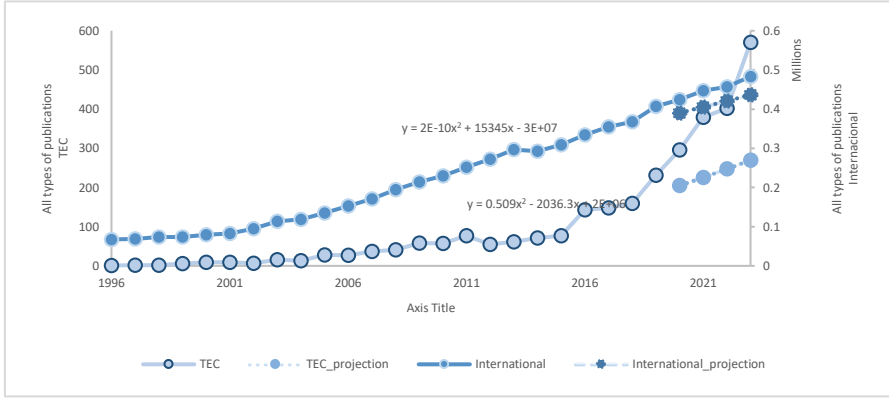

Figure 4. Scientific Production in Social Science

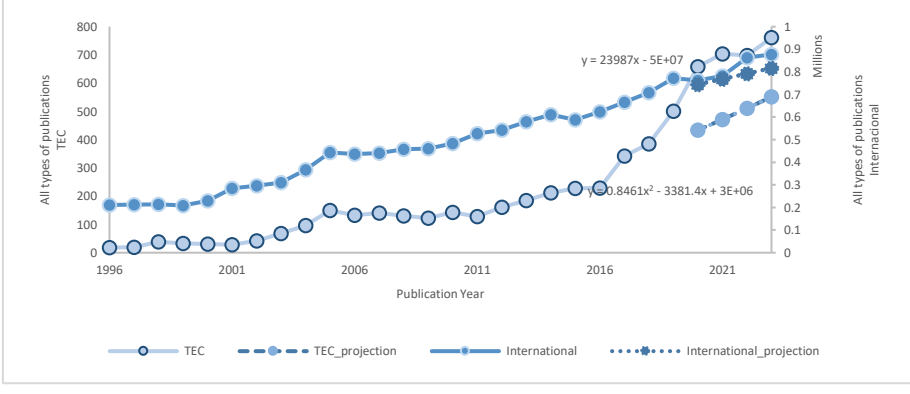

Figure 5. Scientific Production in Engineering

In the Arts and Humanities field, the growth pattern fell below the expected projection for 2020 and 2023 at both the international and institutional levels (Figure 6). The decline trend is particularly noticeable at the institutional level, with decreases of 17%, 26%, and 15% compared to the projection in 2021, 2022, and 2023, respectively. However, it is worth noting that at the institutional and international levels, the trends often display cycles of increase and decrease, complicating the understanding of whether the pandemic is the underlying cause.

In Business, Management, and Accounting, the growth pattern is relatively similar to the expected projection at the international level (Figure 7). Nevertheless, an increase of 8% was noted at the institutional level in 2020 compared with the projection. In 2021 and 2022, the number of publications at both the institutional and international levels was below the projection, although this tendency is more pronounced at the institutional level. Then, in 2023, there was an

increase in the number of publications above what was expected. However, this increase, along with the decreases in 2021 and 2022, appears like the irregular patterns observed in the period from 1996 to 2019, which makes understanding this result challenging in terms of whether the increase followed by the decrease in 2020–2022 is due to the pandemic or other reasons.

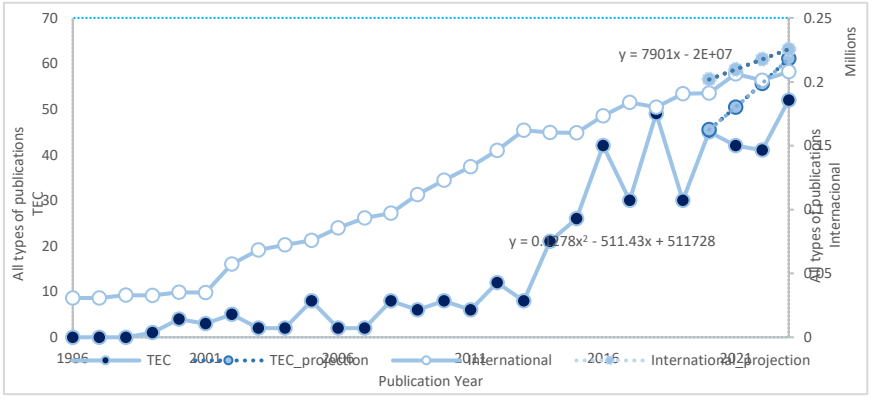

Figure 6. Scientific Production in Arts and Humanities

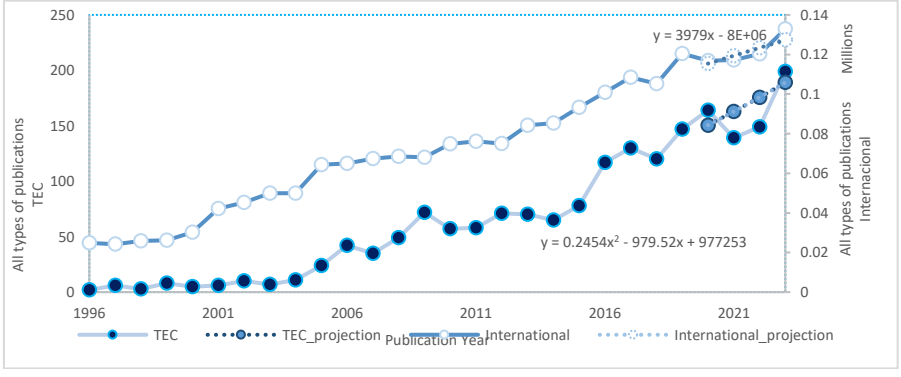

Figure 7. Scientific Production in Business, Management and Accounting

Although we cannot conclusively attribute it to the pandemic, three areas at the institutional level—medicine, social science, and engineering—have been experiencing accelerated growth since 2019. As a suggestion for future research, it could be intriguing to examine the changes within these areas in the institution and, if feasible, explore the possibility of implementing similar strategies in other research domains within the institution.

4. Discussion:

Most respondents expressed a negative impact from the pandemic, often citing delayed projects and funding constraints. However, despite these challenges, respondents anticipated a significant

increase in article production for 2020–2021 compared to previous years. This expectation aligns with findings from Scival Scopus records discussed in the preceding section, corroborating the respondents' views across various domains.

The previous literature revealed that the COVID-19 pandemic led to schedule delays and impacts on human health [18]. In our current investigation, professors from the engineering and science school conveyed perceptions of a fluctuating project delay landscape during the pandemic. This observation resonates with findings by [19], who documented delays and cancellations in several construction projects in Indonesia. Indeed, [20] introduced a graph model to resolve conflicts in engineering projects affected by the pandemic.

Similarly, the current study found that delays occurred for externally funded projects that were dependent on access to laboratories, face-to-face meetings, and travel. Reference [19] mentioned that construction projects were delayed due to restriction on human activity and mass gathering, among others. In addition, [21] mentioned that many students and professors that work in research were impacted by the COVID-19 restrictions regarding access and use of laboratories. Therefore, evidence exists that COVID-19 impacted research in terms not only of access to laboratories and inability to travel but also of restrictions on human activities such as face-to-face meetings.

Although delayed projects affected studies in other areas, others benefited from funding. For example, for COVID-19 research, funding processes were accelerated [22]. In the medical sciences, the research priorities were epidemic prevention and control, the infection process of the disease, and drugs and vaccines against COVID-19 [23]. However, the professors of the engineering and science school reported that COVID-19 negatively impacted the fund attraction they expected. This reason underlying this issue was that research worldwide prioritized topics related to COVID-19. References [9] [24] [25] [26] concluded that publication related to COVID-19 dramatically incremented.

Respondents' perceptions of publications indicated an increase across all areas. Our study substantiated this finding by examining Scival Scopus data for the School of Medicine and Health Sciences at both institutional and international levels, along with relevant literature on COVID-19. Similarly, we confirmed professors' perceptions of the Schools of Social Sciences and Engineering through Scival Scopus records at both institutional and international levels.

Furthermore, perceptions of professors in the Arts and Humanities and Business and Management diverged regarding Scival trends at the international and institutional levels. A decline in publications during 2021 and 2022 was noted, but resembling natural patterns observed in previous years.

5. Conclusion:

This study found that the pandemic affected the academic production of professors in a university in Mexico due to externally funded projects that were dependent on access to laboratories and travel. Furthermore, the results mainly centered on professors in the engineering and science

school; thus, the study infers that the pandemic negatively influenced the fund attraction expected by the scholars.

Meanwhile, other professors did not perceive the impact of the pandemic, because they noted no impact on scientific production or fund attraction. For example, if they expected the number of articles to increase, then the pandemic did not affect.

For the school of medicine and health science, the study validated that the perception of an exponential increase in publication is consistent with Scival Scopus records at the institutional and international levels. Similarly, we validated the expected increase in scientific publication for the social sciences and engineering schools using the Scival records at the institutional and international level. However, justifying that the pandemic positively influenced the number of publications, except for the school of medicine and health science, is difficult.

Notably, the conclusions of the study on the perceptions of the respondents can only be generalized for certain areas of study and cannot be generalized at the national and international levels. A limitation of the study is that the conclusions are based on the opinions and perceptions of teachers, which is outside the scope of the study. In addition, the sample size is limited mainly to the schools of humanities and education and architecture, art, and design. However, the results of the trends noted in Scival records enable this study to report that these areas do not have an accelerated increase in publication during the pandemic, as was demonstrated, for example, by the area of medicine.

To conclude, the study noted a contrast between the positive effect of the pandemic in the number of publications in medicine and between engineering in which the pandemic delayed projects due to access to laboratories, inability to travel, and face-to-face meetings, among others.

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Conflict of interest: The authors declare that there is no conflict of interest.

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