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The influence of technological innovations on international business strategy before and during COVID-19 pandemic

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Abstract

In the last two years, the world has gone through an unprecedented change in the most diverse dimensions (social, economic, and even political), leading that society had to adapt very quickly to the contingencies imposed by COVID-19. All organizations (independent of their area of activity) had to adjust their processes to respond, efficiently and effectively, to these constraints. In this context, companies with concerns in internationalization (those that are already internationalized and those in an internationalization process) have had to resort to technologies to support the change in their *modus operandi*. The digital transformation (until now had an essential role in the transformation of organizations, but which was in a relatively slow implementation process) started to perform, in an accelerated way, the base of work for the heads of the organizations to be able to respond to these challenges. In this context, the transformation of the business model, supported by digital technology, has been documented as one of the strategies used to respond to disruptive environmental changes, particularly technologies that help companies identify new business practices. This study aims to find evidence of the importance of integrating and influencing technological innovations in the practice of international business strategy before and during COVID-19 pandemic. The results show the influence of the digitalization on the business strategies.

Keywords: technological innovations; international business; COVID-19 pandemic; digital transformation.

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1. Introduction

The year 2020 was marked by two events that had a significant impact on society. The first was an unprecedented global crisis due to the pandemic of COVID-19 and the second, induced by the first, the acceptance of several technological innovations which have evolved at an unprecedented rate. The second led that each sector of activity (industry, commercial, education, etc.), was affected by the digital transformation. Vint Cerf, vice president and Chief Internet Evangelist at Google and past Association for Computing Machinery (ACM) president, sees an "awesome responsibility!" as "our profession and the products creates will have a prominent role in shaping our post − COVID-19 society" [1]. These products referenced by Vint Cerf lead to digital innovations, the development of 5th generation wireless networks (5G), artificial intelligence (AI) (machine learning (ML) and deep learning (DL)), and the Internet of Things (IoT), as well as digital security capabilities such as blockchain, have created an extraordinary ecosystem for new opportunities in several activities sectors [2-3]. For example, to realize the importance of these technologies, the IoT will grow to 25 billion connected things by 2021, creating massive data volumes. An organization's ability to derive meaning from it will be essential to its success [4].

Nearly one-third of companies invest up to $50 million in automation, including AI, machine learning, cognitive computing, and robotic process automation. In this context, the transformation of the business model, supported by digital technology, has been documented as one of the strategies used to respond to disruptive environmental changes, particularly technologies that help companies identify new business practices [5]. For example, in [6] it is stated that "We are living in an era of unprecedented technological innovation.", and that 90 % of the world's data has been produced in the past two years, due in large part to the 26 billion smart devices now in circulation. For these reasons, digital technologies and digitization are an adequate response to the disruptive changes caused by the pandemic COVID-19. Thus, according to [7], there are several common advantages of digitalization during this pandemic period: (*i*) More consistent structured collaboration; (*ii*) Greater use of analyzes; (*iii*) Increased frequency of meetings due to lack of travel and disturbing organizational variables in a physical location; (*iv*) More productive general work products due to the mitigation of distractions at the office location; (*v*) Greater transfer of knowledge content through digital collaboration recording; (*vi*) General, more extensive use of existing systems and technologies that reduces the limits of the learning curve for the effective use of technology. The pandemic's impact is different and more dramatic than the traditional one, in which changes are driven by human innovation [8-9]. Under these conditions, managers focus more on rescuing companies from bankruptcy than on creating a sustainable competitive advantage [10].

Digitization makes indistinct the limits between technology and management, facilitating new business models integrated into concepts, methods, and tools of the digital environment [11] that lead to the emergence of digital transformation. In this sense, IDC in [12] presents a study showing the top 10 digital transformation predictions for 2021. According to the same authors, "while 2020 has represented unprecedented times of uncertainty due to global health crisis and the upending of traditional business practices, it has only further fueled growth in digital technology pivots and digital transformation as the global economy has had to adapt to new ways of working".

This study aims to find evidence of the importance of integrating and influencing technological innovations in the practice of international business strategy. We will also try to understand the relevance of integrating these technological innovations more effectively through the discrimination of ten different technological categories, as well as knowing the importance of each of these categories in the business internationalization strategy.

The paper is structured as follows. Section 2 describes the related work regarding digital transformation (DT). Section 3 presents the research methodology. Section 4 summarizes the results and discussion of the research and finally, Section 5 presents the conclusions and future work.

2. Background

In [13] is presented a work that aims to create a unified definition of digital transformation (DT), because up to the time of the publication, there were 134 definitions. The authors of that paper present the following unified definition of digital transformation "A fundamental change process, enabled by the innovative use of digital technologies accompanied by the strategic leverage of key resources and capabilities, aiming to radically improve an entity and redefine its value proposition for its stakeholders."

The definition mentioned above can be materialized with companies that present disruptive digital business models (Google, Tesla, Apple, Amazon, Netflix, Uber, Airbnb, among others), which use most technologies (Cloud computing, IoT, Bigdata Analytics, Machine Learning, etc.) that have been supporting and driving DT. As concrete examples, the business model of Uber and Airbnb is entirely digital and uses the technologies mentioned earlier [14]. Another example is the change seen in the television and film industry with the emergence of companies like Netflix and HBO that use streaming services. Thus, these organizations were able to gain access to the global market because they strategically leveraged their resources and capabilities (using the suitable means, that is, the right technologies) to recreate value (having a far-reaching impact reaching all parts of the world), the that allows them to adapt to changes in customer preferences and market dynamics, as is happening in this pandemic moment that we are experiencing.

All organizations (organization, business network, industry, society) have valuable digital assets, whether data or functionality, but resources (human, financial, and knowledge) and capabilities (digital capabilities and dynamic resources) are the strategic assets for initiate or accelerate DT when they can be safely leveraged, reused, combined, and shared with stakeholders. So, DT is not just about using digital technologies themselves, launching more mobile apps or migrating to the cloud or enjoying machine learning or most of the other finite things that people associate with it [15], but also about the strategic leverage of resources and capabilities to radically improve an organization and redefine its value proposition for stakeholders.

3. Research Methodology

Regarding research methodology, the main concern is using a scientific method, carrying out organized research, and having strict control of the use of theoretical observations and knowledge. Thus, this section presents the procedures used in data collection, which constitute the study. The research carried out used the quantitative methodology that aims to find relationships between variables, describe the variables through the statistical treatment of the collected data, as well as test theories, and reach conclusions [16]. The selection of the quantitative methodology was justified by the need to collect the entrepreneur's opinions and attitudes, that is, the study was descriptive, and the data collection was carried out with the use of a questionnaire. The use of questionnaires requires special attention since it is not enough to collect the answers on the issues of interest because it is also essential to perform statistical analysis to validate the results. That is why, before being sent to companies, the questionnaire was evaluated and validated by four specialists.

Data collection was based on a questionnaire with 33 questions. The questionnaire was developed to study the enhancing factors of Portuguese business internationalization and assess the most frequent barriers and constraints in this process. In this work, special emphasis is given to Business Digitalization, inducted by the Digital Transformation. Through an empirical study from a sample of 310 internationalized Portuguese companies, we intend to understand if the integration of technological innovations in business practice can enable significant competitive advantage in business internationalization and which technologies have a greater degree of relevance in this process. Whether there are significant differences in the period before and during COVID. Therefore, the following information was collected regarding the degree of relevance (measured on a 5-level Likert scale: 1- nothing relevant to 5-extremely relevant) assigned to business digitalization as well as that attributed to the 10 technological tools. The technological tools evaluated were: V1-E-commerce, V2- Cloud solutions, V3- Big Data, V4- IoT/sensors, V5- 3D printing, V6- Virtual reality/Augmented reality, V7- Robotics/automation, V8- Agile tools, V9- Business Intelligence (BI) and V10- AI.

The questionnaire was sent to all companies registered in the AICEP database of Portuguese internationalized companies, by sending a link via e-mail and using the Google Forms tool. Between May 2019 and May 2020, a set of 310 valid answers were obtained, 238 before COVID (in 2019) and 72 during COVID (after March 2020). The two group of companies are independent.

The data collected were treated using the IBM SPSS Statistics 26.0 software and R software. The statistical methods used for the data analysis in the study were: Reliability analysis (Cronbach´s Alpha), Descriptive Statistics, Spearman´s correlation coefficient, Nonparametric Hypothesis testing (Mann-Whitney test) [17], and Random Forest methodology (regression model and classification model) [18].

4. Analysis and Results discussion

The sample of 310 internationalized Portuguese companies used in this research is composed of companies from different sectors (both from industry and services) and of different sizes. Regarding the number of employees, the sample consists of 34.8 % micro firms, 40 % small firms, 17.8 % medium firms, and 7.4 % large firms. Of those companies, 65.8 % are family businesses, and 86.8 % have no foreign capital. It is also interesting to note that concerning the percentage of business resulting from internationalization, 27.1 % of the companies it was less than 10 %. In 24.8 % of the companies, it was 75 % at least.

To verify if the variability of the answers resulted from differences in entrepreneur's opinions, we performed a reliability analysis using Cronbach´s Alpha for the dimension technologies (with the ten technologies categories pointed). The value obtained was 0.918, and given that this measure varies between 0 and 1, we can consider that this dimension is reliable. According to this result, it makes sense to present the descriptive results to have an initial view of the degree of relevance attributed to the technologies tools presented before and during COVID. Table 1 shows the descriptive measures, such as mean, median, coefficient of variation (C.V.).

Table 1. Descriptive measures for the ten technology tools.

		E-commerce	Cloud solutions	Big Data	IoT/ sensors	3D printing	VR/AR	Robotics/ Automation	Agile tools	BI	AI
Before COVID	Mean	**3.54**	3.09	2.72	2.57	2.21	2.28	2.69	**3.37**	3.33	2.49
	Median	4.00	**3.00**	3.00	**2.00**	2.00	2.00	2.00	**4.00**	3.00	**2.00**
	CV (%)	38.39	43.59	47.13	53.04	55.20	57.89	54.28	38.66	40.78	55.1.
During COVID	Mean	**3.90**	3.51	3.08	2.95	2.24	2.30	2.67	**3.59**	3.20	2.78
	Median	4.00	**4.00**	3.00	**3.00**	2.00	2.00	2.00	**4.00**	3.00	**3.00**
	CV (%)	34.26	36.98	42.86	50.81	57.14	58.43	56.55	35.21	40.87	55.43

In terms of the median (most appropriate location measure considering that the data are measured on an ordinal scale), we see an increase in pre-COVID during COVID in the following technological categories: "Cloud Solutions", use of "IoT / sensors", and use of "AI". On the other hand, looking at the mean and median values together, we find that the most relevant technological tools were, in both moments, "E-commerce" followed by "Agile Tools". In terms of variability in responses, we can conclude from the coefficient of variation that the results show a moderate to high dispersion, which suggests some lack of homogeneity in the answers obtained. However, it should be noted that regarding the "E-commerce", "Cloud solutions", "Big Data", "IoT / sensors" and "Agile tools" tools, there was a decrease in variability during COVID, which reveals that opinions about these tools in this period were more consistent than in the period before COVID.

Then, to assess whether the existing correlations between the degrees of relevance attributed to the ten technological tools by the 310 respondents are high, the Spearman correlation coefficient was calculated (r_s – suitable for categorical variables measured on an ordinal scale). We established the usual practical rule for a strong correlation for values of r_s greater than or equal to 0.6. Thus, we conclude that the highest and most significant correlations at the level of 1% (p-value <0.01) occur between (see Figure 1): Cloud solutions (V2) and Big Data (V3) ($r_s = 0.71$), Agile tools (V8) and Business intelligence (V9) ($r_s = 0.64$), VR/AR (V6) and 3D printing (V5) ($r_s = 0.62$) and Big Data (V3) and IoT/sensors (V4) ($r_s = 0.61$).

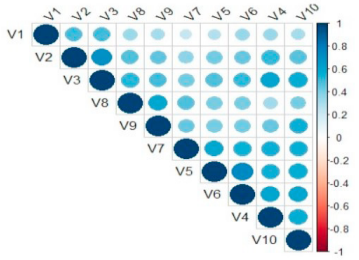


Fig. 1. Spearman correlation coefficients (r_s) for the ten technology tools.

To study the degree of relevance assigned to business digitalization before and during COVID, we began conducting a Mann-Whitney test to assess whether there are significant differences in these two moments. Although the mean degree of relevance attributed rises from 3.87 to 3.99, the test allows us to conclude that there are no significant differences at a level of significance of 5 % (p-value = 0.379 > 0.05). It should also be noted that the median degree is 4 at both moments; that is, at least 50 % of the entrepreneurs consider business digitalization at least very relevant. Based on the frequency table for this variable, we can go further and affirm that 213 of the 310 entrepreneurs, that is 68.7 %, consider the business digitalization to be very or highly relevant, with 32.3 % considering it highly relevant. Likewise, to detect significant differences between the degree of relevance attributed by respondents to each of the technological tools before and during COVID, the Mann-Whitney test was carried out. Although we suspect based on the results obtained in Table 1 the possible existence of significant differences between the two moments for the tools “Cloud solutions”, “IoT / sensors” and “AI”, by the results observed in Table 2, we found that there are only significant differences at 5 %, regarding “Cloud solutions” (p-value = 0.05) and at 10 % regarding “E-commerce” (p-value = 0.1).

Table 2. Results of Mann-Whitney test for technology tools, before and during COVID.

Test Statistics										
	E-commerce	Cloud solutions	Big Data	IoT/ sensors	3D printing	VR/AR	Robotics /automation	Agile tools	BI	AI
Mann-Whitney U	3712	3823	2751	3092	3686	3669	3732	4028	3989	3362
Wilcoxon W	28022	27476	18504	18668	20157	20689	4512	27681	4850	20015
Z	-1.630	-1.915	-1.569	-1.462	-.069	-.031	-.187	-.986	-.620	-1.017
Asymp. Sig. (2-tailed)	**.10**	**.05**	.12	.14	.95	.98	.85	.32	.54	.31

a. Grouping Variable: covid

Given the results obtained, it makes sense to ask the following questions: Which technological tools have the most significant contribution to the degree of relevance attributed to business digitalization before and during COVID? Are there differences in the most relevant technologies in both moments?

In the first phase, we calculated Spearman's correlation coefficients (r_s) to know which technological tools are most correlated with the degree of relevance attributed to business digitalization before and during COVID (see Table 3).

First of all, it is essential to note that although not all the bold values correspond to very high correlation values, they are significant at a 5 % significance level. Table 3 allows us to conclude that before COVID, "E-commerce", "Cloud solutions", and "Big Data" are the technological tools most correlated with the degree of relevance attributed to business digitalization. During the COVID phase, the tools most correlated with the degree of significance attributed to business digitalization are only "E-commerce" and "Big Data" with special emphasis on "E-commerce" ($r_s = 0.607$).

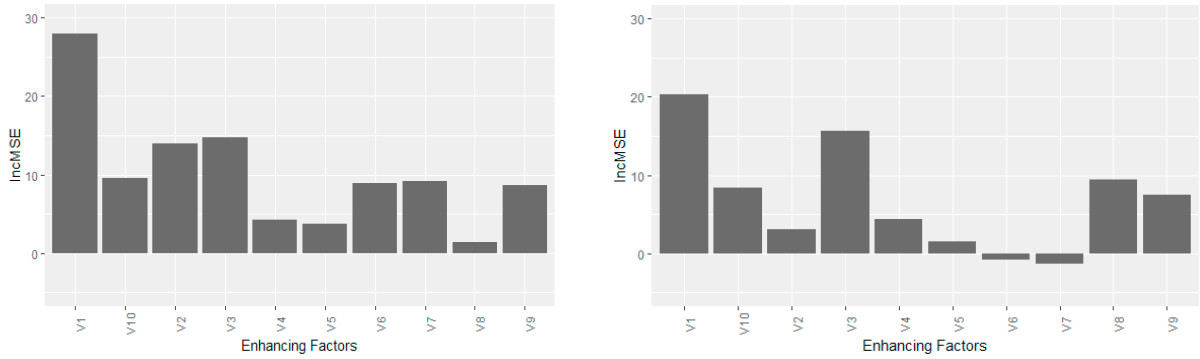
Table 3. Spearman correlation coefficients between technology solutions and degree of business digitalization.

		Correlations									
		E-commerce	Cloud solutions	Big Data	IoT/ sensors	3D printing	VR/ AR	Robotics/ Automation	Agile tools	BI	AI
Before COVID	r_s	**0.467**	**0.445**	**0.439**	0.351	0.196	0.271	0.147	0.255	0.381	0.278
During COVID	r_s	**0.607**	0.316	**0.470**	0.287	0.197	0.191	0.300	0.390	0.378	0.270

We choose the Random Forest methodology to carry out a robust study, which we now briefly explain. The random forest classifier was developed by Leo Breiman [18] and consisted of many decision trees. At each node, a random subset of variables is used to determine the splitting decision. Finally, the model of all classes by the individual fully grown and unpruned trees is returned. Random Forest can be used for either a categorical response variable as "classification" or a quantitative response referred to as "regression" and can be easily implemented in parallel. Random Forest is an ensemble learning model that is attractive because, in addition to other aspects, they provide two essential measures that assess the importance of variables: IncMSE (mean decrease accuracy, MSE) and IncNodePurity (mean decrease Gini).

The splitting criterion gives a measure of "goodness of fit" (regression) or "purity" (classification) for a node, where large values representing poor fit (regression) or an impure node (classification). Regarding the measure that evaluates the degree of importance of a variable, a higher %IncMSE value represents higher variable importance. A higher IncNodePurity value represents higher variable importance (nodes are much purer). The Random Forest Algorithm is explained in [19]. To implement this methodology, we used package randomForest available in R software from the CRAN website www.cran.r-project.org

In a first analysis, we built a regression model to evaluate which technological tools have more contribution to the degree of relevance assigned to business digitalization before and during COVID. Figure 2 presents the results of %IncMSE with the obtained sample before and during COVID.



a) Values of %IncMSE for regression model before COVID.

b) Values of %IncMSE for regression model during COVID.

Fig. 2. Values of %IncMSE for the regression model.

As mentioned above, a higher %IncMSE value represents higher variable importance to explain the target variable, which is the degree of relevance assigned to business digitalization. In Figure 1a), we find that the technologies that most contribute to the degree of significance given to business digitalization before COVID are V1 (E-commerce), V2 (Cloud solutions), V3 (Big Data), V6 (VR/AR), V7 (Robotics/automation) and V9 (BI). Looking now at technologies with greater predictive power during COVID (Figure 1b), we conclude that in this case, the technologies that most contribute to our target variable are: V1 (E-commerce), V3 (Big Data), V8 (Agile tools), V9 (BI) and V10

(AI). It should also be noted that V6 (VR/AR) and V7 (Robotics/Automation) does not make sense to be presented in this regression model as they assume negative values.

Comparing the percentages of contribution (to the regression model) of the various technological tools before and during COVID, we find that V8 (Agile tools) shows a more significant increase of 8.07 percentage points. They were followed by V4 (IoT/sensors) with an increase of 1.56 percentage points (an increase of 57.6 %) and V3 (Big Data) with an increase of 3.11 percentage points (an increase of 23.7 %). The reduction in the percentage of companies that use E-commerce (V1) before (28.3 %) and during (20.7 %) COVID is because companies must adjust their production processes for products that are more transactional and for the internal market. The variables corresponding to "Big Data" (V3) and "IoT / sensors" (V4) have grown due to their greater use to support the various activities and processes of the companies that participated in this study, where it can be highlighted, for example, the need imposed by the pandemic, as was teleworking.

In a second phase, we built a classification model with response 0 - before COVID and 1-during COVID to evaluate which technological tools contribute more before and during COVID. Given that a higher IncNodePurity (mean decrease Gini) value represents a higher variable important (Figure 3), we find the results obtained for this measure. Thus, we can conclude that the technological solutions that contribute most to the classification before and during COVID are V1(E-commerce), V2 (Cloud solutions), V9 (BI), and V8 (Agile tools), and the tool that contributes less to this classification is V5 (3D printing).

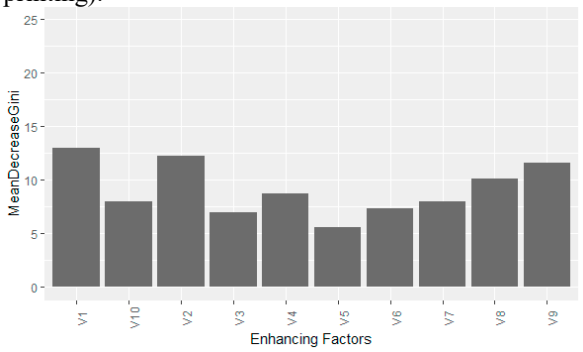


Fig. 3. Values of % mean decrease Gini for the classification model.

Consequently, by crossing the information resulting from this classification model, obtained in the previous regression models, we can conclude the technological tool that most contributes to the degree of relevance attributed to the business digitalization both before and during COVID is "E-commerce" (V1). Although the "E-commerce" tool contributes less to the regression model, since there are other tools that start to stand out more during COVID (such as "Agile tools" (V8) and "Big Data" (V3)), it has great relevance attributed to it both during and before COVID.

In the classification model, in addition to "E-commerce" (V1), we found that another important variable in the classification at both moments is "Cloud solutions" (V2). Compared with what is happening in terms of the regression models, it can be seen that this is more evident in the previous phase to COVID. On the other hand, the technological solution "Agile tools" (V8) enters as an essential tool in the regression model in the COVID phase. Agile tools" (V8) and "Big Data" (V3) have more importance during COVID, in the regression model, due to the need to increase collaborative work and accommodate the large amount of information that is being handled during the confinement period. It should also be noted that, while V9 (BI), in the regression model during COVID, starts to contribute a little less than before COVID, this tool is one of the ones that contribute the most in the classification model. The reduction of the variable values "BI" (V9) has to do with the fact that companies have focused on maintaining their functioning, even if not in their core sector. For that reason, the use of metrics performance and production optimization is no longer a critical factor. One of the most paradigmatic examples in Portugal was the textile sector, where many textile companies had to stop their traditional production and started to produce masks and suits to combat COVID.

Finally, due to having an unbalanced data set (samples of disproportionate dimensions), we took care to apply the Synthetic Minority Oversampling Technique, better known as SMOTE. The results obtained with oversampling techniques were not satisfactory, so we chose not to consider them.

5. Conclusions and Future work

The transformation of the business model, supported by digital technology, is one of the strategies used to respond to disruptive environmental changes. Digital technologies and digitization are an adequate response to the disruptive changes caused by the pandemic COVID-19. Thus, according to [7], digitalization has several common advantages during this pandemic period such as points (*i*) and (*v*), our results show an increase of 8.07 percentage points regarding the utilization of collaborative tools. For points (*iii*), (*iv*), and (*vi*), our results show an increase of big data tools of 3.11 percentage points and, in terms of usage of IoT sensors, a rise of 1.56 percentage points with teleworking.

The results show a change of focus consistently, in some sectors of activity in the use of technologies for the sustainability of associations: (*i*) namely the reduction of electronic commerce due to the bet on the domestic market; and (*ii*) production of new products for maintaining sustainability by sacrificing performance optimizations, achieved at the expense of business intelligence.

On the other hand, a substantial increase in the use of technologies, such as Big Data, IoT / sensors, in the paradigm shift in the essential production of services and non-productive tasks based on teleworking.

The limitation of our work relies on the sample size during a pandemic phase, a diversity of sectors of activity, and little literacy among Portuguese entrepreneurs as emerging telecommunications.

For future work, we want to increase the number and diversity of the sample to measure the degree of digital transformation in the internationalization process of Portuguese companies in a reliable way.

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