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External factors influencing Fablabs' performance

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Abstract. The main contribution of this research project is to provide statistical evidence on some of the external factors that are perceived to have significant impact on the performance of Fablabs. The success of any Fablab requires sound understanding of the external factors that affect its performance. By surveying the sample of 140 Fablabs around the world we could identify four categories of external factors considered to be relevant for the performance of Fablabs, namely – customers/beneficiaries, access to finance, competitive business environment, and volunteers/workers. The original contribution of this research work comes from the lack of detailed knowledge on Fablabs' performance and previous contradictory findings concerning Fablabs' functioning in developed and developing market economies around the world.

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1. INTRODUCTION

Since the financial crisis of 2008 and onwards economic development and economic sustainability have become top-priority for many governments worldwide. In such economic environment, entrepreneurial endeavors constitute a critical success factor for economic progress and the main task of any government is to support them by means of incentives. Fablab is a relatively recent phenomenon introduced by Neil Gershenfeld in the late 1990s at the Massachusetts Institute of Technology (MIT), Center for Bits and Atoms. The Fab Foundation is a US non-profit organization that emerged from MIT's Center for Bits & Atoms Fab Lab Program. The Fab Foundation defines Fablabs as "…a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, to

invent…" (The Fab Foundation, 2018a). The Fab Foundation provides specific examples of Fablabs to demonstrate how each Fablab is different to reflect the particular interests and needs of the community where each resides. One of these examples is the Soshanguve Fab Lab is located in South Africa, just outside of Pretoria, which is operated by a group of local youth called the Bright Youth Council from the community who invested the time and fundraising capacity to build a small community health center that provides printing/resume services[1]. Another example is the Utrect Fablab Proto-space located in Utrecht, the Netherlands, which is a prototyping facility based around small businesses and entrepreneurial activities that provides professional design and fabrication services for small businesses for a fee[2]. Since 1990s, the Fablab model has been developed and became very popular around the world due to the following significant reasons:

- It contributes significantly to innovations' development and entrepreneurship enhancement;
- It provides entrepreneurs (or soon-to-be entrepreneurs) with the access to technology for developing prototypes free of charge;
- It provides connection to other tools of economic development in the ways that will optimize business results.

Since this is a relatively new phenomenon, very little research has been carried out on it. The present research aims to study the external factors influencing the results/performance of the Fablabs. Our findings will contribute to the already available literature by enriching it as well as by offering a new approach to the critical external factors of Fablabs' operations.

2. LITERATURE REVIEW

The literature review on Fablabs remains scant because Fablab is a recent phenomenon. According to Morel "…The first Fab Lab was organized by Neil Gershenfeld in the late 1990s at the Massachusetts Institute of Technology in the Center for Bits and Atoms …" (Morel, 2016). The adoption of the Fablab concept has increased dramatically over the last decade. Indeed, "…in the past few years, the total number has doubled about every 18 months... These labs form part of a larger 'maker movement' of high-tech do-it-yourselfers, who are democratizing access to the modern means to make things..." (Gershenfeld, 2005). Today, there are almost 1,300 Fablabs in 30 countries around the world organized as knowledge sharing networks that allow communication among learners, educators, technologists, researchers, makers, innovators, and many other intended users[3]. There are many definitions of Fablabs. The one used in this research article (due to our belief it is the most relevant and comprehensive) shares the notion of Fablabs as special entities organized to allow intended users to foster innovation and invention by supplying resources that allow the transformation of computer data into tangible objects (e.g. prototypes) for a wide variety of goals, including but not limited to educational and entrepreneurial ones. A more detailed definition of Fablabs describes them as "… fully equipped laboratories (or workshops) with computer-controlled machines that allow anyone to make (almost) anything: from integrated circuit boards to complete houses… they are based on a shared knowledge network which distributes processes and projects on the Internet…" (Diez, 2012). Gershenfeld describes Fablabs as centers for digital "…manufacturing processes in which the materials themselves are digital…" (Gershenfeld, 2005). Capdevila (2014) suggests the notion of Fablabs as spaces of collaborative innovation where entrepreneurs can advance their projects in an environment with appropriate conditions for collective creativity.

[1] See http://www.fabfoundation.org/index.php/the-community-function/index.html
[2] *Ibid.*
[3] See https://www.Fablabs.io/labs

Redlich et al. study 94 Fablabs to identify differences between different world regions. They find that the most important funding sources for Fablabs are through membership fees and external project resources. They also find that membership fees are a common source of funds for 45 percent of Fablabs in developed countries while just 21 percent rely on this funding source. However, they find that Fablabs in developed countries are much more successful in obtaining funds from external projects and donations than developing countries. This research project differs from Redlich's in identifying whether the availability of financial funds is perceived as an external factor that explains the performance of Fablabs.

Sevastanos, Bellini, and Sapienza (2017) study the strengths and weaknesses of the Fablab models implemented in Italy. They identify four specific indicators to assess the performance of Fablabs: number of members, community, number of activities and education hours, and number of projects managed within the Fablab. The present research project provides different results from those of Sevastanos, Bellini, and Sapienza because the sample includes only Fablabs focusing on entrepreneurship enhancement rather than on education. Dreessen, Schepers, and Leen (2016) study the case of the European Fablab Genk where several activities are designed to address the lack of long-term relationships with nontraditional makers, specifically non-expert users like children and teenagers from the surrounding neighborhoods. They conclude that long-term engagement can be achieved by building meaningful relationships with the communities where the Fablab operates. This research project provides results different than those of Dreessen, Schepers, and Leen (2016) since the users of the analyzed Fablabs are traditional makes, namely entrepreneurs, since the sample includes only Fablabs focusing on entrepreneurship.

Mortara and Parisot (2017) classify Fablab-spaces based on the competencies available to entrepreneurs and the way these competencies are delivered. After studying 73 Fablabs they conclude that their predominant business model relies on the knowledge of an extensive community of experts in different areas. Ruberto (2015) studies the relationship between innovation infrastructures, Fablabs and the Italian industry sector. They find that a critical element for a Fablab community is the notion of sharing knowledge so Italian Fablabs are organized in a global network of local labs. They also find that qualified human resources also constitute another critical resource available to Italian Fablabs that allows users to obtain better results. This research project provides a different approach than that of Mortara and Parisot (2017) and Ruberto (2015) by studying the availability of volunteers/workers and its impact on the performance of Fablabs

Mortara and Parisot (2016) study the experience of eight entrepreneurs with Fablabs by applying semi-structured interviews. They find that entrepreneurs can find encouragement and support at Fablab-spaces through appropriate conditions that reduce the fear of failure. Katzy (2012) proposes a model to fund Fablab from individual business angels, corporate investors, or institutional venture capitalists, in exchange for opportunities to join investable projects resulting from the entrepreneurship process taking place at the Fablab.

Osuyomi (2016) et al. study the tools and techniques within 94 Fablabs ecosystems. They find that most Fablabs focus on community-building and educational seminars, while just a few focus on fostering innovation and entrepreneurship. They also find that most surveyed Fablabs are established within educational institutions, so most of their users are students. Similarly, most of their surveyed Fablabs find collaborating with other Fablabs very helpful. Likewise, they also find that most Fablabs use funding and grants from government and other sponsors. This research project differentiates from that of Osuyomi (2016) in that the sample comes from a narrower population of fully operational Fablabs focused on entrepreneurship enhancement. Individual comparisons of Osuyomi's (2016) results with those of this research project are presented in the next sections of this article.

3. METHODOLOGY

This section presents the research methodology and explains the methods of data analysis chosen for this research. In addition, the techniques for empirical data collection and how empirical data has been analyzed are explained. Similarly, the validity and reliability of the research instrument are also examined in this section.

The research data was collected from randomly selected Fablab operators. Fablab is a digital fabrication laboratory, which is set up to inspire people to turn their ideas into prototypes of new products by giving them access to a range of advanced digital manufacturing technologies. There are 1,045 Fablabs in the world as of 2017, of which 10 percent are not operating. From all of those that were working, only 323 were focusing on entrepreneurship enhancement. This study deals with some external factors that may impact the performance of a Fablab. 140 Fablab operators were randomly selected worldwide and primary data were collected using a structured questionnaire intended to be responded by key people, in this case, the Fablab's decision maker. The sample of 140 Fablabs was taken over a population of 219 fully operational Fablabs and focused on entrepreneurship enhancement, which provided a confidence interval of 5 percent with a confidence level of 95 percent. This unique sample makes this analysis original since most of the previous studies do not discriminate during the sample selection process. According to Holm (2015) most Fablabs are highly concentrated in education institutions.

Having observed a number of existing questionnaires and surveys used in similar studies, a completely new questionnaire was constructed intended to measure some external factors and their impact on the performance of Fablabs.

The first part of the questionnaire addresses the demographic information of the Fablab operator, information on the Fablab facility as well as success stories about the institution. The second part contains questions intended to measure the impact of some factors considered to determine the dynamics of achieving Fablab business results. The responses are measured on a Likert scale and appropriate analysis was performed to assure the reliability of responses allowing for partial comparison of the gathered information.

The data collected were further verified in order to remove measurement errors after coding and processing in Microsoft Excel software, The SPSS statistical package was used for quantitative statistical evaluation such as univariate and multivariate analyses, descriptive statistics, as well as relevant test of variable significance. Due to the specific needs of the research, the R statistical programming language was also used (Repeated Measures ANOVA).

Hypothesis 1

• *Fablabs' operators perceive highly qualified human capital (workers/volunteers) as a significant factor that can improve their Fablabs' performance.*

When Fablabs' operators can get superior human capital (employees/volunteers), they develop higher expectations about their Fablabs' social impact determined by the tangible meaningful beneficiaries' participation in the Fablab enterprise. This perceived pro-social impact is associated with superior effort, persistence and improvements on Fablabs' performance (Grant, 2008a; Grant et al., 2007), as the positive impact on entrepreneurs can motivate workers even when they find the situation unpleasant. However, this research examines the interplay of beneficiary/worker and Fablab's accomplishments by suggesting that access to highly qualified human capital strengthens the performance of Fablabs enterprise.

Hypothesis 2

• *Fablabs' operators perceive superior access to various sources of finance as a significant factor that impacts the performance of Fablabs*

According to existing literature, efficiency of Fablabs enterprises may result when there is unlimited access to sources of financial funds. Indeed, if Fablabs can get financial funds through government policies, private donors, or other sources, then the expected impact is improvements on Fablabs' performance. Improving the performance of Fablab's businesses require a lot of factors and one of the key questions asked in this research project was about the perception on financial constraints on efficiency and growth of the Fablabs' enterprise. Superior access to financial resources must have a positive impact on the performance of Fablabs.

Hypothesis 3

• *Fablabs' operators perceive their contribution to a healthy and competitive business environment in its community is a measure of Fablabs success.*

An important external factor that impacts the performance of any Fablab is the conditions of the community's business environment where the Fablab operates. Nowadays, business environments are more global and competitive than in the past and a broad range of business factors are connected to the Fablabs performance. An important objective of this research is to show the importance of a healthy and competitive business environment in the community where the Fablab operates. The resources of a Fablab, including its capabilities, competencies etc. are at the center of this study. Fablabs need to better understand the importance of a healthy and competitive business environment to develop strategies that can create competitive advantages for the business enterprises in its communities.

Hypothesis 4

• *Fablabs' operators recognize a significant relationship between getting support for Fablabs activities and extensive networking.*

Fablab enterprises are different from other organizations in many ways. One of the important aspects of Fablabs' operations is the development of an extensive network of volunteers willing to give their time and effort to the Fablab enterprise. Fablab operators are constantly on the search for volunteers/workers because the successful performance of their Fablabs depends largely on the effectiveness of these of volunteers/workers and how the Fablab's manager can work on retaining and motivating these volunteers. The Fab Foundation emphasizes that all Fablabs should "…share knowledge, designs, and collaborate across international borders... Fab Labs must participate in the larger, global Fab Lab network, that is, you can't isolate yourself… (A Fablab) is about being part of a global, knowledge-sharing community. The public videoconference is one way to do connect..." (The Fab Foundation, 2018b). The Fab Foundation also highlights that "…live help and support from volunteers in the network can be accessed through videoconference… where members hang out during the day and can help one another..." (The Fab Foundation, 2018c). Since the sample of this research project was taken from a population of fully operational Fablabs and focused on entrepreneurship enhancement, the Fab Foundation also explain the expected interaction of entrepreneurs and business-related users with the volunteers in the network as follows: "…Commercial activities can be prototyped and incubated in a fab lab, but they must not conflict with other uses, they should grow beyond rather than within the lab, and they are expected to benefit the inventors, labs, and networks that contribute to their success…" (The Fab Foundation, 2018d).

4. EMPIRICAL RESULTS AND DISCUSSION

This section explains the structured analysis used in this research project. This analysis is based on a sound methodology which will allow for theory development that has a close fit with data collected from the studied Fablabs. Furthermore, this analysis is intended to shed light into some external factors which affect the performance of Fablabs.

Validity Test

The test of validity was used to determine whether there is a good match between the researcher's observations and the theoretical ideas proposed in this research work. The empirical data were subjected to the Cronbach's Alpha test of reliability and the result obtained is displayed in the table below:

Reliability Statistics	
Cronbach's Alpha	N of Items
.649	30

*Number of items refers to the number of questions from the survey

In order to examine the validity of the items used in the assessment, reliability test was conducted on the items presented in the questionnaire using the Cronbach Alpha test of reliability and 0.649 Cronbach Alpha value was obtained. Constructs with Cronbach Alpha value greater than 0.4 are considered to have good reliability. This implies that the construct is good enough to measure some external factors that influence the performance of Fablabs. All the constructs used in this research project are observed to have a relatively high Cronbach Alpha value which is an indication that they can be characterized as reliable constructs.

Results

This section presents the general information about Fablabs and some factors affecting its performance. The section also provides the empirical confirmation of the hypotheses introduced previously in addition to a summary of the most important findings.

The summary of respondents' opinions on their perceptions about some external factors influencing the Fablab's performance is presented below. The values are displayed in percentages and they indicate the proportion of the respondents' opinions on the perceived rating of Fablab's external factors measured on a 5-point Likert scale.

The results on the table above suggest that the respondents agree with maintaining a positive perception on some external factors which are believed to influence the Fablab's performance. The variable of success/failure of Fablabs is defined by a combination of performance indicators on Fablab activities from the respondents' opinion.

In line with the theoretical elaboration provided, five sub-variables measured with a Likert scale (1 – Strongly Agree, 2 - Agree, 3 - Neutral, 4 - Disagree, 5 – Strongly Disagree) were created and defined for each of the external factors stated in the hypotheses.

High correlations among some variables prompted the decision of combining them into 4 categories of external factors. This was done through operating out the mean for all identified similar responses for a particular effect thereby making an overall score for all of the 4 categories of external factors. These four categories generated from the surveyed responses are presented below:

- Customer/Beneficiary
- Access to Finance
- Competitive Business Environment
- Volunteers/Workers

Environment Characteristics	LIKERT SCALE				
	SA	**SA**	**N**	**D**	**SD**
Obtaining Financial Support is one of Fablab's problems.	30	20.7	30	14.3	5.0
Frequency of miss-operation of Fablab's equipment has various consequences.	7.1	20.0	42.1	21.4	9.3
Trying to improve beneficiaries' access to location.	31.4	30.7	32.9	4.3	0.7
Challenge about potential beneficiary awareness.	25.0	32.1	34.3	5.0	3.6
Problem with finding qualified human capital.	26.4	32.1	25.7	10.0	5.7
Increased Startups number in the community due to Fablab activities.	15.0	25.0	39.3	13.6	7.1
Fablab is about spreading know-how and innovativeness.	64.3	27.1	6.4	1.4	0.7
Fablab is about sustainable development of local economy	42.9	31.4	16.4	7.1	2.1
Fablabs contribution is necessary for business competitive environment	27.1	35.0	25.0	10.7	2.1
Fablab is about improving the quality of goods and services	22.9	36.4	24.3	12.9	3.6
4 is vital for Fablab success	68.9	20.0	6.4	3.6	1.4
Benefit of network is the facilitation of access to finance	21.4	27.1	28.6	17.1	5.7
Support for activities is as a result of extensive network	26.4	42.1	22.9	7.9	0.7
Getting more customers will be better	41.4	32.1	20.0	4.3	2.1
Efficient operation is Fablab's Strong point	20.7	31.4	33.6	13.6	0.7
Network extension will be of great help	47.1	31.41	16.4	4.3	0.7
Health and safety are well handled in Fablabs	30.0	37.1	20.7	12.1	0
Fablab's cost is very efficient	17.9	24.3	40.0	15.7	2.1

Note: Likert scale 1-5 where SA = Strong Agree, A = Agree, N = Neutral, D= Disagree, and SD=Strongly Disagree

T-Test

To examine the significance of the external factors and its effect on the performance of Fablabs, the one-tailed student t statistical method was employed to test the significance of the mean value computed for each of the categories of external factors under study.

External Factors	Mean (Standard Deviation)	t-test (*P-Value*)
Customer/Beneficiary	5.27(.95)	5.55(*0.003*)
Access to Finance	3.47(1.08)	5.55(*0.003*)
Competitive Business Environment	5.21(.91)	3.21(*0.046*)
Volunteers/Workers	4.35(.36)	12.08(*0.000*)

The summary of t-test of significance presented in the table above examines the effect of the categories of external factors by setting up a one-tail hypothesis to examine if the means are statistically significant. The results show significant differences for all of the external factors examined with $\alpha < 5\%$ for all of the factors under study. The data were also analyzed using the one sample nonparametric tests with similar significant results, so these results have been omitted in this report.

Repeated Measures ANOVA

Repeated-measures ANOVA examining effects of identified external factors on the performance of Fablabs.

External Factors	*df*	*MS*	*F*	*p-Value*	*Partial η 2*
Customer/Beneficiary	4	81.88	67.57	0.001	.411
Access to Finance	4	36.09	67.41	0.001	.410
Competitive Business Environment	4	59.47	86.81	0.001	.472
Volunteers/Workers	4	58.43	79.34	0.001	.438

Respondents' Perception of the effect of External Factors on Fablabs success or failures

The repeated measure ANOVA was used to examine the relationship between the respondents' opinions on how getting more customers/beneficiaries influences the performance of Fablabs. ($F(4, 137) = 67.57$, $p < .001$, partial $\eta 2 = .41$). Pair-wise comparisons revealed that getting more customers/beneficiaries has a significant effect on the perception of the respondent about the Fablab's success. These results are consistent with those of Osunyomi (2015) who finds that most of the users who visited Fablabs were students while entrepreneurs constituted a minority among Fablab users. However, our analysis is different in the sense that the analyzed sample of Fablabs were focusing on entrepreneurship enhancement. In other words, getting more customer/beneficiaries is still a concerning external factor even for those Fablabs who focus on entrepreneurs.

The relationship between the respondents' opinions about the influence of available financial resources on the performance of Fablabs ($F(4, 137) = 67.41$, $p < .001$, partial $\eta 2 = .41$) was also examined. Pair-wise comparisons revealed that accessible financial resources have a significant effect on the respondents' perceptions about the Fablab's success. These results are different from those of Osunyomi (2016) who only reports the nature of the Fablabs' funding sources. He reports that most surveyed Fablabs obtain fund from government and other sponsors, followed by those Fablabs who charge their members certain amount for sustaining their workshops.

Another important analysis is the relationship between the respondents' opinions on the competitive business environment of the Fablabs' communities and the performance of Fablabs ($F(4, 137) = 86.81$, $p < .001$, partial $\eta 2 = .47$). Pair-wise comparisons revealed that a healthy and competitive business environment in the Fablabs' communities has a significant effect on the respondents' perception about the Fablab's success. These results are consistent with those of Suire (2015) who finds that the performance of Fablabs measured by projects resulting in new business enterprises is a function of interactions between Fablabs and its socio-economic embedding. These results are also in harmony with those of Suire (2018)who find that the performance of Fablabs measured by the number of prototypes increases when interacting with small companies whereas more spin-offs are produced when working with large firms.

The relationship between the respondents' opinions about the availability of volunteers/workers and its impact on the performance of Fablabs was also studied ($F(4, 137) = 79.34$, $p < .001$, partial $\eta 2 = .44$). Pair-wise comparisons revealed that the availability of volunteers/worker has a significant effect on the respondents' perception about their Fablabs' success. These results are in harmony with those of Osunyomi (2016) who finds that surveyed Fablabs operates with the assistance of volunteering enthusiasts as well as the help from instructors or advisors.

The repeated measure ANOVA (F tests) was also used to examine the impact of some selected external factors on Fablabs' successful operations. With the significance level α of 5, the results presented above suggest that the categories of the external factors maintain a positive relationship with the Fablab's performance.

Correlation Coefficient

Ordered responses of support for Fablabs activities and extensive networking were selected and a significant test of Kendall Tau correlation was employed due to the fact that these responses were measured on the ordinal scale. The results of their analysis are presented in the table below:

Kendall Tau Correlation Coefficient	P-Value
0.241	0.001

Based on the result of the Kendall Tau procedure, a significant correlation was observed between the ordered responses from Fablabs operators and this supports the notion of a significant relationship between getting support for Fablabs and an extensive networking intended to support the Fablabs' activities ($r_\tau=0.241$,p-value=0.001). Fablabs allow users to work together collaboratively to design, test,

and manufacture any desired object or solution with the support of the Fablab's manager and its network. Savastano, Belliniand D'Ascenzo (2017) define this Fablab network as "…an open, creative community of fabricators, artists, scientists, engineers, educators, students, amateurs, professionals, located in more than 40 countries…(sharing) the mission of democratizing access to the tolls for technical invention…" (Savastano, Belliniand D'Ascenzo, 2017)

Discussion

The contribution of this research work is derived from a structured approach that covers a range of external factors and their influence on the performance of Fablabs. It is worthy to note that the study does not include any internal factor (i.e. entrepreneurs' personality and strategic measures) which are a common subject of scientific analysis of Fablabs' performance. Even though internal factors were not included in this study, they have undeniable influence on the Fablabs' performance.

This study confirms that some external factors should be considered as critically important for both scientists and Fablab's operators, keeping in mind their dynamism and variability over time. The study also provides additional information about the performance of the Fablab enterprise. This research is equally useful for Fablabs' operators who may use the results to increase their Fablabs' performance and provide a healthy and competitive business environment to the communities where they operate.

Though in general, the results of this research can be said to support most of the up-to-date theoretical and empirical conclusions about some external factors influencing Fablabs' performance, there are limitations to this study regarding a specific and more detailed comparison. Therefore, further research on various Fablab samples are recommended to improve the reliability of the results obtained in this research work.

Innovation and entrepreneurship are two critically important factors that positively impact any national economy. Fablabs can enhance them by providing a physical space with appropriate conditions and resources where users can develop their innovative projects. The collaborative approach of Fablabs fosters sharing knowledge that can facilitate developing concepts and ideas or even prototypes that can result in marketable products. Le Roux describes the Fablab model as one that allows members of a community to exchange ideas, software, ways of doing things, and results "...without difficulty, with no particular effort, with no entry barriers, with no monetary involvement, by respecting the group's basic internal rules, based on mutual recognition and trust..." (Le Roux, 2015). Entrepreneurs can receive significant benefits from Fablabs by supporting them on developing a project out of an idea. Today's competitive economies are those who can deliver innovative products or services to be validated in the market place. For this reason, many national governments consider Fablabs a strategic tool for development and provide them with financial and logistic support. All the external factors affecting Fablabs' performance can be significantly improved by the direct support of national governments. This support can be politically justified by the economic and social benefits derived from the entrepreneurial process.

5. CONCLUSION

It is obviously that Fablabs are contributors to entrepreneurial enhancement. Entrepreneurship contributes significantly to economic progress, worldwide knowledge exchange as well as innovation development. To increase the potential of Fablabs, it would be desirable for business incubators, special economic zones and business parks to have at least one Fablab attached to them according to the nature of their primary economic activities. It would be also beneficial to organize regional Fablabs' clusters based on their specialization and the particular needs of potential users.

We estimate that the Fablab phenomenon will foster innovation and promote economic growth in the future. Fablabs may become serious competitors of business incubators and business accelerators due to the fact that the Fablab model will expand its services and will emphasize meeting the needs of their current customers. Regarding funding, researchers also believe that government should create support programs to spread and fund Fablab activities, as they play a major role in innovation and economic development.

One of the limitations of this research project is that the data were collected from Fablabs' operators, but no information exists about the same external factors from the perspective of Fablabs' users. Future research efforts may arise by collecting data from Fablabs' customers that will allows for the validation of the results presented above. These data may also help to determine whether the analyzed external factors affecting the successful performance of a Fablab can be validated as such by its users, particularly entrepreneurs. Another limitation of this study is the extremely diverse sample that does not allow making relevant analysis among countries. Indeed, the countries with the largest number of Fablabs in the sample are the U.S. and Italy (16 Fablabs each), followed by France (12 Fablabs) and by Canada and Germany (6 Fablab each). These subsamples are so small that no reliable conclusions can be derived from them. This diversity in the sample is consistent with the study of Zee, Rehfeld, and Hamza (2015), who finds that by April 2015, France had 31 percent of all European Fablabs, followed by The Netherlands with 15 percent, Germany with 12.6 percent, U.K. with 11.5 percent, and Spain with 9.19 percent. One possible extension of the current research work would be creating two subsamples with developed and developing countries. The caveat of this extension would be the lack of universally accepted definitions of developed and developing countries. The definitions available classify countries as developed or developing using macroeconomic variables (e.g. GDP, Income per capita, etc.) and this approach may be relevant for some but not all the external factors considered in this study.

Being a click away from the development of new information technologies (e.g. Web 3.0; 5G Mobile network, etc.), we believe that a new improved version of Fablab will be developed allowing entrepreneurs to have fast-prototyping manufactured remotely from the comfort of their offices or homes. This improved version of a Fablab will need to emphasize the needs of its virtual customers and they may be the focal point of future research projects in the field.

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