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# Intellectual Capital of Technology-Based Incubators

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**Abstract:** The objective of this work is to evaluate the associations between the intellectual capital of technology-based incubators in the sustainability of incubated companies located in Portugal. For this purpose, the methodological strategy employed was the survey, and to test the hypotheses the Partial Least Squares Structural Equation Modeling PLS-SEM method was applied from a sample of 82 incubated company managers. The results show that the intellectual capital of the incubator company has a direct and positive relationship with the innovative capacity, satisfaction, and sustainability of the incubated company. In turn, the incubated company's innovative capacity has a direct and positive impact on sustainability itself. In addition, both the sustainability of the incubated company and its levels of satisfaction with the incubated company has a positive and direct impact on its competitive success. The management implications include the perception that the greater the effort to improve the human capital, structural capital, and relational capital of the incubated companies, the better will be the results achieved in supporting companies, helping start-ups develop sustainably and competitively in the market.

**Keywords:** intellectual capital; sustainability; technology-based incubators; success competitive and innovation

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## 1. Introduction

In 1987, the Brundtland Report (ONU-United Nations 1987) analysed the needs of the present without compromising the ability of future generations to meet their own needs. Since then, efforts to build more sustainable societies have filled pages. The sustainability of business has become a constant struggle, not only to ensure that future generations have, in an innovative way, the means to survive, but also to meet the needs of the present without causing deterioration in world conditions (Elkington 1994; Mousavi et al. 2019).

However, for the theoretical approach to be effective in practice, it seems necessary that the intellectual capital of incubators flows to the incubated companies constantly and effectively. The transfer of knowledge, forms of management, relationships, and contacts, will have an impact on the incubated companies, facilitating innovation, ensuring its sustainability, and, finally, guaranteeing its competitive success in the market. Thus, this work is based on relevant issues and seeks to contribute to the current state of science with new theoretical and empirical contributions that bring light to the still little-studied incubator-incubated relationship. There is no consensus in the specialized literature about which components of intellectual capital are most relevant, but there are indications that intellectual capital can be composed of human capital, structural capital, and relational capital (Chen et al. 2014).

Because of this, it emerges as a research question: what associations exist between the intellectual capital of technology-based incubators in the sustainability of incubated companies? To answer this question, the objective of this work is to evaluate the associations between the intellectual capital of technology-based incubators in the sustainability of incubated companies located in Portugal.

With this, it is expected to contribute to correctly channelling the efforts of the public administration and the management of incubated companies to improve their intellectual capital, whose impacts can be positive in the development of a more sustainable and competitive business fabric.

This work is structured in five sections. After this introduction, the theoretical framework is presented, followed by the methodology. The Section 4 discusses the results and the final considerations.

## 2. Theoretical Background

### *2.1. Intellectual Capital*

In establishing a classification of the various elements of intellectual capital, we find in the literature review the existence of contributions from several authors (Huang et al. 2007; Soewarno and Tjahjadi 2020) that refer to the lack of consensus regarding their components. However, in recent years, as already pointed out in the previous point, there seems to be some consensus on dividing intellectual capital into three main components: human capital, structural and relational capital, or client capital (Chen et al. 2014; Mouritsen 2009; Muhammad and Ismail 2009; Sveiby 1997).

On the other hand, other authors consider only two components: human capital and structural capital (Edvinsson and Malone 1997). Giuliani (2013), in his article, mentions that for a company to succeed all the components of intellectual capital need to be combined to generate value. Baron and Armstrong (2007) describe three dimensions: human, social, and organizational capital.

Human Capital includes all the knowledge, qualifications, skills, and abilities to develop and innovate that are held by the people of an organization (Baron and Armstrong 2007). Human capital is the set of all tacit knowledge existing in the company (Sydler et al. 2014). Add to that the skills, experiences, creativity, and knowledge of the human resources that make up the organizational culture (Bayraktaroglu et al. 2019; Soewarno and Tjahjadi 2020).

Social or relational capital is a set of structures, networks, and procedures that allow these people to acquire and develop the intellectual capital represented by the stocks and flows of knowledge derived from internal and external relations of the organization (Baron and Armstrong 2007). Relational capital is an intangible asset that develops, sustains, and maintains good relationships with all stakeholders, internal and external, influencing the performance of the company (Bhatti et al. 2021; Welbourne and Pardo-del-Val 2009).

Organizational capital, also called structural capital, is the institutionalized knowledge and codified experience, stored in databases, patents, and manuals (Youndt and Snell 2004). Structural capital is the institutionalized and codified knowledge that belongs to the company (Bayraktaroglu et al. 2019), included in databases, strategies and organizational routines, and procedures manuals. It can also be considered the skeleton of the company because it includes the necessary tools and architecture to retain, store, reinforce, and transfer knowledge in all activities of the organization (Guthrie et al. 2012).

### *2.2. Incubators*

In the literature, there are several definitions of business incubators. According to Vedovello (2000, p. 280): "there is no single definition that can be applied to all technology parks and business incubators, due to their great diversity and heterogeneity concerning their models".

The concept of a business incubator is usually linked to companies that provide and create a favourable environment for the creation and development of start-ups and small and medium-sized enterprises (SMEs) (Kiran and Bose 2020; Saura et al. 2019). Business

incubators are mechanisms maintained by government entities, universities, groups of entrepreneurs, etc., that drive and help accelerate the business development of incubated companies (Dornelas 2002). The main objective of the incubator is to produce successful, constantly evolving, sustainable, and competitive companies in its market (Saura et al. 2019; Vedovello and Figueiredo 2005).

There are several types of incubators, depending on the type of company to be supported, and different authors present different types, such as technological or university-based, regional, mixed, independent commercial, and virtual (de Souza et al. 2008). Macedo and Boava (2009) and Serra et al. (2011) present and describe 10 types of incubators, according to the type of company: technological base, traditional, mixed, sector, cultural, social, agro-industrial, cooperative, rural, and virtual.

The technology-based incubators are companies that have technology as their core business. They have some distinct characteristics of the traditional industry, such as greater market dynamism and shorter product life cycles. The dimensions of innovation, flexibility, and agility in dynamic environments, which have been transforming the various forms of business competition, are the main attributes of technology-based companies (Lacerda et al. 2017).

### 2.3. Sustainability as a Corporate Goal

The paradigm of Corporate Social Responsibility (CSR) has evolved rapidly since the European Union enacted the Green Paper to promote a European framework for corporate social responsibility (Commission of the European Communities 2001). Today, the concept of CSR has been integrated into a broader concept of corporate sustainability (Silvestri and Veltri 2020; Zhang et al. 2019).

One of the great challenges for companies is to be able to show how they manage sustainability issues, behaving responsibly in environmental and social dimensions, while achieving their economic goals. The integration between these three aspects is called the Triple Bottom Line (TBL) (Elkington 1999).

The expression TBL, also known as the sustainability tripod, refers to the pillars that should guide the management of companies, from their supply chain to sustainable competitiveness (Beske et al. 2014). Thus, sustainability, from the business perspective, must be based in a balanced way on the three dimensions mentioned, so that sustainability is a systemic concept, related to the continuity of economic, social, and environmental aspects of human society (Chang and Cheng 2019; Mcwilliams et al. 2016).

Innovation capacity has been reported to be associated with sustainability in several contexts, as the higher levels of innovation can lead to the adoption of sustainability practices due to new management practices, values, culture, and leadership (Ghobakhloo et al. 2021; Nylund et al. 2021; Schoemaker et al. 2018).

Likewise, through a knowledge-based view (KBV) (Tu and Wu 2021) the organization's intellectual capital can be related to sustainability and innovation (Benevene et al. 2021), due to openness to experiences and multiple skills for new forms of management. Intellectual capital is also able to reinforce the satisfaction of the incubated companies because solid knowledge can favour the satisfaction of the incubated ones concerning the incubators (Abduh et al. 2007).

Regarding the satisfaction of the incubated companies, according to O'Neal (2005), the quality of the service provided by the incubator to the incubated entrepreneurs will be decisive for the success of the incubator, which can be understood as the formation of more lasting and successful companies. In this sense, according to Lam et al. (2005), the quality of services generates satisfied customers. High satisfaction leads to a better reputation, less cost to attract new customers, fewer resources devoted to complaint management, and more referrals from customers.

According to Adlesic and Slavec (2012), when incubated companies are satisfied, they certainly see the benefits of the incubator's programs and will spread "word of mouth" to potential clients and will commit to their incubator. The major concern of companies

has always been customer satisfaction, as a satisfied customer is a step toward competitive success (Mansano and Gorni 2014).

Sustainability, in turn, can increase competitive advantage as a response to strict environmental regulations, highlighting the organization against competitors (Tu and Wu 2021). This is because companies that implement sustainability practices can signal attention to social responsibility and consumer demand (Tu and Wu 2021).

The conceptual model of this research is outlined below.

### *2.4. Conceptual Model*

The hypotheses that configure the theoretical model developed (Figure 1) for this research are the following:

**H1:** *The Intellectual Capital of the incubator (IC) has a positive relationship with the Sustainability of the incubators (SUST).*

**H2:** *The Intellectual Capital of the incubator (IC) has a positive relationship with the Innovative Capacity of the incubators (INVC).*

**H3:** *The Intellectual Capital of the incubator (IC) has a positive relationship with the Satisfaction of the incubates (SAT).*

**H4:** *The Innovative Capacity of the incubators (INVC) has a positive relationship with their Sustainability (SUST).*

**H5:** *The Satisfaction of the incubators (SAT) has a positive relationship with their Competitive Success (COMS).*

**H6:** *Sustainability of incubation (SUST) has a positive relationship with its Competitive Success (COMS).*

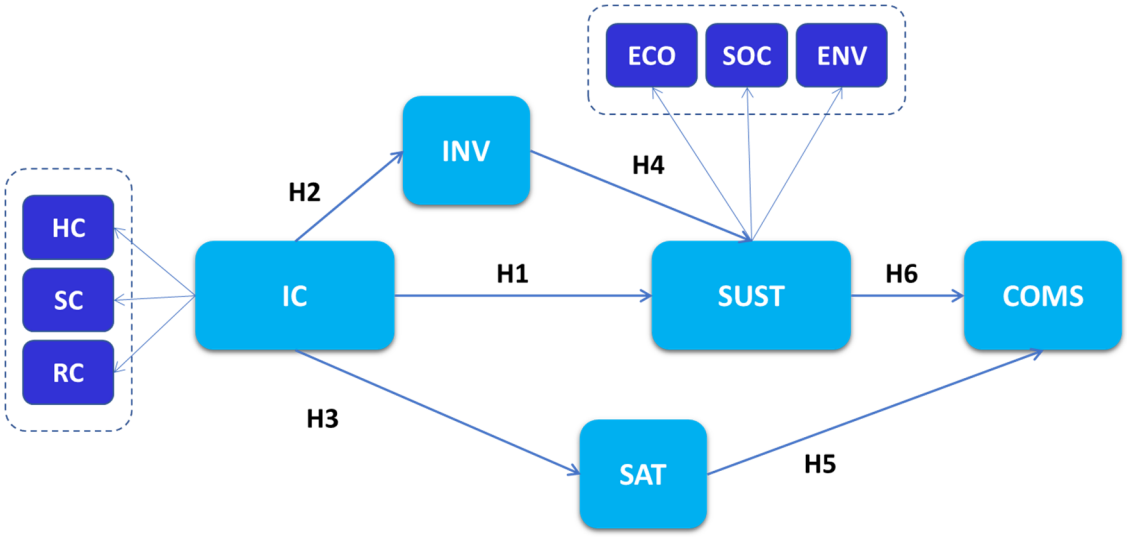


**Figure 1.** Conceptual model Source: prepared by the authors.

The methodological choices of the study are explained below.

## 3. Methodology

This research is from a post-positivist research philosophy, in a deductive approach, where a theory is used and a strategy is sought to test the hypotheses (Saunders et al. 2012). The method is a quantitative one, through the survey strategy. As for the time horizon of the research, we opted for a transversal cut. The techniques and procedures adopted were Partial Least Squares Structural Equation Modelling (PLS-PM) in the Smart PLS 3 software. This technique is based on a graphical representation of the relations between constructs

and their measurements (Hair et al. 2017), and this is called epistemological relations or correspondence rules (Bookstein and Fornell 1982). In these models, the exogenous constructs or independent variables are the predictors or causes of the endogenous constructs.

The use of PLS-PM is justified by the reduced specific sample of the phenomenon studied and the complexity of the structural model with higher-order constructs (HOCs). Thus, the model studied in this work, being a Hierarchical Component Model (HCM), used the two-stage approach described by Hair et al. (2018) to validate and test the proposed hypotheses.

The sample was estimated according to Ringle et al. (2014), and we used the G*Power 3.1 software to calculate it (Faul et al. 2009). The latent construct that receives the highest number of predictors (sustainability and competitive success) was evaluated and used, in this case, two predictors, for calculation within parameters recommended by Cohen (1988) and Hair et al. (2017), with the power of the effect of 0.80, $f^2$ median = 0.15. The minimum sample calculated was 43 cases, as proposed by Ringle et al. (2014), and we collected a sample higher than that indicated by the software G*Power 3.1.

### 3.1. Stages of the Quantitative Study

The quantitative study was divided into several phases. First, the conceptual model was developed exposing the hypotheses for the analysis. Next, the sample selection process and its characterization are explained through descriptive analysis. Then, the measuring instrument is presented detailing the scales used for the study.

Finally, and through a model of structural equations, the measures used for each construct are first analysed, and then the existing relationship between the intellectual capital of the incubator and the other constructs of the model are examined, focusing attention on the sustainability of the incubations.

### 3.2. Measurement Scales

The elaboration of the questionnaire is followed by a rigorous process that involved an exhaustive revision of the bibliography to prepare the initial version of it. To verify if the questionnaire was adequate, and to eliminate possible errors, we proceeded to a pre-test. The questions were tested in personal interviews with two academic experts: one from the greater Lisbon region and the other from the Algarve region, both from the sector under study.

Later, in the process of applying the questionnaire, a pre-test was carried out in a small group of incubated companies, presenting no difficulty in understanding the questions. For the graduation of the answers, a Likert scale of 7 positions was used based on agreement or disagreement with the sentence (1 = strongly disagree to 7 = strongly agree) or based on frequency (1 = never to 7 = always), depending on the case. Theoretical concepts from the literature review were used to create the items and were especially based on the various empirical studies related to intellectual capital (such as those of Bontis et al. (2002).

In the present investigation, the constructs originate from several fields of investigation and follow the lines found in the academic literature previously reviewed in this work. In the final version, the questionnaire was structured, as shown in Table 1.

The first table asked for general data, such as the name of the company, and the position held by the person filling out the questionnaire, and briefly explained the purpose of the questionnaire and instructions for answering it. The following section included questions about the human capital, structural capital, and relational capital of the business incubator. In the following section, we gathered questions about the innovative capacity, competitive success, and sustainability of the incubated companies.

**Table 1.** Questionnaire Structure.

| General Data of the Incubated Company | Name of the Company and Position of the Respondent to the Questionnaire |
|---|---|
| Characteristics of the incubated company | Identification and sectors of economic activity of the company |
| Human capital of the incubator | 20 questions |
| Structural capital of the incubator | 21 questions |
| Relational capital of the incubator | 10 questions |
| Innovative capacity of the incubator | 06 questions |
| Competitive incubation success | 10 questions |
| Satisfaction with the incubation | 12 questions never/no time |
| Sustainability of the incubation | 35 questions |

Source: prepared by the authors.

The intellectual capital scales and their sub-scales were adapted from several studies (Bontis et al. 2000; Neely and Hii 2014; do Rosário Cabrita and Vaz 2005; Hii and Neely 2000; Santos-Rodrigues et al. 2011; Subramaniam and Youndt 2005; Subramanian and Nilakanta 1996; Youndt and Snell 2004). To measure the structural capital, 21 items were defined to evaluate the director's perception of the determinant aspects for the sustainability of the incubation, based on several academic works. To measure relational capital, 10 items were defined to assess the director's perception of the determinants for the sustainability of the incubation and the measurement of the construct relative to the innovative capacity, the scale of Santos-Rodrigues et al. (2011) was adapted to the studies of Hii and Neely (2000) and Neely and Hii (2014) Aspects related to product/service innovation, aspects related to process innovation were considered and, finally, we considered aspects related to management innovation.

The representative construct of competitive success materialized through items adapted from (Gallardo Vázquez et al. 2012). These focus on the competitive success of the incubated company seeking to know to what extent the company's achieved success through the introduction of various indicators.

The measure of satisfaction was adapted to the scale of Adlesic and Slavec (2012) and materialized through 12 items.

The sustainability construct measure was adapted from Gallardo Vázquez et al. (2012) scale, which divides the construct into three sub-constructs: economic, social, and environmental dimension.

### *3.3. Procedure, Sample Selection, and Characterization*

The study was developed through the preparation and administration of an ad hoc questionnaire prepared by the researchers from the academic literature consulted and the available scales of measurement adapted to the objective of the study. The questionnaire was sent to the entire population census, 103 companies incubated by the 16 business incubators of the qualitative study previously conducted, located in Portugal. The questionnaire was sent by e-mail in October and November 2016. The companies were contacted by telephone, by e-mail, and even in person to get the largest number of answers. Finally, we finalized the fieldwork with 82 valid questionnaires, answered by directors or managers of the incubated ones, which presupposes about 80% of the population object of study.

Although the sample for this research was collected in 2016, the theme of the associations between the intellectual capital of technology-based incubators and the sustainability of incubated companies located in Portugal remains relevant, as the theme addressed in this research on intellectual capital has not yet been explored by other researchers or published in the specialized literature. The COVID-19 pandemic that started at the end of 2019 and lasted until 2022, made it hard to do new research, which is another reason why this article is important for the field.

## 4. Results and Discussion

### *4.1. Analysis of the Measurement Model*

First, we evaluate the validity and reliability of the measurement model. For this, we calculate the individual reliability of each indicator by evaluating the loads (λ) or simple correlations of the indicators with their respective construction. According to the most demanding criteria for the validation of indicators, the indicators should have a load greater than 0.700 (Pestana and Nunes 2014), although some authors consider loads of 0.5 or 0.6 acceptable in recent measuring instruments (Chin 1998).

It should be noted that the model considers two higher-order constructs (HOCs), intellectual capital and sustainability. The two-stage approach described by Hair et al. (2018) was used to validate the model. Firstly, loads of the indicators of each lower-order construct (LOCs) relative to sustainability were calculated, which presented three lower-order constructs (economic, social and environmental), and then to intellectual capital, which is also composed of three lower-order constructs (human capital, relational capital, and structural capital). In the first stage, the indicators of the lower-order constructs were repeated in the higher-order constructs. Then, the LOC scores were saved to be used in the second stage. The final model after the second stage described by Hair et al. (2018) can be seen in Figure 2.

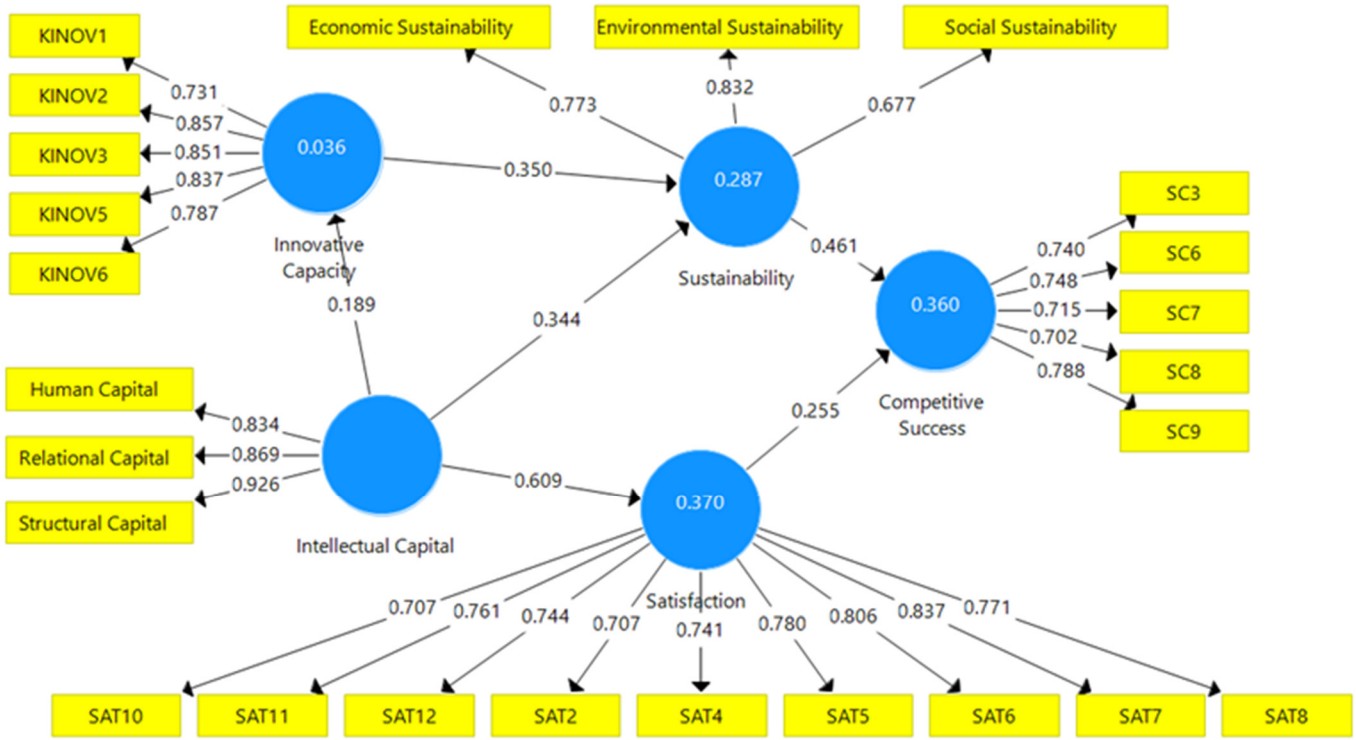


**Figure 2.** Measurement model. Source: prepared by the authors.

The evaluation of the measurement model was carried out, and Table 2 shows that the items comply with the reliability criteria established by Hair et al. (2017). The sustainability construct presented a Cronbach's α marginal of 0.645, but the reliability of this construct was confirmed by the criteria of rho. A and composite reality, both excellent (Hair et al. 2017). Since composite reliability is a measure of internal consistency reliability, which, unlike Cronbach's alpha, does not assume equal indicator loadings, it is preferable to Cronbach's alpha for PLS-PM. Cronbach's alpha is limited by the sample size and the number of items in each construct, but composite reliability is not (Hair et al. 2017). Cronbach's alpha is the lower limit, and composite reliability is the upper limit for internal consistency reliability.

The rho A reliability coefficient usually falls between these limits and serves as a good representation of the reliability of the internal consistency of a construct (Hair et al. 2017).

**Table 2.** Adjustment quality parameters.

| Construct | Indicators | Loadings | Cronbach's α | rho_A | CR | AVE | $R^2$ |
|---|---|---|---|---|---|---|---|
| Sustainability | Economic | 0.773 | 0.645 | 0.655 | 0.806 | 0.583 | 0.287 |
| | Environmental | 0.832 | | | | | |
| | Social | 0.677 | | | | | |
| Intellectual Capital | SC | 0.926 | 0.850 | 0.856 | 0.909 | 0.769 | - |
| | RC | 0.869 | | | | | |
| | HC | 0.834 | | | | | |
| Innovative Capacity | KINOV1 | 0.731 | 0.872 | 0.876 | 0.907 | 0.663 | 0.036 |
| | KINOV2 | 0.857 | | | | | |
| | KINOV3 | 0.851 | | | | | |
| | KINOV5 | 0.837 | | | | | |
| | KINOV6 | 0.787 | | | | | |
| Satisfaction | SAT10 | 0.707 | 0.910 | 0.912 | 0.926 | 0.582 | 0.370 |
| | SAT11 | 0.761 | | | | | |
| | SAT12 | 0.744 | | | | | |
| | SAT2 | 0.707 | | | | | |
| | SAT4 | 0.741 | | | | | |
| | SAT5 | 0.780 | | | | | |
| | SAT6 | 0.806 | | | | | |
| | SAT7 | 0.837 | | | | | |
| | SAT8 | 0.771 | | | | | |
| Competitive Success | SC3 | 0.740 | 0.794 | 0.803 | 0.857 | 0.546 | 0.360 |
| | SC6 | 0.748 | | | | | |
| | SC7 | 0.715 | | | | | |
| | SC8 | 0.702 | | | | | |
| | SC9 | 0.788 | | | | | |

Source: prepared by the authors.

A measure of the predictive power of our model is obtained by analysing the value of $R^2$ that indicates the amount of variance of a construct that can be explained by its predictors, in this study the sustainability of incubates and as an expected consequence, its competitive success. In the evaluation of Pearson's coefficient of determination ($R^2$) calculated for the latent variable sustainability was 0.287 considered large; for the variable innovative capacity $R^2$ was 0.036 considered small; for the variable satisfaction, $R^2$ was 0.370 considered large. Finally, for the competitive success variable, $R^2$ was 0.360 considered large (Cohen 1988). In general, in this model, we find acceptable values.

The average variance extracted (AVE) developed by Fornell and Larcker (1981) represents a convergent validity measure and is applied mainly to reflective indicators. This measure provides the amount of variance that a construct obtains from its indicators concerning the amount of variance due to the measurement error. According to Fornell and Larcker (1981), AVE values must be greater than 0.50, which means that more than 50% of the variance of a construct is due to its indicators. Thus, the convergent validity was confirmed (Hair et al. 2017).

Once the convergent validity was verified, the discriminant validity was analysed. It is assumed that any construction should share more variance with its indicators than with the other constructs in the model (Fornell and Larcker 1981). One way to analyse and confirm discriminant validity is to analyse whether the square root of the mean extracted variance (AVE) is greater than the correlation between this construct and all the others that make up the model, and it has been proven that effectively all cases comply with the established condition, according to Table 3.

**Table 3.** Discriminant validity Fornell and Lacker.

| Construct | COMS | INVC | IC | SAT | SUST |
|---|---|---|---|---|---|
| Competitive Success (COMS) | **0.739** | | | | |
| Innovative Capacity (INVC) | 0.488 | **0.814** | | | |
| Intellectual Capital (IC) | 0.396 | 0.189 | **0.877** | | |
| Satisfaction (SAT) | 0.416 | 0.315 | 0.609 | **0.763** | |
| Sustainability | 0.550 | 0.415 | 0.411 | 0.348 | **0.763** |

Source: prepared by the authors.

For the discriminant validity in the criterion of the cross-loadings value, the loads must be higher in the original latent variables than in others (Ringle et al. 2014). Thus, discriminant validity was achieved, as can be seen in Table 4.

**Table 4.** Cross-loadings values.

| Indicators | COMS | INVC | IC | SAT | SUST |
|---|---|---|---|---|---|
| SC3 | **0.740** | 0.337 | 0.286 | 0.296 | 0.455 |
| SC6 | **0.748** | 0.395 | 0.276 | 0.361 | 0.320 |
| SC7 | **0.715** | 0.396 | 0.239 | 0.260 | 0.302 |
| SC8 | **0.702** | 0.353 | 0.255 | 0.333 | 0.371 |
| SC9 | **0.788** | 0.344 | 0.379 | 0.292 | 0.529 |
| KINOV1 | 0.200 | **0.731** | 0.122 | 0.208 | 0.312 |
| KINOV2 | 0.357 | **0.857** | 0.180 | 0.279 | 0.367 |
| KINOV3 | 0.457 | **0.851** | 0.098 | 0.289 | 0.355 |
| KINOV5 | 0.462 | **0.837** | 0.154 | 0.257 | 0.348 |
| KINOV6 | 0.498 | **0.787** | 0.212 | 0.243 | 0.304 |
| SC | 0.343 | 0.132 | **0.926** | 0.506 | 0.347 |
| HG | 0.297 | 0.250 | **0.834** | 0.483 | 0.311 |
| RC | 0.391 | 0.123 | **0.869** | 0.599 | 0.412 |
| SAT10 | 0.316 | 0.236 | 0.464 | **0.707** | 0.251 |
| SAT11 | 0.463 | 0.473 | 0.395 | **0.761** | 0.308 |
| SAT12 | 0.301 | 0.312 | 0.408 | **0.744** | 0.243 |
| SAT2 | 0.448 | 0.278 | 0.458 | **0.707** | 0.290 |
| SAT4 | 0.258 | 0.177 | 0.417 | **0.741** | 0.301 |
| SAT5 | 0.212 | 0.140 | 0.419 | **0.780** | 0.231 |
| SAT6 | 0.268 | 0.197 | 0.512 | **0.806** | 0.253 |
| SAT7 | 0.339 | 0.214 | 0.523 | **0.837** | 0.289 |
| SAT8 | 0.197 | 0.103 | 0.553 | **0.771** | 0.214 |
| Soc | 0.314 | 0.323 | 0.269 | 0.266 | **0.677** |
| Eco | 0.510 | 0.382 | 0.338 | 0.261 | **0.773** |
| Env | 0.403 | 0.229 | 0.324 | 0.273 | **0.832** |

Source: prepared by the authors.

### *4.2. Structural Model Analysis*

Once we have verified the validity and reliability of the constructs, we proceed to the analysis of the structural model to verify if the proposed relationship derived from the theoretical foundations can be proved. To analyse the direct effects of the latent predictor variables of competitive success, the blindfolding technique was used, which allowed the calculation of Stone-Geisser's $Q^2$ value (Stone 1974; Geisser 1974), for the evaluation criteria for the predictive relevance of the model. To evaluate how representative each construct is for the model, Table 5, the effect size ($f^2$) or Cohen indicator, the values 0.02, 0.15, and 0.35, considered small, medium, and large (Cohen 1988; Hair et al. 2017), were calculated.

**Table 5.** Predictive validity ($Q^2$) or Stone-Geisser indicator, and effect Ssize ($f^2$) or Cohen indicator.

| Construct | CV RED ($Q^2$) | CV COM ($f^2$) |
|---|---|---|
| Competitive Success | 0.174 | 0.312 |
| Innovative Capacity | 0.018 | 0.483 |
| Intellectual Capital | - | 0.517 |
| Satisfaction | 0.205 | 0.476 |
| Sustainability | 0.144 | 0.194 |

Source: prepared by the authors.

The analysis of the structural model in these parameters shows that the model has an excellent predictive capacity, especially for the endogenous intellectual capital variable of the incubator, which has the highest values. Like the $R^2$ tests, this test confirms that the structural model predicts much better the relationship between the intellectual capital of the incubator and the sustainability of the incubates than the rest of the relationships of the model. All the constructs of the model are representative and have predictive relevance (Hair et al. 2017).

Finally, and to test the hypotheses, we conducted the non-parametric test that provided us with the standard error and values of the Student t statistical model. Specifically, and to calculate the relevance of the path coefficients, we performed a bootstrapping test of 5000 sub-samples using a Student's T Distribution of two tails, with n-1 degrees of freedom, where n is the number of sub-samples. After performing this test, with our sample, we obtained the data from Table 6.

**Table 6.** Decision on the hypotheses.

| Hypotheses | β | STDEV | T Statistics | *p* Values | Decision |
|---|---|---|---|---|---|
| H1: Intellectual Capital > Sustainability | 0.344 | 0.087 | 4.566 | 0.000 | Supported |
| H2: Intellectual Capital > Innovative Capacity | 0.189 | 0.098 | 1.923 | 0.027 | Supported |
| H3: Intellectual Capital > Satisfaction | 0.609 | 0.081 | 7.510 | 0.000 | Supported |
| H4: Innovative Capacity > Sustainability | 0.350 | 0.075 | 4.041 | 0.000 | Supported |
| H5: Satisfaction > Competitive Success | 0.255 | 0.118 | 2.160 | 0.015 | Supported |
| H6: Sustainability > Competitive Success | 0.461 | 0.099 | 4.645 | 0.000 | Supported |

Source: prepared by the authors.

As we can see, the structural paths addressed by the model are positive and significant, so all our hypotheses are supported and there is a positive relationship between the intellectual capital of incubators and the other variables of the model.

## 5. Conclusions

The present study examined the associations between the intellectual capital of technology-based incubators and the sustainability of incubated companies located in Portugal. Our goal was to understand the impact of factors such as innovation capacity and intellectual capital on the competitive success of companies, and the central role of sustainability and satisfaction in this process. The results indicate positive effects of intellectual capital on sustainability, innovation capacity, and satisfaction, as well as revealing the positive effects of satisfaction and sustainability on the competitive success of incubated companies. Finally, we show that the capacity for innovation can lead to higher levels of sustainability in the organizations studied.

By agreeing that sustainability, innovation capacity, satisfaction, and intellectual capital are related, the study contributes to the literature by revealing the antecedents of sustainability and competitive advantage. This is especially important in dynamic and uncertain environments with high levels of environmental demand (Bag et al. 2022) guided by global discussions, such as the sustainable development goals (Lahane and Kant 2022).

By focusing on a robust model, we suggest that investment in innovation capacity, intellectual capital, sustainability, and satisfaction, converge to competitive success, and

in this way, we contribute to management practice, since the competitiveness advantage starts to be understood in a more multifactorial and integrated (Lopes et al. 2022).

In line with what was theoretically pointed out, the intellectual capital of the business incubator is a multidimensional construct constituted by human, structural, and relational capital. In addition, the sustainability of the incubated companies responds to the multidimensional pattern of three dimensions: economic, social, and environmental.

As regards the relationships raised in the study, it should be noted that the intellectual capital of the business incubator effectively presents a direct and positive relationship with the innovative capacity, satisfaction, and sustainability of the incubated company. In turn, the innovative capacity of the incubated company has a direct and positive impact on sustainability itself. In addition, both the sustainability of the incubated company and its levels of satisfaction with the business incubator has a positive and direct impact on its competitive success.

All these findings have implications for the management of incubated companies. The greater the effort to improve the human capital, structural capital, and relational capital of the business incubators, the better the results will be achieved in their primary function, which is to support start-up companies to develop sustainably and compete in the market with guarantees of success. Thus, all the efforts that can be made by public administrations (through public policies for entrepreneurship promotion and the development of new enterprises), and from the management of the incubated companies to the reinforcement of their intellectual capital, will be positive, and will have an impact on the development of a more sustainable and competitive business fabric. This research contributes to the confirmation of a reliable tool to measure the latent variables used. In organizational environments of incubated companies in Portugal, it is expected that the results may help incubated companies to achieve and increase competitive success, highlighting the role of intellectual capital, satisfaction, and sustainability as determining factors.

The limitations of the study refer to the study being carried out in only one country, notably Portugal, added to the cross-cutting employing a survey. Because of this, possibilities emerge for future studies, such as expanding the sample, both in the country studied and replicating the study in other countries, to discover common patterns and differences inherent to each business ecosystem. The use of primary data and the inclusion of secondary data of an objective nature would also improve the understanding of the phenomenon studied. Panel studies to check trends over time are also recommended.

Finally, it is considered necessary to include in future works mediation analyses of the considered constructs, or other new ones related to the object of study, as well as to analyse possible moderation effects by size or sector, to deepen the relationships verified here. It is also proposed that future research will continue to look for the factors that influence the relationship of other variables with competitive success. A greater understanding of the relationship between these variables has the potential to contribute to various aspects of incubated companies and incubators.

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