

Assessing the Intellectual Capital and Related Performance in the Teaching Process using FES models: first evidence in Italian Universities

MANUELA LUCCHESI¹, NATALIA AVERSANO², *FERDINANDO DI CARLO³, PAOLO TARTAGLIA POLCINI⁴

¹ Department of Economics, University of Campania “Luigi Vanvitelli”, Corso Granpriorato di Malta, Capua (CE), ITALY

² Department of Mathematics, Computer Science and Economics, University of Basilicata, Via dell’Ateneo Lucano, Potenza, ITALY

³ Department of Mathematics, Computer Science and Economics, University of Basilicata, Via dell’Ateneo Lucano, Potenza, ITALY

⁴ Department of Management and Innovation Systems, University of Salerno, Via Giovanni Paolo II 132, Fisciano (SA) – ITALY

Abstract: - Our study provides to define two frameworks of indicators to assess both the Intellectual Capital (IC) employed in the Educational Process in the University sector and the Performance Educational Process reached. The scope is to obtain two tools for measuring, on the one hand, the level and the determinant variables of the IC that represents the input of the Educational Process. On the other hand, the level and the determinant variables of the outcome of the Educational Process. The comparison of the tools scores allows you to understand if at a high level of Educational Performance corresponds to a high level of IC trying to evaluate the ability of the IC to create value. The research questions are answered using a quantitative methodology using the FES models. We define two models to measure the IC Educational Index and Educational Performance. We construct the FES models in compliance with the previous literature on the IC and the theoretical model report of the Intellectual Capital of the Austrian Universities. To define the frameworks of indicators to assess the IC Educational Index and the Educational Performance we use, compliant to the previous literature, the SMA Indicators required by the AVA-MIUR for Italian University Sector. We collected 30 Italian public Universities. Thus, we determined and compared both the IC Educational Index and its determinants and Educational Performance Score and its determinants. Our main result is the construction of two toolboxes to assess the level of IC and the connected Performance of the Educational Process in the University sector. The findings suggest which are the indicators to improve the IC Index or the Educational Performance Score for an in-depth understanding of the value creation process. The paper is novel because it contributes to the literature examining the model to measure both the IC employed in the Educational Process and the Educational Performance. Moreover, comparing the resultant scores, we investigated the relation between input and output in the Educational value creation.

Key-Words: - Intellectual Capital; Performance; University; Fuzzy; Teaching Process; Assessment

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1. Introduction

In many developed countries, public universities face an increased reduction of public funds and the consequent need to reorganize their *research* and *teaching* activities in a way that is consistent with requests from industries and territory. A stronger focus on the outcome, the need to attract private resources, and a change in the decision-making process based on increased autonomy have imposed strengthened accountability and control to

react to mechanisms as “marketization” and “performance measurement” of academic activities [63] [78].

Since the first half of the 2000s, Italian public universities have been increasing in autonomy and becoming responsible for strategic profile-building in the national and international contexts of research and teaching. An increase in effectiveness and efficiency has been complemented by a growing competition between higher education

institution systems on a European and international level. The Declaration of Bologna of 1999 defined the route towards a European landscape of harmonized national education systems and contributed to developing the need for a systematic evaluation activity [44].

In this context, intangible assets are considered critical success factors in a knowledge-based system such as a university, in which the value-creating process is multi-dimensional and characterized by multiple values [17]. Universities create, transfer, and employ knowledge through *research* (and *third mission*) and *teaching* activities [18].

From this perspective, higher education institutions need to adopt management and measurement models/tools of intellectual capital (IC) able to raise awareness about the contribution of intangible assets to the development of knowledge flows. We adopt the definition of IC provided by the European Commission [35] that considers IC as the knowledge-based resources and activities capable of creating value for the stakeholders [2] [15] [58] [68]. Knowledge is neither observable nor measurable, but the resources and activities related to the IC are [7] [16]; therefore, proper management and measurement of the IC of the university become essential [70]. In particular, the project of the Observatory of European Universities, where 15 European research institutions developed a catalogue of performance measures for the outcomes of research activities, is a primordial attempt “to understand the importance of managing intangibles in public universities in order to improve their level of quality and competitiveness [68] (p. 538). Secundo et al. [70] highlighted that it should be important to deal with the specific trade-offs between IC internal managerial information and IC external reporting, between possible comparison and sound representation [35], and between adjustment and comparability over time [44] [69].

At present, as a result of the explicit recommendations of the European Union that encouraged the reporting of IC for universities and research Institutes, a few universities¹ and research centers have begun to develop a report to describe their intellectual assets and knowledge flows [3] [4] [11] [36] [51] [68] [69]. Particularly important is the reporting experience carried out by Austrian universities (*Universitätsgesetz*, 2002 – UG, 2002) that prepare IC reporting in compliance with the

requirements of government. In Italy, universities have increased the provision of IC disclosure, but often not through structured or standardized reports [54].

With these assumptions, this study aims to propose an assessment of the IC, based on the Fuzzy Expert System model (FES model), to qualify the intangible resources involved, as inputs, in the *teaching* process of universities. Moreover, the study proposes an assessment, employing another FES model of the knowledge created, which is the output of the teaching process. Comparing the results (*teaching* IC index and *teaching* score), we aspire to understand the relationship between the level of created knowledge and the level of IC of the universities, and to explore the main factors for value creation. We construct two FES models: the first one to assess IC on which the teaching process is based; the second one to evaluate the results. The aim is to understand if a high IC might be related to high output, and which might be the IC elements that affect the outcome.

The study contributes to the debate on IC measurement and management in the university, focusing on the *teaching* activity. On a management side, the possibility to observe the combination of the determinants of different IC (sub)components (human, structural, and relational capital), composing the final IC index allows the practitioners to use this information for decision-making purposes. Thus, this research paper would contribute to theorizing about strategies to support IC development and assessment in universities. The main objectives of the present study are (1) to assist practitioners in identifying and classifying their knowledge assets and the knowledge outcome, (2) to provide practitioners with internal reporting toolboxes to evaluate their entity’s ability to achieve the strategic performance targets, and (3) to offer suggestions to legislators and standard setters to increase the reporting and accountability of the IC in the higher education domain.

The study is novel because it proposes two toolboxes to understand the university intangible resources (IC) dynamics, on the one hand, and the impact in terms of the *teaching* performance, on the other hand. The first toolbox evidences the IC index. It is based on the Austrian IC reporting model [77] [81], but adopted mainly the indicators, compliant with the IC literature, suggested by the Italian Ministry of Education (MIUR) and ANVUR. The second toolbox assesses the teaching

¹ The IC reporting experiences involved, among others, the Universities of Poznan in Poland, the Corvinus University of Budapest, and the Autonomous University of Madrid.

performance using the indicators suggested by MIUR-ANVUR as compliant with IC literature. Finally, the study observes the relationship between the IC index and the *teaching* score (one of the primary determinants of university performance indicators).

The paper is organized into five further sections. Section 2 presents the theoretical background. Section 3 describes the research design, methodology, and data selection. Section 4 shows the results, and the last section concludes the study.

2. Theoretical Background

2.1. Measuring IC in the university sector: previous literature

Universities are evolving towards a broader managerial autonomy [64], new way of teaching [86], new assessment processes and systems to ensure quality and improved performance measurement, management, and reporting mechanisms. This leads to a consideration of IC as a conceptual basis for the university setting [81].

The main reason universities should start measuring, managing, and reporting their IC is linked to their core business: knowledge. Universities generate knowledge (research) and transmit knowledge (teaching), employing knowledge workers [69]. Intangible resources are critical factors in universities, which thus have to use new tools to measure and manage the IC and to disclose information on IC to their stakeholders [25].

The tripartite classification of IC in Human Capital (HC), Structural Capital (SC), and Relational Capital (RC), that is most widely accepted in specialized literature [23] [51] [59] [70], could also be accepted for the IC of universities.

According to Guthrie et al. [43], the third stage of IC research examines how IC can be used as a management tool [43] and highlights the influence of identifying and measuring intangible assets to increase the performance of the entity [32]. This approach is more suited to public organizations such as universities, as the value created is intangible since financial performance is not the primary objective of universities [31]. Indeed, as the present study examines the measurement approach of the IC in the universities from a management view, it is placeable in the third stage of IC research.

Specifically, in the attempt to elaborate parameters for the measurement of resources and results relevant to the teaching process in the university system, it is necessary to consider that the three institutional missions (teaching, research, and third mission) are closely intertwined [37]. The activities

of teaching and research are carried out by the same subjects in different ways, but in times and places that do not lend themselves to be easily distinguished [87]. Moreover, the two activities mostly use common resources (teachers, equipment, laboratories, offices) and produce distinct but complementary results, which, however, can be analysed in a specific way [60]. Therefore, the measurement of the results of the university teaching process requires the construction of specific indicators referring to the potential growth of the professional, social and human dimension of the students, which represents its main output [8] [9] [40].

In Europe, several initiatives have been launched to support the development of IC measurement and reporting in universities [7] [27] [36] [69] [70] [81], and the European Union issued a recommendation to encourage IC measurement by universities and research institutions. In 2004, the Observatory of the European University (OEU), a project involving 15 universities and research institutes across Europe, was developed. This project aimed to provide tools to foster a better understanding of the importance of the management and reporting of intangibles in universities. Therefore, a "strategic matrix", an analytical framework with five thematic dimensions and five transversal questions, has been developed with the purpose of improving the analysis of university research activities and representing a benchmark for comparisons with other universities [16] [23] [68].

In spite of this, except for Austria (in which in 2002, IC reporting based on a process-oriented approach became mandatory for universities and research organizations), in most countries, there is no obligation or recommendation to solicit the IC disclosure in universities. This scenario has inspired several scholars to focus attention on the measurement of the IC in universities [7] [26] [36] [52]. The analysis of these previous studies has shown the use of two different approaches in the development of IC measurement models, which can be used as a reference for the measurement and evaluation of the university teaching process. On the one hand, some studies [7] [26] [36] have proposed IC measurement and recognition models, which declined in the three single IC components (human, organizational, and relational capital) without highlighting any interconnections present among them. On the other hand, other studies [51] [73] [74] have proposed a holistic approach in the development of IC measurement models for the teaching and research activities; these models take

in consideration the value and systemic combination of the different IC elements.

As stated in the introduction, the present paper adopts an FES approach in the issue of IC assessment, through a view that involves both the measurement and management of IC. This approach has been chosen, as its features allow the formalization of the decision-making process related to IC valuation, handling qualitative and quantitative variables, and exploring the cognitive mechanism underlying this process [53].

From an IC perspective, there is a need to understand which definition of IC is suitable and how to handle the IC measurement issue [10]. It is possible to say that the description of IC as the dynamic, context-specific systems of intangible-knowledge-based resources and activities at the basis of an entity's success [59] [80] could provide an answer to the first problem. To respond to the second one, we have to consider that the methods for IC measurement can be classified into four main categories [76]: market capitalization, return on assets, direct IC, and scorecard. The scorecard approach could be identified as the starting point for our research because, while the other three methods focus on the financial aspect of measurement and intangibles, the scorecard approach follows qualitative and quantitative indicators used to measure intangible resources and activities, aiming to show the role of IC in the value creation [18] [79] [81].

In these models, the measurement of IC is necessary for the management of knowledge, and the main aim is to identify the process in the organization that leads to a value creation based on knowledge [81]. Among these methods, some try to return a sort of IC composite index, expressing the IC value of an organization and improving the visualization of the value-creating process of the entity [12] [28]. However, these measures have a mainly monetary basis or derive from a complex calculation of IC indicators. None of them could be adapted to different sectors and, at the same time, succeed in considering the qualitative nature of intangibles and the interactions among IC variables and categories as a source of an organization's value creation.

Starting from these limitations, an FES model will be employed in this article. The model is based on "a cognitive framework that adequately replicates the natural way human beings cognize the world and think about problems and situations and enables us to formalize qualitative and vague concepts" [53] (p. 197). Indeed, measuring the IC through FES models implies the use of crisp values to assess the knowledge assets. Moreover, the

process of measuring IC takes place under ambiguities, uncertainties and vagueness, coping with inexact information. This use of approximate rather than exact models of thinking fits with a flexible tool as the FES model, created to deal with ambiguity, uncertainty and vagueness.

2.2. The Italian AVA system through the IC reporting framework

Recently, both at an international and national level, the debate about the assurance of the quality of university education has gradually increased. Indeed, on a global scale, in 2012-2014, the ENQA (European Association for Quality Assurance in Higher Education) issued and revised the "Standards and guidelines for quality assurance in the European Higher Education Area" (ESG). At a national level, the MIUR, in cooperation with the ANVUR, defined the guidelines (continuously in progress) for an internal evaluation of the teaching process.

The 240 "Gelmini" law of 2010 for the reform of the Italian university system has seen, among its chief effects, the establishment of the ANVUR steering committee in May 2011, which immediately moved to direct its activity along three main thematic axes:

1. the process of self-assessment, periodic evaluation and accreditation (AVA);
2. the new research quality assessment procedure (VQR);
3. the national scientific qualifications (ASN), aimed at inclusion in the roles.

Regarding the first aspect, a long and complicated path of continuous updating of the rules and regulations led to the issuance of many documents that, along the years, led to the development of the "AVA system". In these documents, the ANVUR identifies some specific indicators for the evaluation of the courses, which are considered the elementary entities within university teaching. In this sense, the evaluation of universities is mostly dependent on the accreditation of the courses, which effectively become the primary elements of the teaching assessment system.

In the Ministerial Decree no. 987 of 2016, which develops the implementation of the new AVA system, three groups of indicators are identified for the periodic evaluation of the courses: teaching indicators, indicators of internationalization, and further indicators for the assessment of teaching. These indexes, which are of a quantitative nature, together with others defined as "in-depth indicators for experimentation", complete the picture present

in the Annual Monitoring Report (SMA)², which, introduced with AVA 2.0, represents the main instrument for a quick and timely self-evaluation of the courses based on a quantitative-oriented system. Specifically, it is possible to identify the following classifications of indicators:

- Teaching indicators (from iC01 to iC09);
- Indicators of internationalization (from iC10 to iC12);
- Additional indicators for teaching evaluation (from iC13 to iC19);
- In-depth signs for experimentation – Study path and regularity of careers (from iC21 to iC26);
- In-depth indicators for testing – Teaching quality (iC27 and iC28).

Together with these quantitative indicators, the AVA system also includes a series of qualitative indicators, included in the broadest category of quality requirements (R1-R4) for locations and courses, for accreditation. With specific reference to the teaching methodology, the courses are required to comply with the AQ requirement no. 3 (hereafter, R3) related to the management of the high-quality system at the level of the degree course, subdivided into four sub-objectives (R3.A, R3.B, R3.C, and R3.D).

In light of what has been observed so far, before proceeding with our analysis, a preliminary logical classification of the teaching evaluation proposed by ANVUR appears necessary. It is worth noting that the first aim of the AVA system (self-assessment, periodic assessment, accreditation) is to direct the behaviour of the universities towards the management of the core processes inspired by the logic of autonomy, responsibility and evaluation. Consequently, the ministerial matrix evaluation system, as those underlying the philosophy of drafting the IC reports, is designed to assume both external and internal information relevance.

The idea underlying the AVA system seems to be not just to assess teachers [26], but rather a complex training process that, through a dialectical relationship of *teaching* and learning, moves from the competences of teachers and develops skills in students [74]. In this context, the seat assigned to the mission of the I- and II-level training, from the current ministerial system, can only be identified in the degree courses, understood as a sub-entity of the department, whose evaluation is crucial to appreciate the performance in university teaching methods.

² ANVUR, Guidelines for the periodic accreditation of the Universities, and the Degree Courses provided.

On these assumptions, accurate analysis of the AVA evaluation system becomes relevant concerning the IC reporting models to identify possible opportunities for improvement. Specifically, it is possible to intend the Italian AVA system as a likely primordial systematized report of the IC in the universities.

As can be seen from Tables 1 and 2, the logical assumptions underlying the AVA model appear to be profoundly in line with the theoretical models of IC reporting models based on the holistic IC measurement and communication approach [51] [74]. It focuses not only on the outputs and inputs of the training activity, but also focuses on the combination of intellectual resources in the critical processes of universities, teaching and research, and how these intangible inputs can jointly influence the outputs [54] [80]. In this perspective, it is not difficult to identify the degree course as the natural context in which it is produced and develops the activity of I- and II-level university education. There, the intangible components (Human capital, Structural capital, and Relational capital) represent the inputs of the teaching process, which are combined to obtain an intangible output (the knowledge produced) falling within the types of IC.

Table 1 – The theoretical model of IC report vs. the AVA system indicators

Components of IC	Indicators	AVA Systems (Indicators SMA-R3)
Human Capital		
Consistency of teaching staff	<i>The flexibility of teaching staff N. of professors and researchers at the University</i>	<i>University Information</i>
The average age of teaching staff	<i>The average age of professors and researcher</i>	<i>N/A</i>
Teacher Skills	<ul style="list-style-type: none"> - Bachelor and Masters Degree - Ph.D. and post-doctoral degree - Professional experiences - International study and work experience - Competence in the English language - Teaching experiences 	<i>N/A</i>
Qualification of teaching staff	<i>Percentage of qualified teachers</i>	<ul style="list-style-type: none"> - % regular professors belonging to the SSD basic and characterizing (iC08); - (for the LM) Value of the quality indicator of the research of teachers for the LM (iC09) - R.3.C1 Teaching equipment and qualification;
Teaching skills and abilities	<ul style="list-style-type: none"> - Teacher-student relationship - Participants in training programs 	<ul style="list-style-type: none"> - Report of registered students / teachers (iC27; iC28) - Report of regular students / teachers (iC05);

<https://www.anvur.it/attivita/ava/accreditamento-periodico/linee-guida-per-laccreditamento-periodico>

	- Hours dedicated to training	
Mobility of teachers and researchers	Percentage of teachers who hold or have held scholarships in other universities	N/A
Research skills and abilities	- Percentage of participation in research projects - Production of doctoral theses - Number of scientific publications	N/A
Structural capital		
Organization and teaching management	- Percentage of classes with less than 50 students - Number of credits in English in the three-year degree course - Places in the bookstore	- R.3.B1 Orientation and tutoring; - R.3.B2 Required knowledge at entry and recovery of deficiencies; - R.3.B3 Organization of flexible routes; - R.3.B4 Internationalization of teaching; - R.3.B5 Learning assessment procedures
Relational capital		
Employability of graduates	- Employment rate - Unemployment time until first employment	- 1-year graduates from the title (iC06); - (for the LM) Graduates three years from the title (iC07)
University teaching efficiency	- Percentage of abandonment - Efficiency rate - Degree rate - Academic performance rate	- % drop out after the MC after N + 1 years (iC24) - % regular graduates (iC02) - % registered students who graduate regularly or within one year of the normal duration of the course (iC22 and iC17) - % CFU achieved / CFU to achieve (iC01; iC13; iC15; iC15BIS; iC16; iC16BIS)
Student satisfaction	- Level of appreciation of the graduates about the study course carried out (surveys) - Number of pre-enrolled students in the first option concerning the total number of places offered	- Graduate satisfaction (iC25) - Graduates who would rewrite (iC18)

Table 2 – The theoretical report model of the IC for Austrian universities vs. AVA system indicators

	Output indicators of teaching and continuing teaching processes	AVA System (Indicators SMA-R3)
Indicators of process	Number of academic programs offered [per university] (according to the type of degree courses, kind of learning)	University information
	The average length of study in semesters [per university, per curriculum] (according to gender, stage of degree program)	N/A
	Success rate of degree program students in bachelor's, master's and diploma programs [per university, per curriculum] (according to gender)	% registered who graduate the standard duration of the course (iC22)
	Number of students [per university] (according to gender, nationality, type of enrolment, type of student)	Registered students
	Degree program students actively taking exams within the minimum duration of studies according to the curriculum and in addition to one tolerance semester in bachelor's, master's and diploma programs [per university] (according to gender, nationality)	- % Credits obtained/Credits to obtain (iC01; iC13; iC15; iC15BIS; iC16; iC16BIS)

	Number of degree programs [per university, per curriculum] (according to gender, nationality)	university information
	Number of degree program students participating in international mobility programs (outgoing) [per university] (according to gender, nationality, host country, type of mobility program)	-% of CFU earned abroad by regular students on the total of credits earned by students within the standard duration of the course (iC10)
	Number of students of degree courses participating in international mobility programs (incoming) [per university] (according to gender, nationality, host country, type of mobility program)	N/A
	Number of international joint degree/double degree programs [per university]	N/A
	Funding for teaching projects in Euro [per university] (according to the type of project)	N/A
		-% regular professors belonging to the SSD basic and characterizing (iC08); - Report of enrolled students / teachers (iC27; iC28) - Report of regular students / teachers (iC05); - % teaching hours provided by teachers hired permanently on the total number of teaching hours delivered (iC19) -% quitting the Course after N + 1 years (iC24); -% of enrolled students who continue their careers in different university courses; - R.3 (see table 1)
Indicators of Output and impact of core processes	Number of awarded degrees [per university, per curriculum] (according to gender, nationality, type of awarded degree, type of degree program)	% regular graduates (iC02);
	Number of awarded degrees with funded temporary stays abroad during the study [per university] (according to gender, the host country of temporary stay abroad)	% of graduates (L; LM; LMCU) within the standard duration of the course who have acquired at least 12 CFU abroad (iC11)
	Number of graduates pursuing continuing degree courses at the university [per university] (according to gender, nationality)	(only for LM)% enrolled in the first year coming from other universities (iC04)
	Number of degrees awarded within the minimum duration of studies in addition to one tolerance semester according to the curriculum [per university, per curriculum] (according to gender, type of degree awarded, type of degree program)	% registered students who graduate within one year of the standard duration of the course (iC17)
		- Graduate satisfaction (iC25) - Graduates who would rewrite (iC18)

2.3. The fuzzy logic expert system for measuring the IC

In recent literature, many studies applied the fuzzy logic expert system for assessing the IC and/or knowledge assets. Traditional performance measurement models (Performance Measurement Matrix, the SMART Pyramid, the Balanced Scorecard, the Tableau de Bord, the Performance Prism) do not provide a systemic and comprehensive framework for measuring knowledge assets, even if they implicitly acknowledge the importance of nonfinancial assets in performance management. To date, practitioners

and academic scholars have provided other intellectual capital performance models [33] [34] [65] [66] [67] [75] that allow for the measurement of the knowledge assets of firms.

The existent literature identifies two generations of IC thinking. The first generation focuses on the stocks of knowledge assets and on measuring a firm's IC, while the second one criticizes this approach, assuming that the identification of stocks of knowledge assets is not enough. Indeed, the presence of stocks is not sufficient to create value; it is important also to understand the transformations between stocks of knowledge assets, identified as "flows" between knowledge assets [33] [41] [47] [62] [66] [67] [75]. According to many authors [29] [45] [55] [57] [61] [82], the modality of interaction among IC components affects the value creation process. Thus, IC assessment should be based on the identification/categorization of those essential constituents of IC, which should be able to provide organizations with a higher degree of competition by improving the value creation process.

Intangible resources embody the core competence of the entities and directly influence the value creation process. For this reason, many authors have suggested to screen among the IC elements and select those key value drivers critical to support the value creation process and the organizational performance [1] [6] [28] [41] [48] [56].

The use of FES models to measure IC allows for considering the qualitative nature of intangibles and the interactions among IC variables and subcategories as a source of an entity value creation. Fuzzy set theory tries to solve the problem of fuzzy phenomena, which refer to uncertain situations about which the information is incomplete or behave unpredictably. Fuzzy set theory represents a field using a membership function that permits situations like "incompletely belong to" and "incompletely not belong to" [84]. In other words, the FES model is a cognitive framework that adequately replicates the natural way human beings react cognitively to the world and think about problems and situations, enabling us to formulate qualitative concepts [53]. The underlying logic of FES is fuzzy logic, introduced to manage the concept of intermediate degrees of truth. This choice derives from some considerations:

- a) The FES model is a formal one, which rationalizes the evaluation process, giving a final result that is a specific numerical value for the organization, or university as in our case.
- b) FES, which allows codification of human knowledge in the form of a mathematical

algorithm, takes both the measurement and management perspectives into account.

c) FES is based on the fuzzy approach, which, different from classical numerical methods, is capable of integrating qualitative and quantitative analysis, so the model can handle any qualitative indicator.

d) FES is flexible. The FES model is extremely flexible; it is possible to introduce several value drivers and to change the rules connecting drivers and intermediate variables at any time.

As observed in 2.1, using an FES model allows us to take into consideration the issues deriving from the advanced IC measurement models. FES combines the intuition and experience of experts (management view) and the formal rigor of a logic system (measurement view).

Many research papers are employing fuzzy logic to measure IC and/or knowledge with the aim to define the contribution of IC to the value creation process [13] [14] [28] [46] [49] [81] [83] [85]. The FES model allows for considering the interdependencies among the IC components and their contribution to the firms' value creation. Fuzzy set theory should make firms able to create a hierarchical structure for identifying, classifying, and evaluating the IC components and how they affect the level of the IC and its ability to create value.

3. Research design, Methodology and Data selection

3.1. Research design and model definition

This section illustrates the research design, methodology, and data selection employed to answer our research aim. We start from the assumption that the *teaching* is one of the core processes of the universities. The main determinants of an effective and efficient *teaching* process are the intangible resources that are involved in it. Thus, we provide a framework of indicators that, in compliance with the existent literature, might be able to describe the single IC components (human, structural and relational capital) employed in the *teaching* process, determining a synthetic IC index.

At the same time, we define a model to assess the *teaching* performance as a result of the *teaching* process, based on the elements suggested by the

AVA-ANVUR Guidelines (2017)³ and compliant with the effects of the Bologna Process. In this way, we can compare the performance in *teaching* process with the level of the specific IC employed to produce knowledge.

3.1.1. IC index model definition

To determine the IC index, we start from the IC indicators provided in the IC report published by Austrian universities and required by the Austrian Universities Organization and Studies Act [77]. In this perspective, the UG 2002 Report provides, based on a process-oriented approach, a set of indicators to quantify and qualify different phases of the core activities (*teaching, research, and third mission*) of a higher education institution. In this identified process, the IC, sub-classified into its three main determinants (human, structural and relational capital), is considered the input, while the quality/effectiveness of the core processes of universities represents the output.

Veltri et al. [81] provided a measure of the IC index of the first 20 Austrian universities implementing FES models by reference to the 2016 reports. To construct their model, illustrated in Table 3, they also started from the UG 2002 set of indicators defined for the Austrian universities, deleting the soft signs. The authors specified that the most crucial advantage of the dataset was the standardization of the information because the Austrian Ministry obliged universities to provide the data. The availability of the data made it possible to implement a model to measure the IC index and to compare the results among the different institutions. For choosing the indicators, the authors adopted the approach of Corcoles et al. [24] that underline the essential elements a university should disclose.

To define our model, we identify our set of indicators starting from those selected in the study of Veltri et al. [81] and replacing those more difficult to find with SMA indicators or eliminating them. Table 4 shows the starting model of Veltri et al. [81] and the indicators applied in our model. Their denomination depends on whether we used the signs of the IC report of the Austrian universities or the SMA indicators and the proxy to determine it. All the variables of the model refer to the subcategories of the IC (human capital, structural capital, and relational capital). The indicators related to human capital are weighted with the number of staff. We do not consider the

signs about the students because, in compliance with the previous literature [51], they are considered the final users of the *teaching* process; thus, they are not included in the set of IC resources upon which this process is based.

Table 3 – IC indicators selected by Veltri et al. (2012) for measuring the IC

INTELLECTUAL CAPITAL		
HUMAN CAPITAL		
	ICR Numeration	Indicators
DIDACTICS		
<i>Staff's abilities</i>		
Didactics qualification	II.1.2/II.1.1	No. awarded teaching qualification (habilitations)/staff
Training	II.1.7/II.1.1	No. participants in programmes for continuing education and personnel development/staff
Activities that improve teaching qualifications	II.1.5/II.1.1	No. academic staff who have completed a temporary stay abroad amounting to at least five days (outgoing)/staff
<i>Staff's dynamic composition</i>		
Professors called to work at universities	II.1.3/II.1.1	No. appointments to university/staff
Professors who leave university for an external professorship	II.1.4/II.1.1	No. appointments from university/staff
New teachers	II.1.6/II.1.1	No. incoming academic staff/staff
RESEARCH		
No. of ongoing research and development projects supported by external funds	III.2.2	No. ongoing projects within research and development supported by third-party funds
Acknowledgment of the research ability of researches	IV.2.3	No. presentations held as an invited speaker or selected presenter at scientific events
Researches productivity	IV.2.2	No. scientific publications of the staff
Investments in future university researchers	III.2.6	No. of doctoral programmes
STRUCTURAL CAPITAL		
	ICR Numeration	Indicators
<i>Hardware and databases</i>		
Databases	II.2.7	Cost for available on line research data bases in euro
Scientific journals	II.2.8	Cost for available scientific journals in euro
Infrastructure	II.2.9	Total funds for large equipment for research and development
<i>Innovation</i>		
Patents	IV.2.4	No. patents awarded to the universities
<i>University Culture</i>		
The social culture	II.2.3	No. staff active at special institutions
	II.2.4	No. staff active in institutions for students with special needs or with a chronic disorder or both
RELATIONAL CAPITAL		
	ICR Numeration	Indicators
<i>Scientific relationship</i>		
External relationships	II.3.1	No. staff with function as chairs, member or reviewers in external appointment committees
Cooperation agreement	II.3.2	No. partner institutions/enterprises incorporated in cooperation agreement

³ In this study, we referred to the AVA Guidelines 2017 because our analysis is on 2017 universities' annual reports. In 2019, the Italian Ministry updated some of

the indicators used, but the data are not yet available or issued (DM 6/2019).

Scientific relationships	II.3.3	No. staff with functions in a scientific journal
	II.3.1	No. staff in scientific panel

Table 4 summarizes the IC indicators of the teaching process selected in our model.

Table 4 – IC indicators of the teaching process for measuring the IC as input.

INTELLECTUAL CAPITAL OF THE TEACHING PROCESS		
HUMAN CAPITAL		
	ICR Numeration	Indicators
DIDACTICS		
Teaching Qualification		
Degree courses qualification (teachers)	iC08 (SMA Indicator)	No. tenured teachers belonging to scientific-disciplinary sectors (SDS) (based and characterizing) indicated as a referent of the Course of Study / total staff belonging to scientific-disciplinary areas (SDA) (based and characterizing)
Consistence and qualification of teaching	iC27 (SMA Indicator)	Enrolled students (academic year X/X+1) /staff (weighted by teaching hours)
Teaching Sustainability	iC05 (SMA Indicator)	Regular Students/staff
Staff's dynamic composition		
Δ Professors from year X-1 to X	USTAT 1	Difference between No. Professors tenured in X less No. Professors in - 1 year/total professors
RESEARCH		
Research Quality	iC09 SMA Indicator)	Coefficient QRDLM
Researches productivity	IRIS	No. scientific publications of the staff for X years/X year/staff
Investments in future university researchers	III.2.6 (UG 2002)	No. of doctoral programs
STRUCTURAL CAPITAL		
	ICR Numeration	Indicators
Hardware and databases		
Databases and Scientific journals	II.2.7 (UG 2002)	Cost for available online research databases and scientific journals in euro
Infrastructure	II.2.9 (UG 2002)	Total funds for large equipment for research and development
Innovation		
Patents	IV.2.4 (UG 2002)	No. patents awarded to the universities
University Culture		
The social culture	II.2.4 (UG 2002)	No. staff active in institutions for student's disability
RELATIONAL CAPITAL		
	ICR Numeration	Indicators
Scientific relationship		
Cooperation agreement	II.3.2_1 (UG 2002)	No. partner institutions incorporated in ERASMUS agreement
	II.3.2_2 (UG 2002)	No. partner institutions/enterprises incorporated in OTHER agreement

Source: Authors' elaboration

Human Capital

In compliance with Veltri et al. [81], we consider two determinants of the human capital level: *didactics* and *research*. The first determinant refers to the aspects of the intangible human resources that should create value in the organization of a degree course. The *research* determinant refers to

the quality of the scientific production of the staff that should improve the quality of the transmitted knowledge into the *teaching* process.

The primary existent literature tends to consider *research* as the knowledge product and *teaching* as the knowledge to transfer, while the outcome of the degree course is the employment of knowledge by workers [22] [50].

In the Italian context, we tried to define the indicators of the *didactics* determinant of human capital, but we were not able to find the same data as provided by the Austrian universities in the consulted sources. Mainly, the information regarding *staff's abilities* is not available, so we replaced these with the SMA indicators required of the Italian universities by MIUR-ANVUR, which imposes the sustainability and the capability of degree course in regard to human resources. This choice is coherent with the part of the literature that identified, among the components of the human capital of the IC, the *qualification of teaching staff*, the *teacher skills*, and the *teaching skills* (see Table 1). Similarly, concerning the section *staff's dynamic composition*, we did not find the information related to the number of appointments to/from university and new incoming academic staff.

The Italian Ministry provides synthetic data that indicate the difference between the total tenured teachers as compared to the previous year (www.ustat.miur.it/dati/didattica/Italia/Atenei).

Thus, we use this indicator as a proxy for the staff's dynamic composition.

For the *research* determinant, indicator III.2.2, the Italian universities do not provide comparable data (EU funds or competitive bids funds), so we cannot consider these data in the study. The indicator IV.2.3, at the moment, is not available, because it represents information of the *third mission*. It will be available when the section SUA-TM/IS (SUA - Third Mission and Social Impact) is active. This section is the area in which universities provide their output about the third mission; for this reason, we cannot consider it in our study. The indicator IV.2.2 is replaced in our model by the number of scientific publications of the staff. These data are available on the IRIS platform, and it is referred to as the scientific production of the staff for ten years. Thus, we consider the following indicator: the total scientific outputs of the staff divided for the number of years, divided again for the staff. The indicator III.2.6 is available in the universities' social reporting. In our view, the *research* (and its results) is a factor that can increase the potential knowledge transfer to the students [77].

In our model, we add another indicator directly defined by MIUR-ANVUR, the research quality (iC09) that weights the research scores of the disciplinary-scientific area, which make up the "second cycle" or the "unique cycle" of the education program.

Structural Capital

Structural capital is organized into three determinants, as reported in the panel below: 1) *hardware and databases*, 2) *innovation* and 3) *university culture*.

For the *hardware and databases* determinant, the indicators II.2.7 and II.2.8 were not always available as specific items in the notes of the financial statements of the universities. Sometimes, the higher education institutions present an analytic disclosure of these kinds of costs; in other cases, they consider this information in a synthetic item. For this reason, our model takes into account the single indicator *database and scientific journals*. The indicator II.2.9 corresponds to the funds for large equipment for the R&D as accounted in the investment budget.

For the *innovation* determinant, the indicator IV.2.4 is available for universities that provided it in the sustainability report.

For the *university culture* determinant, the indicators II.2.3 and II.2.4 are assimilated to the number of dedicated staff for students' disabilities

Relational Capital

Compared with the IC Report of the Austrian Universities [77], in our model, the relational capital section is made up of cooperation agreements, while the other indicators regarding the scientific commitments (e.g., chair, (co)editor, etc.) are not considered because of the unavailability of the data.

3.1.2. Teaching score model definition

As we have already remarked, this study is compliant with the literature on IC that in the last decades has discussed the importance of the measurement of IC [43] and the importance of correlating IC measurement with the management of IC [5] [19] [20] [21] [30] [38] [39] [44] [72]. Specifically, we investigate the complex phenomenon of the IC, whose boundaries are not always easy to define [42], trying to explain how its selected determinants might affect the quality of its output.

In our understanding, the main effect of the IC in the university sector, particularly in the degree courses provided, should be expected on the performance level in education quality.

Even if the existent literature does not identify in the *teaching* process a specific direct correlation

between the IC, as the input, and the performance, as the output, it could be interesting to compare the level of the results of the *teaching* process with the level of the IC involved. On these assumptions, we need a specific index for the outcomes of this process to compare to the IC index previously identified. Thus, we imagine synthesizing the *teaching* performance in a *teaching* score that is affected by four determinants, suggested by the AVA Guidelines (2016, 2018) and compliant with the results of the Bologna Process: *attractiveness, regularity, effectiveness, and internationalization of the degree course*. This index (the *Teaching Score – TS*) is based on the assumption that the Italian Ministerial (MIUR-AVUR) indicators to evaluate a degree course could be equivalent to the indicators of output and process provided by the UG 2002 to evaluate the level of quality of the *teaching* process (see para. 3.2.2). Table 5 below represents the indicators that were used to measure the *Teaching* score.

Table 5 – Indicators selected for the teaching score for measuring the performance in teaching

TEACHING SCORE		
ATTRACTIVENESS		
	<i>Source</i>	<i>Indicators</i>
Attractiveness Degree Courses I level		
No. of I level Degree Courses	Sustainability Report	No. of I level Degree Courses
% students come from other Region	iC03 (SMA Indicator)	% Enrolled students at the I year (X-2/X-1) which come from other Regions
Attractiveness Degree Courses II level		
No. of II level Degree Courses	Sustainability Report	No. of II level Degree Courses
% of students come from other Universities	iC04 (SMA Indicator)	% Enrolled students at the I year (X-2/X-1) which come from other Universities
REGULARITY		
	<i>Source</i>	<i>Indicators</i>
Enrolled students	iC00d (SMA)	No. enrolled students in each academic years (X-2/X-1; X-3/X-2; X-4/X-3)
Regular graduates	iC22 (SMA Indicators)	% of students graduating in the three-year course
Students who do not leave the course of study	1-iC24 (SMA Indicators)	1-% enrolled students that at the first year of Degree course goes away
EFFECTIVENESS		
	<i>Source</i>	<i>Indicators</i>
Employees after graduation	iC07 (SMA Indicators)	% of graduate employed (1st level degree) one year after graduation
Employees after graduation	iC26 (SMA Indicators)	% of graduate employed (2nd level degree and Unique cycle degree) one year after graduation
INTERNATIONALIZATION		
	<i>Source</i>	<i>Indicators</i>
University Credits obtained abroad	iC10	% CU obtained abroad/total CU of the Degree course
Enrolled Students with a previous degree get abroad	iC12	% Enrolled Students with a an earlier degree get abroad
Regular Graduates with at least 12 CU obtained abroad	iC11	% of Regular Graduates with at least 12 CU earned abroad

3.2. Method: The FES models implemented

To define the FES model of the IC index of the *teaching* process, first, and of the TS, second, we followed these five steps:

- 1) We select the type of fuzzy system.
- 2) We define the fuzzy modular system, selecting for each FES model the inputs that characterize the related scores (output).
- 3) We set the linguistic attribute (fuzzy value) for each variable (fuzzification of inputs and outputs) and the relative rule blocks ("if-then" rules).
- 4) We establish the fuzzy inference method.
- 5) We defuzzificate the outputs in a crisp value.

Tables 6 and 7 illustrate the modular fuzzy logic decision tree defined respectively to assess the IC of the *teaching* process and the TS.

To understand the modular system, we have to read the figure from right to left. Thus, we observe that the IC of the teaching process is the aggregation of the three main types of capital, identified by the literature (human, structural, and relational). These capitals represent the "intermediate variables", which, in turn, are the aggregation of other factors described above and defined in compliance with the literature on the IC reports.

Similarly, we also define the fuzzy modular system to assess the TS. We start from the right of the figure that shows the four fundamental determinants affecting a successful degree course, in accordance with the Italian Ministry.

On a mathematical perspective, this modular decision tree can also be expressed as a function of n independent variables (inputs) x_i , $i = 1, 2, 3, \dots, n$, that affect the dependent variable $y = f(x_1, x_2, x_3, \dots, x_n)$.

The degree of the memberships for each rule's premise is determined by matching the linguistic terms with the actual values of the input variables (*fuzzification*) [88]. A fuzzy set can be formed by assigning a membership value to each object in the interval of $[0,1]$. Membership values represent the degree to which an object belongs to a fuzzy set. Let X denotes the universe of discourse, where x represents an element of the universe, X and A denote a fuzzy set. A fuzzy set is hence characterized by its membership function, $\mu_A(x)$ [89] as

$$\mu_A(x) : X \rightarrow [0, 1]$$

Membership function states that values assigned to the elements of the universal set, X , fall within a specified range. In the meantime, it indicates the membership grade of these elements in fuzzy set A . A fuzzy set A , on universe of discourse of X , can also be defined as a set of ordered pairs as [89].

$$A = \{(x, \mu_A(x)) \mid x \in X\}$$

The membership functions of fuzzy sets "very low", "low", "medium", "high", and "very high" are represented in a graph. The horizontal axis of the graph represents independent/intermediate variable in percentage (the universal set X), and the vertical axis represents the degree to which this proportion for a university can be labeled "very low", "low", "medium", "high", and "very high" [88]. In this way, the variable is defined in a fuzzy set.

The construction of the FES tree is based on the ability of experts to determine to what degree the variables are effective on outputs. Next, they were asked to connect indicators to one another, outputs to one another, and indicators to outputs through rules. For example, one of the extracted rules is as follows: IF (intermediate) variable is low, THEN the output is very poor.

The crisp values are defined generally considering the distribution in quartiles and elaborated by experts.

Referring to the final value of the IC index, and the TS, is the result of many aggregations that depend on linguistic rules and a selected fuzzy inference method called rule blocks (RB). In these FES models, the RB are defined by consulting two experts (two exponents of the evaluation teams of two Italian universities). These rules summarize all the different combinations of the "independent variables" that define an "intermediate variable". They derive from expert consultation and the selection of the linguistic attribute and the monotonicity of heuristic functions. The inference method is chosen according to the related problem [81]. To better understand the working of the RB, we show in Table 8 an example of RB for the intermediate value teaching qualification.

The FES model allows obtaining a synthetic number, included in the range $[0; 1]$. The FES model of the IC index explains the potential ability of the IC involved in the *teaching* process to create value, on the one hand, while the FES model of teaching score explains a high/low performance in the teaching process on the basis of the Ministerial indicators, on the other.

3.3. Data selection

The data used in the model are related to the information provided by the annual or sustainability 2017 reports, by SMA 2017, and on the website for the same period. On these bases, our sample consists of only those universities that have published a 2017 sustainability report. Specifically, 30 universities compose our sample and are

reported in Table 9. The attributes of the data used are given in Table 10.

Table 6 – The FES Models of the IC Teaching Process

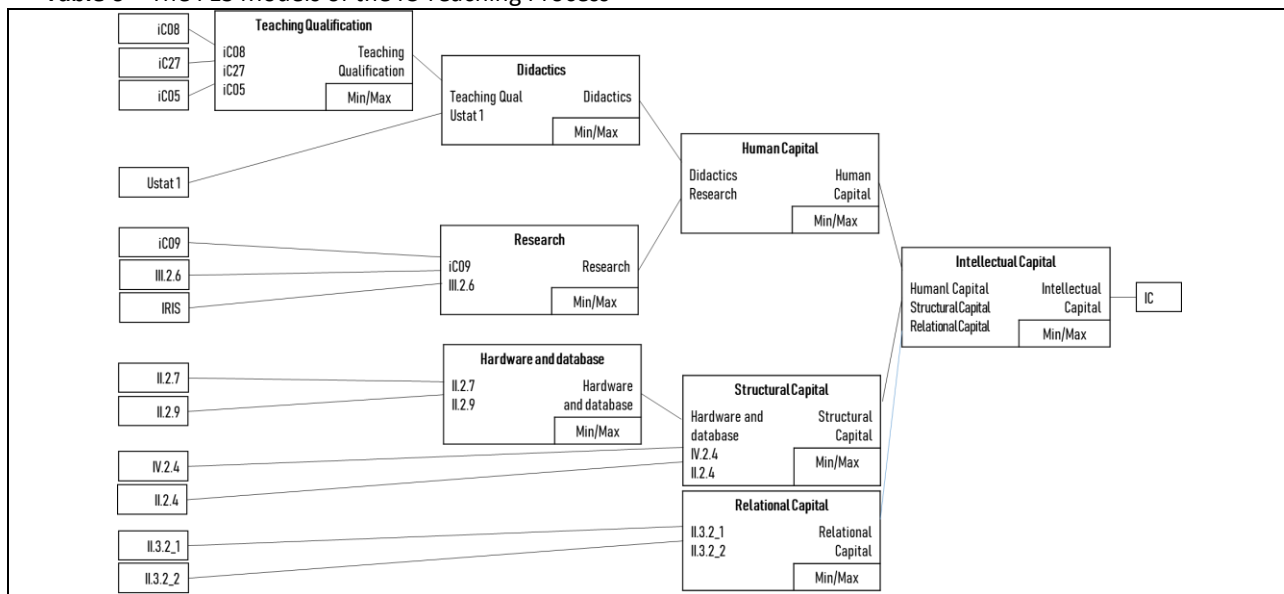


Table 7 – The FES Models of the Teaching Score

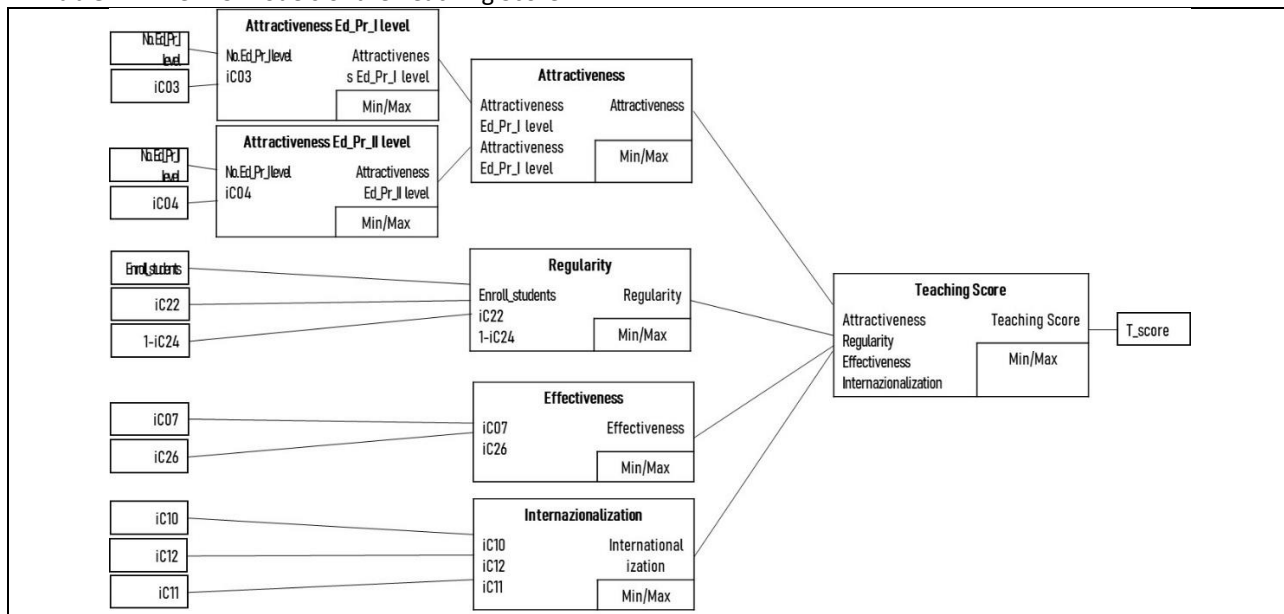


Table 8 – Rule block of intermediate value Teaching Qualification

No.	IF			THEN	
	iC08	iC27	iC05	DoS	Teaching Qualification
1	Low	Low	Low	1.00	Very low
2	Low	Low	Medium	1.00	Very low
3	Low	Low	High	1.00	Low
4	Low	Medium	Low	1.00	Very low
5	Low	Medium	Medium	1.00	Low
6	Low	Medium	High	1.00	Medium
7	Low	High	Low	1.00	Low
8	Low	High	Medium	1.00	Medium
9	Low	High	High	1.00	High
10	Medium	Low	Low	1.00	Very low
11	Medium	Low	Medium	1.00	Low

12	Medium	Low	High	1.00	Medium
13	Medium	Medium	Low	1.00	Low
14	Medium	Medium	Medium	1.00	Medium
15	Medium	Medium	High	1.00	High
16	Medium	High	Low	1.00	Medium
17	Medium	High	Medium	1.00	High
18	Medium	High	High	1.00	Very high
19	High	Low	Low	1.00	Low
20	High	Low	Medium	1.00	Medium
21	High	Low	High	1.00	High
22	High	Medium	Low	1.00	Medium
23	High	Medium	Medium	1.00	High
24	High	Medium	High	1.00	Very high
25	High	High	Low	1.00	High
26	High	High	Medium	1.00	Very high
27	High	High	High	1.00	Very high

Table 9 – University sample selected

Università Politecnica delle Marche	Università degli Studi di Roma "La Sapienza"	Università degli Studi di Bari Aldo Moro
Università di Pisa	Università degli Studi di Pavia	Università degli Studi dell'Insubria
Università di Bologna	Università degli Studi di Napoli Federico II	Università degli Studi dell'Aquila
Università del Salento	Università degli Studi di Messina	Università degli Studi del Sannio
Università degli Studi di Udine	Università degli Studi di Macerata	Università degli Studi del Piemonte
Università degli Studi di Trieste	Università degli Studi di Genova	Oriente Amedeo Avogadro
Università degli Studi di Trento	Università degli Studi di Foggia	Università degli Studi del Molise
Università degli Studi di Torino	Università degli Studi di Firenze	Università Ca' Foscari Venezia
Università degli Studi di Sassari	Università degli Studi di Ferrara	Politecnico di Torino
Università degli Studi di Salerno	Università degli Studi di Cassino e del Lazio Meridionale	
Università degli Studi di Roma Tor Vergata	Università degli Studi di Cagliari	

Table 10 – The attributes of the IC and TS scores dataset of the study

Variable Name	Variable Code	Mean	Std. Dev.	95% Conf. Interval
Degree courses qualification (teachers)	iC08	.9434693	.0256909	.9338761 – .9530624
Consistence and qualification of teaching	iC27	21.2591	6.639094	18.78002 – 23.73817
Teaching Sustainability	iC05	10.34445	1.823072	9.663701 – 11.02519
Δ Professors from year X-1 to X	USTAT 1	-0.0155	.0249376	-0.0248 – -0.0062
Research Quality	iC09	.9993151	.1136115	.9568919 – 1.041738
Researches productivity	IRIS	3837.25	3207.621	2639.505 – 5034.995
Investments in future university researchers	III.2.6	19.72414	16.54193	13.43192 – 26.01635
Databases and Scientific journals	II.2.7	2059095	2187102	1242417 – 2875772
Infrastructure	II.2.9	3305986	5749537	1159073 – 5452898
Patents	IV.2.4	83.73333	137.4346	32.41441 – 135.0523
The social culture	II.2.4	10.66667	11.20755	6.481698 – 14.85163
Cooperation agreement	ERASMUS	531.3667	350.115	400.6316 – 662.1018
Cooperation agreement	OTHER	176.2759	500.995	-14.29245 – 366.8442
No. of I level Degree Courses	n. CDL Trnrl	41.43333	29.13072	30.55574 – 52.31092
% students come from other Region	iC03	.284022	.164836	.2224712 – .3455728
No. of II level Degree Courses	n. CDL Magist	44.83333	30.60435	33.40548 – 56.26119
% of students come from other Universities	iC04	.270515	.1215842	.2251147 – .3159153
Enrolled students	iC00d	132866.4	111588.6	91198.5 – 174534.2
Regular graduates	iC22	.5016965	.0997842	.4644365 – .5389565
Students who do not leave the course of study	1 – iC14	.2118483	.043134	.1957418 – .2279548
Employees after graduation	iC07	.7378667	.0952918	.7022841 – .77344492
Employees after graduation	iC26	.548301	.1173913	.5044664 – .5921357
University Credits obtained abroad	iC10	.0183817	.0117968	.0139767 – .0227867
Enrolled Students with a previous degree get abroad	iC12	.0290407	.0320896	.0170582 – .0410231
Regular Graduates with at least 12 CU obtained abroad	iC11	.0948177	.0634824	.0711113 – .1185225

The primary sources of our set of indicators were the SMA dataset, the university website, the STAT website, the sustainability reports, and the financial statements.

4. Findings

Table 11 shows the level of the IC index and the level of the *teaching* performance (TS) of the universities of our sample. We identify the higher education institutions considered as U_n . Table 11 displays two panels. Panel A illustrates the synthetic value of the IC index and its “intermediate variables” of the FES model (human capital – made up of its two determinants, *didactics* and *research*, structural capital, and relational capital). Panel B shows the synthetic value of the TS, represented as the aggregation of its determinants (*attractiveness*, *regularity*, *effectiveness*, and *internationalization*). Specifically, we can read the values of the IC index determinants from the left to the right of Panel A, while we can observe the signs of the TS determinants from the right to the left of Panel B. In this way, we could compare the level of the IC index with the level of the teaching performance (TS). Thus, we obtain a tool to understand what IC components better explain the final level of IC. Moreover, this tool can enable the understanding of

whether and how the levels of IC components affect the degree of the TS.

We define the level of IC as high (H), medium (M), and low (L), depending on the teaching IC index. Thus, the universities with an IC value over 0.6 should have a potentially high level to create value (H). The universities with an IC value between 0.4 and 0.6 should have a potentially medium level to create value (M). All the rest should have a potentially low ability to create value (L). Similarly, we consider a high performance in the teaching process when the TS is over 0.6 (H); it is medium when it is between 0.4 and 0.6 (M), while it is considered low in all the other cases (L).

Table 11 – Panel A shows that when the IC value is the highest in the sample, the corresponding values of the Human Capital, Structural Capital, or Relational Capital are not necessarily the greatest in the sample. For example, the university U_8 presents a very high (the highest in the sample) level of IC index (0.762) caused by a high (not the highest) level of Human Capital (0.587), a high level (not the highest) of Structural Capital (0.661), and a very high (the highest) level of Relational Capital (0.75). Indeed, the university U_{24} presents a level of IC index (0.621 – not the highest), which is associated with a very high level of human capital (0.795 – the highest), and a medium level of both Structural Capital (0.405) and Relational Capital (0.5).

Table 11 – *The Teaching Score and its determinants, compared to the IC Index and its determinants of the Italian Universities*

	Panel A – IC Index				Panel B – Teaching Score				
U_n	Human capital	Structural capital	Relational capital	Intellectual capital	Teaching score	Attractiveness	Regularity	Effectiveness	Internationalization
U_8	0.587 (M)	0.661 (H)	0.75 (H)	0.762 (H)	0.832 (H)	0.75 (H)	0.405 (M)	0.75 (H)	0.672 (H)
U_6	0.699 (H)	0.427 (M)	0.5 (M)	0.596 (M)	0.737 (H)	0.75 (H)	0.732 (H)	0.75 (H)	0.173 (L)
U_1	0.612 (H)	0.462 (M)	0.503 (M)	0.625 (H)	0.695 (H)	0.75 (H)	0.613 (H)	0.66 (H)	0.174 (L)
U_{10}	0.718 (H)	0.402 (M)	0.459 (M)	0.531 (M)	0.67 (H)	0.483 (M)	0.361 (L)	0.75 (H)	0.389 (L)
U_4	0.302 (L)	0.5 (M)	0.5 (M)	0.443 (M)	0.647 (H)	0.549 (M)	0.459 (M)	0.75 (H)	0.174 (L)
U_3	0.742 (H)	0.413 (M)	0.484 (M)	0.57 (M)	0.646 (H)	0.637 (H)	0.512 (M)	0.683 (H)	0.174 (L)
U_{25}	0.543 (M)	0.5 (M)	0.5 (M)	0.668 (H)	0.646 (H)	0.548 (M)	0.459 (M)	0.75 (H)	0.173 (L)
U_{30}	0.668 (H)	0.274 (L)	0.5 (M)	0.448 (M)	0.624 (H)	0.75 (H)	0.43 (M)	0.671 (H)	0.174 (L)
U_{13}	0.42 (M)	0.239 (L)	0.5 (M)	0.4 (M)	0.616 (H)	0.363 (L)	0.594 (M)	0.75 (H)	0.175 (L)
U_{28}	0.374 (L)	0.173 (L)	0.5 (M)	0.354 (L)	0.615 (H)	0.541 (M)	0.403 (M)	0.739 (H)	0.25 (L)
U_{21}	0.426 (M)	0.5 (M)	0.5 (M)	0.595 (M)	0.57 (M)	0.447 (M)	0.469 (M)	0.743 (H)	0.174 (L)
U_{15}	0.495 (M)	0.17 (M)	0.5 (M)	0.352 (L)	0.544 (M)	0.579 (M)	0.368 (L)	0.726 (H)	0.174 (L)

U ₁₉	0.559 (M)	0.5 (M)	0.5 (M)	0.669 (H)	0.505 (M)	0.574 (M)	0.361 (L)	0.699 (H)	0.174 (L)
U ₂₇	0.661 (H)	0.485 (M)	0.25 (L)	0.472 (M)	0.5 (M)	0.589 (M)	0.25 (L)	0.75 (H)	0.25 (L)
U ₁₁	0.638 (H)	0.167 (L)	0.5 (M)	0.349 (L)	0.495 (M)	0.401 (M)	0.267 (L)	0.75 (H)	0.328 (L)
U ₁₆	0.405 (M)	0.173 (L)	0.27 (L)	0.219 (L)	0.468 (M)	0.25 (L)	0.598 (M)	0.678 (H)	0.174 (L)
U ₇	0.4 (M)	0.238 (L)	0.5 (M)	0.388 (M)	0.436 (M)	0.368 (L)	0.364 (L)	0.75 (H)	0.173 (L)
U ₂₃	0.249 (L)	0.5 (M)	0.5 (M)	0.405 (M)	0.422 (M)	0.351 (L)	0.48 (M)	0.49 (M)	0.175 (L)
U ₂₂	0.554 (M)	0.5 (M)	0.25 (L)	0.388 (L)	0.419 (M)	0.363 (L)	0.367 (L)	0.56 (M)	0.173 (L)
U ₂₄	0.795 (H)	0.405 (M)	0.5 (M)	0.621 (H)	0.413 (M)	0.25 (L)	0.586 (M)	0.541 (M)	0.175 (L)
U ₉	0.48 (M)	0.256 (L)	0.5 (M)	0.41 (M)	0.395 (L)	0.29 (L)	0.343 (L)	0.75 (H)	0.174 (L)
U ₂	0.405 (M)	0.332 (L)	0.588 (M)	0.389 (L)	0.379 (L)	0.25 (L)	0.662 (H)	0.502 (M)	0.175 (L)
U ₂₀	0.209 (L)	0.173 (L)	0.5 (M)	0.22 (L)	0.364 (L)	0.25 (L)	0.5 (M)	0.545 (M)	0.175 (L)
U ₁₄	0.244 (L)	0.5 (M)	0.5 (M)	0.402 (M)	0.351 (L)	0.25 (L)	0.428 (M)	0.492 (M)	0.175 (L)
U ₂₆	0.278 (L)	0.327 (L)	0.5 (M)	0.306 (L)	0.339 (L)	0.326 (L)	0.298 (L)	0.504 (M)	0.25 (L)
U ₁₇	0.498 (M)	0.169 (L)	0.75 (H)	0.351 (L)	0.33 (L)	0.25 (L)	0.325 (L)	0.533 (M)	0.174 (L)
U ₂₉	0.393 (L)	0.5 (M)	0.5 (M)	0.565 (M)	0.32 (L)	0.25 (L)	0.327 (L)	0.512 (M)	0.174 (L)
U ₁₈	0.236 (L)	0.167 (L)	0.5 (M)	0.24 (L)	0.315 (L)	0.25 (L)	0.307 (L)	0.544 (M)	0.174 (L)
U ₅	0.544 (M)	0.192 (L)	0.5 (M)	0.37 (L)	0.314 (L)	0.25 (L)	0.311 (L)	0.523 (M)	0.174 (L)
U ₁₂	0.567 (M)	0.5 (M)	0.5 (M)	0.669 (H)	0.26 (L)	0.25 (L)	0.264 (L)	0.484 (M)	0.175 (L)

High level (H); Medium level (M); Low level (L)

Undoubtedly, the employment of a similar model should help practitioners to understand the area (IC components) to be improved. The case of U₁₀ suggests, for example, that the IC index could improve if the levels of the *Relational Capital* and *Structural Capital* are increased.

Generally, the findings concerning the IC index suggest that in 2017 (the sample period) the Italian higher education institutions of the sample invested/managed their intangible resources. They increased the *Erasmus cooperation* (one determinant of the *Relational Capital* in our FES model), and the level of *teaching qualification* (one determinant of the *Human Capital* in our model). As a consequence, the value of Intellectual Capital has been affected. More specifically, the IC index shows that, on average, when the IC value is medium, the *Structural Capital* offers the lowest value compared to *Human Capital* and *Relational Capital*. That could be because 2017 was a particularly problematic period for the Italian university sector as characterized by a reduction of public funding.

Our results show that, in the significant cases, the universities with a high/medium/low IC index present a respectively high/medium/low performance in *teaching*, as would be reasonably expected.

Assuming that the intangible assets should be considered as elements essential to creating value, and seeing the comparison of IC and teaching performance, the university with a high TS generally presents a high or medium IC index. This should represent the evidence of the abilities of the university to correctly manage the intangibles and generate value. The missing alignment of these values (IC index > TS) should suggest an inability of the institution to manage the intangible assets related to the teaching performance. In these cases, practitioners could try to improve the determinants of the TS. In our sample, typical is the case of the U₁₂, in which the IC is 0.669, while the TS is 0.26. These assumptions are consistent with the Pearson correlation among the IC and the TS, and the relevant intermediate variables. Table 12 shows that

the IC score has a significant positive relationship (p-value < 0.01) with the TS score.

Moreover, the results evidence a significant positive correlation between HC (p-value < 0.05) and SC (p-value < 0.1) with the TS score. Specifically, the HC has a significant positive correlation with the ATT (p-value < 0.01) and the EFF (p-value < 0.1); the SC has a significant positive correlation with the ATT

(p-value < 0.1); and the RC has a significant positive correlation with the INTERN (p-value < 0.1). We do not consider the correlation found between the IC score and its intermediate variables and between The TS score and its intermediate variables, because of the IC and TS scores depend on their intermediate variables.

Table 12 – Pearson correlation

	HC	SC	RC	ICscore	ATT	REG	EFF	INTERN	Tscore
HC	1.0000								
SC	0.2096 0.2664	1.0000							
RC	-0.0680 0.7211	-0.0010 0.9959	1.0000						
ICscore	0.5846 0.0007	0.7820 0.0000	0.2478 0.1867	1.0000					
ATT	0.4906 0.0059	0.3493 0.0585	0.0612 0.7479	0.5126 0.0038	1.0000				
REG	0.0794 0.6765	0.0818 0.6675	0.0309 0.8710	0.1248 0.5112	0.2127 0.2591	1.0000			
EFF	0.3595 0.0510	0.0004 0.9981	-0.0983 0.6052	0.2387 0.2040	0.6490 0.0001	0.0917 0.6298	1.0000		
INTERN	0.2243 0.2335	0.2814 0.1320	0.3438 0.0629	0.3067 0.0993	0.3368 0.0688	-0.2055 0.2760	0.3014 0.1056	1.0000	
Tscore	0.4325 0.0170	0.3128 0.0924	0.1063 0.5760	0.4778 0.0076	0.8778 0.0000	0.4099 0.0245	0.7703 0.0000	0.4598 0.0106	1.0000

5. Conclusions

In the last decades, the studies on the need to measure and manage knowledge assets have increased because it is considered a key skill for entities in today’s business environment. In particular, in the university sector, the success in all the core missions (*teaching, research, and third mission*) depends mainly on the level of intellectual capital that characterizes most of the phases of the knowledge-productive process [17]. It follows that higher education institutions should develop or adopt models, tools, and techniques that can enable them to manage their primary source of competitive advantage: knowledge assets [7] [16] [70].

The present study proposes a model to assess the level of IC, focusing only on the *teaching* process, for Italian universities. This model is compliant with the existent literature on IC reporting and measurement [7] [27] [36] [69] [70] [81] and is reformulated on the indicators required by the Italian Ministry (MIUR-ANVUR) that, on their own, were developed as part of the international quality assurance system of universities (Bologna Process). Although the Italian higher education system lacks mandatory reporting on intellectual capital, the model allows us to understand, by following the indicators defined by the MIUR-ANVUR and those compliant with the IC reporting/disclosure literature, what could be the

determinants of the IC and, consequently, on which elements a university could invest (or not) to improve its IC.

In addition, this study proposes a second model to place alongside IC model that allows measuring the TS – a synthetic indicator of the knowledge created. This second model is built by considering the indicators required by MIUR-ANVUR to evaluate the performance of university degree courses. We selected the indicators compliant with both the IC literature and the Austrian UG IC Framework (2002).

These two models allow the assessment of both the IC relevant for the teaching area and the teaching performance. In addition, they allow the comparison of the value of the inputs of the knowledge-productive process, the IC index, and its output, the TS. In this way, it is possible to understand for each final index (IC or TS) the impact of the determinants (indicators selected) on the synthetic value. At the same time, it is possible to interpret these values in the paradigm of the knowledge-productive process [IC (as input) → knowledge-productive process → teaching score (as output)].

Thus, when the IC index is minor/equal to the TS, a practitioner could interpret that he or she is using his or her knowledge assets to create or not destroy value. Otherwise, instead, when the IC index is

more than the TS, a practitioner could interpret that he or she is not using his or her knowledge assets efficiently, identifying the less-performing variables.

Both models are based on fuzzy set theory, a rare approach in this field of research [53]. As most of the information used in the evaluation process of IC is vague or relative, fuzzy set theory, which can adequately handle vagueness and relativity, seems to be the right tool to manage this kind of process.

This study was just a first approach to the issue; the idea of the application of FES model to the IC assessment needs a deeper investigation, especially of the real relationship between the determinants of IC and the final results [81]. Moreover, it is important to consider that the results could be influenced by the particular situation of the Italian higher education system, with low funding and complex enrolment processes.

The limitation of this study is basically linked to the set of indicators employed, as derived from the Italian ministerial (MIUR-ANVUR) dataset. Thus, the indicators we analysed are specifically coherent with the Italian model, and our results could be extended to an international context by adapting them to more widespread and general frameworks.

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