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Patent Management:

Scale development and validation

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Abstract

There is a great interest by practitioners and academics to consider patents as a strategic and organizational concern aiming to bring economic and competitive advantage, in addition to its legal value. To this end, patent management has a critical importance for enterprises operations, and successful firms are also known by their well-structured management process and organizational structure for patenting. However, there is a demand for a holistic, valid and practical measurement instruments to monitor patent management and assess firm patent portfolios. To fill this gap, the current study develops and validates patent management measurement scales at the firm level. To this purpose, a four-step (i.e. specify domain of the construct, item generation, scale purification, and scale finalization) widely recognized and structured scale development and validation procedure towards developing psychometrically sound measures is adopted.

The first two steps focus on the development of measurement scales within a defined scope of investigation. To this end, an in-depth literature review supported by a qualitative analysis through interview with experts is carried out. These analyses allowed conceptualizing the theoretical background of the constructs under investigation, which leads us to develop a theoretical framework of patent management with core processes and supporting dimensions and associated activities and organizational aspects. Then, the pool of measurement items for each activities and organizational aspects are generated.

In the third and fourth steps, we carried out exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) to purify and validate, respectively, the measurement items using two samples of primary data collected through an online survey sent to firms located in Southern and Northern European countries (the EFA) and Central European countries (the CFA). The results of EFA and CFA yield some changes to the initial framework and the measurement items. More particularly, the study demonstrates that patent management is composed of five core processes (i.e. patent generation, freedom to operate, patent portfolio management, patent exploitation and enforcement, and patent intelligence) and two supporting dimensions (patent strategy and organization for patenting). For each core process and supporting dimension, the underlying factor structure with the associated measurement items are finalized after removing some items based on established criteria for item retention. Reliability and validity are also assessed to further support the soundness of the measurement scales.

This study has both theoretical and practical implications. For academics, the study extends existing research by offering an up-to-date and comprehensive conceptualization of firm patent management activities, thereby enriching patent management body of literature. Moreover, it offers researchers a basis to test hypotheses about the relationships among processes and dimensions of patent management, and firms output attributes (e.g. performance) using real data collected from firms. In addition, the scales developed in this study for each core process and supporting dimension can also be used separately to suit specific research needs and examine a particular aspect of patent management. For managers, the study offers a comprehensive framework that can be used as an assessment tool to evaluate firm patent management. Moreover, the measurement of the current level of patent management can be used as a basis for managers and entrepreneurs to adopt a proactive attitude towards patent management.

Sommario

Considerare i brevetti come un aspetto strategico-organizzativo che mira a portare un vantaggio economico e competitivo, in aggiunta al suo valore legale, sta diventando una pratica sempre più consolidata tra professionisti e accademici. In tal senso, la gestione dei brevetti ha un'importanza fondamentale per le imprese, tanto che le aziende di successo sono altrettanto note per la struttura organizzativa ed i loro efficaci processi di gestione dei brevetti. Tuttavia, vi è una richiesta di strumenti di misura olistici, validi e pratici per gestire i brevetti e valutare portafogli brevetti delle aziende. Per colmare questa lacuna, tale lavoro di tesi sviluppa e convalida delle scale di misura con riferimento al processo di gestione brevettuale a livello aziendale. A questo scopo, è stata adottata un'ampiamente conosciuta procedura di sviluppo e validazione di scale di misura strutturata in quattro fasi (i.e. specificare il dominio del costrutto, generare gli item, purificare le scale e finalizzare le scale).

Le prime due fasi si concentrano sulla definizione dell'ambito di indagine e sullo sviluppo di scale di misura in questo ambito. A tal fine, è stata effettuata una revisione approfondita della letteratura supportata da un'analisi qualitativa attraverso delle interviste con esperti. Queste analisi hanno permesso di concettualizzare il *background* teorico dei costrutti oggetto di indagine, il che ha portato a sviluppare un framework di gestione dei brevetti composto da processi *core* e dimensioni di supporto, al cui interno sono state definite le rispettive attività e gli aspetti organizzativi. Quindi, è stato generato l'insieme di item di misura per ciascuna attività e aspetto organizzativo.

Nella terza e quarta fase, sono state effettuate un'analisi fattoriale esplorativa e un'analisi fattoriale confermativa per purificare e validare, rispettivamente, gli *item* di misura utilizzando due campioni di dati primari raccolti attraverso un sondaggio online inviato alle aziende situate in Paesi dell'Europa meridionale e settentrionale (analisi esplorativa) e paesi dell'Europa centrale (analisi confermativa). I risultati di tali analisi hanno portato ad alcune modifiche al framework iniziale e agli *item* di misura. Più in particolare, lo studio dimostra che la gestione dei brevetti è composta da cinque processi fondamentali (i.e. generazione di brevetti, *freedom to operate*, gestione del portafoglio brevetti, sfruttamento e *enforcement* dei brevetti e *intelligence* sui brevetti) e due dimensioni di supporto (strategia dei brevetti e organizzazione per la brevettazione). Per ciascun processo principale e dimensione di supporto, sono stati definiti attività e fattori organizzativi (i cosiddetti "fattori"), con i relativi item di misura, dopo aver rimosso alcuni item in base a precisi

criteri stabiliti in precedenza. Al fine di supportare ulteriormente la solidità delle scale di misurazione, sono state valutate l'affidabilità e la validità delle scale di misura con appositi test statistici.

Questo studio ha implicazioni sia teoriche che pratiche. Dal punto di vista accademico, lo studio estende la ricerca esistente offrendo una concettualizzazione completa e aggiornata delle attività di gestione dei brevetti a livello aziendale, arricchendo in tal modo la letteratura sulla gestione dei brevetti. Inoltre, offre ai ricercatori una base per testare le ipotesi sulle relazioni tra i processi e le dimensioni della gestione dei brevetti e le caratteristiche di output delle imprese (e.g. prestazioni) utilizzando dati reali raccolti dalle aziende. Inoltre, le scale sviluppate in questo studio per ciascun processo *core* e dimensione di supporto possono anche essere utilizzate separatamente per soddisfare esigenze di ricerca specifiche ed esaminare un aspetto particolare della gestione dei brevetti. Per i manager, lo studio offre un quadro completo sulla gestione brevettuale che può essere utilizzato come strumento di valutazione per analizzare la gestione dei brevetti. Inoltre, la misura dell'attuale livello di gestione dei brevetti può essere utilizzata come base per manager e imprenditori per adottare un atteggiamento proattivo nella gestione brevettuale.

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Mehari B. T – September 2019

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Acronyms

CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis
EPO	European Patent Office
FA	Factor Analysis
IP	Intellectual Property
IPR	Intellectual Property Right
JPO	Japan Patent Office
PM	Patent Management
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization

Chapter one

Introduction and objectives

1.1 Introduction and theoretical background

According to the world intellectual property office (WIPO[1]), intellectual property (IP) refers to creation of the mind (i.e. inventions, literary and artistic works, and symbols, names and images used in commerce) that can be protected by law and enables people to recognition or financial benefit from their inventions. More specifically, it represents the legally protected and codified knowledge of its owners [149]. Initially, the importance of IP was first recognized in the Paris Convention for the Protection of Industrial Property (1883) and the Berne Convention for the Protection of Literary and Artistic Works (1886)[1] and focused more on legal protection of inventions. Then, IP has been assuming an increasing importance in the activities of recent firms and their management cannot be left to technology managers or corporate legal staff alone, rather IP management should be a matter of concern for functional and business-unit leaders as well as a corporation's most senior officers [130]. Therefore, the existence of a substantial portion of many firms' markets value within their IP leads to the extension of IP management from its purely legal perspective towards managerial/strategic and organizational approach [7,146].

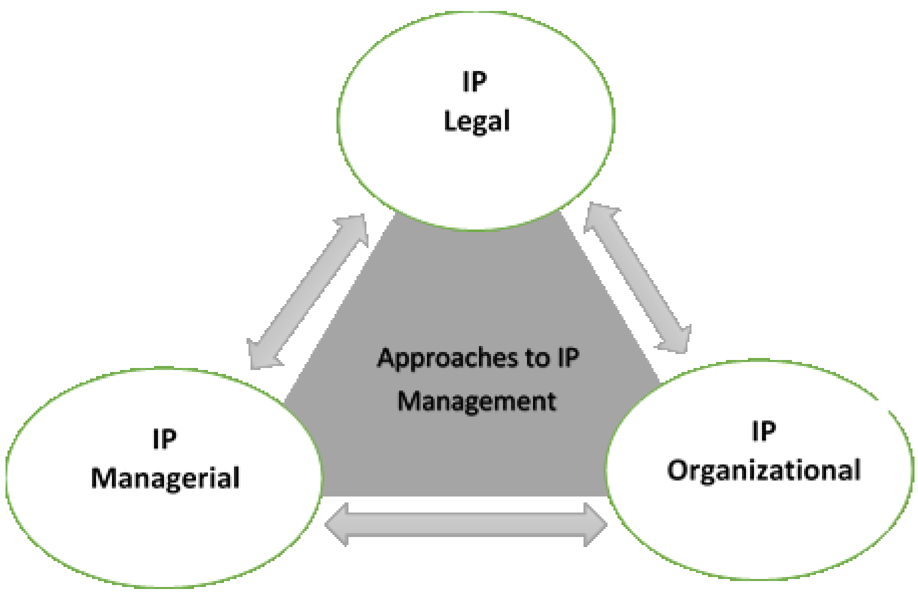

Figure 1.1 The multi-disciplinary structure of intellectual property

[1] https://www.wipo.int/about-ip/en/

This transition is challenging for firms both in terms of its process and scope of IP management. The first challenge arises due to the limitation in managing IP according to business strategy and the difficulty of valuing intangible assets (e.g. IP) that are not well recorded on the traditional balance sheet [143]. Secondly, effective IP management poses a significant challenge for firms because it needs an understanding of a wide range of issues from technology innovations to product/service design to competitive strategies, under rapid pace of technological advances with various players [177]. In addition, the nature of knowledge which might be subject to leakage, spillover, imitation, and mobility, has also contributed to this challenge [144]. To overcome this challenge the legal protection of IP is governed by intellectual property rights, IPRs (*see Table 1.1*), that include trademarks, trade secrets, patents, copyrights, utility models, industrial design rights [1,12,15,32,61,104] and companies should consider IPRs as their strategies to enhance competitiveness [29]. Among diverse types of IPRs, patents, the central body of this thesis, are the best known and strongest form of legal protection [99,146] and have the greatest effect on commercial success and market value [133].

Table 1.1 The different types of IPRs

Types	Description	Application	Life time	Coverage	Reference
Patents	A patent is an exclusive right granted for an invention in exchange for the disclosure of its technical information to the public by the patent owner	Must be filed with the appropriate national or regional patent office	20 years	In the country where the application filled	WIPO[1]
Trademarks	A distinctive sign that identifies certain goods or services produced or provided by an individual or a company	Must be filed with the appropriate national or regional trademark office	can be renewed indefinitely upon payment of the corresponding fees	Country it registered	[65], WIPO[1]
Copyrights	A legal term used to describe the rights that creators have over their literary and artistic works	Copyright protection is obtained automatically for	Can vary according to national law. For countries which		[65], WIPO[1]

		Berne Convention member countries	are members of Berne Convention >= 50 years after the creator's death		
Utility models	It protects functional design that meets the same general criteria of patent				[65]
Industrial design rights	An industrial design constitutes the ornamental or aesthetic aspect of an article. A design may consist of three-dimensional features, such as the shape or surface of an article, or of two-dimensional features, such as patterns, lines or color	>Registered under industrial design law as a "registered design" or >protected under patent law as "design patents "		In country it registered	WIPO[1]

A patent is a monopoly granted by a state to an inventor or their assignee for a limited period, generally 20 years, in exchange for full public disclosure of the invention [16,32,125,178]. The invention may be a composition of matter, machines, man-made products or processing methods (including business process) that provides a new way of doing something, or that offers a new technical solution to a problem [44, WIPO[1]]. The minimum technical requirement for an invention to be considered as patentable [69,98] includes.

- It must be new or novel to the world: it refers that the invention has not been known before or there has been no written public record of the invention, and no public disclosure of the invention.
- It must be industrially applicable or useful: it means that the invention must have technical character and can be carried out or enabled.
- It must be non-obvious: it means that the invention must exceed a certain minimum inventive step (level of invention) like the invention must not be obvious extension of previous inventions or technology.

According to the *economic theory of patents*, patents and other forms of intellectual property encourage innovation by delaying the arrival of imitators, thus giving pioneer firms time to recoup their sunk costs of research and development through monopoly pricing [184]. In this regard, the exclusive right granted to a patentee in most countries primarily gives legal right to prevent others from making, using, selling, or distributing the patented invention without permission [25,86,125] and the public will benefit from the disclosure of technical knowledge that promotes further creativity and innovation. But, a patent by itself do not guarantee the owner to practice the patented invention, rather it gives only to exclude others from using it [98]. The owner of a patent may practice his invention as long as it, or any part of it, is not covered in a valid patent by someone else.

Here, patents compensate an innovator efforts and resources invested into research and development by providing a prohibitive right with respect to a given invention and thus affect free competition [183]. In this regard, patents raise barriers to imitation of the firm's technological resources, thus acting as an isolator mechanism [182]. Beyond this strategic approach, there are other patent strategies firms may pursue, namely proprietary, defensive and leveraging [144]; the differences among these strategies depends on "logics" of decision making about patents in three domains of activity: rights, licensing, and enforcement.

To this end, the *rights* represent all firms' patent-related activities, expenditures, status and utilization of external resources to acquire patent rights [25, 144]. Patent rights are important as competitive means for the protection and commercial exploitation of new technologies [69] and thus greater emphasis is given on its acquisition as part of the business strategy [156]. Firms can acquire patents in their portfolio by constructing or joining related patent pools, own patents for most of their products and processes, and putting substantial investment in R&D and patents [25, 129]. However, not all patents in the portfolio are used by the firm itself nor licensed out [113]. To this end, firms must give due attention to patent renewal that can be viewed as an optimizing process. In the process of patent renewal, throughout patent lives, firms compare the renewal costs with the expected future patent returns and decide whether to pay the renewal fees and keep the patents alive or not [47]. Furthermore, the acquisition of important or attractive patents not only assures firms of their product superiority in the market, but also allows for better negotiation opportunities for business cooperation [156], or as blocking patents or patent fencing, which refers not only to the patenting of technologies for production, but also to the substitution of technologies in order to keep other firms from inventing around them [113].

Patent *licensing* indicates the activity of a patent owner to grant a license to another to practice the invention claimed in the patent, and in return he receives a licensing fee on the patent and royalties on the sale of whatever is made using the invention [98]. Many firms make a deliberate choice to license or cross-license the technology in their patents and, in so doing, they will generate additional revenues for their firms [98, 114]. In addition, firms can also join a patent pool, which is a typical patent alliance of patent holders or a scheme for the one-stop licensing of all patents held by patent pool members, to get access for patented inventions under a single license agreement [66].

Lastly, patent *enforcement* refers to the ability of a firm to appropriate patent value, or to threaten to block the use of a technology or to pay royalties [144, 110]. But a patent is only enforceable if a court will find it both valid and infringed [110]. When a firm decides to enforce its patents, the legal staff establishes methods and procedures to identify infringers and then to require the firm to demand a royalty payment from them in lieu of costly litigation [44]. When the cost of litigating patents is perceived to be higher, then firms can use the less formal methods of enforcement such as the sending of letters notifying a competitor of the right and alternative dispute resolution mechanisms [164]. The direct costs of enforcing patents include the costs of filing suits, attorney fees, and fees for examining the scope of patents, whereas the indirect costs include organizational dislocation, absorbing of time and energy for key managers, lawyers and engineers [30]. In addition, enforceability of a patent can be considered as indicators for patent value. In this regard, poor enforceability not only reduces patent value, but also reduces the ability to transact at arm's length [110].

On such grounds, the theoretical focus in this thesis is on the activities in which patent related actions are undertaken [144].

1.2 Worldwide trends in patenting

Patenting covers all activities by a patent applicant (i.e. an individual inventor or organizations) from the filing of patent application and to its follow-up until the grant of the patent or the rejection of the patent application by the patent office [139]. In this regard, as one form of IP, a patent must pass through a series of time-sensitive legal formalities for its creation, protection and enforcement [103]. Once the applicant files a patent application at a national patent office, then the information contained in the patent application becomes publicly available 18 months after filing [55]. In most countries, an invention novelty and obviousness are determined by the state of the art existing on the date the patent application was filed, not the date the invention was invented [103]. A patent applicant for an invention in one country has a twelve month 'priority period' during which the applicant can file the application for another country under the Paris convention for the protection of industrial property [18]. Furthermore, through patent cooperation treaty, inventors can obtain patents in multiple countries using international patent application system [56].

Regarding patent application, after 1980s especially in USA, the patent system became significantly strengthened [69] and the number of patent applications increased dramatically, which led to a so called 'pro-patent' era since the beginning of 1990s [69,144,152], but later China took the leading position in 2011. To get an overview of patent applications by the leading countries, Figure 1.2 below shows the worldwide trends in patent applications by the top five patent offices based on their 2016 totals. Overall, the graph clearly indicates the significant growth of patent application, especially from 1980s onwards. Initially, U.S. was the leading office for world patent filling followed by Japan, and both had stable applications until 1970s, then Japan began to see rapid growth of patent application, a pattern also observed for the U.S. from the 1080s onward. Among the top five offices, Japan surpassed the U.S. in 1968 and maintained the top position until 2005. Since the early 2000s, however, the number of applications filed in Japan has trended downward. Both the EPO and the Republic of Korea have seen increases each year since the early 1980s, as has China since 1995. China surpassed the EPO and the Republic of Korea in 2005, Japan in 2010 and the U.S. in 2011, and it now receives the largest number of applications worldwide.

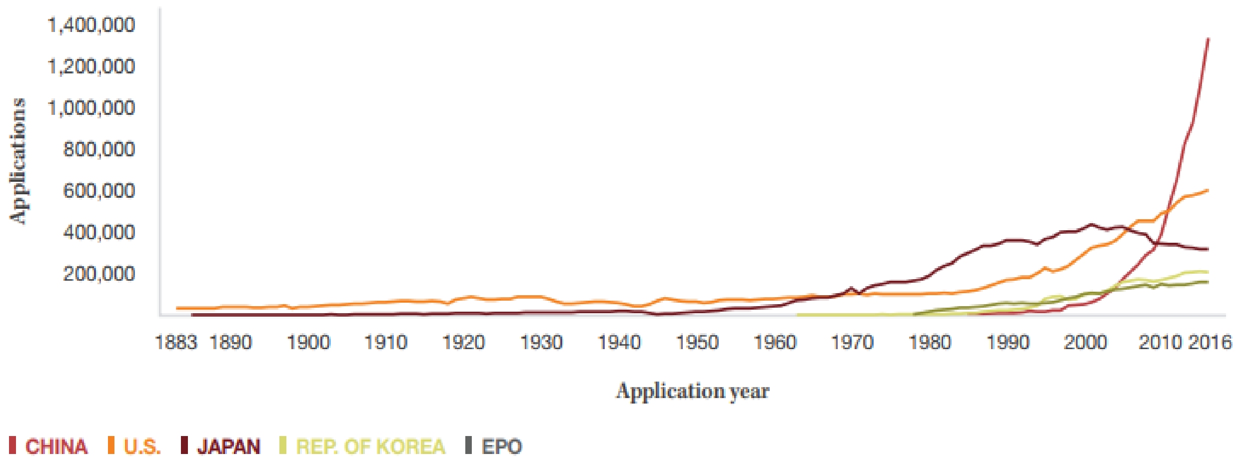

Figure 1.2 Trend in patent applications for the top five offices (Source: WIPO Statistics Database, September 2017)

This significant growth in firm patenting activities is driven by various motives, mainly related to the protection of innovation and inhibition of competitors' patenting to get market shares [16,17,69]. Beyond these classic motives, other firms focused on different strategic ways in the market place to pursue and maintain competitive advantages that do not necessarily conform to the original idea of patent [85,105], such as the blocking motive (offensive blocking, defensive blocking) and the exchange motive (income from licensing, use for cross-licensing, co-operation) [17], the use of patents to negotiate and prevent lawsuits [72,125], or to push the reputation of a company [152], to use patent data to explore managerial issues [29] and measure knowledge flows [134]; to safeguard future technologies and used as a basis for alliances [152]. To this end, there exist an increased R&D expenditures by many firms in which some understood the real value of patents lies not in their individual significance, but instead in their aggregation into a patent portfolio, i.e. a strategic collection of distinct-but-related individual patents that, when combined, confer an array of important advantages to the portfolio holder [171].

1.3 Motivation of the research

This thesis has both a theoretical and practical motivation. The theoretical motivation departs from the analysis of literature related to patent management and the identification of potential areas that need further investigation. To this regard, we carried out an extensive literature review that helped us to understand the demand for measurement instruments to assess patent management activities at firm level. In addition, the motives of patenting that goes beyond the legal aspect mentioned above assumed increasing importance [152], which contributed to attract the attention of scholars and practitioners to use patent data as an output measurement of firm's various aspects of business activities. Moreover, the literature [52,53] proves that those firms that have active and systematic patent management practices perform better than firms that are not using their patent for strategic purposes. However, generating value from patents is a challenging activity, since much of the economic and competitive benefits from these assets depends on their effective management [55,64]. Despite these evidences, insights in how firms manage their patents from a holistic, strategic perspective, and how the portfolio value of patents can be optimized are scarce [7], and there are still limitations in the literature for detail patent management tasks [112].

From a practical standpoint, the patent awareness within firms, irrespectively of their size, is still scarce, leading to an ineffective management of these assets [126]. Indeed, some managers admit their lack of time and competences to manage their company patent portfolio and some others are not completely aware of the potential benefit they can gain from correct exploitation of the patent portfolio. To this end, though patent management is critically important in the operation of enterprises [178], it seems that the current studies on the measurement of patent management do not cover all of its relevant activities through a holistic approach from an organizational and strategic perspective. Even though there exist some scales to measure specific aspects or attributes of patent management, to the best of our knowledge there is no systematic attempt that has been made to develop a valid and comprehensive framework and measure of patent management. On the other hand, Hinkin [81] stresses the importance of measurement scales, and the difficulty in drawing strong conclusions and in getting the required results from a body of research without adequate measurement instruments.

1.4 Objectives of the study

Taking into consideration the limitations of sound measurement scales in the field of patent management, the purpose of this thesis is to develop and validate firm-level patent management scales, which can be achieved through the application of a structured methodology. To this purpose, and considering that that managing patents entails managing the process of patenting activities and exploiting value from firm's patent portfolios this thesis aims to understand the conceptual dimensions of patent management in the transition from a legal perspective to an organizational and strategic approach. To illustrate this phenomenon, we propose a firm-level patent management framework, consisting of core processes and supporting dimensions including activities and organizational and managerial aspects, with their associated constructs and measurement items.

Therefore, specifically, this thesis addresses the following points in detail:

- Identifying the conceptual processes and dimensions of patent management to design the theoretical measurement framework;
- Breaking-down processes and dimensions into activities and organizational and managerial aspects;
- Identifying measurement items that adequately operationalize the constructs under investigation;
- Validating the measurement scales designed.

1.5 Thesis outline

This thesis is organized into six chapters. Chapter one provides a brief introduction on the thematic area beginning from the broader domain of IP management to the specific focus of the research, which is patent management. Then, research motivation and objectives to be achieved are presented. Chapter two investigates the research methodology used in the development and validation of robust measurement scales. Chapter three develops and discusses the theoretical measurement framework of patent management, including the specification of the constructs of interest, in terms of processes, dimensions, activities and organizational aspects, and the generation of associated measurement items, through a broad literature review and interviews with experts. Chapter four discusses the scale purification by presenting the results of the exploratory factor analysis based on quantitative survey data from firms located in Southern and Northern European countries. Chapter five focuses on scale finalization by presenting the results of the confirmatory factor analysis always based on survey data but collected from a second survey to firms located in Central European countries. Lastly, Chapter six discusses the results obtained from the analyses, implications, limitations and future directions.

Chapter Two

Methodology

2.1 Research method for scale development and validation

This chapter discusses the methodological approach used in this thesis during the design and development of psychometrically sound measurement scales for firm-level patent management. To identify the most appropriate methodology, we carried out a literature review mainly focused on the methodological articles that propose methods or steps for new scale development and validation. In this regard, we mapped the scientific publications from which we adapted the methodological steps as shown in Table 2.1 below.

Table 2.1 Some of the common methodological steps in new scale development and validation

Authors	Proposed steps	Citations
[36]	1. Specify domain of construct, 2. Generate sample of item, 3. Collect data, 4. Purify measure, 5. Collect data, 6. Assess reliability, 7. Assess validity, 8. Develop norms	17943
[132]	1. Item Generation, 2. Item Refinement, 3. Reliability, 4. Scale validation	3278
[80]	1. Item generation, 2. Content adequacy assessment, 3. Questionnaire administration, 4. Factor analysis, 5. Internal consistency assessment, 6. Construct validity, 7. Replication.	437
[79]	1. Item generation, 2. Questionnaire administration, 3. Initial item reduction, 4. Confirmatory factor analysis, 5. Convergent/discriminant validity, 6. Replication	2462
[81]	1. Item generation, 2. Scale development (design of the developmental study, scale construction, reliability assessment) 3. Scale evaluation	2561
[175]	1. Item generation, 2. Item purification, 3. Reliability assessment and construct validation 3.1 Dimensionality and reliability 3.2 Construct validity 3.3 Test of hierarchical factor structure, 4. Nomological validity	613
[163]	1. Theoretical foundation, 2. Generation of scale items, 3. Scale purification 3.1 Identifying factor structure, 4. Reliability and validity assessment (reliability, content validity, criterion-related validity, discriminant and convergent validity)	528

Note: The citations were updated on 30/06/2019

According to the literature [79], there are several criteria set as a rule of thumb to assess the psychometric soundness of a measurement instrument. In this regard, from the analysis presented above (see Table 2.1), we understood that there is a saturation of methodological steps and most of them are set their base on the standard and well-accepted scale development paradigm suggested by Churchill [36]. Accordingly, we followed a four-step structured scale development procedure (i.e. specify domain of construct, item generation, scale purification, scale finalization) adapted from Churchill [36] and further augmented by Hinkin et al. [80] and Hinkin [79] to develop multidimensional firm-level patent management (see Figure 2.1).

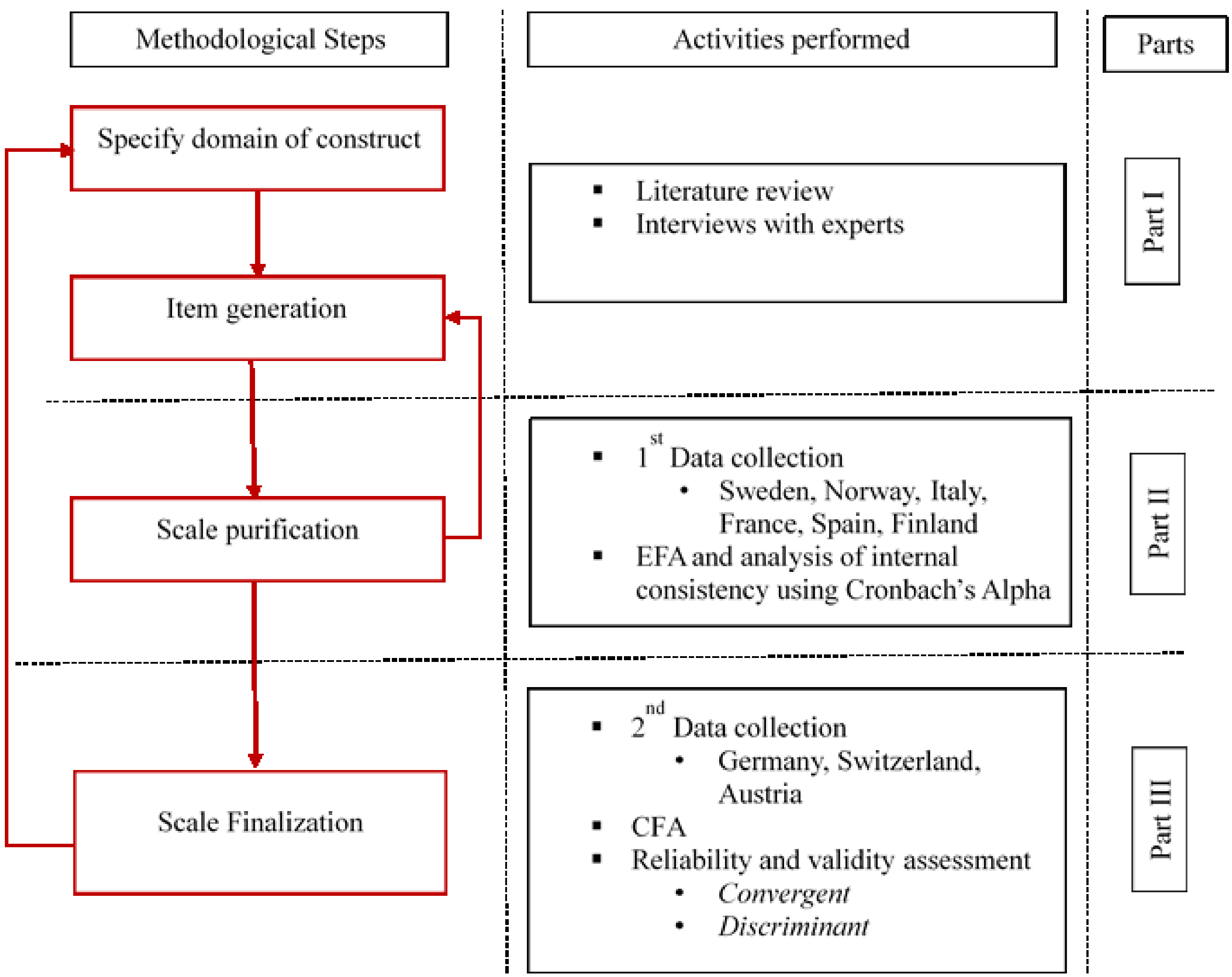

Figure 2.1 Methodological approach adapted from Churchill [36], Hinkin [79], Hinkin et.al. [80]

Furthermore, we divided the scale development process of this thesis into three broad consecutive parts based on the type of study and input data. The first part covered a theoretical analysis and qualitative study aiming to design a theoretical measurement framework for firm-level patent management through a deep investigation of literature and preliminary interviews with experts on patent management. Following the theoretical framework of patent management, the underlying constructs were specified with the generation of their respective measurement items. The second part of the study mainly concerned with the purification of the initially generated pool of measurement items. For this purpose, we collected our first primary data (Sample I) and carried out an exploratory factor analysis. Whereas, in the third part, different tests of construct validation such as convergent validity and discriminant validity, and internal consistency assessment were carried out on a second sample of primary data (Sample II) through a confirmatory factor analysis. The section below provides the details for each of the methodological steps under the three parts.

2.2 Specify domain of construct and item generation

The very beginning of scale development is specifying the domain of construct [36], that can be used as a basis for operational definition of patent management as well as of the underlying constructs and to set a well-articulated theoretical foundation for the new scales. Then, the subsequent step is the generation of pools of items [36,79] that is maybe the most important part of developing sound measurement scales [81]. The generation of items relied on gleaning published theoretical conceptions from the literature of patent management, examining qualitative data gathered in an exploratory investigation from expert interviews, and converting frequently mentioned descriptions of firm-level patent management activities into items. To this end, we conducted a theoretical study through an extensive literature review and qualitative study through a discussion and an interview with experts to conceptualize the constructs and generate measurement items.

2.2.1 Analysis of the literature

In this section, we explain the methodological procedures and considerations for the fist-two steps of the scale development and validation procedure, i.e. specify domain of construct and item generation. In this regard, we begin from a broad literature review on patent management taking into consideration that the construct is a representation of unobservable dimensions [79], concepts, attribute, or variables [77] which is the target of measurement. The review of a literature is used to enabled us both to map and to assess the existing intellectual core and, have a vital contribution to the relevance and rigor of the research by avoiding repetition on what is already studied and effective use of the existing knowledge base [159,165]. The knowledge base provides the foundational theories, frameworks, constructs, measurements, models, and methods used in the development phase of the research [154,160]. Since the increasing wealth of literature on the topic of patents makes it difficult to keep up-to date with ongoing research (Müller et al., 2004), we used a systematic literature review using keywords to identify the intellectual core. To start the systematic literature review, it is recommended to search any of the existing literatures and consider the current evolutionary state of the research field [121] and identify relevant articles for further analysis. The search of the literature comprises querying scholarly databases [159] by using keywords [165] to identify the intellectual core. Furthermore, to improve the quality of the review and to capture important concepts for construct development, our search covered a range of journals, geographic regions and different keywords. This helped us to gather the most comprehensive list of prominent articles related to patent management from which we selected the relevant one. To this end, we incorporated papers related to patent management published from 1985 to January 2018 in different disciplines.

Table 2.2 Cluster of papers used from Web of Science [searched from June 2017 to Jan. 2018]

Keywords	Total papers	Papers under business, management and OR&MS	Articles, proceedings, book chapters
Patent + manag*	337	69	36, 27, 6
Patent + plan*	193	23	17, 2, 4
Patent + evaluat*	327	26	16, 8, 2
Patent + information	406	73	35, 38, 0
Patent + enforce*	63	35	29, 2, 4
Patent + defen*	52	19	14, 2, 3
Patent + scal*	31	4	4, 0, 0
Patent + measure*	166	54	38, 9, 7
Patent + construct	14	4	2, 2, 0

Patent + validat*	12	3	3, 0, 0
Patent + methodology	19	6	3, 1, 2
Patent + map	129	26	14, 11, 1
Patent + landscape	79	2	1, 1, 0
Patent + life cycle management	6	1	0, 1, 0
Patent + exploit*	24	9	6, 3, 0
Patent + business method	49	12	9, 3, 0
Patent + alliance	18	9	9, 0, 0
Patent + strategy*	447	147	82, 54, 11
Patent + commercial*	107	34	26, 8, 0
Patent + fenc*	6	3	3, 0, 0
Patent + litigat*	250	55	45, 10, 0
Patent + appropriate*	27	17	13, 3, 1
Total	2,762	631	405, 185, 38

The search of scholarly articles was carried out in two phases. In the first phase, since the focus of this thesis was the development and validation of firm-level patent management measurement scales, we used keywords that were initially generated based on the definition of patent management that encompasses the five sub-processes (i.e. patent planning, evaluation, information screening, enforcement and defensive measure). This definition provides an all-inclusive description of patent related activities or processes within the firm, thus it can be used as a good starting point to get deeper understanding of patent management. To this reason, we combined the keyword patent* with other keywords from sub-processes as: manag*, plan*, evaluat*, information, enforce*, defen*, and carried out the search on the scientific database ISI Web of Science core collections, as shown in Table 2.2. In the second phase, after reading the articles retrieved in phase one, we updated our search using other new keywords or references that emerged from articles examined [159]. To this regard, we used again a combination of patent* and the new keywords emerged from backward search as: scale, measur*, construct, validat*, map*, landscape, "life cycle management", exploit*, "business method", alliance*, commercial*, fenc*, litigat*. Overall, we found a total of 2,762 papers, as shown in Figure 2.2.

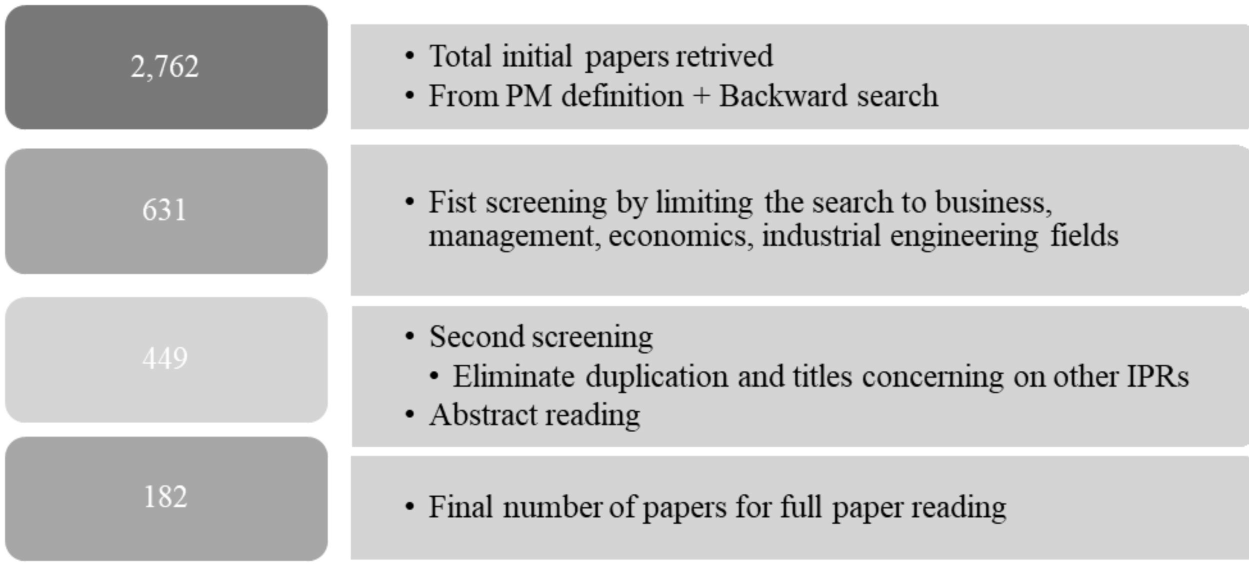

Figure 2.2 Literature search and refinement

After we retrieved all papers from ISI Web of science using keyword search, we moved to filter the relevant papers for this study. Since the concern of the study was not the legal perspective of patents, as shown in Figure 2.2 the initial filtering began by limiting our search to business, economics and management discipline categories, thus reducing the number of articles to 631. This exclusion criteria provided us with articles more focused on the managerial, strategic and organizational aspects. Then, we further refined these articles by excluding duplicates and removing articles reporting other types of IPRs in the title, which gave us 449 articles. Finally, by reading the abstracts, we filtered 182 relevant articles for our construct development by selecting articles related to patent management processes and excluding those articles that have not a direct relation with the topic of investigation. The exclusion criteria included for example studies that used patent statistics for quantitative estimation of technological impact, studies that did not focus on general aspect of patent management, but examined specific aspects of patents, studies with different main focus, but the used keywords present in their titles, studies that used patent data for technology road-mapping using text-mining approach and/or those focused on technology innovation capacity and technology proximity between R&D partners. Then we prepared a spreadsheet to map the relevant patent-related dimensions and constructs with their definition and associated features.

While analyzing the literature, we directed our attention to articles that are related to patent management, as it is the focus center of the thesis. In the first hand, the literature review aims to identify core processes and supporting dimensions that were used as pillars for the design of a theoretical patent management measurement framework (see Figure 3.5 in Chapter 3). Based on the core processes and supporting dimensions, we further conceptualized and defined the constructs of patent management that are used as a basis for the next step of item generation. While defining the latent constructs, we took into consideration the importance of understanding what is to be included in the domain and what is to be excluded [36]. The results of this literature review will be presented in chapter three under specify domain of construct and item generation section, whereas this chapter concentrates on the methodological aspects.

As for item generation, based on the relationship between the measurement items and the unobserved latent constructs, the measurement model can be done in two ways [108,167], namely formative and reflective as shown in Figure 2.3. Understanding the distinction between the two models is important to develop a framework with a strong theoretical justification for constructs followed by consecutive empirical tests or validation to support causal relationships between constructs and their measurement items [40].

In the case of reflective model, the measurement items are considered as a manifestation of the construct [49]. These measurement items are expected to correlate, and to improve the psychometric measurement properties, some of the items will be removed based on empirical analysis [167].

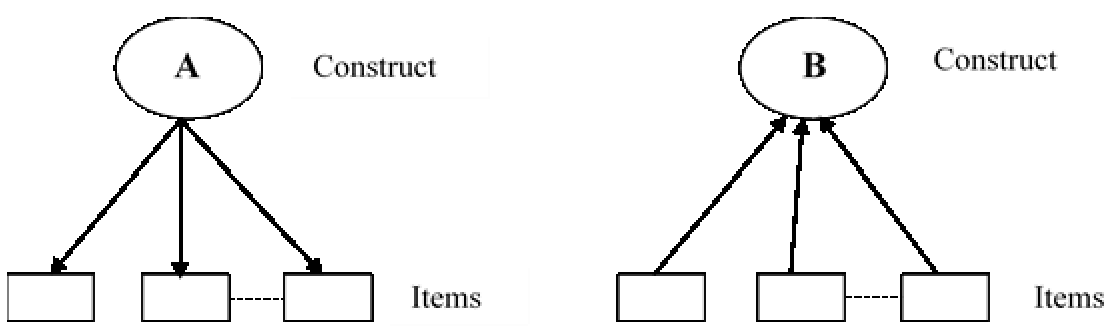

Figure 2.3 Reflective (A) and formative (B) models

In a formative model or causal index results each measurement items captures a unique aspects or unique portion of the construct to be measured, and when all the items are combined, they will give the aggregate construct [108]. The causality flows in opposite direction from the measurement items to constructs.

The practice of these two approaches varies with respect to study disciplines. The practice of reflective approach is mostly dominating in the psychological and managerial sciences, whereas the formative view is common in economics and sociology [40]. In addition, the choice of these two approaches depends upon the conceptualization of the constructs: one can treat the construct as giving rise to its items (reflective indicators) and follow the conventional scale development procedure to generate a multi-item measures, or one can treat the items (formative indicators) as a defining character for the construct and form the construction of an index [50]. The former approach is more suitable for the current thesis because due to enough theoretical background on patent management.

The literature explains the different approaches for generating the pool of items by which the constructs can be measured. The first approach departs from the existing theory around developed around a construct, from which items can be generated, which is also called deductive or classification from above or logical partitioning [80]. This approach is mostly used for scale development in which the area of study has enough theoretical background [36,174,175] and the researcher can generate the measurement items by investigating the literature. Whereas, the second approach is inductive, usually used to explore unfamiliar phenomena in which the theoretical basis for a latent construct may not result in easily identifiable dimensions from which items can be generated or when the theoretical background of the study area is scarce [80]. In this case, experts on the subject are asked to provide their description or opinion on the topic of interest through experience surveys [36], open ended questionnaires [137,179] and interviews [120] to generate initial items. Lastly, it is also possible to combine these two approaches [150] to reach a better result. Considered our domain of investigation, we concluded that a combination of deductive and inductive approaches is suitable for the current thesis because, on the one hand, there is some literature on patents and some authors have investigated in deep details some particular activities of patent management, whereas, on the other hand, there are still missing elements of patent management that we cannot find in the literature.

In addition, when generating measurement items, the primary concern of the researcher should be the content validity, which may be viewed as the minimum psychometric requirement for measurement adequacy and is the first step in construct validation of a new measure, whereas the other concern is to establish a clear link between items and their theoretical domain [81]. The latter concern is accomplished by developing a theoretical framework (see Figure 3.5 in Chapter 3) of patent management with different core processes and supporting dimensions from which we began the generation and sorting process of measurement items.

The content validity refers the degree to which a measure's items are a proper sample of the theoretical content domain of the construct [140] and it must be considered at the time of developing measurement items [81]. To this regard, our generated items satisfy the basic criteria set for initial item generation:

a) item wording should be precise [36] simple, as short as possible and the language used should be familiar to target respondents [80]

b) double-barrelled statements would be split into two single-idea statements, and if that proved impossible, the statement would be eliminated altogether [36, 80]

c) items must be understood by the respondent as intended by the researcher to obtain meaningful responses and content redundancies are desirable when creating multiple items because they are the foundation of internal consistency reliability [80]

d) items rejected if the sub-object was not unambiguously and specifically identified or if the component attribute was not specifically and uniquely identified [136]

e) leading questions should be avoided, as they may bias response

f) items that all respondents would answer similarly should not be used, as they will generate little variance

g) if the researcher choses to use reverse-scored items, they must be carefully worded to assure appropriate interpretations by respondents, and careful attention should be paid to factor loadings and communalities at the factor analytical stage of scale development [80].

2.2.2 Interviews with experts

The qualitative study includes in-depth interviews and discussions with experts in the field of patent management. While carrying out the qualitative study, we maintain the sample size requirements. According to the literature [51] the sample size for qualitative study is normally smaller than that needed by quantitative studies. But still there are debates to determine the right sample size during qualitative studies and most scholars argue the concept of saturation as the most important factor in sample size decision [51,111,116]. Taking this into consideration, we carried out our interviews until we reached a theoretical saturation [148] on the processes, dimensions and activities of patent management. The theoretical saturation here refers to the point at which further interviewing of the experts provides no more relevant aspects or information on patent management. In this regard, we selected experts from companies, consulting firms, and academia who have different professional backgrounds, and they have also different positions as patent attorneys, IP managers, technology scouting representatives and academic professors as shown in Table 2.3; in particular, we opted for interviewing both academic experts carrying out research on the topic, patent experts who have a direct contact and expertise gained within different companies and representatives of companies with a large patent portfolio that actively manage it. Since the required information is collected directly from experts, key informants interviews provide relevant information and insights that are not found in the theoretical literature. Furthermore, the interviews provide a flexibility to explore new ideas and perspectives that were constructive for our initial theoretical framework. In general, the interviews and discussions with experts had a two-fold objective. Firstly, we used the interviews to get constructive comments and practical insights on the structure of the theoretical framework for patent management. At this point, the experts are asked to provide opinions and give comments on the core-processes and supporting dimensions of patent management, and the respective constructs based on their practical experience (e.g. how they define patent management in their firms, the scope of patent management, the processes included in the patent management macro-process and associated activities, their level of agreement with core processes and supporting dimensions developed theoretically, their level of agreement on each core process and supporting dimensions activities, whether and what they would change or add to the overall structure).

Table 2.3 Summary of companies interviewed in Italy

Company	Position	Scope of the interview	
		Specify domain of construct	Item generation
Barzanò & Zanardo	Patent Attorney	15/01/2018 2 hours	
Brembo S.p.A.	IP manager	29/01/2018 1.5 hours	19/02/2018 3 hours
Finmeccanica	Head of IP management	02/02/2018 1.5 hours	22/02/2018 2 hours
SAES Getters S.p.A.	IP Manager, European &Italian Patent Attorney; Technology scouting resp.; IP manager	07/02/2018 1.5 hours	26/02/2018 2 hours
Chalmers University (Sweden)	Associate Professor, expert in Patent Management	07/02/2018 1.5 hours	06/03/2018 3 hours 17/04/18 3 hours
University of Ingolstadt (Germany)	Full Professor, expert in Patent Management	16/03/18 1 hour	06/03/18 1 hour

The second round of interviews focused on measurement items aimed to check the content validity of generated items and the possibility to add some additional items that may not be identified in the theoretical investigation (e.g. their insights on how the items measure the concept).

2.3 Scale purification: exploratory factor analysis (EFA)

2.3.1 Introduction

Even within a well thought out item development procedure, in the subsequent sorting or factor analytical techniques, items may not be perceived by the respondents to tap the predicted constructs and, thus, these items can be deleted from further analysis due to their low loadings on the factors/constructs [81]. In this regard, the scale purification process involves reduction of items and assessment of the scale's dimensionality [6] that consider statistical and judgmental decisions [167]. The decisions that base on statistical techniques are used to summarize the information contained in a number of original variables (items) into a smaller set of new, composite dimensions (constructs/factors) with minimum loss of information using factor analytic techniques [74]. The factor analytics technique is based on a correlation matrix in which a factor represents a set of items that correlate highly within a group but has very low correlation with other groups of items. Correlation of items with a factor represents the "factor loading" that determines the importance of an item to a factor, and the squared correlation of items determines the amount of variance accounted for by that item [4,74]. For the purposes of this study, we used both exploratory and confirmatory factor analysis to make a statistical decision in two different parts of the scale development and validation process. In this section, we discuss more specifically the exploratory factor analysis (EFA) based on the first sample data.

2.3.2 Sample I and questionnaire

The most important considerations in determining a reliable factor solution are the absolute sample size and the higher magnitude of factor loadings [4]. Factor analysis is generally regarded as a technique with large sample size. It is not possible to factor analyze a sample of fewer than 50 observations, and preferably the sample size should be 100 or more [74,170]. According to Hair et al. [74], the general rule of thumb for factor analysis requires the minimum sample size of at least five times as many observations as the number of variables to be analyzed, and the more acceptable sample size would have 10:1 ratio. On the other hand, some scholars [46] showed the possibility of using fewer sample sizes even below 50 observations when the data are well conditioned (i.e. with high item loadings, low number of factors, and high number of items). In this case, it is possible to use smaller sample size if the items have a higher factor loading. Whereas, when the value of communalities (recommended > 0.5), which represents the proportion of variance in the variable explained by each of the items [80], becomes lower, the importance of sample size increases [4]. The communalities represent variables (items) variance accounted by all factors, and the higher the communality the more reliable the factor analysis is [4,80,175]. In addition, while carrying out the EFA, SPSS has a convenient option to check the appropriate size of the sample using Kaiser-Meyer-Olkin (KMO) test. A value greater than 0.5 of this measure of sampling adequacy indicates that the sample used for the analysis is adequate [4,58,74]. Therefore, the sample chosen, which should be representative of the population that the researcher based his further analysis on and to which results will be generalized, is considered as one component among the different issues that impact scale development and validation [81].

For the purpose of scale purification using EFA, we used an online survey as a means of primary data collection [97] based on a questionnaire. The first phase of the survey covers the Southern and Northern European countries (including Italy, Norway, Sweden, Finland, France and Spain) as shown in Figure 2.4. Considered the aim of the thesis, we adopted a purposive sampling technique. More specifically, we focused on getting information from people who hold a formal role within the patent management area in companies. Therefore, the target respondents of the survey include patent managers, intellectual property managers, patent engineers, patent analysts and other employees who have a direct involvement in patenting activities e.g. in some company's innovation managers and/or technology transfer managers handle patents under their departments.

During the data collection, we first sent invitation request with a short brief summary of the project using LinkedIn and once we received confirmation of acceptance from contacted respondents, a link containing survey questionnaire in Surveygizmo was forwarded. The survey questionnaire consisted of 118 measurement items of firm-level patent management generated from the theoretical and qualitative study in item generation steps. The majority of the questionnaires are developed in the format that respondents can rate on a five-point Likert scales (1=strongly disagree, 5=strongly agree) and some questions require a yes or no answer and others need figure values. Initially we sent the online questionnaire to 1312 respondents and collected 225 responses among which 101 completed questionnaires were used in the EFA after checking the normal distribution of collected data. We used skewness and kurtosis measures to check the normal distribution of the data by considering the acceptable values of $< |1|$.

Figure 2.4 Geographical coverage of data collection (Red circle = Sample I, Purple = Sample II)

2.3.3 Exploratory factor analysis

EFA is a statistical technique suitable for analyzing the patterns of complex, multidimensional relationships for large number of variables and to determine whether the information can be condensed into smaller sets of factors [74]. The tool we used to compute the EFA is SPSS V.24. According to Osborne et al. [123], some of the major issues that should be considered during EFA includes the extraction method, the number of factors to retain for rotation, the rotation method, the sample size used to get adequate statistical results, and factor loadings.

The extraction method

Based on the different approaches of variance partitioning, principal component analysis and common factor analysis (see Figure 2.5) are the two commonly used approaches of factor extraction from a set of items. Principal component analysis assumes that there is no unique variance, and the total variance is equal to common variance. Furthermore, if the total variance is 1, then common variance and communality become equal. The latter approach, common factor analysis, assumes that the total variance can be partitioned into common and unique variance. Both approaches reduced the dimensionality of a data set into smaller number of unobserved variables/factors. To purify our measurement items, we used principal component analysis extraction method because it has the ability to transform data in to a simplified structure. This method is descriptive and used to form uncorrelated linear combination of observed variables or items in which the fist component has the maximum variance while the last component will have the minimum variance.

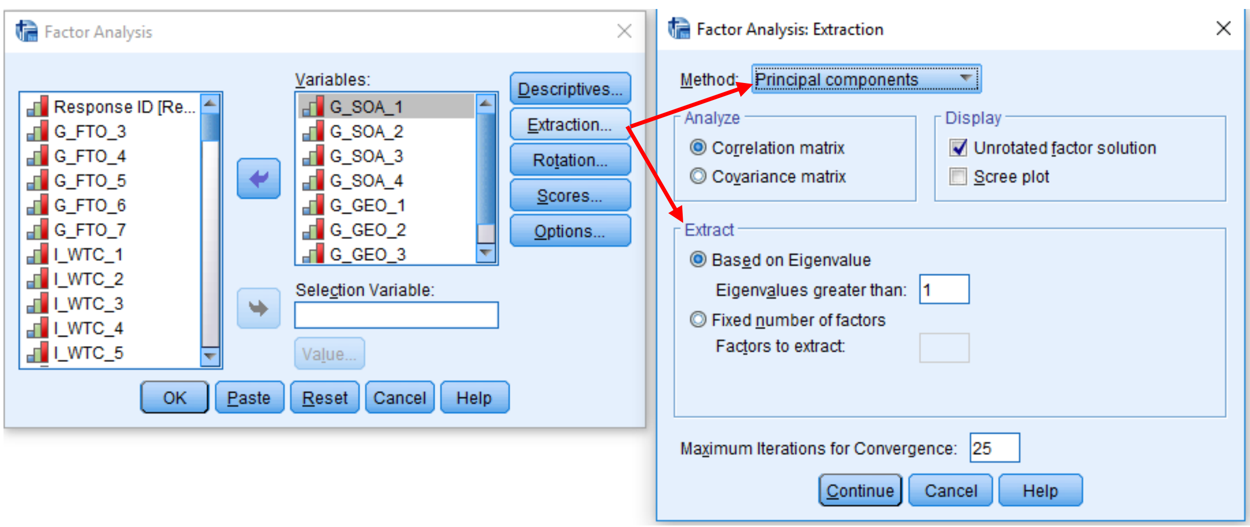

Figure 2.5 Factor extraction in SPSS

Number of factors to retain for rotation

As shown in Figure 2.5, there are two alternative approaches to set the number of factors for a given factor analysis. The first, and used for the EFA in this thesis, is based on eigenvalue, i.e. setting eigenvalue greater than one and allow the software to determine the number of factors by setting the maximum iteration for convergence, we used the default 25 iteration in this thesis. Here eigenvalues represent the total amount of variance that can be explained by a given principal component or the sum of squared component loadings across all items for each component, which represents the amount of variance in each item that can be explained by the principal component. In this regard, both the underlying theoretical background and quantitative results were used to determine the number of factors retained [79] for the core processes and supporting dimensions of patent management. The eigenvalues greater than 1 (Kaiser criterion) and scree test (see Figure 2.6) of the percentage of variance explained support the theoretical distinctions [80,95,107,161,175].

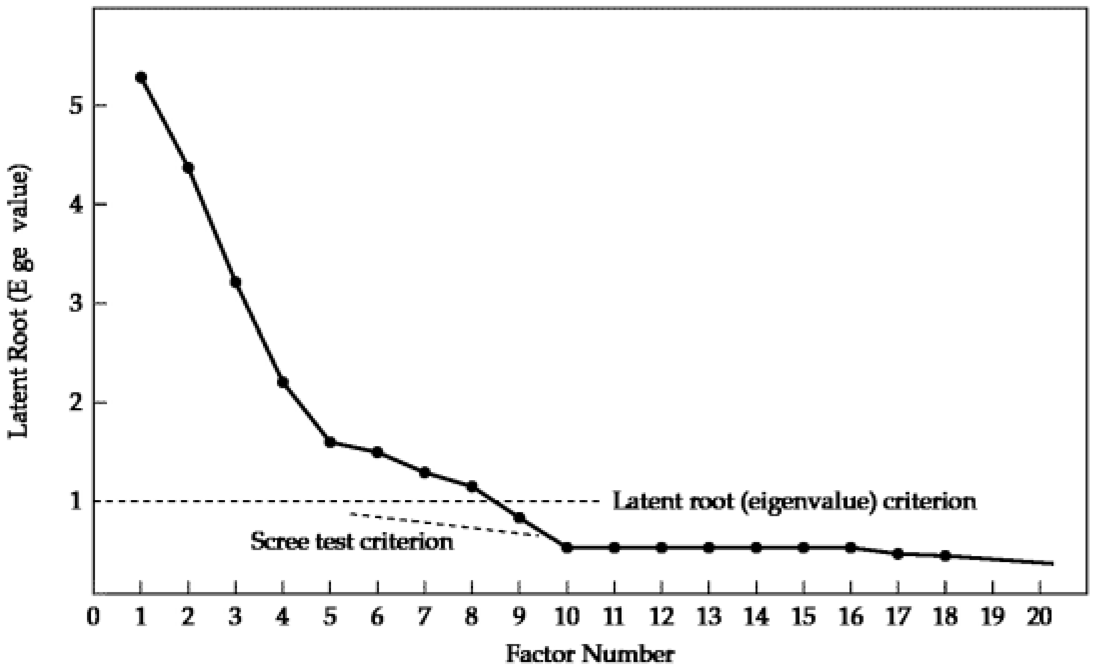

Figure 2.6 Eigenvalue plot for scree plot criterion, source: Hair et al. [74]

As shown in the scree plot the first factor always have the highest total variance while the last factor has the least. The point with large drop or at which the graph becomes horizontal is considered as a marking point to set the number of factors because continuing further extraction may not have a benefit [74]. The second approach to determine the number of factors is performed by setting a fixed number of factors to which the measurement items are expected to load. This approach is useful when the factor structure is already known before starting the analysis like confirmatory factor analysis, and it is not the concern of this section.

The rotation method

After the extraction of factors, the subsequent step is to select a rotation method that helps factors to better fit the data. The rotation methods are used to determine the dimensionality of a measure [57] and creates a simple structure in which each item load highly on as few factors as possible, or more preferably, has a substantial loading on only one factor [117]. The rotation methods may be orthogonal (e.g. varimax, quartimax, equamax) or oblique (e.g. promax, oblimin, quartimin). In the case of oblique rotation, factors that represent a construct need to be correlated, whereas, in orthogonal rotation, factors representing a construct are not correlated. Since the intent of this thesis was to develop measurement scales of patent management by which the constructs within each core-processes and supporting dimensions are expected to have some extent of dependency on one another, we used the recommended oblique rotation [79], specifically promax with Kaiser normalization and examined the rotated pattern matrix.

Factor loadings

The factor loading represents the correlation between an item and its underlying factor. Different scholars used varying cutoff levels for the factor loading values of items on their corresponding factors as: factor loading should be > 0.60 [107], > 0.50 [35,179]. The most commonly used item loading values were the ones recommended by Hair et al. [74] which vary with respect to different sample sizes, as shown in Table 2.4, that are the ones applied in this study.

Table 2.4 Factor loading based on sample size, source Hair et al. [74]

Factor loading	Sample size needed for significance*
0.30	350
0.35	250
0.40	200
0.45	150
0.50	120
0.55	100
0.60	85
0.65	70
0.70	60
0.75	50
* Significance is based on a 0.05 significance level (α), a power level of 80 percent, and standard errors assumed to be twice those of conventional correlation coefficients.	

Internal consistency assessment

The degree of consistency between a set of measurement items can be assessed using a reliability test. The reliability of a scale measures the proportion of variance attributable to the true score of the underlying latent construct [49]. Furthermore, internal consistency is a measure of reliability that applies in a summated scale to show the consistency among measurement items or to describe how well a set of items measures the same construct [49,70,108]. Some of the commonly used criteria for assessing internal consistency includes individual corrected item-to-total correlations, the average inter-item correlation among scale items, and the number of reliability coefficients [36,117,119]. The most widely used coefficient to assess initial internal consistency reliability is Cronbach's alpha [43,74,117]. The value of Cronbach's alpha greater than 0.70 [119], which may decrease to 0.60 in exploratory research [74], shows a strong item covariance or homogeneity, and the sampling domain has adequately captured [80,36]. Here homogeneity indicates the degree to which items assess a single underlying factor or construct [37,70].

2.4 Scale finalization: confirmatory factor analysis (CFA)

2.4.1 Introduction

The validation of a scale involves the assessment of the degree of generalizability of the result obtained to the population, and the influence of individual cases or respondents on the overall results [74]. To this end, construct validity shows how well a measure actually measures the construct it is intended to measure, and includes convergent, discriminant and nomological validity [117]. To test the construct validity or to confirm a particular pattern of relationships that was predicted on the basis of theory or previous analytic results [49], we collected a second sample of data and carried out a confirmatory factor analysis.

2.4.2 Sample II and questionnaire

We used similar sample size considerations as described in the previous section of EFA to collect the second primary quantitative data. The purpose of the second survey is to assess the internal consistency of items and test scale validation using CFA. To this end, the second phase of the survey covered central European countries as Germany, Austria, Switzerland, Belgium, Hungary, and Poland as shown in Figure 2.4 (circles in purple). Also, we followed the same procedure of data collection as we did for Sample I, except that we used SurveyMonkey as the online tool to carry out the online survey. Regarding the questionnaire, we used the refined measurement items, reflecting firm-level patent management activities, retained from scale purification process using EFA (i.e. the output of step 2). After recalls and cleaning of the database, we obtained 103 complete questionnaires to be used for subsequent CFA analyses.

2.4.3 Confirmatory factor analysis

Once items load clearly on factors using the EFA, the resulting factor structure should be checked statistically by testing the significance of the overall model and of item loadings on factors. This test provides a stricter interpretation of the unidimensionality than EFA and the process is called, as anticipated, CFA that confirms the result of prior analysis [74]. The internal consistency of items can be assessed using composite reliability (CR) [60,108] and the average variance extracted (AVE) which captures the amount of variance by a construct measure in relation to the amount of variance due to measurement error [117]. Furthermore, the processes of CFA aims to validate individual constructs. In this regard, we used the different types of validity tests [74,108,117,138] including convergent validity, discriminant validity plus other fit indices.

Convergent validity

It refers to the degree of relatedness between measurement items that are intended to measure the same construct [74]. The methods used to estimate the relative measure of convergent validity include:

- Factor loading, where the high loading of items on a factor is an indicator that these items converge to the common point, latent construct. The threshold value is that the standard factor loading should be 0.50 or greater, and the best value is 0.70 or above.
- AVE, which refers to the mean variance extracted for the items loading on a construct. The minimum threshold value is 0.50, and higher values are considered as the best.
- CR – this measure is also an indication for convergent validity with minimum threshold value of 0.70.

Discriminant validity

Discriminant validity assesses the extent to which a construct is truly distinct from other constructs both in terms of how much it correlates with other constructs and how distinctly measured variables represent only this single construct. A low to moderate correlation can be used as evidence of discriminant validity. Moreover, the discriminant validity of construct can be measured by comparing the square of inter-construct correlation with the AVE: if the former is higher than the latter, discriminant validity is supported. In addition, if the individual items within a factor have low or no cross-loading with items within another factor, then discriminant validity is supported [74].

Fit indices

Following the validation of constructs there are different indices that assessed the goodness of fit of CFA with the data. Some of the commonly used indices with their minimum threshold values are presented in Table 2.5 below.

Table 2.5 Indices value used in CFA analysis

References	Indices	Values
[79,80,170]	Cronbach's alpha	> 0.70
	Chi-square	2/3 x df
	CFI, GFI, AGFI	0.90
	RMSEA	> 0.05
[74,141,158,174,175,179]	Cross-loading	<0.40
	MSA	>0.80
	Standard loading	>0.50, ideally >0.70
	AVE	>0.50
	CR	>0.70
	CFI, NFI, NNFI, GFI	>0.90
	RMSEA	>0.08
	X^2/df	<2
[27]	ICCs	0.61 to 0.81
	Cronbach's alphas	0.74 to 0.90
	CFI	>0.95
	RMSEA; SRMR	<=0.06; <=0.08
[35]	Corrected item-to-total correlations	>=0.50
	Commonalities	>=0.50
	Cross-loadings	<=0.40

Note: Adjusted Goodness of Fit Index (AGFI), Goodness of fit index (GFI), Comparative fit index (CFI), Normed fit index (NFI), Non-normed fit index (NNFI), Chi-squared per degree of freedom (X^2/df), Root mean square error of approximation (RMSEA), Standardized root mean squared residual (SRMR), Measure of sampling adequacy (MSA), Composite reliability (CR), Average variance extracted (AVE), and test-retest reliability [intra-class correlations (ICCs)]

Chapter Three

Specify domain of construct and item generation

3.1 Introduction

The purpose of this study is to develop and validate measurement scales for patent management. To this end, this chapter presents the first part of the study (i.e. development of measurement scales) which includes, according with the literature [36,79,80] the specification of domain of construct and item generation. The following sections describe the results of specifying domain of constructs, the updated framework for patent management, and the generated measurement items through extensive literature review and interview with experts.

3.2 Specify domain of constructs

3.2.1 Literature review on patent management

Patent management is defined as a macro process where different patent-related processes (e.g. planning, evaluation, enforcement) with associated activities can be undertaken [89,127,146] in an organizational supporting context. Taking this into consideration, we carry out a broad literature review on patent management and cluster papers into different groups. The first group contains articles that examine general aspects as patent strategy or patent behavior [,13,139], motives for patenting [16], patent propensity [104]. The second group encompasses papers which adopt a more focused approach on one or a few specific activities of patent management, as patent licensing [113], patent road-mapping [135], prior art search [100]. The third and most recent cluster consists of papers which propose a framework for patent management, and, in this thesis, they are used as a basis for the development of our theoretical measurement framework. The papers within this cluster are further grouped into four approaches, namely patent management through activities/dimensions [89], patent management along the patent lifecycle [7], patent management through maturity levels [44], and plus a fourth approach that is a combination of some of the previous ones, i.e. patent management through dimensions and maturity levels [112].

The first approach, through patenting activities/dimensions, considers patent management as a macro process made up of different patent-related activities like: patent planning, evaluation, information screening, enforcement, and defensive measure [69,89,127,145] as shown in Figure 3.1. The patent planning and evaluation processes are recognized among the most important ones [89]. In this regard, patent planning refers to the selection of the inventions that, if patented, has more potential for contributing to the firm capabilities and competitiveness in the marketplace. Whereas, patent evaluation entails routinely reviewing the firm's patent portfolio to find out whether the patents are still bringing value to the firm [89,145]. Here, patent portfolio assessment refers a business responsibility to support the company's value creation process and strategic business objectives [71].

Furthermore, patent information screening uses to perform sketching of the firm's technological and competitive landscape using information about third parties' patents [89,101]. This process is greatly enhanced by the presence of patent databases that improve the possibility of data retrieval on a large scale [52]. To this end, firms can use patent information analysis for different purposes such as: monitoring competitors' activities and managing R&D portfolios [52,109]; assessing their technological strengths and weaknesses [115]; and for technology forecasting, strategic planning and analysis of the trends in technological innovation [87]. In addition, the extraction of patent information from the company's patent portfolio supports the managers' decision for patent management and verifies their harmony with technological and innovative strategy in the company [71]. When we come to patent enforcement, it focuses on routinely searching for infringement of the firm's patent rights by third party [89,145] and apply to the court to stop the unauthorized manufacture, sale or use of the invention, so that the court may grant the appropriate order and stop the infringement [169]. However, the processes of patent enforcement are time consuming and costly, to this reason patentees first must be sure about the validity of their patent, because during prosecution no patent system guarantees the validity of a granted patent, and second they must be sure that the patent is infringed [110,169]. In the case when the litigation cost is perceived to be impossible, then informal enforcement mechanisms also exist, such as sending notification letter to the infringer and come up with an alternative dispute resolution mechanism [164].

Lastly, the defensive measures respond to the preparation of a legal defence in case the own firm is accused of infringement [89,145]. For this purpose, some firms have patent infringement insurance that covers their legal fees and expenses they spend to defend in the case when their activities result unintentional infringement of someone else's patent [22]. However, the context of defensive measure here is different from defensive patents. The former focuses on the action and/or activities a firm takes when they are accused as infringer, while the later refers to a patent right that is not used by the firms as a core business rather, they are used to prevent other firms to use the technology protected by the patents [122].

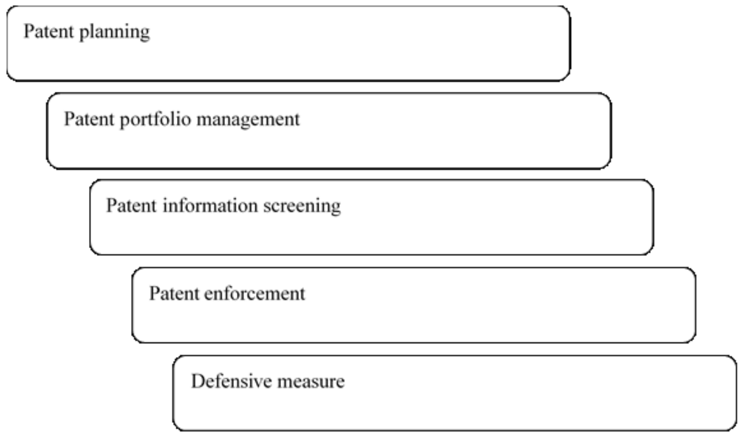

Figure 3.1 Patent management activities/dimensions adopted from [89]

In the second approach, the life cycle management of patents is strongly intertwined with technology life cycle. On one hand, patent data can be used as a basis for technology life cycle assessment [63,76]; in this context, researchers use the variations in patent indices value (as: number of patent application, forward citation, backward citation) with respect to the different life cycle stage of a certain technology as an appropriate life cycle indicator [76]. On the other hand, Bader et al. [7] develop a patent life cycle management model and identified five distinctive phases as: explore, generate, protect, optimize and decline as shown in Figure 3.2. The framework is based on a patent's strategic value and firms' internal resources in which each phase addresses three dimensions of patents as freedom to operate, differentiations from competitors and external patent exploitations. The *exploration phase* is similar to that of patent planning for the first approach through activities/dimensions and focused more on activities performed before formal application of patents to patent office. One of the most common activity at this stage is prior art search [67] by which firms use the technical, legal and strategic information from published patent documents [55] for their new inventions. The search for other firms patented inventions would help firms to identify patentable inventions, and freedom to operate. To this end, well-planned patents have an important role to prevent competitor's imitation and lead to successful technology commercialization during new product development and finding new market destination at R&D planning stage [91].

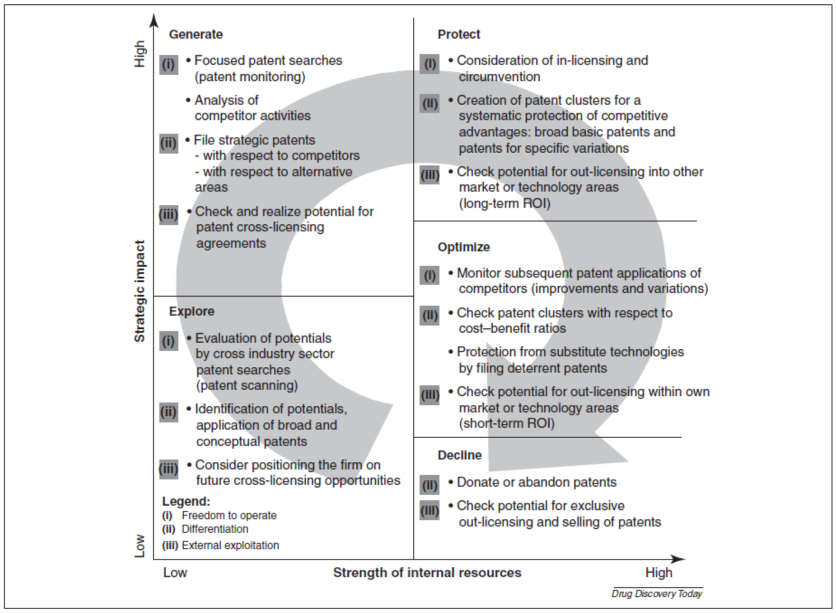

Figure 3.2 Patent life cycle management, source [7]

Based on exploration activities, firms turn their inventive ideas into a new product [7] and fill patent application to national or regional patent office's [169]. In line to patent applications, firms also perform a monitoring of competitors activity [16,25,62], looking for potential cross-licensing agreement [14,33,114], and identify patent that have strategic importance with respect to competitors or alternative technological areas [152]. Furthermore, the *protection* phase focuses on creating strategic impact and accumulating the necessary resources. In this regard, firms fill patents not only for the core-technologies, but also for technologies surrounding the core to create a patent fence [147]. In addition, firms also patent their inventions aiming in-licensing and circumvention, or for the potential out-licensing [7]. The fourth *optimization* phase deals with activities on firms' patent portfolio in comparison with competitors patenting activities based on cost-benefit considerations. Lastly (*decline phase*), when the strategic importance of technologies begins to decline the firms must look for out-licensing, selling or donation opportunities [7] because after the 20-year life span, the patent office makes patent protected technology open to the public.

The third approach that proposes a framework for patent management is the work of Davis and Harrison [44]; here authors identify five different levels of patent management and for each level they outline some best practices. The five levels are: defensive ownership, controlling cost, extracting profits, integrating with other aspects of a business, or mapping out a future strategy as shown in Figure 3.3.

Each level of the pyramid represents the contribution of a firms' patent management to corporate goals. The maturity level begins from the bottom of the pyramid with the classical sense of patenting, to protect the own technology and to hinder competitors patenting activities around a specific technology [16], to build its base [44] and exploit more value from their inventions [7,86,144,153]. The defensive level further covers the tactical aspects of patent management like creating patent shield to protect firms from litigation [44,147,180], cross-licensing with other firms [7,17,78], blocking of competitors further technical development by surrounding their invention [62], and in the case of infringing other firms' patent try to reach a settlement agreement [90].
Then the second level, cost center, mainly focuses on optimizing patent portfolio management with respect to fees required to apply and renew patents [47]. The other costs of patent include litigation cost [164] when the owner accuses of infringing others patented inventions, the direct enforcement costs as filing suits, attorney fees, and fees for examining the scope of patents [3].

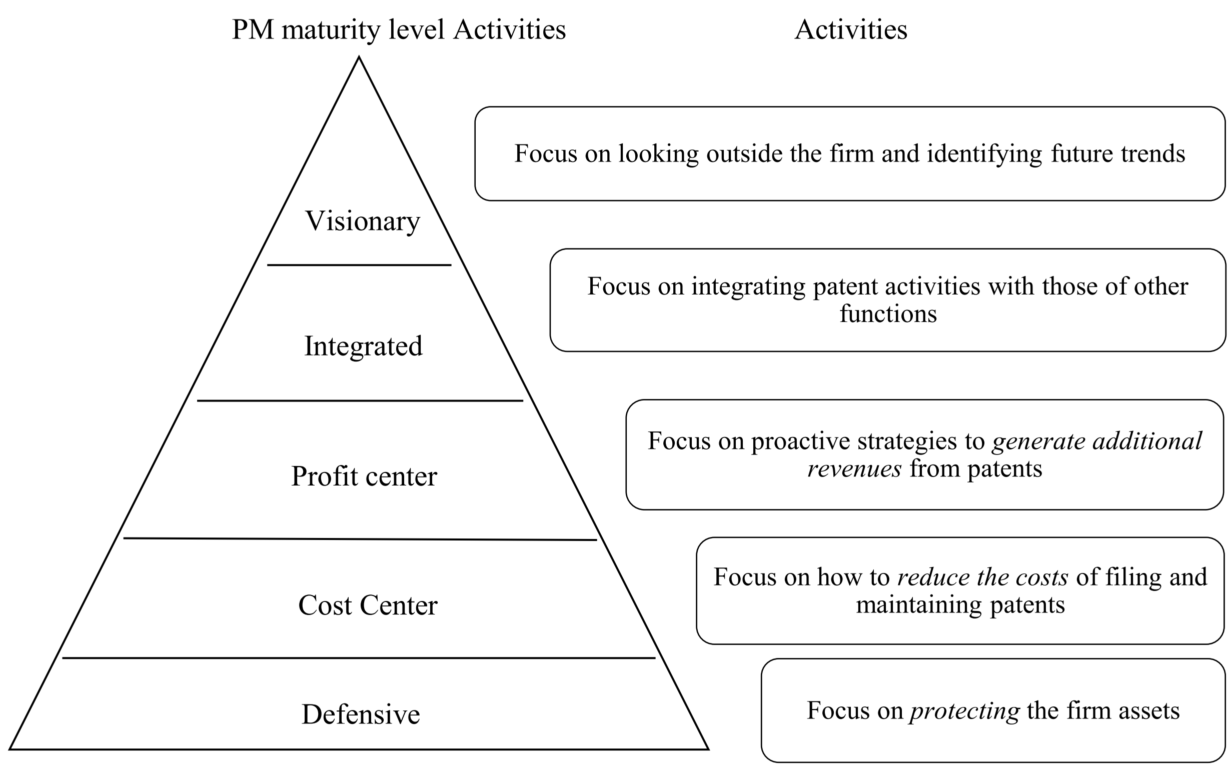

Figure 3.3 Patent management value hierarchy, source [44]

To reduce these costs, firms establish patent pools to share costs and gain better communication with other firms [45,62,66]. The third level of profit center deals with the commercialization of granted patents to recover costs and reap profits [25] through proactive strategies that consider patents as a business asset, rather than just the legal asset [44]. In the fourth integrated level, the function of patent management focuses on intra-departmental interactions. This cross-functional patent management involves the interaction of experts from different departments of a firm such as marketing, sales, strategy, management and R&D in decisions regarding further processing of applied patents [89]. Whereas, in the last visionary level firms fully integrate patent strategies with their business strategies and take on the challenge of identifying future trends in the industry and customer preference. Firms that reach this level are able to anticipate technological revolution and seek to position themselves as a leader by acquiring or developing patents that will protect their future market shares [44].

The fourth approach of patent management framework is the maturity model by Moehrle et al. [112] which combines one or more dimensions of the other frameworks. Based on theoretical investigation and qualitative study, they identify five core dimensions as portfolio, generation, intelligence, exploitation and enforcement, and two support dimensions as organization and culture to develop patent management maturity model (see figure 3.4). For each dimension, they define five maturity levels, namely neglector (level N), starter (level 1), intermediate (level 2), performer (level 3), and conductor (level 4).

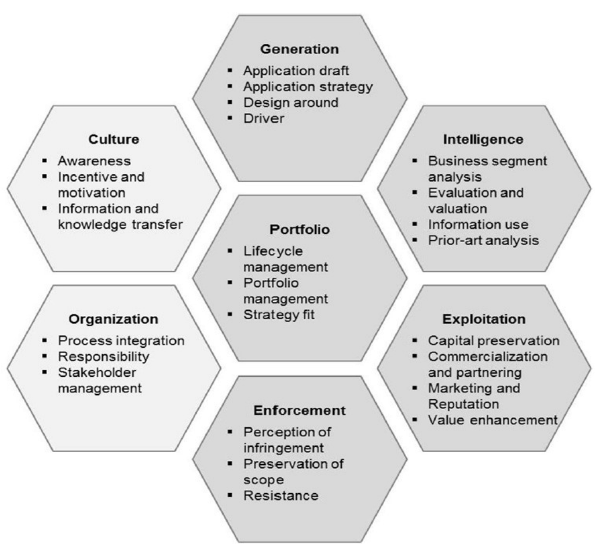

Figure 3.4 Patent management maturity model with its dimensions, source [112]

3.2.2 An updated framework for patent management

Considering the different proposed framework for patent management, the approach based on activities/dimensions seems the most suitable to the research objectives, i.e. development and validation of measurement scale for firm-level patent management. The macro-process description of patent management with clear description of activities in this approach helps us to propose a firm-level patent management measurement framework reflecting its underlying multidimensional structure and developing associated measurement scales. Indeed, the work of Bader et al. [7] that calibrate patent life cycle with technology life cycle, and the one of Davis and Harrison [44] of patent value hierarchy are useful to compare the situation of patent management at different time periods and different firms. Therefore, the development of patent management measurement framework for this thesis takes inspiration from Moehrle et al. [112], Jell et al. [89] and Soranzo et al. [146]. In particular, the identification and definitions of patent management core-processes and supporting dimensions depart from the most recent contribution by Moehrle et al. [112], enriched with recent contributions of the literature.

The result is a framework made up of six core dimensions and two support dimensions, as Table 3.1 exhibits.

Table 3.1 The conceptual model of patent management (definitions adapted from [89,112,146])

Processes/Dimensions	Description
	Core Processes
Patent generation	It refers to the sequence of activities that should be performed to determine, in a rational and conscious way, the inventions that are to be patented.
Patent portfolio	It entails routinely reviewing the firm's patent portfolio to find out whether its patents are still bringing value to the firm.
Patent intelligence	It refers to activities performed to sketch the firm's technological and competitive landscape using information about third parties' patents.
Patent enforcement	It refers to the search for infringement of the firm's patent rights by other firms and enforcement of patent rights.
Patent exploitation	It refers to the search of prospective application fields of patents in addition to legal and information perspectives.
Defensive measures	It deals with preparing a legal defense in case own firm is accused of infringement.
	Supporting dimensions
Organization	It refers to the organizational arrangements devoted by firms in the management of IP.
Culture	It refers to the firm's culture about patents.

The theoretical investigation of the literature was followed by a qualitative study in which we presented the above conceptual model of patent management to experts. The main purpose of the qualitative study was to obtain a practical opinion from experts of patent management that helped us to validate the theoretical model with the practice of firms, and to have a clear understanding of the relevant patenting activities within each dimension.

From the discussion and interview with experts, we reached an agreement upon the dimensions and general approach of our proposed model, i.e. multidimensional nature of patent management discriminating between a set of core dimensions and a set of support dimensions. In particular they suggested some modifications on the proposed framework. On the first hand, they consider patent exploitation and enforcement as a single dimension rather than two different dimensions, since both of them refer to external valorization of patents and recommended them to be included in one dimension. Secondly, they do not consider defensive measures as a core process of patent management rather they consider it as a legally mandatory response when the firm is accused of infringement. So, they recommend removing this dimension from the proposed model since it is an operative task of the legal department. Thirdly, they recommend that there is no sequential order to perform the first three core-processes (i.e. patent generation, portfolio management, and exploitation and enforcement), and they just represent the different patent management activities. Whereas, patent intelligence has a cross-sectional nature, in the sense that results deriving from patent intelligence serve all the other core-processes. Finally, regarding support dimensions, experts emphasized patent strategy as a fundamental guide to the whole process of patent management and it should be considered as independent support dimension. On the other hand, experts suggest that patent culture is one element of the organization for patenting dimension rather than an independent support dimension. this consideration is also in agreement with the organizational theory in which culture is a component of the organization for patenting dimension [28].

Based on these suggestions, the theoretical framework was modified by including the experts' suggestion, thus the resulting framework consists of four core-processes (i.e. patent generation, patent portfolio management, patent exploitation and enforcement, and patent intelligence), and two support dimensions (i.e. strategy and organization for patenting), as shown in Figure 3.5. Each dimension needs separate management decisions and can be practiced independently [112].

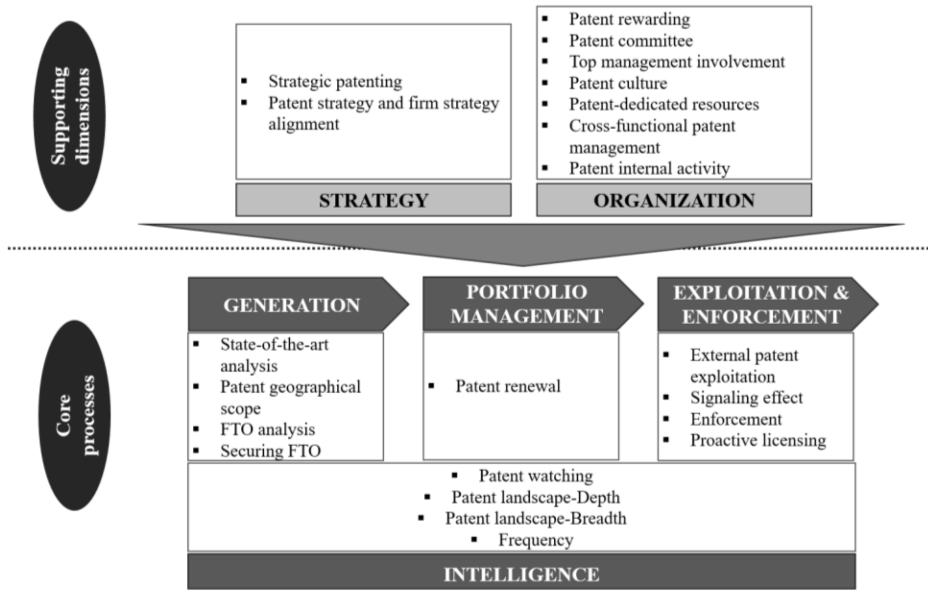

Figure 3.5 Updated framework for patent management

This framework is the result of an extensive literature review further enriched with the expertise of different actors with an academic, professional and managerial background. Therefore, we believe it is a good starting point for subsequent validation.

Taking this theoretical patent management framework into consideration, the following section describes the details of each of the four core-processes and the two supporting dimensions.

Patent generation

As one of the core processes, patent generation includes aspects related to the identification of patentable inventions and associated activities from the invention disclosure to the filing of the patent. The patenting process begins from drafting patent application by the applicant and the search of prior art with respect to that specification [67]. In most countries an invention's novelty and obviousness are determined by the state of the art existing on the date the application is filed, not the date invention is invented [103]. To this end, the applicant should consider the patent office invention novelty time period while carrying out prior art search. To investigate patentability (i.e. novelty, non-obviousness and industrial capability) of an invention the applicant firm or individual should identify and store all relevant information to base *state of the art analysis* using public and private databases of existing, granted, and pending patents on a given technological areas.

In addition to patentability, from the view point of patent management beyond getting just patent rights for an invention, the applicant firm is expected to regularly monitor its granted and pending patents to prevent accusation of infringement by others and block the patenting activities of competitors. As argued by Granstrand [69] blocking competitors can be seen from two perspectives: first, to block their R&D and business activities, and second, to block the possibilities of their blockings to the firm's own R&D and business activities. The former represents the "strategic" motives of patents by which it acts as an instrument for securing one's own future technological space against competitors or for restricting competitors' future technological opportunities [17], we call it as *securing freedom to operate* construct. While the later considered as *freedom to operate* construct, which allows the firm to perform a specific commercial business without infringing valid intellectual property rights held by others within a certain domain [84].

Furthermore, the firm also takes into account the possibility of having additional patents and searching for technological white spaces or patent vacuum [54,142,172] in the areas of few patents, to benefit from first mover advantages. This patent vacuum is a blank zone surrounded by many existing patents which represents the unexplored technological areas, but the one which may have the development potential for the future, given the active development of adjacent areas [102]. Finally, firms also take into consideration in which countries to fill patent application where the company has a business or expects to have a business within the lifetime of the patent, and where the value of the patent for protecting the company's own business exceeds the costs of obtaining and maintaining it [69]. However, after filling patent application the patent office examination of applications and their decision outcomes are out of the firms' control, so we do not include those activities in the generation dimensions. We call it *patent geographical scope.*

Patent portfolio management

Every granted patent is subject to the payment of renewal fees, which must be paid to maintain the patent in force [96]. This *patent renewal* activities can be viewed as an optimizing process in which it needs firms continuous follow up throughout patent lives to compare the renewal costs with the expected future return and decide whether to pay the renewal fees and keep the patents alive, or not to pay and let the patents lapse [47]. According to the resource-based view, patent portfolios are valuable strategic resources that can help firms to improve core competences and sustain competitive advantage [171]. This aggregation of patents within a firm can be audited to assess the financial, business and commercial value [133]. This shows that the longer patents stay within the firm's patent portfolio or the firms' willingness to keep them alive, the more valuable they should be [47]. To this regard, patent portfolio management concerns the activities and decisions on whether to maintain or abandon granted or pending patents and on the strategic focus of the portfolio.

Patent exploitation and enforcement

Patent *exploitation* refers to the identification of potential applications of patents to exploit their economic benefit [153]. Patents can be exploited with the aim of building competitive advantage by creating a legal monopoly in the market or to maintain a competitive edge by protecting business image and goodwill [162]. This shows that firms consider patents as an important asset to gain benefits from the revenue of patent *licensing* and to get better access to the capital market, especially for start-up companies [17,162]. In addition to individual patent transaction firms can also made a single patent license agreement [66] in the form of patent pools. Here, the patent pools refer to an arrangement between multiple patent holders to aggregate their patents for a one-stop licensing of all patents held by patent pool members [34,48,66,129] from which a firm can benefit from decreasing transaction costs by reducing the number of licenses for a potential licensee, and reduce double marginalization problem by allowing patent owners to coordinate their behaviors on royalties [45]. Furthermore, patents also have a *signaling effect* such as improving the technological image of a firm [16], influencing standard setting [92], and setting better condition in merger and acquisition operations [10,19,88].

Patent *enforcement* refers to elements related to the search for infringement of the firms' patent rights by other firms and enforcement of patent rights [89]. Infringement of patent rights covers activities related to the use and/or production of firms' invention or a technology by others without obtaining its permission [45]. If a firm finds someone infringing its patent rights, then it can enforce its monopoly by a mean of legal actions through requesting the court an injunction against the infringer to stop the infringing activities and to repair the monetary damages suffered by the owner [139]. Therefore, patent enforceability can be defined as the predicted probability of patent owner to win an infringement suit in a court by verifying the validity of infringed patents [110]. However, not all patent infringement cases reach the level of judicial decisions and patent owner firm would like to face a challenge when an accused infringer attempts to challenge the validity of the patent [45]. In such cases the conflicts are resolved by a bargaining between the possible infringer and the patent holder. Firms with more enforceable patent portfolios are more likely to engage in consolidation, whether as acquirers or as targets; however, enforceability increases the likelihood of spinoffs rather than complete acquisitions of targets [45,110].

Patent intelligence

Patent intelligence transforms the content found in patent documents into technical, business and legal insights [124]. The firms careful analysis of information on patent documents can give a visual expression as patent maps [101], making it possible to understand the status and pattern of competition, infringement risks, areas of overall or specific technology focus and technology gap in a given technological domain, and future market directions that increase user understandability [101,124,162]. Firms can also use keyword-based patent intelligence tools to identify technological white spaces and forecast new technological concepts [124]. We call this motive of patent intelligence analysis as *patent landscaping breadth*. Whereas, patent *landscaping depth* refers to the process that arranges the raw data of patents using keyword-based patent intelligence approach to create patent networks in the form of patent citation, co-occurrence among the keywords, bibliographic analysis [124,176]. Thus, the result of these analysis gives a collection of patent statistics like patent count analysis, country analysis, competitor analysis, inventor analysis, citation analysis, and classification analysis, resulting in several statistical indicators that captured various aspects of patenting activities [9]. In addition, *patent watching* focuses on the analysis of competitors patenting activities [7] through regular monitoring of granted patents and/or newly issuing as well as pending patents.

Patent strategy

Through the review of extant literatures focused on patent strategy, Somaya, [144] identifies two broad research themes. The first theme focuses on the connection between patent strategic actions and firms' effort towards achieving competitive advantage which includes three generic strategy approaches as proprietary, defensive, and leveraging strategies. This *alignment of patent and firm strategy* helps firms to look their actual and future positions in comparison to competitors. The second theme relates to the strategic management of patents that considers the implementation of the different generic strategies like signaling and information disclosure strategies, managing patents as real options, nonmarket strategies, and patent related managerial capabilities. However, there is no general consensus on the definition of patent strategy from patent management and patent strategy literatures [86]. Motohashi [113] defines patent strategy as a firm's management of its technology pool or capacity, based on in-house R&D or acquired technology from external sources, which is used for innovation outputs such as new products and processes. Granstrand [69] proposes seven patent portfolio strategies: ad hoc blocking, inventing around, strategic patents, blanketing and flooding, fencing, surrounding, and portfolios. Reitzig [131] defines the dimension of patent strategy as one that includes patent acquisition and generation, patent protection, and patent exploitation and enforcement, and that involves corporate, business, and functional levels of the organization. In this thesis we consider *patent strategy* as a long-term strategy which includes the basic questions as 'why to patent', 'what to patent', 'when to patent' and 'where to patent' [139], in line with the firm's overall strategies.

Organization for patenting

The literature argues that a *cross-functional patent management* is the basis for firms' long-term success though it incurs a short-term coordination, communication and agency costs [89]. To this end, the patent system is intended to be a stimulus to investments in R&D, as well to production and marketing activities [69]. However, intellectual property (e.g. patents) management as corporate function has not attracted a great deal of resources and attention to how to organize them [28]. Thus, patent management can be either performed by patent departments (mostly in large firms), dedicated patent officers (mostly in smaller firms) or partly outsourced to independent attorneys [69].

Therefore, it is important to understand the interfaces of patent management with other functions of a firm such as production, R&D, legal, strategy, marketing, and sales that needs strong cross-functional integration which depends on supporting corporate *culture* and management structure [89]. In this context, *patent committee* represents the team of experts from different functional departments responsible for collective decisions on how and when to apply and maintain patents. This committee pushes firms to improve their organization for patenting and consider patenting activities as a strategic concern [28]. The emergence of pro-patent era in 1980s strengthens firms *patent culture* by creating awareness at business unit heads and corporate executive levels [28,44].

In addition, firms also have an award or recognition mechanism (monetary or non-monetary) to encourage their employees to generate new ideas and apply for patents [44,86,104]. We call it *patent rewarding*. In the Table 3.2 we summarize the underlying constructs of the four core-processes, and the two supporting dimensions with their respective definitions.

Table 3.2 – Description of constructs for the four cores and two supporting dimensions

Core processes			
Process	**Activity**	**Description**	**Reference**
Generation	State-of-the-art analysis	Gain insights into what has been patented in a certain technological field.	[146]
	Patent geographical scope	Definition of the number of jurisdictions in which patent protection is sought.	[26]
	Freedom to operate analysis	Activity aimed at verifying whether the particular configuration of the product/component under development is infringing valid intellectual property rights of others.	[146]
	Securing freedom to operate	Actions taken to pre-empt others from holding patents in the field of interest of the applicant.	[2,73]
Portfolio Management	Patent renewal	Evaluation of patent portfolios to see if all the technologies are crucial for current and future business and are well protected in order to decide on whether to renew their patents or dispose of them.	[86,96,131]
Exploitation & Enforcement	External patent exploitation	An organization's deliberate exploitation of patents to another independent organization with or without know-how transfer involving a contractual obligation for monetary or non-monetary compensation.	[106,181]
	Signalling effect	The activity carried out by firms aimed at voluntarily disclosing knowledge to less informed economic agents, to convince them of their firms' specific attributes.	[59]
	Enforcement	The search for infringement of the firm's patent rights by other firms and enforcement of patent rights	[89,112]

	Proactive licensing	Gaining the interest of another party in a technology that the firm has patented.	[93,118]
Intelligence	Patent watching	A scan of existing or emerging patents in a given technology space (service) and looking possible future R&D directions (white spaces).	[5]
	Patent landscape_ Depth	Analysis of the relationships between multiple sets of indicators or of those indicators measured against temporal, technical or spatial dimensions.	[42]
	Patent landscape_ Breadth	The number of different reasons why firms engage patent landscape.	[98,101,135]
	Frequency	Frequency with which the firm performs intelligence activities.	From interview
Supporting dimensions			
Dimension	**Aspect**	**Description**	Reference
Strategy	Strategic patenting	Approach that sees patenting as a vital source of competitive advantage that can generate value for the firm.	[31]
	Patent strategy and firm strategy alignment	Alignment of the patent portfolio with business strategy to enhance the effectiveness and efficiency of the patent activity	[44]
Organization for patenting	Patent rewarding	Patent incentives for employees to disclose their inventions and go through the patent process	[8]
	Patent committee	A body charged with the responsibility of deciding in which of the employee's innovation the company will invest as decision to pursuing a patent.	[44]
	Top management involvement	Top management's commitment and support to patenting.	[44,86]
	Patent culture	It refers to the firm's culture about patents.	[112]
	Patent-dedicated resources	Resources allocated for the execution of patent management.	[83,86]
	Cross-functional	Organization of patent management in a cross-functional manner so that employees from different corporate function areas, such as sales, marketing, and	[89]

	patent management	R&D, interact to reach decisions related to patent management	
	Patent internal activity	How much of the patent activity is carried out internally	From interview

3.3 Item generation

After the theoretical base is set and constructs identified for each dimension, we generate an initial pool of items (see Table 3.3) using an extensive review of the literature and in-depth interviews. To this end, firstly we mapped the definitions of identified constructs, descriptive features and existing items that we found in previous studies. For those constructs that has some measurement items already tested and validated in the previous literature, we checked whether they reflected well the definition provided and, if not, we adjusted the items accordingly. Secondly, for those constructs that did not have any measurement items already tested and validated, we developed them based on the definition and associated features. Thirdly, for those constructs literature did not provide enough information, we generated items based on interviews with experts working actively on patents.

Content validity

Subsequent to item generation, we conducted content validity assessment. To this purpose, we carried out a second round of interviews with experts (see Table 2.3 of chapter 2) for reviewing all the items. Experts were asked to comment whether the generated items reflected well the constructs defined in the previous step, to suggest necessary rephrasing and to propose additional items that were deemed necessary to be included. In this regard, we carried out content validity of generated items in two stages. In the first stage three academicians, familiar with intellectual property management specially on patent management, identified and mapped items onto the underlying constructs of the defined dimensions that are expected to capture patent management activities within firms.

Second, we brought the initial mapping of items with their proposed constructs for each core processes and supporting dimensions to patent experts actively practicing patenting activities within their firms. The focus of the second stage evaluation of items was to include the practical views by practitioners and to select items belonging to specific dimensions that are supposed to be retained for empirical analysis. Finally, we maintained a total of 118 items that passed content validity in which items reflected the defined dimensions of patent generation, portfolio management, exploitation and enforcement, intelligence, strategy and organization for patenting (see Table 3.3). The item distribution for the dimension was: 24 items for patent generation, 11 items for patent portfolio management, 24 items for patent exploitation and enforcement, 15 items for patent intelligence, 8 items for patent strategy, and 36 items for organization for patenting. These items, that were assigned to the proper dimensions of patent management were retained to be used in the first questionnaire survey to conduct exploratory factor analysis. Table 3.3 shows the list of measurement items for each construct with their respective scales.

Table 3.3 Measurement items

Core Processes				
Processes	Constructs	Items	Scales	Reference
GENERATION	State-of-the-art analysis (G_SOA)	While carrying out an R&D/innovation project in our company, we: (Please rate your level of agreement or disagreement) > Base our state-of-the-art analysis on a specified concept (G_SOA_1) > Identify and store all information that might be relevant to a patent's claims of novelty/patentability (G_SOA_2) > Gain insights into what has been patented in a certain technological field (G_SOA_3) > Use public and private databases to check relevant existing patents/prior art in the technological field (G_SOA_4) > Rank the state-of-the-art in a technology field (G_SOA_5)	Level of agreement (1- strongly disagree; 5- strongly agree)	[8,146]; From interviews
	Patent geographical scope (G_GEO)	While carrying out an R&D/innovation project in our company, we: (Please rate your level of agreement or disagreement) > Examine carefully in which countries we want to file each patent (G_GEO_1) > Carefully analyze the specific rules/procedures/fees of each jurisdiction (G_GEO_2) > Consider current and future market needs in different countries (G_GEO_3) > Follow specific criteria (e.g. location of manufacturing facilities, target market, core countries, cost of filing/renewal, activities of competitors) to select in which countries to file patents (G_GEO_4)	Level of agreement (1- strongly disagree; 5- strongly agree)	[44,86,122]; From interviews
	FTO analysis (G_FTO)	While carrying out an R&D/innovation project in our company, we: (Please rate your level of agreement or disagreement) > Freeze the invention concept before carrying out the freedom to operate analysis (G_FTO_1) > Use public or private databases to check whether there is a risk of infringing other firms' patents	Level of agreement (1- strongly disagree; 5- strongly agree)	[7,44,54,146]; From interviews

		(G_FTO_2) > Analyse the most critical in force patents (all independent claim) with technical staff for the most critical cases (G_FTO_3) > Check the probability of litigation (G_FTO_4) > Use databases to check the evolution of other firms' pending patents (G_FTO_5) > Formulate a formal opinion on the freedom to operate of the freezed concept (G_FTO_6) > Consider in-licensing and circumvention of other companies' patents (G_FTO_7)		
	Securing FTO (G_SEC)	While carrying out an R&D/innovation project in our company, we: (Please rate your level of agreement or disagreement) > File patent application to defensively prevent other firms' grant of exclusive rights over markets and technologies (G_SEC_1) > Use offensive patenting to exclude competitors from using a technology (G_SEC_2) > Consider developing a thicket of patents surrounding the single invention (G_SEC_3) > Use defensive publications (i.e. publish articles with relevant knowledge on products, methods, etc.) to prevent other firms' patents in a certain technological field (G_SEC_4)	Level of agreement (1-strongly disagree; 5-strongly agree)	[44,54 62,152]
PORTFOLIO MANAGEMENT	Patent renewal (P_REN)	Please rate your level of agreement or disagreement with these statements regarding patent renewal in your company: > We always check, either manually or through automatic systems, that all maintenance fees have been paid (P_REN_1) > We regularly monitor the spending for filing and maintaining patents (P_REN_2) > We maintain patent protection only in those countries where it makes sense (e.g. economic, competitor) to do so (P_REN_3) > We follow specific criteria (e.g. location of manufacturing facilities, target market, core countries, cost of filing/renewal, activities of competitors) to select in which countries maintaining patents (P_REN_4) > We regularly check whether expected future benefits of a patent exceed the cost of renewal in a particular country before renewing it (P_REN_5) > We regularly review our patent portfolio to see if all company technologies that are crucial for current and future business are well protected (P_REN_6) > We regularly review patent portfolio to consider which patents to maintain (P_REN_7) > We use methods (e.g. grids, schemes) to evaluate/score patents in our portfolio (P_REN_8) > We make patent renewal decisions using patent forward citation analysis (i.e. as quality indicator) (P_REN_9) > We consider the technological impact of patents when making patent renewal decisions (P_REN_10) > We regularly assess how to use patents in our portfolio (e.g. to support an existing technology, to prevent a competitor to use that technology, to sell the patents) (P_REN_11)	Level of agreement (1-strongly disagree; 5-strongly agree)	[44,47,86,151]

EXPLOITATION AND ENFORCEMENT	External patent exploitation (E_EXT)	Please rate your level of agreement or disagreement with the following statements regarding patent portfolio in your company: > We check potential for patent cross-licensing agreements (E_EXT_1) > We check potential for out-licensing into other markets or technology areas (E_EXT_2) > We check potential for out-licensing within our own markets or technology areas (short-term ROI) (E_EXT_3) > We check potential for patent sales (E_EXT_4)	Level of agreement (1-strongly disagree; 5-strongly agree)	[7,86]
	Signalling effect (E_SIG)	Please, rate your level of agreement or disagreement with the following statements regarding patent exploitation in your company: > We use patents to increase our reputation/market perception (E_SIG_1) > We use patents to attract debt capital, such as bank loans (E_SIG_2) > We use patents to attract equity capital, such as venture capital (E_SIG_3) > We use patents to increase technology transfer and technology trade (E_SIG_4) > We use patents to increase collaborative and joint R&D work with other firms and/or organizations (E_SIG_5) > We use patents to set better conditions in merger and acquisition operations (E_SIG_6) > We use patents to influence standard-setting (E_SIG_7)	Level of agreement (1-strongly disagree; 5-strongly agree)	[75,83,112]; From interviews
	Enforcement (E_ENF)	Please, rate your level of agreement or disagreement with the following statements regarding enforcement in your company: > We regularly look for infringers (E_ENF_1) > We focus our monitoring on patents with broad claims (E_ENF_2) > We pursue patent enforcement in case of infringement (E_ENF_3) > We prepare sufficient evidence of infringing activities by the infringers before taking legal action (E_ENF_4) > When we find an infringer, we send a letter of cease and desist (E_ENF_5) > When we find an infringer, we try to reach a settlement (E_ENF_6) > When we find an infringer, we try to sell a license (E_ENF_7)	Level of agreement (1-strongly disagree; 5-strongly agree)	[30,42,44,55]
	Proactive licensing (E_LIC)	Please, rate your level of agreement or disagreement with the following statements regarding licensing in your company: > We assess the patents that are suitable to be externally out-licensed (E_LIC_1) > We put a lot of commitment in licensing out (E_LIC_2) > We give a high-priority to non-core patents during out-licensing decisions (E_LIC_3) > We actively search overseas alliances for out-licensing (E_LIC_4) > We search similar technologies (e.g. through the analysis of citations) to find firms potentially interested in licensing our technologies (E_LIC_5) > We actively search other industries for out-licensing (E_LIC_6)	Level of agreement (1-strongly disagree; 5-strongly agree)	[39,44]; From interviews

INTELLIGENCE	Patent watching (I_WTC)	Please rate your level of agreement or disagreement with these statements regarding patent monitoring in your company: > We regularly monitor granted patents and/or newly issued patents as well as possibly pending patent applications (I_WTC_1) > We regularly build a picture of external patent activity around a particular technology (I_WTC_2) > We regularly build a picture of external patent activity around a particular competitor (I_WTC_3) > We disseminate and/or discuss results of patent monitoring to relevant R&D and business staff (I_WTC_4) > We take into account the possibility of having additional patents in areas with a few patents (I_WTC_5)	Level of agreement (1-strongly disagree; 5-strongly agree)	[41,54,155]
	Patent landscape – Depth (I_LSD)	Please, rate your level of agreement or disagreement with the following statements about patent landscape in your company: > We use multiple indicators (e.g. citations, number of inventions, geographical scope) to analyze patent data (I_LSD_1) > We compute/calculate indicators with the aim of analysing patent data along different dimensions (e.g. temporal, technical, geographical) (I_LSD_2) > We create patent maps that allow complex patent information to be understood easily (I_LSD_3) > We create patent networks that visualize complex technological relationships (I_LSD_4)	Level of agreement (1-strongly disagree; 5-strongly agree)	[101, 124]
	Patent landscape – Breadth (I_LSB)	Indicate for which of the following motives your company performs patent landscaping (more than one answer is allowed): > To search information during new product development (I_LSB_1) > To collect information on competitors' R&D activity (I_LSB_2) > To screen technological complementarity and interdependence between different firms and thus allowing to identify potential R&D collaborators (I_LSB_3) > To understand the relative patent position of a company with respect to competitors in a certain technological field (I_LSB_4) > To identify potentially interesting areas for the future development (e.g. white spaces, patent outliers) (I_LSB_5)	Yes/No for each item	[72,102,135]; From interviews
	Frequency (I_FRQ)	Your company performs landscaping search (I_FRQ_1): > Never > Only when an R&D project is launched or on demand (e.g. valuating a firm acquisition, valuating a technology acquisition, explore a new market) > Once a year, independently of the launching of a project > Twice a year, independently of the launching of a project > More than twice a year, independently of the launching of a project	Only one answer	[54,86]; From interviews

Supporting Dimensions				
Dimensions	**Constructs**	**Items**	**Scale**	**References (adapted from)**
STRATEGY	Strategic patenting (S_PAT)	Please rate your level of agreement or disagreement with these statements regarding the patent strategy in your company: > We have a clear plan for patenting (S_PAT_1) > We see patenting as a corporate strategic decision (S_PAT_2) > We file a patent when an explicit request is forwarded and authorized (e.g. by business manager, CTIO) (S_PAT_3) > We build our patent portfolio based on how patents can help our company to gain and sustain competitive advantage (S_PAT_4)	Level of agreement (1-strongly disagree; 5-strongly agree)	[31,152,156]
	Patent strategy and firm strategy alignment (S_ALI)	Please rate your level of agreement or disagreement with these statements regarding the alignment between patent strategy and firm strategy: > Our company looks at the corporate vision and objectives to determine what the company wants to accomplish with patent management (S_ALI_1) > Our company decides how to organize patent management based on the overall strategy of the firm (S_ALI_2) > Looking at the actual and expected future position of the firm, our company sets the activities, decisions and outcomes of patent strategy (S_ALI_3) > Based on the allocated budget, our company shapes the patent strategy (S_ALI_4)	Level of agreement (1-strongly disagree; 5-strongly agree)	[44]; From interviews
ORGANIZATION FOR PATENTING	Patent rewarding (O_REW)	Please rate your level of agreement or disagreement with these statements regarding awards and incentives for patenting in your company: > We have incentives (monetary or nonmonetary) for idea generation (O_REW_1) > We have incentives (monetary or nonmonetary) for employees notifying patentable discoveries (O_REW_2) > We have incentives (monetary or nonmonetary) for employees who file a patent application (O_REW_3) > We have incentives (monetary or nonmonetary) for employees who obtain a granted patent (O_REW_4)	Level of agreement (1-strongly disagree; 5-strongly agree	[8,44,86,104]
	Patent committee (O_COM)	Is there a committee for determining which patents to apply for and maintain in your company (O_COM_1)?	Yes/No	[44]
		(Only for firms that answer "Yes" to the previous question) Please rate your level of agreement or disagreement with these statements regarding the presence of a patent committee in your company: > Technology staff submits invention disclosures to the patent committee for evaluation (O_COM_2) > The committee encourages the staff to submit disclosure forms (O_COM_3) > The committee meets regularly (O_COM_4)	Level of agreement (1-strongly disagree; 5-strongly agree	
	Top management involvement (O_TOP)	Please rate your level of agreement or disagreement with these statements regarding the involvement of top management in patent management in your company: > Top management is actively involved in patent strategy definition (O_TOP_1) > We develop a common language to share issues regarding patent management with top management	Level of agreement (1-strongly disagree; 5-strongly agree	[44,86,173]

		(O_TOP_2) > Concerning patent management, we try to find an ally or sponsor in top management (O_TOP_3) > Top management is regularly informed on ongoing activities related to patenting (O_TOP_4)		
	Patent culture (O_CUL)	Please rate your level of agreement or disagreement with these statements regarding patent culture in your company: > Patenting is a common concern for all employees (O_CUL_1) > We emphasize education and training for managers, engineers, and researchers to improve their knowledge and skills in patent management (O_CUL_2) > We foster behavioural attitudes and norms regarding patenting (O_CUL_3) > We make efforts to spread the patent culture at all levels (O_CUL_4) >Patenting is embedded in our company's day-to-day operations and procedures (O_CUL_5)	Level of agreement (1- strongly disagree; 5- strongly agree	[44,68,86]
	Patent-dedicated resources (O_RES)	Our company has: > A central patent department (O_RES_1) > A patent/IP manager and dedicated resources (O_RES_2) > A dedicated budget for patenting (O_RES_3)	Yes/No	[83]
	Cross-functional patent management (O_CROS)	Select which of the following departments, in addition to R&D, are actively and significantly involved in patenting activities and decisions: > Production (O_CROS_1) > Marketing and sales (O_CROS_2) > Top management (O_CROS_3) > Legal (O_CROS_4) > Finance (O_CROS_5)	Yes/No	[44,89]
	Full time equivalent (O_FTE)	Please, indicate the number of Full Time Equivalent employees working in your patent department and/or with related activities (O_FTE_1)	Number	
	Patent internal activity (O_ACT)	Please, indicate which of the following activities are performed mainly internally (more than 50%) Vs externally: > Patent drafting (O_ACT_1) > Patent filing (O_ACT_2) > Decisions about the countries to file our patents (O_ACT_3) > Decisions regarding patent renewal (O_ACT_4) > Decisions regarding how to exploit the patent portfolio (O_ACT_5) > Enforcement of the patent portfolio (O_ACT_6) > Checking patent potential (O_ACT_7) > State-of-the-art analysis (O_ACT_8) > Freedom to operate analysis (O_ACT_9) > Technology intelligence (O_ACT_10)	Yes/No	From interviews
		Would you like to receive the final report with the framework and dimensions of patent management?	Yes/No	
		If you have any comments related to your answers, please write them here.		

Chapter Four

4.1 Scale Purification: Exploratory Factor Analysis

In Chapter 3, we defined the constructs of patent management and generated the initial pool of items followed by the content/face validity (i.e. the first two steps of the scale development methodology). This chapter focuses on the refinement of measurement items which is the third step of the methodology. While eliminating the measurement items, we considered the principles of domain sampling [119] in order to keep at least three items per construct. Domain sampling here suggests that the initially generated items should be large enough to represent the underlying patent management constructs. So, when we refined the scales the initial pool of items was reduced to manageable size by eliminating some measurement items that failed to meet certain psychometric criteria [4,80]. Taking this into consideration, we conducted empirical test on the items based on a relevant sample of quantitative data to examine the theoretical priori initial factor structures as shown in the patent management framework and assess initial internal consistency using Cronbach's alpha. To this purpose, we carried out exploratory factor analysis (EFA) using SPSS V24.

4.1.1 Sample description (Sample I)

Taking into consideration the sample size required to conduct EFA (see section 2.3 of chapter 2), we prepared an online questionnaire survey using SurveyGizmo and sent it to firms. The targeted respondents for this survey were firms' patent managers, IP managers, patent engineers and/or those who actively involved in patenting activities. We used contacts already within our personal database, as well as the professional social network LinkedIn to identify respondents and send the survey. Firstly, we sent an e-mail briefly summarizing the research purpose and the link to the questionnaire to 1312 firms from Southern (Italy, France and Spain) and Northern (Sweden, Norway and Finland) European countries followed by three reminders. At the end, we collected 225 responses of which 101 completed questionnaires are used for EFA analysis with SPSS.v24, representing a 7.70% percent of response rate (the remaining 124 were not complete). Our sample size satisfies the minimum threshold of 100 responses recommended by Hair et al. [74] to conduct factor analysis.

The questionnaire contained all of the 118 measurement items of patent management generated in the previous chapter, and most of them were based on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree), some of the questions were based on a yes/no answer, and a few questions needed figural values. In the EFA, only Likert scales are included.

4.1.2 Data distribution assessment

We analyzed the distribution of the variables with skewness and kurtosis measures to check the normal distribution of items [38]. According to Bulmer [21], if the skewness = 0, the data are perfectly symmetrical as shown in the middle of the figure, but this is unlikely to happen in real data, and the following are the general rule of thumb.

- If skewness is less than -1 or greater than 1, the distribution is highly skewed as shown on the right (negative skewed) and left (positive skewed) side of Figure 4.1a.
- Moderately skewed data distributions range between [-1, -1/2] and [1/2, 1], and approximate symmetrical distribution ranges between [-1/2, ½].

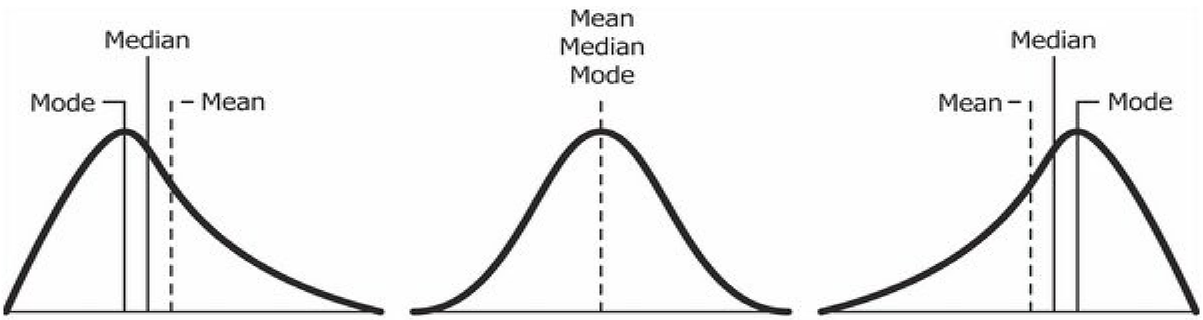

Figure 4.1a Data distribution, skewness measure

To this regard, our data distribution showed that the skewness coefficients ranged between -1.982 and 0.672 and was more or less within the acceptable limit, except from a few items skewed positive due to low practice of these items within the firm.

Similarly, the standard normal distribution has kurtosis value of zero (mesokurtic), whereas the distribution with kurtosis less than zero is called platykurtic and distribution with kurtosis value of greater than zero is called leptokurtic [166]. The range of our data with respect to kurtosis measure ranged between -1.819 and 1.575. Only three items exceeded the limits and were removed.

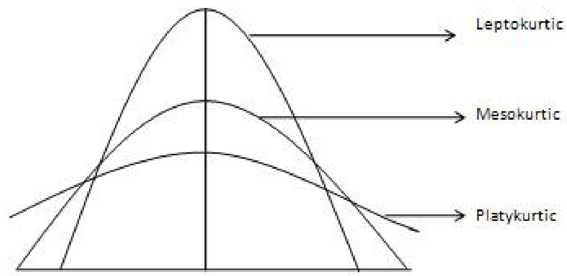

Figure 4.b Data distribution, kurtosis measure

After data distribution was assessed, we carried out six separate EFA for each of the core-processes and supporting dimensions, as discussed in section 4.2.

4.1.3 Considerations for item retention

To get a meaningful factor structure with manageable item size, we used a set of recommended criteria to retain items. After the pre-assessment of collected data using skewness and kurtosis, we also checked its suitability for factor analysis by examining the Kaiser – Meyer – Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity with p-value lower than 0.05 [58,74,94]. The KMO measures whether the responses given by a sample of respondents are adequate or not; the minimum cut-off is a value of 0.5, between 0.7 to 0.8 it is considered acceptable, and values greater than or equal to 0.9 are superb [94]. Then, we used principal component analysis [74] as the factor extraction method to determine the number of factors that represent a given pool of items. Principal component analysis (PCA) is recommended when there is no prior theory or no models exist in the literature [168]. Most of our measurement items were generated deductively from the constructs, also there were some inductively generated items. To this reason, we took an assumption that there exists a theoretical correlation among measurement items [38] and looking at the output of correlation matrix, we used the PCA extraction method with oblique rotation, i.e. Promax with Kaiser Normalization [74]. The number of factors to be extracted was determined through an examination of the conventional Kaiser criterion (i.e. maintain factors with eigenvalues greater than one) in combination with the scree plot [74,128,168].

To retain items, communality should be above 0.45, the minimum acceptable threshold for factor loadings was set to 0.50, and cross-loading for two or more factors should not be higher than 0.40 [38,175]. Finally, initial internal consistency of the constructs was assessed using Cronbach's alpha value with the cut-off value of 0.70 [119].

4.2 Results of exploratory factor analysis

This section presents the results of scale purification based on the results of EFA. Since the four core-processes (i.e., patent generation, patent portfolio management, patent exploitation and enforcement, and patent intelligence), and the two supporting dimensions (i.e. patent strategy and organization for patenting) were independent of each other, we carried out six separate exploratory factor analyses that we present in the subsequent sections.

4.2.1 The patent generation core process

We began our fist EFA on patent generation core process based including 19 items that measure its underlying constructs. The purpose of EFA is to identify the factor structure from a set of variables. To this end, our analysis aimed to determine the relationship between these 19 measurement items or observed variables with each other and with their constructs. These items were included in the online survey questionnaire and 101 completed responses were used in this analysis. The EFA analysis began by investigating whether the responses collected were good enough for factor analysis by determining the Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO) value that equals to 0.872 which is higher than the minimum cut-off threshold (0.70) suggested by Hair et al. [74]. In addition, the Bartlett's Test of Sphericity was significant (X^2 = 1017.58; $p < 0.000$). This result indicated that the sampling was adequate for conducting the next stage of the EFA, which consists of extracting factor structures that condense items into factors. However, the result of the factor analysis showed that there were many cross-loadings, which created difficulty to get a clear factor structure. Item retention criteria discussed above would have led to the loss of a significant number of items, which can be perceived as an indication of trouble in the theoretical framework. To handle the problem, we carried out a special interview session to discuss this issue with experts to find possible explanations and solutions. During the discussion, the experts suggested that the concept of patent generation and freedom to operate may be different in the fact that the former deals with the patent (i.e. whether an invention is patentable), and the latter focuses on the product (i.e. whether an invention can be commercialized). Taking this into consideration, we carried out two separate factor analyses for patent generation and freedom to operate. The first EFA considered 9 items under state-of-the-art analysis and patent geographical scope constructs, and the second EFA considered 10 items under freedom to operate and securing freedom to operate constructs. To extract the factors structures, we applied the commonly used extraction method of Kaiser's criteria (eigenvalue > 1 rule), and the Scree test. To this regard, the analysis provided a two-factor structure for both dimensions (see Table 4.2) explaining 70.59% and 63.67% of the total variance respectively (see Table 4.1). And in both analysis the rotation converged in 3 iterations.

Table 4.1 Total variance explained of patent generation and freedom to operate

Patent generation						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**4.305**	**53.809**	**53.809**	**4.305**	**53.809**	**53.809**
2	**1.343**	**16.783**	**70.592**	**1.343**	**16.783**	**70.592**
3	.647	8.086	78.678			
4	.564	7.053	85.731			
5	.407	5.084	90.815			
6	.307	3.834	94.649			
7	.231	2.886	97.535			
8	.197	2.465	100.000			
Freedom to operate						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**3.174**	**45.344**	**45.344**	**3.174**	**45.344**	**45.344**
2	**1.283**	**18.330**	**63.674**	**1.283**	**18.330**	**63.674**
3	0.776	11.080	74.754			
4	0.656	9.367	84.121			
5	0.449	6.418	90.539			
6	0.369	5.272	95.810			
7	0.293	4.190	100.000			

Following to the extraction of factors, we checked how strongly each of the measurement items loaded on their respective factors, and the analysis showed that the factor loading values ranged from 0.681 to 0.917 for patent generation and from 0.577 to 926 for freedom to operate, which satisfies the recommended value of above 0.50. In both cases, some items were eliminated due to their low communalities, low factor loadings or cross-loading. The Cronbach's alpha value for the first three factors were high enough, ranging from 0.825 to 0.883, whereas the fourth factor has Cronbach's alpha value of 0.636, but since items are theoretically related to each other, we kept it for further analysis.

Table 4.2 Item acronyms, means, standard deviation, communality, Cronbach's alpha, and factor loadings of the patent generation and freedom to operate (N = 101).

Patent generation						
Item acronyms	M	SD	Communality	α	Factor 1	Factor 2
G_GEO_1	4.08	1.093	0.739	**0.883**	0.831	
G_GEO_2	3.36	1.188	0.666		0.794	
G_GEO_3	3.76	1.069	0.782		0.905	
G_GEO_4	3.93	1.107	0.783		0.897	
G_SOA_1	3.76	0.929	0.541	**0.831**		0.748
G_SOA_2	3.93	0.962	0.795			0.917
G_SOA_3	3.86	0.949	0.766			0.874
G_SOA_4	4.38	0.881	0.575			0.681
Freedom to operate						
Item acronyms	M	SD		α	Factor 1	Factor 2
G_FTO_3	3.97	1.044	0.743	**0.825**	0.793	
G_FTO_4	3.48	1.154	0.706		0.803	
G_FTO_5	3.86	1.132	0.690		0.789	
G_FTO_6	3.58	1.080	0.582		0.824	
G_SEC_1	3.65	1.062	0.528	**0.636**		0.712
G_SEC_2	3.62	1.173	0.768			0.926
G_SEC_3	3.42	1.143	0.440			0.577

4.2.2 The patent portfolio management core process

The second EFA on patent portfolio management core process was carried out using 11 measurement items. The patent portfolio management included items related to the characteristics and maintenance of a patent portfolio within a firm. The analysis in this section also aimed to investigate the extent to which these 11 items of patent portfolio management are related to each other, and to check the presence of possible factor structures. Since these items were included in the online survey questionnaire the 101 completed respondents answer were used for the subsequent analysis. The Kaiser—Meyer Olkin (KMO) value of 0.895 and significant chi-square value for the Bartlett's test of sphericity ($X^2 = 425.983$, $p < 0.000$) showed that factor analysis was appropriate for these data. In order to extract the factor structure of the 11 items, we looked at the total variance explained, as shown in Table 4.3 below where eigenvalues greater than one indicate the possible number of factors. The result of our analysis provided the existence of a single factor structure (i.e. "patent renewal") that explained 65.52% of the total variance.

Table 4.3 Total variance explained of patent portfolio management core-processes

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**4.586**	**65.520**	**65.520**	**4.586**	**65.520**	**65.520**
2	0.670	9.575	75.095			
3	0.527	7.527	82.622			
4	0.408	5.827	88.448			
5	0.339	4.847	93.296			
6	0.250	3.573	96.869			
7	0.219	3.131	100.000			

In addition, we also considered the item retention criteria described in section 4.1.3, so the factor loadings ranged from 0.767 to 0.891, and the communalities from 0.588 to 0.794, both of which were above the acceptable limit of 0.50. During the iteration process, four measurement items were eliminated from the analysis due to low communality values. Furthermore, the single factor, namely "Patent renewal", has a high Cronbach's alpha value (i.e. 0.910), which showed the items had a high initial internal consistency. Table 4.4 below summarizes the descriptive statistics and factor structure of the analysis.

Table 4.4 Item acronyms, means, standard deviation, communality, Cronbach's alpha, and factor loadings of the patent portfolio management (N = 101).

Items acronyms	M	SD	Communality	α	Factor 1
P_REN_2	4.20	0.949	0.629	**0.910**	0.793
P_REN_4	4.11	0.937	0.588		0.767
P_REN_5	3.42	1.235	0.639		0.799
P_REN_6	3.71	1.169	0.794		0.891
P_REN_7	4.14	0.990	0.665		0.815
P_REN_10	3.45	1.261	0.679		0.824
P_REN_11	3.45	1.179	0.592		0.769

4.2.3 The patent exploitation and enforcement core process

In the third EFA for patent exploitation and enforcement, we included 24 measurement items related to how firms exploit and enforce their patents, such as licensing, signaling, and litigating. To this end, we determined the relationship between the 24 items, and their underlying constructs. The Kaiser—Meyer Olkin (KMO) value of 0.873, and significant chi-square value for the Bartlett's test of sphericity ($X^2 = 1573.620$, $p < 0.000$) indicated that factor analysis was appropriate for the data. The analysis of EFA revealed a four-factor structure, explaining 73.32% of total the variance from which the first factor explained 38.08% of the variance, the second, third, and fourth factors explained 19.62%, 9.02% and 6.60% of the variance respectively as shown in Table 4.5.

Table 4.5 Total variance explained of patent exploitation and enforcement core-processes

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**7.617**	**38.084**	**38.084**	**7.617**	**38.084**	**38.084**
2	**3.924**	**19.622**	**57.706**	**3.924**	**19.622**	**57.706**
3	**1.803**	**9.017**	**66.723**	**1.803**	**9.017**	**66.723**
4	**1.320**	**6.599**	**73.322**	**1.320**	**6.599**	**73.322**
5	0.779	3.895	77.217			
6	0.633	3.167	80.384			
7	0.606	3.030	83.414			
8	0.533	2.665	86.078			
9	0.509	2.544	88.623			
10	0.406	2.028	90.651			
11	0.381	1.905	92.556			
12	0.334	1.668	94.224			
13	0.251	1.254	95.478			
14	0.209	1.044	96.522			
15	0.204	1.018	97.540			
16	0.139	0.693	98.233			
17	0.121	0.604	98.837			
18	0.102	0.510	99.347			
19	0.074	0.369	99.716			
20	0.057	0.284	100.000			

Overall, according to the item retention criteria described in section 4.1.3 the communality values for most of the items satisfied the recommended acceptable thresholds and the factor structure has acceptable Cronbach's alpha values ranging from 0.742 to 0.958. However, during the scale purification process four items were deleted because of their low factor loading and communalities (lower than 0.5). Table 4.6 summarizes the descriptive statistics and the resulting factor structure.

Table 4.6 Item acronyms, means, standard deviation, communality, Cronbach's alpha, and factor loadings of the patent exploitation & enforcement (N = 101).

Items acronyms	M	SD	Communality	α	Factor 1	Factor 2	Factor 3	Factor 4
E_LIC_1	2.92	1.316	0.772	**0.958**	0.868			
E_LIC_2	2.46	1.337	0.891		0.968			
E_LIC_3	2.42	1.121	0.618		0.770			
E_LIC_4	2.29	1.149	0.858		0.957			
E_LIC_5	2.30	1.120	0.813		0.880			
E_LIC_6	2.26	1.220	0.850		0.972			
E_EXT_2	2.66	1.336	0.766		0.755			
E_EXT_3	2.80	1.349	0.817		0.841			
E_SIG_1	3.81	1.065	0.460	**0.840**		0.671		
E_SIG_2	2.37	1.206	0.835			0.857		
E_SIG_3	2.52	1.301	0.813			0.818		
E_SIG_6	2.84	1.294	0.567			0.690		
E_SIG_7	2.56	1.135	0.609			0.771		
E_ENF_1	3.27	1.122	0.666	**0.810**			0.773	
E_ENF_2	2.84	1.195	0.635				0.770	
E_ENF_3	3.46	1.091	0.761				0.768	
E_ENF_4	3.79	1.143	0.758				0.723	
E_ENF_5	3.67	1.146	0.646	**0.742**				0.551
E_ENF_6	3.51	0.994	0.810					0.875
E_ENF_7	2.94	1.127	0.720					0.783

From the factor analysis we noticed that some constructs were merged and other split; more particularly, "external patent exploitation "and "proactive licensing" were merged, whereas the construct "patent enforcement" was split into two parts, namely "infringement detection" (factor 3) and "infringement reaction" (factor 4). This indicates that firms treat these activities separately.

4.2.4 The patent intelligence core process

In the same manner, we used 10 measurement items to carry out the factor analysis of patent intelligence. This core process included items on how firms use patent search and other intelligence measures that enabled firms to have an understanding on patenting activities within their firms or by their competitors. The KMO value of 0.813 and Bartlett's test of sphericity ($X^2 = 319.503$, $p < 0.000$) showed that the 101 responses collected from the online survey were adequate for factor analysis. The EFA analysis on patent intelligence gave us a two-factor structure explaining 78.91% of total variance of which the fist factor explained 52.36% and the second factor explained 26.55%, as shown in Table 4.7 below.

Table 4.7 Total variance explained of patent intelligence

	Initial Eigenvalues			**Extraction Sums of Squared Loadings**		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.189	52.360	52.360	4.189	52.360	52.360
2	2.124	26.551	78.911	2.124	26.551	78.911
3	0.442	5.526	84.437			
4	0.415	5.194	89.631			
5	0.325	4.063	93.694			
6	0.236	2.952	96.645			
7	0.144	1.802	98.447			
8	0.124	1.553	100.000			

As shown in Table 4.8, the results of EFA confirmed the existence of two factors as identified theoretically without removal of measurement items; indeed, factor loadings and communalities of all items were within the acceptable limits. Furthermore, the internal consistency of items was assessed by checking the Cronbach's alpha values that are 0.887 and 0.927 for the first and second factors respectively. Table 4.8 summarized the descriptive statistics and factor structure of the patent intelligence core process.

Table 4.8 Item acronyms, means, standard deviation, communality, Cronbach's alpha, and factor loadings of the intelligence (N = 101).

Item acronyms	M	SD	Communalities	α	Factor 1	Factor 2
I_WTC_1	3.88	1.080	0.693	**0.887**	0.858	
I_WTC_2	3.28	1.159	0.767		0.816	
I_WTC_3	3.53	1.128	0.825		0.898	
I_WTC_4	3.56	1.081	0.731		0.875	
I_LSD_1	2.99	1.330	0.790	**0.927**		0.859
I_LSD_2	2.59	1.266	0.835			0.924
I_LSD_3	2.61	1.265	0.824			0.913
I_LSD_4	2.44	1.135	0.847			0.934

We remind that, beyond these two factors included in the EFA, the Patent intelligence core process included also other activities, namely patent landscape _ breadth and frequency.

4.2.5 The patent strategy supporting dimension

For the supporting dimension patent strategy, we used 8 measurement items to conduct exploratory factor analysis. The patent strategy dimensions included items that represent the strategic concern of patenting, and alignment of patent strategy with overall firm strategy. We used the 101 respondents answer as quantitative data to carry out EFA. The KMO value of 0.855 and Bartlett's test of sphericity ($X^2 = 313.420$, $p < 0.000$) showed that the sample was adequate for factor analysis. The EFA analysis of patent strategy dimension revealed a single-factor structure explaining 63.59% of total variance as shown in Table 4.9.

Table 4.9 Total variance explained of patent strategy dimension

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**3.815**	**63.589**	**63.589**	**3.815**	**63.589**	**63.589**
2	0.707	11.783	75.372			
3	0.565	9.419	84.791			
4	0.377	6.277	91.068			
5	0.319	5.316	96.383			
6	0.217	3.617	100.000			

According to the item retention criteria described in section 4.1.3, we removed two items that had a low factor loading. For the remaining items, the loadings ranged from 0.640 to 0.856, that is above the acceptable limit of 0.50 as shown in Table 4.10 below.

Table 4.10 Item acronyms, means, standard deviation, communality, Cronbach's alpha, and factor loadings of Patent strategy (N = 101).

Items acronyms	M	SD	Communality	α	Factor 1
S_ALI_1	3.78	1.006	0.704	**0.884**	0.839
S_ALI_2	3.68	1.067	0.733		0.856
S_ALI_3	3.60	1.078	0.721		0.849
S_PAT_1	3.98	1.039	0.652		0.807
S_PAT_2	4.13	0.966	0.596		0.772
S_PAT_4	4.12	0.972	0.409		0.640

From the factor analysis we noticed the merge of the construct “strategic patenting” and “patent strategy and firm strategy alignment” that were originally separate constructs. The resulting factor has a high Cronbach’s alpha value of 0.884, that shows a good internal consistency.

4.2.6 The organization for patenting supporting dimension

The last factor analysis was carried out for the organization for patenting supporting dimension, with 16 measurement items, to understand the underlying factor structure. The organization for patenting dimension included items on rewards, culture, and top management support for patenting. The data were first checked using KMO values of 0.773 and Bartlett’s test of sphericity ($X^2 = 1050.664$, $p < 0.000$) to show the sample was adequate for factor analysis. The EFA analysis revealed a four-factor structure explaining 73.935% of total variance of which the first factor explained 37.327% of the variance, and the second, third, and fourth factors explained 17.103%, 10.793% and 8.712%, as shown in Table 4.11 below.

Table 4.11 Total variance explained of patent exploitation and enforcement

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**5.972**	**37.327**	**37.327**	**5.972**	**37.327**	**37.327**
2	**2.736**	**17.103**	**54.430**	**2.736**	**17.103**	**54.430**
3	**1.727**	**10.793**	**65.223**	**1.727**	**10.793**	**65.223**
4	**1.394**	**8.712**	**73.935**	**1.394**	**8.712**	**73.935**
5	0.817	5.103	79.038			
6	0.647	4.041	83.079			
7	0.514	3.214	86.293			
8	0.459	2.867	89.160			
9	0.383	2.392	91.552			
10	0.329	2.057	93.608			
11	0.297	1.857	95.465			
12	0.235	1.468	96.933			
13	0.181	1.128	98.061			
14	0.149	0.933	98.994			
15	0.094	0.586	99.581			
16	0.067	0.419	100.000			

According to the item retention criteria described in section 4.1.3, all measurement items of the organization for patenting supporting dimensions were within the acceptable limits. Therefore, EFA confirmed the existence of four factors as identified theoretically and all items load on the intended factors that had an acceptable Cronbach's alpha value ranging from 0.763 to 0.945. Table 4.12 summarized the descriptive statistics and factor structure for the resulting output from EFA.

Table 4.12 Item acronyms, means, standard deviation, communality, Cronbach's alpha, and factor loadings of the organization for patenting (N = 101).

Items acronyms	M	SD	Communality	α	Factor 1	Factor 2	Factor 3	Factor 4
O_CUL_1	2.62	1.126	0.701	**0.913**	0.779			
O_CUL_2	3.36	1.221	0.777		0.915			
O_CUL_3	3.56	1.014	0.794		0.845			
O_CUL_4	3.56	1.284	0.792		0.863			
O_CUL_5	3.20	1.208	0.717		0.785			
O_COM_2	2.98	1.761	0.893	**0.945**		0.967		
O_COM_3	2.81	1.719	0.914			0.937		
O_COM_4	2.90	1.775	0.863			0.891		
O_REW_1	2.31	1.322	0.782	**0.822**			0.859	
O_REW_2	2.39	1.384	0.810				0.893	
O_REW_3	2.91	1.594	0.739				0.709	
O_REW_4	2.74	1.573	0.688				0.749	
O_TOP_1	3.66	1.160	0.687	**0.763**				0.802
O_TOP_2	3.57	1.099	0.695					0.665
O_TOP_3	3.27	1.127	0.402					0.596
O_TOP_4	3.97	0.953	0.578					0.719

Also in this case, beyond these four factors included in the EFA, the Organization for patenting supporting dimension includes also other activities, namely patent dedicated resources, cross-functional patent management, and patent internal activity.

4.3 Summary on the results of EFA

This main purpose of this chapter, exploratory factor analysis, was twofold. The primary concern was to determine the underline factor structure for each of the core processes (i.e. patent generation, portfolio management, exploitation and enforcement, and patent intelligence) and supporting dimensions (patent strategy and organization for patenting), whereas the latter was the purification of the initially generated pool of item based on the recommended criteria to retain items, whereas the . To this purpose, we used items generated in Chapter 3 to develop the questionnaire survey that was used to collect primary quantitative data. The initial questionnaire consisted of 118 item and, after sending the online survey in Southern and Northern European countries, we received 101 completed responses. For the purpose of EFA, we used only items that were measured using the five-point Likert scale. The result of EFA showed that there were some changes with respect to the initial theoretical relationships between patent management constructs and their measurement items. Specifically, patent generation process split into two independent processes, thus resulting in patent generation and freedom to operate as a separate core process. This separation caused a change in the framework of patent management as shown in Figure 4.2 below with five core processes. The result of EFA revealed a two-factor structure for both the freedom to operate process ("freedom to operate" with four items and "securing freedom to operate" with three items) and for patent generation process ("state-of-the-art analysis" with four items and "patent geographical scope" with four items).

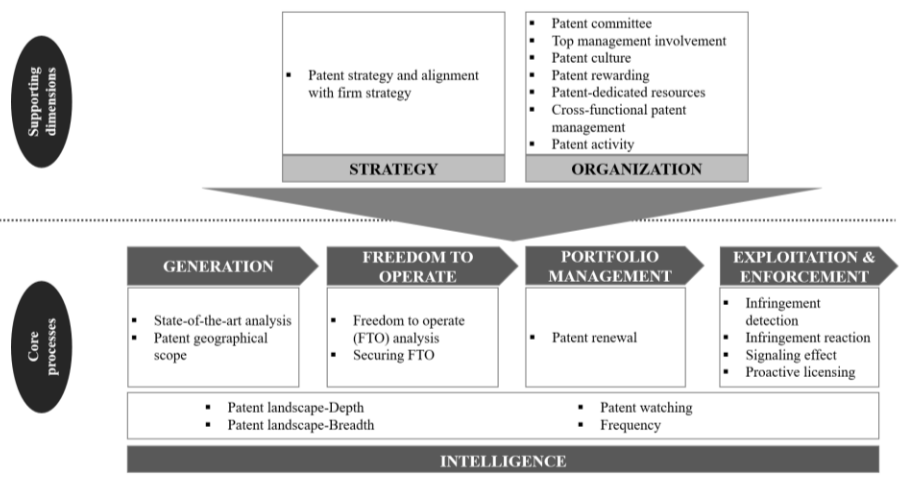

Figure 4.2 The updated framework for measuring patent management

Considering patent portfolio management, the results of EFA revealed a single-factor structure, namely "patent renewal", with seven items. For patent exploitation and enforcement processes EFA revealed a four-factor structure ("licensing" with eight items, "signaling" with five items, "infringement detection" with four items, and "infringement reaction" with three items). In this core process the theoretically formulated "patent enforcement" construct split into "infringement detection" and" infringement reaction", whereas "proactive licensing" and "external patent exploitation" were merged together. Lastly, the EFA revealed a two-factor structure for the last core process of patent intelligence ("patent landscape depth" with four items, and" patent watching" with four items).

On the other hand, for the supporting dimension of patent strategy, the EFA showed a single-factor structure, namely "strategic patenting", with six items. Here the theoretically hypothesized items of the constructs "strategic patenting" and "alignment of patent strategy and firm strategy" merged together. Lastly, EFA revealed a four-factor structure for the supporting dimension of organization for patenting ("patent culture" with five items, "patent committee" with three items, "top management involvement" with four items, and "patent rewarding" with four items).

Chapter Five

5.1 Scale finalization: confirmatory factor analysis

It is not possible to come up with valid conclusions without a valid measurement [74]. Along this line, this chapter focused on the procedure followed and results obtained from analyses carried out to finalize the measurement scales, based on a second data sample to which confirmatory factor analysis (CFA) was applied using SPSS and Amos V23. Chapter Four, using exploratory factor analysis, focused on unveiling the underlying factor structure of core processes and supporting dimensions that made up the patent management process and purifying the measurement scales by removing items that failed to satisfy the item retention criterion established. Differing from EFA, for which factors are obtained from statistical results, in CFA using SPSS we specified both the number of factors that exist for each set of measurement items. CFA is applied to test the extent to which a researcher's *a-priori* theoretical pattern of factor loading on prespecified constructs (variable loading on specific constructs) represent the actual data, instead of allowing the statistical method to determine the number of factors and loadings as in EFA. When CFA results are combined with construct validity and reliability tests, it helped us to obtain a better understanding of the quality of the measures. Therefore, CFA is a tool that enabled us to either "confirm" of "reject" our preconceived theory [74].

5.1.1 Sample description (sample II)

For the purpose of CFA, we updated our questionnaire considering the elimination of some items from the first survey, i.e. items removed after item purification using EFA and re-phrasing some other items to make it more descriptive for the constructs. To this end, considering the recommended sample size to carry out factor analysis, CFA, we prepared an online survey questionnaire that consisted the refined items related to patent management. The questions were prepared in the format by which respondents' rate on a five-point Likert scale (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, and 5=strongly agree) and/or just a simple yes/no response. We reached the target of respondents using the professional social network, LinkedIn, and direct email addresses of previous direct contacts. Our second sample covered firms found in central European countries as described in section 2.4. Overall, we collected a total of 103 responses to carry out confirmatory factor analysis, and distribution of the data was analyzed with skewness and kurtosis measure [38]. Items were within the acceptable limits and they can be considered as adequately distributed.

5.1.2 Considerations for scale validation

Factorability of the sample was first checked using the Kaiser–Meyer–Olkin measure of sampling adequacy (with a threshold of 0.70) and Bartlett's Test of Sphericity with p-value lower than 0.05 [58,74,94]. The principal component analysis extraction method with oblique rotation, i.e. Promax with Kaiser Normalization [74], was used. The recommended item retention criteria were in line with those used in EFA, that are the following: items should have a factor loading higher than 0.50, the communality should be above 0.45, and cross-loading for two or more factors should not be higher than .40 [38,175]. Furthermore, the reliability of the constructs was measured using composite reliability, with the cut-off value of 0.70 [60].

Composite reliability (CR): Similar to the Cronbach's alpha coefficient, composite reliability is a measure of the internal consistency of items in a scale [23,117]. The composite reliability of a construct is calculated as follows [60,117].

$$\boldsymbol{CR} = \frac{(\sum_{i=1}^{p} \lambda_i)^2}{(\sum_{i=1}^{p} \lambda_i)^2 + \sum_{i}^{p} V(\delta)}$$

Where λ_i = the completely standardized loading for the indicator/item i,
$V(\delta)$ = variance of the error term for the indicator/item i, and p = the number of indicators/items.

In addition, we tested convergent and discriminant validity to determine the extent to which a set of measured items correctly represents the theoretical latent constructs. The statistical significance of an item's loading and its magnitude have been referred to as the convergent validity of the item to the construct [117]. The convergent validity was examined using factor loading and AVE of the constructs with a minimum threshold value of 0.50 [60].

Average variance extracted (AVE)**:** It assesses the amount of variance that is captured by a set of items in a scale relative to measurement error with a threshold value of 0.5 [60,117], but for newly developed scales values near to 0.5/0.45 are acceptable. Average variance extracted can be calculated as follows:

$$AVE = \frac{\sum_{i=1}^{p}(\lambda_i)^2}{p}$$

Whereas, the discriminant validity tests that theoretically different constructs are not highly correlated with each other. The test was carried out by comparing the AVE with the corresponding inter-construct squared correlation estimates [60]. If the AVE value was greater than the squared inter-construct correlation estimates, then discriminant validity was found.

5.2 Results of confirmatory factor analysis

In this section, the results of CFA are presented. The analysis was performed independently for each of the five core processes (i.e. patent generation, freedom to operate, portfolio management, exploitation and enforcement, and patent intelligence) and two supporting dimensions (strategy and organization) as shown in the framework above (see Figure 4.2 of Chapter 4). To this end, the following sections describe the details of CFA for each core process and supporting dimension.

5.2.1 The patent generation core process

The CFA here showed the pattern of relationships of items that measured the latent constructs of patent generation [49]. The analysis focused on verifying the factor structure, identifying the level at which items represented the constructs by looking the value of factor loadings and communalities, and evaluated the validity of constructs. For this purpose, we used the 103 respondent answers from the second sample of data collection in the central European countries. The adequacy of collected data for factor analysis was first determined using the Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO) of value 0.788, which was above the acceptable level of 0.70, and Bartlett's Test of Sphericity was significant ($X^2 = 239.480$; $p < 0.000$). Then, we conducted the factor analysis using SPSS V.24 by fixing the number of factors to two, according to the results obtained from EFA of patent generation. The CFA analysis began including eight measurement items of patent generation that had a two-factor structure (i.e. "state-of-the-art analysis" and "patent geographical scope"). The underlying factor structure was extracted using principal component analysis method with oblique rotation, i.e. Promax with Kaiser Normalization. The CFA confirmed a two-factor structure that explained 66.24% of total variance, as shown in Table 5.1. The output of CFA provided items with communality value ranging from 0.518 to 0.750 and factor loading from 0.657 to 0.902, which satisfied the item retention criteria established. During the iteration process, only one item was removed from the “state-of-the-art analysis” construct due to its low communality value.

Table 5.1 Confirmatory factor analysis (CFA) for generation core-process

Factor/Items	Factor loading	CR	AVE
State-of-the-art analysis (SOA)		**0.86**	**0.67**
G_SOA_2	0.657		
G_SOA_3	0.876		
G_SOA_4	0.902		
Patent geographical scope (GEO)		**0.87**	**0.63**
G_GEO_1	0.857		
G_GEO_2	0.753		
G_GEO_3	0.872		
G_GEO_4	0.674		

Reliability: the composite reliability value of 0.86 and 0.87 respectively confirmed the two constructs, “state-of-the-art analysis” and “patent geographical scope”, had items that were internally consistent.

Convergent validity: For both “state-of-the-art analysis” and “patent geographical scope” constructs, the measurement items had a factor loading higher than the threshold level of 0.5. In addition, the average variance extracted (AVE) for each construct was greater than the minimum threshold value of 0.50 (see Table 5.1), which further supported the convergent validity of the constructs.

Discriminant validity: The inter-construct correlation between “state-of-the-art analysis” and “patent geographical scope” constructs was 0.401; when we squared it, the value became 0.16 that was below the AVE of both constructs (see Table 5.1). Thus, the measurement model demonstrated discriminant validity. Overall, the results of this confirmatory factor analysis confirmed that the core process patent generation had a two-factor structure as determined by EFA in Chapter 4.

5.2.2 The freedom to operate core process

The second confirmatory factor analysis was carried out for freedom to operate to verify the pattern relationships of measurement items and their underlying factors. In the same manner, the Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO) value of 0.801, and Bartlett’s Test of

Sphericity was significant ($X^2 = 250.705$; $p < 0.000$) that showed the sample was adequate for factor analysis. CFA began using seven measurement items under two factors (i.e. "freedom to operate" and "securing freedom to operate") obtained from the EFA. We used principal component analysis with oblique rotation i.e. Promax with Kaiser normalization to extract the factor structure, and it confirmed that freedom to operate has a two-factor structure as shown in Table 5.2.

Table 5.2 Confirmatory factor analysis (CFA) for freedom to operate core process

Factor/items		**CR**	**AVE**
Freedom to operate (FTO)	**Factor loading**	**0.89**	**0.67**
G_FTO_3	0.826		
G_FTO_4	0.885		
G_FTO_5	0.793		
G_FTO_6	0.762		
Securing freedom to operate (SEC)		**0.84**	**0.65**
G_SEC_1	0.831		
G_SEC_2	0.905		
G_SEC_3	0.654		

The factor structure explained 66.98% of the total variance of which 48.39% is explained by the fist factor and 18.59% by the second. The item retention criteria showed an acceptable value of factor loadings ranging from 0.654 to 0.905 and communalities from 0.559 to 0.748.

Reliability: The reliability of the two constructs "freedom to operate" and "securing freedom to operate" were tested using composite reliability with values 0.89 and 0.84 respectively. These values assess the internal consistency of items and were within the acceptable limits above 0.70.

Convergent validity: The convergent validity was examined using factor loading values ranging from above the threshold of 0.5 and supported by an acceptable level of AVE as shown in Table 5.2.

Discriminant validity: The inter-construct correlation between "freedom to operate analysis" and "securing freedom to operate" constructs was 0.412, when we squared it the value became 0.170 that is below the AVE values .67 and .65 for constructs FTO and SEC respectively. Thus, the measurement model demonstrated discriminate validity. The overall result of the factor analysis confirmed that freedom to operate core process has two-factor structure as obtained in EFA.

5.2.3 The patent portfolio management core process

The third CFA showed the pattern of relationships of patent portfolio management items with the underlying factor. Appropriateness of the sample for factor analysis was checked using the Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO) test with value of 0.826 and Bartlett's Test of Sphericity was significant ($X^2 = 201.322$; $p < 0.000$) that were acceptable. The CFA analysis began with seven items that measured a single factor (i.e. "patent renewal"). Similarly, to previous analyses, we used principal component analysis method with oblique rotation, i.e. Promax with Kaiser normalization that extracted a single factor structure explaining 54.13% of the total variance as shown in the Table 5.3.

Table 5.3 Confirmatory factor analysis (CFA) for patent portfolio management

Factor/Items	Factor loading	CR	AVE
Patent renewal (REN)		**0.88**	**0.54**
P_REN_4	0.750		
P_REN_5	0.713		
P_REN_6	0.707		
P_REN_7	0.815		
P_REN_10	0.719		
P_REN_11	0.704		

During the iteration process of factor analysis one item was removed due to low communality, whereas we kept two other items with a very little deviation of communality values from the threshold value of 0.50 because these two items had good factor loadings and were theoretically related with others. Items had high factor loadings that ranged from 0.704 to 0.815.

Reliability: The reliability of patent renewal construct was measured using composite reliability which had a value of 0.88, thus satisfying the recommended minimum threshold value of 0.7 required to check internal consistency of items.

Convergent validity: The convergent validity of the construct patent renewal was examined using factor loadings with values above the threshold of 0.5, and AVE value of 0.54. Since the model is explained using single factor, discriminant validity test was not necessary. Therefore, the over analysis of CFA confirmed that patent portfolio management had a single-factor structure.

5.2.4 The patent exploitation and enforcement core process

The fourth CFA focused on the pattern of relationships of patent exploitation and enforcement items with their respective constructs. The Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO) of 0.858 and Bartlett's Test of Sphericity was significant ($X^2 = 769.106$; $p < 0.000$) were above the acceptable thresholds, therefore the appropriateness of the second sample was verified. Then, we conducted factor analysis using 20 measurement items within four factors (i.e. "patent licensing", "signaling effect", "infringement detection", and "infringement reaction") obtained from EFA. The underlying factor structure was extracted using principal component analysis method with oblique rotation, i.e. Promax with Kaiser normalization, and the analysis provided a three-factor structure explaining 70.47% of total variance as shown in Table 5.4. Contrarily to the output of the EFA, the three items of patent enforcement, that were separated as an independent factor (i.e. "infringement reaction"), were eliminated from the analysis due to low communalities. The remaining items had communality values ranging from 0.584 to 0.787 and factor loadings from 0.762 to 0.891, which satisfied the item retention criteria.

Table 5.4a Confirmatory factor analysis (CFA) for patent exploitation and enforcement

Factor/items	Factor loading	CR	AVE
Infringement detection (ENF)		**0.81**	**0.59**
E_ENF_1	0.762		
E_ENF_2	0.769		
E_ENF_3	0.764		
Signaling effect (SIG)		**0.77**	**0.53**
E_SIG_2	0.891		
E_SIG_3	0.839		
E_SIG_6	0.787		
Patent licensing (LIC)		**0.95**	**0.74**
E_LIC_1	0.871		
E_LIC_2	0.832		
E_LIC_4	0.824		
E_LIC_5	0.865		
E_LIC_6	0.878		
E_EXT_2	0.881		
E_EXT_3	0.850		

Reliability: The reliability of the three constructs "patent licensing", "signaling effect", and "infringement detection" were tested using composite reliability with values of 0.95, 0.77, and 0.81 respectively. These values were within the acceptable range and, thus, confirmed the internal consistency of items.

Convergent validity: for all the three constructs, the factor loadings of all measurement items were above the threshold of 0.5. In addition, the AVE for constructs "patent licensing", "signaling effect", "infringement detection" were 0.74, 0.53, and 0.59 respectively, which is above the acceptable value of 0.5.

Discriminant validity: as Table 5.4b shows, that the AVE for each construct (in the diagonal) were higher than the squared correlation estimates (below the diagonal) between constructs, which demonstrated discriminant validity.

Table 5.4b AVE (in the diagonal) and correlations (below the diagonal) among patent exploitation and enforcement constructs

	Patent licensing	Signaling effect	Infringement detection
Patent licensing	**.74**		
Signaling effect	.081	**.53**	
Infringement detection	.001	.007	**.59**

5.2.5 The patent intelligence core process

The fifth confirmatory factor analysis departs from eight measurement items within two factors (i.e. "patent landscape depth" and "patent watching") of the core process patent intelligence obtained from the output of EFA. The analysis aimed at verifying the relationship within these items, and their relations with the factors. For this purpose, we used the 103 sized data from the second survey in the central European countries. The KMO value of 0.788 and Bartlett's Test of Sphericity was significant ($X^2 = 352.081$; $p < 0.000$) showed the sample size was acceptable for factor analysis. Principal component analysis method with oblique rotation, i.e. Promax with Kaiser normalization was used to extract the factor structure by fixing the number of factors to two. The result of factor analysis verified that patent intelligence has a two-factor structure explaining 73.51% of the total variance as shown in Table 5.5 below.

Table 5.5 Confirmatory factor analysis (CFA) for patent intelligence

Factor/items	Factor loading	CR	AVE
Patent landscaping _ Depth (LSD)		**0.91**	**0.72**
I_LSD_1	0.859		
I_LSD_2	0.842		
I_LSD_3	0.835		
I_LSD_4	0.854		
Patent watching (WTC)		**0.89**	**0.74**
I_WTC_1	0.911		
I_WTC_2	0.761		
I_WTC_3	0.892		

During the iteration process of the factor analysis only one item was removed from the second factor, “patent watching”. The remaining items satisfied the item retention criteria described above with acceptable communality values ranging from 0.700 to 0.807 and high values of factor loading ranging from 0.761 to 0.911.

Reliability: The reliability of the two constructs, patent landscape depth and patent watching, was tested using composite reliability with values of 0.91 and 0.89 respectively, thus above the threshold of 0.70. These values verified the internal consistency of items.

Convergent validity: The high factor loadings of all measurement items of patent intelligence supported convergent validity of the model by satisfying the minimum threshold value of .50. Furthermore, this result was corroborated by the AVE of the two constructs “patent landscape depth” and “patent watching” that showed values of 0.72 and 0.74 respectively.

Discriminant validity: The comparison of average variance extracted with the corresponding inter-construct squared correlation estimate confirmed the discriminant validity between the two constructs. The inter-construct correlation between patent landscaping depth and patent watching constructs was 0.392, when we squared it the value became 0.15 which is below the AVE values 0.72 and 0.74 for constructs I_LSD and I_WTC respectively. The overall CFA analysis confirmed that patent intelligence can be measured using a two-factor structure.

5.2.6 The patent strategy supporting dimension

The sixth CFA showed the pattern of relationships of patent strategy items with the underlying constructs. Similarly, we used data collected from the second sample to carry out CFA analysis, always after checking KMO (0.83) and Bartlett’s test was significant (X^2 =253.13; $p <0.000$) that confirmed appropriateness of data. The CFA analysis was carried out including six measurement items and fixing one single factor (i.e. "strategic patenting"), as obtained from EFA. Using principal component analysis method with oblique rotation, i.e. Promax with Kaiser normalization, the factor analysis verified that patent strategy had a single-factor structure explaining 58.21% of total variance as shown in Table 5.6. According to the factor retention criteria described above, all measurement items satisfied the recommended values, i.e. communalities ranged from 0.512 to 0.665 and factor loadings from 0.716 to 0.816.

Table 5.6 Confirmatory factor analysis (CFA) for patent strategy

Factor/items	Factor loading	CR	AVE
Strategic patenting		**0.89**	**0.58**
S_PAT_1	0.720		
S_PAT_2	0.766		
S_PAT_4	0.716		
S_ALI_1	0.749		
S_ALI_2	0.816		
S_ALI_3	0.806		

Reliability: The composite reliability value of 0.89 for the single construct confirmed that the model was reliable.

Convergent validity: The values of factor loadings above the threshold value of 0.5 and the AVE value of 0.58 showed the measurement items converged into a single construct. The overall result confirmed that patent strategy supporting dimension has a single-factor structure.

5.2.7 The organization for patenting supporting dimension

The last CFA was conducted for patent organization that had a four-factor structure (i.e. "patent culture", "patent committee", "patent rewarding", and "top management involvement") with a total of 16 measurement items obtained from EFA. The concern of this section was to verify the output of EFA i.e. to show whether patent organization had a similar structure as that obtained from EFA or not using a different sample of data. We assess the appropriateness of the sample for factor analysis using the Kaiser Meyer-Olkin Measure of Sampling Adequacy (KMO) of value 0.788, which was above the acceptable level of 0.751, and Bartlett's Test of Sphericity was significant ($X^2 = 769.11$; $p < 0.000$) showed the sample size was acceptable for factor analysis.

The result of factor analysis verified that patent organization had a four-factor structure explaining 71.14% of the total variance of which the first factor explained 32.03%, the second, third, and the four factors 15.62%, 14.72%, and 8.77% respectively.

Table 5.7a Confirmatory factor analysis (CFA) for patent organization

Factor/items	Factor loading	CR	AVE
Patent culture (CUL)		**0.89**	**0.62**
O_CUL_1	0.754		
O_CUL_2	0.754		
O_CUL_3	0.748		
O_CUL_4	0.808		
O_CUL_5	0.864		
Patenting committee (COM)		**0.96**	**0.90**
O_COM_2	0.985		
O_COM_3	0.980		
O_COM_4	0.872		
Patent rewarding (REW)		**0.86**	**0.62**
O_REW_1	0.879		
O_REW_2	0.812		
O_REW_3	0.671		
O_REW_4	0.771		
Top management involvement (TOP)		**0.79**	**0.56**
O_TOP_1	0.855		
O_TOP_2	0.679		
O_TOP_4	0.709		

During the iteration process only one item was removed from the fourth factor, “top management involvement”, due to its low factor loading. According to the item retention criteria described above, all measurement items satisfied the recommended values: the communalities varied from 0.495 to 0.919 and factor loadings ranged from 0.671 to 0.985. The overall analysis confirmed that patent organization supporting dimension has four-factor structure.

Reliability: The reliability of the four constructs “patent culture”, “patent committee”, “patent rewarding”, and “top management involvement” were tested using composite reliability with values 0.89, 0.96, 0.86, and 0.79 respectively. These values were within the acceptable threshold of 0.70 and, thus, verified the internal consistency of items.

Convergent validity: For all of the four constructs, the measurement items loaded on the intended factor with factor loadings above the threshold level of 0.5. In addition, the AVE for constructs “patent culture”, “patent committee”, “patent rewarding”, and “top management involvement” were 0.62, 0.90, 0.62, and 0.56 respectively, that is higher than the minimum threshold value of 0.50.

Discriminant validity: The discriminant validity test was carried out by comparing the AVE with the corresponding inter-construct squared correlation estimates. As Table 5.7b shows, the measurement model demonstrated discriminate validity.

Table 5.7b AVE (in the diagonal) and correlation among patent organization constructs (below the diagonal)

	Patent culture	Patent committee	Patent rewarding	Top management involvement
Patent culture	**0.62**			
Patent committee	0.12	**0.90**		
Patent rewarding	0.07	0.02	**0.62**	
Top management involvement	0.13	0.01	004	**0.56**

Chapter Six

6.1 Discussion

Although there exist some frameworks for patent management, the lack of theoretically sound, valid and practical measurement scales motivates the current study focused on the development and validation of multidimensional measurement scales for patent management using a robust methodology. To this purpose, we adapted the widely recognized methodological steps recommended by Churchill et al. [36] and Hinkin [79,80]. Accordingly, this study is broadly composed of three sequential parts consisting of scale development (specification of the domain of constructs and item generation), scale purification using EFA and initial internal consistency assessment, and then scale finalization through assessment of internal consistency and statistical validation using results of CFA.

6.1.1 Results of scale development

The first part of the study, based on an extensive literature review and interviews with experts, initially conceptualized patent management as a multi-dimensional concept consisting of four core-processes (i.e. patent generation, patent portfolio management, patent exploitation and enforcement, and patent intelligence) and two supporting dimensions (i.e. patent strategy and organization for patenting), each including activities and organizational aspects. Always based on the literature and interviews with experts, the measurement items were generated for each core process and supporting dimension. The results of literature review and interviews with experts provided an initial pool of 118 measurement items for patent management. The distribution of these items is as follows: 24 items for patent generation, 11 items for patent portfolio management, 24 items for patent exploitation and enforcement, 15 items for patent intelligence, 8 items for patent strategy, and 36 items for organization for patenting. These measurement items were converted into a questionnaire survey to collect primary quantitative data that were used for the next part of scale purification using EFA.

6.1.2 Results of EFA

In this second part, an EFA was performed separately for each core process and supporting dimension using SPSS V.24. For this purpose, we conducted an online questionnaire survey for firms found in the Southern and Northern European countries. The iterative process of EFA provided the underlying factor structures and the number of items retained within each factor according to minimum thresholds required (i.e. factor loading > 0.5, communalities > 0.5, Cronbach's alpha > 0.70, and cross-loading should not be > 0.4). Overall, the EFA highlighted deviations regarding some processes and supporting dimensions as described below.

Core processes

While performing EFA for *Patent generation*, we obtained inconsistent results due to significant loss of items because of high cross-loading. We perceived this result needed further investigation and we, thus, carried out additional interviews with experts that led to the separation of the process into two, namely *Patent generation* with "state-of-the-art analysis" and "patent geographical scope" constructs, and *Freedom to operate* with "freedom to operate" and "securing freedom to operate" constructs. The underlying motivation emerged while discussing with experts here is that the object of patent generation is the patent (i.e. whether an invention is patentable), whereas the focus of freedom to operate is the product (i.e. whether the invention can be realized and commercialized). Then, we carried out EFA again for these two core processes independently and the results improved significantly. The result of EFA for these two core processes confirmed the presence of two-factor structure as identified from the qualitative analysis, with only the elimination of some items and high Cronbach's alpha values supporting initial internal consistency.

On the other hand, the EFA analysis for *Patent portfolio management* supported the presence of a single factor structure, namely "patent renewal", consisting of items that have high internal consistency with high Cronbach's alpha value of 0.910, but four items were eliminated due to low factor loadings. In the same manner, the EFA analysis for the *Patent intelligence* core process confirmed the two-factor structures, "patent watching" and "patent landscaping - depth" with high Cronbach's alpha, but with the elimination of one item which has low communality.

Lastly, the EFA for the core process *Patent exploitation and enforcement* provided a four-factor structure. During the process of EFA, items from the two constructs "external patent exploitation" and "proactive licensing" converged to a single factor, and the construct "patent enforcement" split into two, namely "infringement detection" and "infringement reaction". In this process, four items were also eliminated from the analysis.

Supporting dimensions

The EFA analysis for *Patent strategy* brought to the merge of the two constructs “strategic patenting” and “patent strategy and firm strategy alignment” into a single construct which has highly consistent items. Instead, the EFA for the supporting dimension *Organization for patenting* verified the presence of a four-factor structure as that of the theoretical and qualitative analysis, with only one item removed from the analysis. Of course, these four factors were enriched by those that, for their nature, were not included in the EFA that are “patent dedicated resources”, “cross-functional patent management”, and “patent internal activity”.

Overall, the results of the EFA provided patent management measurement scale with five core-processes, instead of the initial four, and two supporting dimensions. In addition, it purified the scales by eliminating 15 measurement items.

6.1.3 Results of CFA

In the third part, scales finalization, the study focused on the internal consistency assessment (composite reliability) and the validity of the measurement scales for each core process and supporting dimension. For this purpose, first we updated and administered items for the second sample of data collection. Then, we carried out the second quantitative data collection on firms located in Central European countries and collected 103 complete responses. Using this second sample data, CFA for each core process and supporting dimension were carried out with results as follows.

Core processes

Based on the number of factors and measurement items retained from scale purification, we carried out CFA for all of the five core processes separately to validate the results by means of a different data sample. The overall results of CFA confirmed the factor structure of core processes. In the case of *Freedom to operate*, all items satisfied the item retention criteria, whereas, only one item was removed from the three core processes *Patent generation* under the construct “state-of-the-art analysis”, *Patent portfolio management* under the construct “patent renewal”, and *Patent intelligence* under the construct “patent watching”. However, the low communality value of all the three items that build “infringement reaction” results in removal of this construct from *Patent exploitation and enforcement* core process. Furthermore, one item was removed from the constructs “patent licensing”, two from “signaling effect”, and one from “infringement detection”. The removal of one construct for this core process brought us to conclude that it needs further investigation.

Supporting dimensions

The results of the CFA validated the factor structure for both of the supporting dimensions. In the case of the *Organization for patenting*, only one item was eliminated from the construct “top management involvement”.

Furthermore, the internal consistency assessment of items for each construct were confirmed using composite reliability with recommended threshold value of 0.70 [60,108]. To this end, the result of CFA provided a higher value of CR (ranges from 0.77 for the construct “signaling effect” (SIG) in *Patent exploitation and enforcement* process, and 0.96 for “patent committee” in *Organization for patenting* support dimensions) that supports the consistency of items within their respective construct. On the other hand, to have a reliable measurement, one should demonstrate the validity of the scale [157]. The convergent validity was examined by considering the presence of higher factor loading and average variance extracted (AVE) with minimum threshold greater than 0.5 [60,74]. The result of CFA here also supported the convergent validity of constructs within each process and dimension by satisfying the minimum threshold. Whereas, the discriminant test was checked for each core process and supporting dimension by comparing their AVE with the corresponding inter-construct squared correlation estimates [60]. The result shows that AVE values are higher than squared inter-construct correlation for all processes and dimension that support discriminant validity. In the case of *Patent portfolio management* and *Patent strategy* both have a single construct, so we did not need to check the discriminant validity. To sum up the results of CFA, we can argue that the scales for core processes and supporting dimensions are valid as well as generalizable in different firms at least in the European countries context, with the only exception of *Patent exploitation and enforcement* that needs further investigation. Figure 6.1 depicts the final framework.

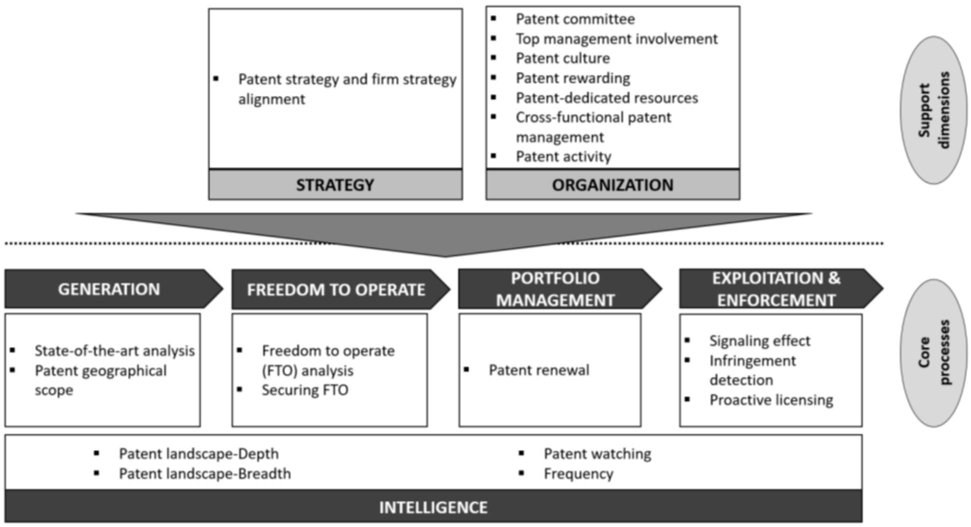

Figure 6.1 The final framework for measuring patent management

On such basis, the contribution of this thesis lies in offering measurement scales with an overarching perspective on patent management seen as a macro-process. The description of patent management using core processes and supporting dimensions illustrates the significant contribution of patent management in appropriating its values rather than the size of patent portfolio [55]. Differing from previous studies on patents, which consider patents as performance indicators [17], measure of knowledge flows [134] and innovation output [20], and bargaining power [72], this study aims to identify and explore patent management as a managerial domain in its own right, following several recent calls [24,82]. Even though there is also some recent literature that provides frameworks for patent management like along the life-cycle [7], through maturity level [44], considering activities and dimensions [89], and through dimensions and maturity level [112], neither of them addresses the measurement gap yet. This study therefore approaches this theoretically and managerially relevant research gap highlighted in the literature [178]. Apart from the scales themselves, the processes/dimensions and the underlying factors provide a framework that can help to better understand the multiple facets and granularity of patent management, thus clarifying the urgency of adopting a strategic and managerial approaches regarding patent management According to Somaya [144], patent management is the managerial capability allowing firms to gain value from their patents. Along this line, this work of thesis offers managers a tool to implement this managerial capability.

6.2 Academic and managerial implications

The scales developed in this study are useful not only in an academic research but also for practitioners who practice patent activities in firms. For academicians, the study extends existing research by offering an up-to-date and comprehensive investigation on firms' patent management activities, thereby enriching patent management and IP bodies of literature. To have a clear understanding of patent management, one needs to look at its different processes and dimensions. In this regard, the study provides a clear conceptualization of patent management as a macro-process with five core processes (i.e. patent generation, freedom to operate, portfolio management, exploitation and enforcement, and intelligence) and two supporting dimensions (i.e. strategy and organization for patenting) that contributes to develop further theoretical basis for the field by extending existing research on patent management. Moreover, it proposes a firm-level measurement framework for which its underlying factor structure is tested empirically, which enables researchers to advance the theory in the area of patent management. The theoretical framework developed suggests that patent management is a cumulative effect of patenting activities and its supporting strategic and organizational aspects. In addition to analyzing the literature, we also conducted interviews with experts and tried to address to fill measurement gaps of patent management using a holistic approach. Actually, the literature asserts the difficulty of drawing strong conclusions from a body of research if there is a problem in measurement [81]. In this sense, this thesis provides a significant contribution because it offers researchers a basis to test hypotheses about the relationships among processes and dimensions of patent management, and firms output attributes (e.g. performance) using real data collected from firms. Since patent management is a new research thematic area, future researchers may expand the measurement scales by including other constructs, as claim patentability examination or confidentiality mechanisms and/or other emerging constructs in the field, as well as the relationship between patent strategies and activities. The scales developed in this study for each core process and supporting dimension can also be used separately to suit specific research needs and examine a particular aspect of patent management. Furthermore, the measurement framework developed allows other researchers not only to use the scales but also to open the possibility of further modifications.

As far as practical implications are concerned, practitioners (e.g. patent managers, patent attorneys, individual innovators, R&D managers, technology managers) who engage in projects to understand and improve patent management in their firms can use these scales for different purposes, as assessment, planning and evaluation of their patenting activities. Managers can use the measurement scales to identify the strengths and weaknesses of their patent management process, thus unveiling relevant improvement areas. In addition, the proposed framework can enable understanding and communication of the multi-faceted role of patent management. This might be especially useful in the communication with other functions of firms, such as with business and engineering units. The developed patent management measurement framework provides actionable items for managers to use in their firms' daily patent related activities. The key managerial property of this framework and associated measurement scales is the clear conceptualization of processes/dimensions and activities that need to be implemented in the firm to exploit the potential benefit they can get from patents. Managers can use the framework and the measurement scales as a management assessment tool to understand the level of sophistication of patent management within their firms and exploit the full potential from their patent portfolios.

6.3 Limitations and avenues future research directions

Like any other study, this research is not without limitations. Firstly, though this study tested patent management scales with two separate samples, more research is required to support its generalizability using different large samples. In addition, the data was collected from different types of firms, for example in terms of size, and industries, which overlooks issues related to contingencies. Therefore, future studies can test whether and how the baseline framework and associated measurement scales need to be adapted to different contexts, considered that the scale validity is linked to the context in which the scale is used. Along the same line, since the study is done based on data from European countries, future studies could test the results in different geographical areas to broaden its significance. In addition, the nomological validity of the scales can be tested more intensively in the future studies. Lastly, the *Patent exploitation and enforcement* core process still needs further examination due to the elimination of one activity after the CFA.

As for any research aiming to create new tools for understanding and measuring a phenomenon, the value of this research will primarily be realized when the framework and each measurement scale are used in future research. In this perspective, future researchers may expand the measurement scales by including newly emerging constructs that could even improve reliability and validity of these constructs. Furthermore, as anticipated, the dimensions of patent management may be influenced by contextual factors, such as firm size, domain-specific industrial sectors, geographical and/or country-specific rules, etc. For example, large companies may have well established patent departments with fully equipped resources, whereas small start-up companies may treat patent management together with other managerial activities. Therefore, future studies can show the impact of such factors on the patent management process and see whether and how the proposed framework may change. Moreover, future research may need to test the impact of patent management on firm performance, with a focus on the overall process or on some specific core processes or supporting dimensions, or also test whether there is an interplay among the different processes and supporting dimensions. Although we proposed different core processes and supporting dimensions that impact the management of firms' patenting activities, it is also likely that some processes or dimensions will have greater influence than others, which could lead researchers to investigate such perspectives.

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