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Organizational innovation: Interactive role of external knowledge strategies and market dynamisms

Maryam Hajialibeigi*

Abstract

There are different determinants for organizational innovation. By taking an encompassing look into dynamics of organizational innovation, this paper examines how organizational innovation is an outcome to interaction of knowledge search strategies and underlying market conditions. Although the role of knowledge management capabilities on organizational innovation have been studied in literature but the effects of external knowledge strategies as an external KM enabler on different parts of organizational innovation has not been covered. To fill that gap and to capture deep dynamics of organizational innovation this paper analyzes the relationship between external knowledge diversity and organizational innovation under the influence of competition intensity and uncertain demand trends which is the second contribution of this study. It is demonstrated that the effects of competition intensity or uncertain demand trends on organizational innovation are diminished through their interactive manifestation with knowledge search diversity. By applying quantile regression in different levels, we additionally indicate that such diminishing effect varies among different industries depending on their organizational innovation intensity as the third novel analytics of this paper.

Keywords: Organizational innovation, External Search diversity, Competition intensity, Uncertain demand

JEL Classification: O_3, C_1

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1. Introduction

Innovation is a non-linear and dynamic process of information analysis. How this information is captured and analyzed very much depends on many environmental and organizational factors which cooperate interdependently. Organizational characteristics of innovative firms have been interest to innovation research since long ago (Burns & Stalker, 1961; Lawrence & Lorsch, 1967; Pugh et al., 1969; Hinings & Turner, 1969; Blau, 1970; Perrow, 1970; Mintzberg, 1979; Chesbrough & Teece, 1998). Why such organizational forms would lead to different innovative performance is related to the capacity of such enterprises in knowledge creation and aggregation (Agyris & Schoen, 1978; Nanoka & Takeuchi, 1995). Literature has also reviewed the relationship between knowledge management and organizational performance as one of firms' economic performance factors (Liao & Wu, 2010; Ramirez et al., 2011; Abubakar et al., 2019). Environmental changes draw firms' attention into the necessity of implementing shifts in their currently organizational settings for not getting behind in the competition in the market (Hannan & Freeman, 1977; Burgelman, 1991; Romanelli & Tushman, 1994; Child, 1997). Such organizational transformations also take place in direct relationship with firms' knowledge accumulation and information processing capabilities. This is where organizational innovation takes its identity as the most highlighted non-technological creativity (Utterback & Abernathy, 1975; Dosi, 1988; Freeman, 1992; Evangelista & Vezzani, 2010; Gunday et al., 2011). There are studies in the literature which investigate the role of internal knowledge sources on organizational innovation (Damanpour & Schneider, 2006; Lichtenthaler, 2009; Ben Zaied et al., 2015). After introduction and adaptation of open innovation with seminal work of Chesbrough (2003) as *searching and utilizing external knowledge,* the role of external knowledge sources and strategies on technological innovation has been widely focused on open innovation literature (Katila & Ahuja, 2002; Gassmann & Endkel, 2004; Laursen & Salter, 2006; Dahlander & Gann, 2010; Leiponen & Helfat, 2010; Greco et al., 2015; Gómez et al., 2016; Radicic, 2020). This research stream has also considered organizational learning and absorptive capacity of firms in relationship with their technological innovativeness (Cohen & Levinthal, 1990; Zahra & George, 2002; Escribano et al., 2009; Ferreras-Mendez et al., 2015; Flor et al., 2017). The adjacent research area to the latter is the one examining the effect of search for external knowledge (in terms of sources) on different organizational innovation branches (Mol & Birkinshaw, 2009; Freitas et al., 2011; Simao & Franco, 2018). Organizational innovation in many studies refers to the application of new ideas into the firms 'functions (Teece, 1998; Weerawardena et al., 2006). That implies the ability of firms to implement organizational transformations in response to technological breakthroughs and new management and marketing systems introduced by their peers or to adopt organizational practices which are not necessarily new in the state of the art but practiced by other players in the market (Mol

& Birkinshaw, 2009). Search for information about such new organizational mechanisms highlights the role of knowledge strategies firms decide to follow through their innovation process. Acquiring such knowledge and assimilating it with internal knowledge production and transfer mechanisms plays substantial role on firms' innovation performance (Fey & Birkinshaw, 2005; Rosenkopf & Nerkar, 2001).

External knowledge acquisition as a component of external knowledge management capability (Ozer & Vogel, 2015; Mehta & Bharadwaj, 2015; Hock-Doepgen et al., 2021) can take different forms (Laursen & Salter, 2006; Leiponen & Helfat, 2010). Search breadth and search depth as prominent external knowledge acquisition practices have attracted much academic attention in innovation literature (Laursen & Salter,2006; Katila & Ahuja, 2002; Greco et al., 2015). Nevertheless, when analyzing how search for external knowledge affects organizational transformations it is the underlying diversity in knowledge search that is mostly emphasized to be influential on dynamics of organizational innovation rather than other aspects (Kaplan, 1998; Hargadon, 2002). Therefore, this article formulates a search approach (as a supplement to search breadth), which captures diversity in search in a more dynamic and rigorous way. On the other side of the analytical reviews on organizational innovation in practice, the impact of organizational traits is playing a substantial role. The features which Mol and Birkinshaw (2009) phrase as 'Context' are enabling factors in business and management practices. Firms' size (Kimberley & Evanisko, 1981) and training activities (Chandler, 1962) are among the most treated ones in previous analyses. In order to take a more encompassing view on the dynamics of antecedents for organizational innovation, this article analyses the roles of external knowledge strategies under the effect of market dynamics. Different trends in markets explain how other determinants shape innovation outcomes (organizational innovation in this study) in the sense of strengthening or weakening them. Firms decide for innovative campaigns in response to market circumstances to maintain competitive advantage or to create it as entrants. Thus, changes in firms' inside and outside take place based on underlying market structures and trends which conduct them. One prominent market condition is the intensity of competition in the relative market. The important effect of competition intensity on innovation in organizations has been examined (Kimberly & Evanisko, 1981, Estrada-Cruz et al., 2020) but how as a market contextual determining factor it establishes relationships with other antecedents (external search strategies in this article) is one of the main analytical contributions of this paper. By introducing a new metric for capturing diversity inherent in the external knowledge that firms acquire, this study also examines how uncertainty in market demand as another market based influential factors exerts impact on the link between external knowledge strategies and organizational innovation.

Three arrangements for organizational innovations (Hamel, 2006; 2007; 2009) are considered in this analysis and the roles of different level inputs into their process are analyzed. (1) New business practices, (2) New methods of organizing external relations (3) New methods of organizing work responsibilities and decision making, are the three elements of organizational innovation which are of interest to this study. This paper investigates how search diversity as a search mode (conceptualized and formulated in this study) establishes relationship with the three types of organizational innovation. Secondly it examines whether the association of market dynamisms with organizational innovation is affected by the role of knowledge diversity. Thirdly it provides answer to the question whether the effect of market dynamisms on organizational innovation on one hand and its interacting effect with search diversity on organizational innovation on the other hand, are volatile among industries based on the intensity of organizational innovation in different industries and finally it investigates whether such volatility varies in case of the three types of organizational innovation.
The rest of this paper is organized as follows: The next section shapes the theoretical background on organizational innovation and its two-level influencing factors. Second the central hypotheses are advanced. In the following section the analyzing methods are presented. Research findings are reviewed in the next section. Finally theoretical and practical implications as well as the conclusion to the whole study are discussed.

2. Theoretical background

2.1 Organizational innovation

Organizational innovation is the incident of taking something new into the organizational processes. As Damanpour (1991,P. 556) puts it : „ It is the adoption of an internally generated or purchased device, system , policy, program, process, product or service that is new to the adopting organization.“ Our analysis relates better to the definition which Lam (2005,P.3) suggests: „ Creation or adoption of an idea or behavior new to the organization.“ Such changes either as the institutional theory of firms suggests (Meyer & Rowan, 1977; DiMaggio & Powell, 1983; Scott, 1987) can be placed by firms to create and maintain an influence in their market or as the behavioral theory of firms suggests (March & Simon, 1958) is an active decision of improving performance. In either of the cases there are influencing mechanisms into innovation at organizational level. One of the enablers is the incentives of firms to be more productive through making changes in their organizational practices. In that case organizational innovation acts as an input into the technological innovation process (Camison & Villar-Lopez, 2014). On the other hand, technological innovations might put challenges and opportunities in front of enterprises which requires them or provides them with incentives (in terms of competitive advantage) to make changes in their organizational procedures (Schumpeter, 1950; Lam, 2005). To be able to analyze the underlying motives for organizational transformations it is

essential to take an encompassing view on its internal and external promoters. One of the highlights in that regard is the capacity of firms for learning. Organizational learning capacities has a two-fold association with changes in organizational level. Firstly, for being learning organizations, enterprises are in need of mild to significant organizational transformations (Fiol & Lyles, 1985; Levitt & March, 1988). Secondly by learning about their functional ecosystems, enterprises know how to improve their performances through shifts in their organizational architecture. The learning mechanism in turn associates with enterprises' knowledge management policies and their effects on technological and non-technological breakthroughs. Contextual characteristics of enterprises and their environmental conditions are further promoters of organizational innovation (Hannan & Freeman, 1977; Mintzberg, 1979; Kimberly & Evanisko, 1981). Analysis of the interdependent roles of these explaining factors enriches views into dynamics of organizational innovation.

2.2 External knowledge strategies

The prominent effect of search for knowledge from outside of the enterprise on innovation has been evaluated even before the theory of open innovation was formulated (Utterback, 1994; Nahapiet & Ghoshal, 1998; McEvily & Zaheer, 1999). The primary external knowledge strategies introduced and measured by Laursen and Salter (2006) are search breadth and search depth. The former reflects number of external sources being explored by firms for knowledge, the latter refers to the importance and weight of usage of each source. Technological innovation literature has seen comprehensive analysis of the roles of search broadening and search deepening on innovation (Cohen & Levinthal, 1990; Rosenkopf & Nerkar, 2001; Katila & Ahuja, 2002; Greco et al., 2015).

There are studies concluding overall positive relationship for search strategies with innovation capabilities of firms (Leiponen & Helfat, 2010) and there are others which consider curvilinear relationship for search strategies with innovation (Laursen & Salter, 2006; Hwang & Lee, 2010). When accessing to knowledge from different sources, firms gain general spectrum of information which contributes to their capacities to cover greater ranges of customer needs. Knowledge acquisition process and its proceeding conversion and application procedures might provide one of the perspectives for organizational transformations. In the sense that for organizations in order to create mechanisms for diversifying their search and to process such heterogenous knowledge, it brings up the needs to improve such procedures through making changes in their organizational settings. As well as the fact that knowledge gained from market-based sources provides firms with information about market dynamics and practices of other rivals which provides another avenue for changes in organizational practices and decision-making procedures. The role of network of partners is very highlighted in innovation processes (Grant 1996; Criscuolo et al., 2018) and broad knowledge provided to firms from market and professional sources gives them overviews on establishing

productive cooperate networks which contributes to their further performances. Therefore, the policies firms pursue for absorbing external knowledge in respect to their objectives and according to their internal information processing capabilities is a big explainer of their organizational mechanisms. In analyzing the link between knowledge search and organizational innovation, it is prominently the diversity dimension of search (as a component of search breadth) that is found to be predominant (Mol & Birkinshaw, 2009; Chiang & Hung, 2010) Therefore, by distinguishing between *diversifying* and *expanding* of search domain, this paper proposes a new metric for capturing diversity inherent in the knowledge explored by firms (industries). As a knowledge search mode, *external search diversity* is a supplement to search breadth but more rigorous in apprehending the heterogeneity intrinsic in the searching network of firms. For having a reference to build up a knowledge search network for each firm or in a broader sense for each industry we clear up a general clustering among eleven possible knowledge sources as an extension to the literature (Cassiman & Veugelers, 2002; Dong & Netten, 2017) in which three categories of sources for deepening search are discussed (1) Vertical class: suppliers, private clients, public clients. (2) Horizontal class: competitors (3) Societal class: government, consultants, professional associations, private research institutes (4) Specialized class: universities, conferences, scientific journals.

The knowledge delivered by any of the categories inherits similarities in nature. But distinct categories deliver differentiated knowledge. For example, suppliers and clients as direct market players provide knowledge about market trends or consumption patterns while conferences and scientific journals supply information about new technologies or new standards. Being inspired by the diversity index practiced in biology (Simpson index, 1949) and Herfindahl-Hirschman index (HHI score, Hirschman, 1946; Herfindahl, 1950) employed in economics, *Knowledge diversity index* (KDI) for firm level (which corresponds a heterogeneity metric to search networks) is defined as follows:

$$KDI_1 = \frac{1}{\sum_{i=1}^{4} {P_i}^2} \tag{1}$$

Where *N* illustrates the total number of sources (external search breadth) utilized by a firm and n_i indicates the number of sources lying in each cluster (for i=1,..,4) and p_i for each class is :

$$p_i = \frac{n_i}{N} \tag{2}$$

In industry level, KDI is equated as follows:

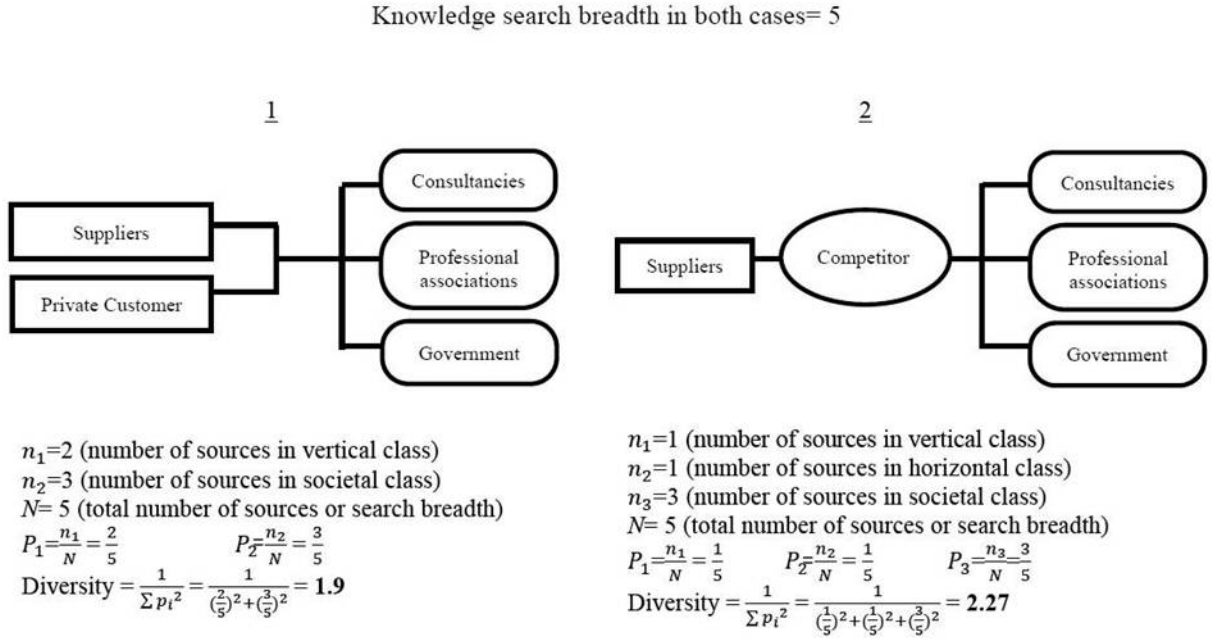
$$KDI_2 = \frac{1}{\sum_{i=1}^{4} (\frac{U_i}{N})^2} \tag{3}$$

Where *N* indicates total percentages of firms having used all eleven sources (search breadth) and u demonstrates the percentage of firms in a specific industry using a specific external source lying in

one cluster (e.g. suppliers) and U_i (e.g. summation of percentages of firms having used suppliers, private clients and public clients) for each of the four source classes (for i=1,.., 4) is formulated as:

$$U_i = \sum u \tag{4}$$

Figure 1 below illustrates the computation of knowledge diversity as a component of search breadth and how it is distinguished for two different networks of external sources.



2.3 Market conditions

Enterprises select their innovative policies according to their environments. It is the opportunities and challenges identified by market forces that determines how firms or industries decide about their innovative goals. Environmental drivers are identified by other players in the markets. Competitors, suppliers, customers, government agencies and other professional and private research institutes' behavioral patterns determine the dynamics of markets. According to the contingency theory of markets (Kerin et al., 1992; Green et al., 1995) when firms set their strategies in pursuing competitive advantage, there is not a specific strategic choice beneficial to all firms with different market conditions (Zhou, 2006). The consequence of all such forces as phrased by Voss and Voss (2000) comes in three forms: demand and uncertainty associated to it, competition and intensity associated to it, technological turbulence and the risk associated to it. Institutional framework of markets and changes associated to it can be considered as a fourth driver being added to this scheme. Those four characteristics although are analytically distinguished but they associate with market dynamics interdependently. When customers' needs and preferences change rapidly, demand estimation becomes a challenging task to innovation pursuing enterprises (Gatignon & Xuereb, 1997). Demand uncertainties might exist due to changes in income and in turn changes in purchasing patterns of

inferior and superior goods, or due to changes in norms and values of the society as well as changes in trends or hypes. They might also exist due to technological turbulences and short product life cycles which generates instability in customers choices. The latter can be the origin to another market contextual factor which is intensity in competition which refers to the degree of rivalry that enterprises encounter in the industries they are active in. When the market faces with close substitutes (product or services) competition for being recognized and differentiated increases. That in turn implies strong incentives to employ new strategies be it pricing strategies or other unilateral policies such as severe marketing and advertising or raising rivals' costs. Competition intensity might also be followed by cooperative strategies such as mergers and acquisitions. In fact, competition intensity generates a situation of interdependency across rivals' acts. When firms are encountered with fast shifts in demand patterns, or with high intensity in competition they need to make adaptations in their strategies. It becomes vital for enterprises who face with such market forces to be able to quickly shift direction in their policies for exploring and exploiting new opportunities to tackle the forces and to survive. This in turn requires them to incorporate flexibility in their structures and decisions. They need to reestablish their business model elements to be able to maintain sustainable competitive advantage. This is how the relationship between market conditions and organizational transformations becomes highlighted. This article covers the analysis of the explaining roles of these two environmental forces of the three modes of organizational innovation.

3. Hypotheses development

3.1 External search diversity and organizational innovation

To be innovative for firms it is vital to concentrate on their knowledge architecture. Part of the knowledge exploration and exploitation process of firms seeking for new business opportunities is related to their strategies for gaining knowledge from their external environment. It is the primary goal of enterprises in search for external knowledge to utilize it as complement for internally developed knowledge to fill gaps in their information stock and to reduce redundancy rates. In that sense diversifying search prevents firms from investing more expensively on obtaining knowledge from external sources which is substitutional to internally developed knowledge. Thus, acquisition and assimilation of heterogenous knowledge in addition to possession of technological and non-technological assets increases the likelihood of capturing complementary knowledge which in turn requires firms to update their organizational procedures related to knowledge development and transfer mechanisms. In a second conduct, the capacity of firms in learning about the value of external knowledge and to optimize the assimilation process is referred to as absorptive capacity (Escribano et al., 2009; Ferreras-Mendez et al., 2015). Exploring more diverse sources improves absorptive capacity and that in turn necessitates firms to upgrade their organizational settings in accordance to

promoted capacities in absorbing external knowledge .The third conduct in the relationship between external search diversity and new organizational practices is in the fact that gaining knowledge from diverse sources (which are the related players in the market) provide enterprises with more information about their environmental dynamics in the sense that what the driving forces of the market are, how intense the competition is, what the rates of introduction of new technologies and services are and much more. That in turn provides firms with deeper knowledge about their environment, thus contributing to appropriate direction settings in order to sustainably survive and prosper. That fact helps establishment of more efficient business practices to catch up with contemporary market trends.

Open innovation literature has abundantly focused on the importance of knowledge flow (inbound and outbound) on performance of firms (Parida et al., 2012; Cheng & Shiu, 2015; Popa et al., 2017). Optimization of such knowledge flows is captured through firms' network structures and their external settings (Pettigrew & Fenton, 2000; Powell & Grodal, 2005). Therefore, for firms to acquire knowledge as an enabler of their performance it becomes vital to reformulate their supply chain relationships and relationships with other relevant parties in their corresponding market. When seeking complementarity and divergence in knowledge from different sources, firms (industries) form new ideas for shaping their relationships and boundaries. Therefore, firms' attempts in gaining divergent knowledge promotes creation of new channels to external actors related to their business models.

When firms involve in strategic planning towards innovative goals, they are encountered with challenges which require decisions to be made (Nicolas, 2004). Decision making processes very much depend on organizational features of firms in addition to their understanding of their environment. Acquiring knowledge from diverse sources gives enterprises more opportunities in gaining information about environmental dynamics. That in turn has effect on their decision-making processes in the sense of their limited resources to exploit. On the other hand, as discussed above gaining knowledge from more diverse sources has an advantage in intensifying organizational learning. Due to exitance of a causal relationship between knowledge acquisition and absorptive capacity, improvements in the latter allows creation of mechanisms which exploit useful knowledge in appropriate time and appropriate situations (King et al., 2008). That is another runner of advancing decision making processes towards boosting performance. Therefore, external search diversity as an external knowledge acquisition strategy provides opportunities and in some cases necessities for the establishment of organizational innovation. On the other hand, exploring much differentiated knowledge requires to access to additional technological and non-technological resources for processing functions which frustrates part of firm's investments for organizational changes. Due to

attention theory of firms (Simon, 1947; Ocasio, 1997, 2011) for converting and applying much differentiated information, firms might face with shortage of necessary assets and that in turn might mitigate the association of search diversity with organizational innovation. Following the reasoning above we hypothesize that external knowledge diversity as a search strategy establishes a curvilinear relationship with three different modes of organizational innovation:

Hypothesis 1a. External search diversity settles a non-linear relationship with advancement of new business practices in an inverted U-shaped form.

Hypothesis 1b. External search diversity settles a non-linear relationship with advancement of new external relationships in an inverted U-shaped form.

Hypothesis 1c. External search diversity settles a non-linear relationship with advancement of new work assignment and decision- making processes in an inverted U-shaped form.

3.2 Market conditions and organizational innovation

When demand trends are steady, firms' investments in activities which direct them to competitive advantage could be by good extents predictable, conversely when uncertainties increase in demand patterns estimating varying needs becomes complex (Golder & Tellis, 1993). To tackle uncertainties in demand firms are required to focus on having flexible organizational dynamics. Solid organizational structures do not help with catching up with technological turbulences which affect consistent changes in environmental patterns. Furthermore, firms need to create flexibilities in the links between their business model elements. Whether it is the value creation element, or customer channels or creating transparent and proactive relationships with their partners. In realizing pliable strategies to survive in an uncertain environment they also need to improve their decision-making processes for gaining more opportunities and resolve challenges towards a sustainable functional existence. Moreover, when competition intensifies, firms need to take cost management into great account (Baker, 2007). Hence, they are forced to shift direction rapidly and to re-engineer policies in time if they wish to sustain competitive advantage (Eagley & Karau, 2002). Establishing flexible structures makes it possible for firms to set a perspective for finding an equilibrium between opportunity exploration and benefit exploration (Shirokova et al., 2013). In order to find such equilibrium within their organizational settings firms are urged to adapt their business strategies. Which in turn implies resilience in transforming traditional business practices, establishment of transparent corporation and partnership networks and pliable business decision processes. Thus, two hypotheses are followed:

Hypothesis 2a. Intensity in competition creates positive synergies for introduction or adoption of organizational innovation modes.

Hypothesis 2b. Uncertainty in demand creates positive synergies for introduction or adoption of organizational innovation modes.

3.3 Interaction of knowledge search diversity and market conditions

As Schumpeter (1934) states ‘’competition in the market and constantly environmental changes in markets requires firms to take potential opportunities of creating competitive advantage from new and different types of knowledge’’. Revisiting his statement suggests that uncertainties and competition intensities which provide incentives or necessities for firms to reform organizational transformations shapes paths to organizational innovation partially different compared to the ones which occur through diversifying search for knowledge. Under the influence of market forces (demand uncertainty and competition intensity), one road to achieve and sustain competitive advantage passes through acquiring information from different actors in the market. That leads enterprises to diversify search for knowledge from different market actors which directs them making shifts in their organizational mechanisms but the fact that diversified information (as discussed in theoretical background) promotes organizational innovation in two other conducts needs to be greatly accounted: Firstly, conversion and application processing of heterogenous knowledge for cultivating new ideas might require changes in business practices or decision-making processes. Secondly it leads to improvement of absorptive capacity which in turn necessitates minor to major organizational transformations in sense of creating new cooperation networks with external parties or other organizational changes. Therefore, the effect market uncertainties and competition intensity exert on organizational innovation has overlaps with the one diversifying search from external sources does. In other words, these two antecedents of organizational innovation are imperfect substitutes rather than complements. In that sense their mutual occurrence frustrates individual associations of each with organizational innovation. Hence, we hypothesize the following statements:

Hypothesis 3a. The effect of competition intensity on organizational innovation is diminished by external search diversity

Hypothesis 3b. The effect of demand uncertainty on organizational innovation is diminished by external search diversity.

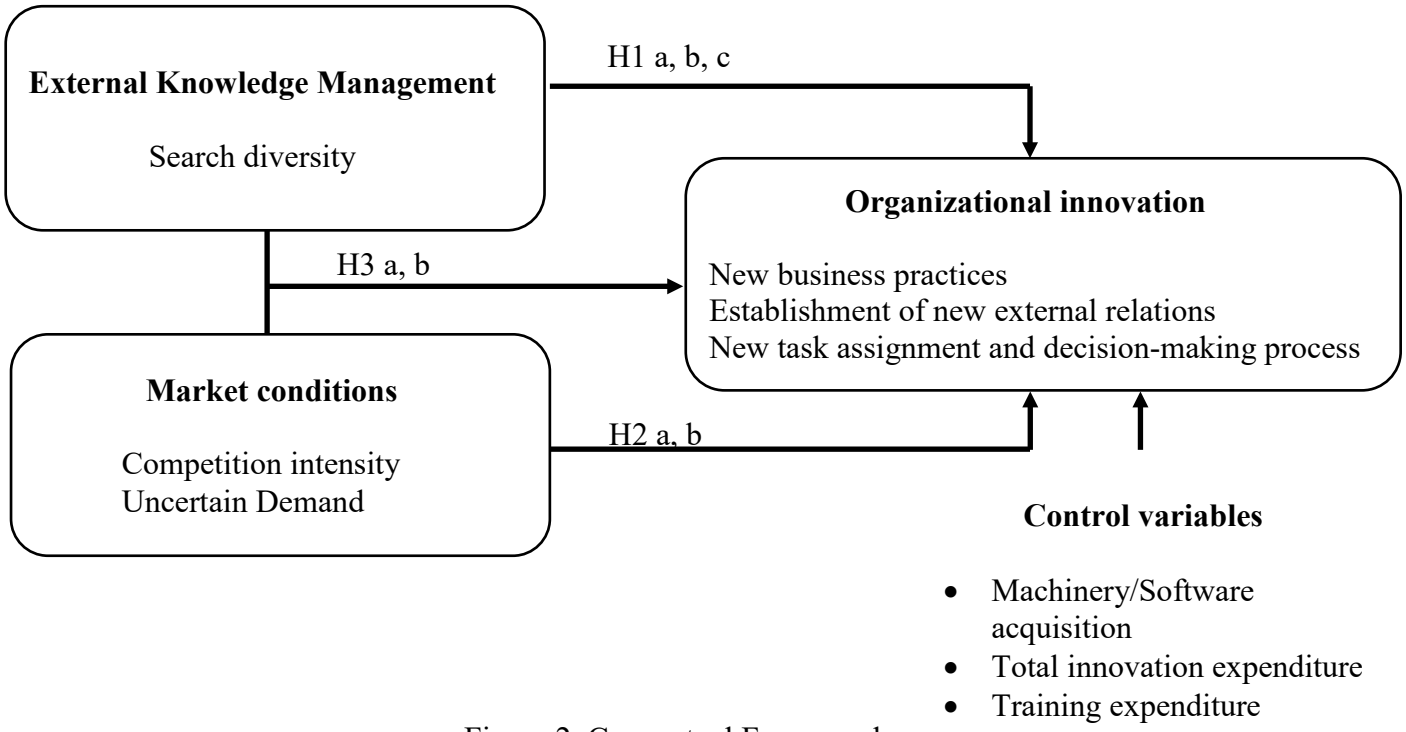


Figure 2. Conceptual Framework

4. Data and measurements

4.1 Data

A large Metadata set is built up for quantitative analysis in this study which has been utilized as the empirical analytic basis in some other studies (Dong & Netten, 2017; Radicic, 2020). The set is constructed based on Mannheim Innovation Meta data supplied by Leibniz Center for European Economic Research. The meta data is evolved as the German part of European Commission's Community Innovation Survey (CIS) and it has been developed in accordance with protocols suggested by the Organization for Economic Cooperation and Development (OECD). It comprises the innovative behavior of industries in the whole German economy. Innovative metrics and patterns of industries from mining to energy supply to broadcasting are included in the dataset. It encapsulates information about newly introduced or significantly improved products and processes, new organizational and marketing practices as well as enabling and hampering factors to innovation. There are other parties who have collaborated for the supply of the dataset including Federal Ministry of Education and Research (BMBF), Institute of Applied Science (Infas) and Institute for Systems and Innovation Research (Frauenhofer ISI). The dataset is revised every two years to remove firms and industries not active as independent entities anymore due to M&A or other reasons and to add entrants and their innovation behaviors. The dataset includes information about external knowledge sources,

expenditures on innovation activities, firms and industries turnovers, merger and acquisition behaviors of firms in all industries and expenditures on machinery/software acquisitions. For the purpose of this study, CIS16 derived from the time span between 2014-2016 is utilized. The final reference dataset comprises 82 industries and 91,192 enterprises including manufacturing, service and retaining companies.

4.2 Variables and measures

4.2.1 External search diversity

This study aims to analyze the relationship between external search diversity on different organizational innovation modes in industry level. Therefore, the modified version of knowledge diversity index (formulated in equation 3) is utilized as the explaining factor of organizational innovation modes and as the independent variable into analyzing models. Respondents were asked to select between two values, whether an external source was highly important for their innovative activities (1) and not important (0). We took the high important responses as the number of enterprises having used specific sources.

4.2.2 Competition intensity

As measured in CIS16, the percentage of firms in each industry who have faced competition intensity in their corresponding industry during 2014-2016 for their innovative activities is proxied and utilized as one of the independent variables and its role in organizational innovation modes as well as its interaction effect with knowledge diversity is analyzed.

4.2.3 Demand uncertainty

It is measured in CIS16 as the percentage of firms having faced with demand uncertainty during the time span of two years (2014-2016) for their innovative activities. Such measurement is proxied for demand uncertainty and is utilized as another independent variable and its individual and interaction effects with search diversity are analyzed.

4.2.4 New business practices

The percentage of firms in each industry who have introduced new or highly improved business practices is used as a proxy to introduction of new business practices as an organizational innovation mode. It is treated as one of the dependent variables in the study.

4.2.5 Organizing new external relations

As measured in CIS16 the percentage of firms who have established new relationships with external actors in each industry during the time span of 2014-2016 is considered as a proxy to foundation of new external relationships as an organizational innovation factor. It is treated as a second dependent variable in the evaluating models in this study.

4.2.6 New methods of organizing work responsibilities and decision making

In this paper introduction or adoption of new methods of organizing work responsibilities and decision-making procedures is addressed as the third dependent variable. It is proxied by the percentage of firms in each industry who have practiced new methods of organizing work responsibilities and decision making during 2014-2016.

4.3 Control variables

4.3.1 Innovation expenditure

The average of total expenditure of enterprises in each industry allocated for innovation activities including in-house R&D expenditures and all external resource acquisitions is considered as the proxy to total innovation expenditure of the industries in evaluating models to be controlled.

4.3.2 Training Expenditure

The average expenditure allocated to training employees during the time span of 2014-2016 for all firms in one industry is proxied and treated as training expenditure variable and its effect on organizational innovation is controlled in the evaluating models.

4.3.3 Machinery/Software acquisition

The total expenditure expended for machinery and software acquisition by manufacturing,
retail and service enterprises are an influencing factor of organizational innovation therefore the average machinery / software acquisition expenditure is proxied and incorporated in the evaluating models in the study.

Table 1

Summary of measures

Variable	Description	Scale
Diversity	Inverse of the summation of fraction of clusters divided by total sources squared $\frac{1}{\sum_{i=1}^{4}(\frac{U_i}{N})^2}$	0-2
Machinery/software acquisition	Expenditure on machinery/software acquisition	7.5-71
Training expenditure	Expenditure on training activities	4.3-60.6
Total R&D	All in-house and external R&D activities expenditures	27-110
Competition intensity	Percentage of innovative firms in each industry with high coemption intensity in their industry	0-29%
Uncertainty in demand	Percentage of innovative firms in each industry facing with uncertainty in demand	0-32%
New business practices	Percentage of firms having introduced newly or immensely improved business practices	1.6-10%

New external relations	Percentage of firms having established new external relations	1.4-10%
New decision making	Percentage of firms having introduced newly or immensely improved decision-making procedures	0-9%

Table 2

Descriptive statistics and correlations

	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)
Diversity	0.5	0.29	1	-0.32	-0.13	0.038	-0.26	0.01
Machinery/Software	328.4	138.7		1	0.6	-0.18	0.45	-0.12
Training Expenditure	27.17	13.4			1	-0.17	0.45	-0.02
Competition Intensity	7.3	6.1				1	0.31	--------
Total R&D	68.5	16.76					1	0.4
Demand Uncertainty	7.4	5.8						1
New Business Practices	5.8	1.6	-0.03	-0.05	0.17	0.58	0.56	0.57
External Relations	5.7	1.6	-0.03	-0.12	0.11	0.61	0.54	0.67
New Decision-Making Processes	4.9	1.9	0.003	-0.002	0.2	0.56	0.53	0.62

5. Methodology and results

5.1 Methodology

To check for the normality in distribution of residuals quantile-quantile plot are sketched (Bai & NG, 2005) for an ordinary least squares regression. Although the residuals demonstrate normality for ordinary least square fitting, we select to utilize quantile regression based on weighted least squares (Lesage, 1999; Mohammadi, 2008) for testing the validity of our hypotheses due to skewness in competition intensity and demand uncertainty variables. In this paper, the target population is built up of distinct industries in the German economy and the variables are measured in a way that produce analysis of the hypotheses in industry level. Quantile regression evaluates the effect of explanatory factors based on the quantiles of response rather than the mean of the response. It has the flexibility to cover outliers and gives good understanding of non-linear relationships. Thus, is able to produce robust outcomes in absence of linearity assumptions. Non-parametric bootstrapping with 1,000 iterations is utilized to capture variance-covariance of the coefficients. Bootstrap standard deviations are estimated based on Green (2008).

The testing models (1,2,3,4,5,6) are performed in three quantile levels (t=0.2, t=0.5, t=0.8) for each of the three dependent variables and results are compared. Equation (5) encapsulates models 1,2,3 which produce estimated coefficients of knowledge diversity, competition intensity and their interaction effect in three levels. Equation (6) on the other hand embodies models 4, 5, 6 which fabricate estimated coefficients of knowledge diversity, demand uncertainty and their interaction effect in three levels. *Y* corresponds to the estimated rate of the three organizational innovation modes. It explains rates of (1) creative business practices (2) creative external relations (3) creative work assignments and decision-making processes by search diversity, market dynamisms and their interaction effects.

$$Y = \beta_0 + \beta_1 diversity + \beta_2 diversity^2 + \beta_3 Competitionintensity + B_4 machinery/software + \beta_5\, totalR\&D + \beta_6\, trainingex + \beta_7 diversity * competitionintensity \quad (5)$$

$$Y = \beta_0 + \beta_1 diversity + \beta_2 diversity^2 + \beta_3 demanduncertainty + B_4 machinery/software + \beta_5\, totalR\&D + \beta_6\, trainingex + \beta_7 diversity * demanduncertainty \quad (6)$$

5.2 Results

Table3, Table 4 and Table 5, illustrate the findings of bootstrapping quantile regressions for new business practices, new external relationships and new responsibility assigning and decision-making processes respectively

Table 3

Quantile regression models for analysis of introduction of new business practices in three levels

	(1) t = 0.2	(2) t = 0.5	(3) t = 0.8	(4) t = 0.2	(5) t = 0.5	(6) t = 0.8
Diversity	6.14*** (1.9)	4.48*** (1.2)	5.91*** (1.13)	5.21*** (1.91)	3.75*** (1.35)	4.2*** (0.9)
$Diversity^2$	-4.54*** (1.44)	-3.13*** (0.99)	-4.36*** (0.88)	-3.65** (1.42)	-3.0*** (1.1)	-3.7*** (0.67)
Competition intensity	0.6** (0.23)	0.68*** (0.14)	0.4*** (0.14)	----------	----------	----------
Demand uncertainty	----------	---------	----------	0.63*** (0.22)	0.3** (0.14)	0.26** (0.13)
Machinery/ Software	-0.05*** (0.01)	-0.02** (0.01)	-0.01 (0.01)	-0.04** (0.01)	-0.02* (0.01)	-0.02* (0.008)

Total R&D expenditure	0.57*** (0.12)	0.44*** (0.07)	0.32*** (0.07)	0.48*** (0.14)	0.34*** (0.09)	0.23*** (0.06)
Training expenditure	0.04*** (0.02)	0.03*** (0.01)	0.01 (0.01)	0.03** (0.01)	0.01 (0.01)	0.003 (0.007)
Competition* diversity	-0.86*** (0.39)	-0.93*** (0.24)	-0.47* (0.24)	----------	----------	---------
Demand uncertainty*diversity	----------	----------	----------	-0.82** (0.34)	-0.23 (0.23)	0.07 (0.001)
Pseudo R^2	0.42	0.43	0.45	0.41	0.42	0.53

Note: *p<0.1; **p<0.05; *** p<0.01 - standard errors are in parenthesis. Dependent variable is new business practice

Table 4

Quantile regression models for analysis of establishment of new external relations in three levels

	(1) t = 0.2	(2) t = 0.5	(3) t = 0.8	(4) t = 0.2	(5) t = 0.5	(6) t = 0.8
Diversity	5.58*** (1.9)	5.29*** (1.29)	5.91*** (1.13)	6.24*** (1.68)	4.43*** (1.23)	3.25*** (0.84)
$Diversity^2$	-4.37*** (1.57)	-4.01*** (0.99)	-4.36*** (0.88)	-4.83*** (1.24)	-3.5*** (0.97)	-3.1*** (0.62)
Competition intensity	0.65*** (0.24)	0.35*** (0.13)	0.4*** (0.14)	----------	----------	----------
Demand uncertainty	----------	---------	----------	0.64*** (0.2)	0.33** (0.15)	0.25** (0.11)
Machinery/ Software	-0.03** (0.02)	-0.02** (0.01)	-0.01 (0.01)	-0.04*** (0.01)	-0.04*** (0.01)	-0.02** (0.006)
Total R&D expenditure	0.48*** (0.14)	0.35*** (0.08)	0.32*** (0.07)	0.46*** (0.13)	0.4*** (0.08)	0.22*** (0.06)
Training expenditure	0.03 (0.02)	0.01 (0.01)	0.01 (0.01)	0.03** (0.01)	0.01 (0.01)	0.006 (0.006)
Competition* diversity	-0.92** (0.39)	-0.74*** (0.24)	-0.35* (0.23)	----------	----------	---------
Demand uncertainty*diversity	----------	----------	----------	-0.85** (0.34)	-0.16 (0.26)	0.03 (0.2)
Pseudo R^2	0.42	0.46	0.49	0.43	0.46	0.55

Note: *p<0.1; **p<0.05; *** p<0.01 - standard errors are in parenthesis. Dependent variable is new external relations

Table 5

Quantile regression models for analysis of establishment of new decision-making processes in three levels

	(1) t = 0.2	(2) t = 0.5	(3) t = 0.8	(4) t = 0.2	(5) t = 0.5	(6) t = 0.8
Diversity	5.2** (2.49)	5.8*** (1.33)	4.8*** (1.17)	4.9* (2.54)	4.27*** (1.29)	3.7*** (0.97)
$Diversity^2$	-4.00** (1.93)	-3.09*** (1.02)	-4.04*** (0.9)	-3.42* (1.92)	-3.37*** (1.15)	-3.3*** (0.76)
Competition intensity	0.52 (0.34)	0.6*** (0.16)	0.11*** (0.15)	----------	----------	----------
Demand uncertainty	----------	---------	----------	0.68** (0.28)	0.34** (0.14)	0.17 (0.11)
Machinery/ Software	-0.05** (0.02)	-0.03*** (0.01)	-0.02** (0.01)	-0.05*** (0.02)	-0.03*** (0.01)	-0.01 (0.006)
Total R&D expenditure	0.62*** (0.17)	0.45*** (0.08)	0.38*** (0.08)	0.46*** (0.14)	0.35*** (0.08)	0.24*** (0.07)
Training expenditure	0.05** (0.02)	0.02* (0.01)	0.02* (0.01)	0.04** (0.02)	0.01 (0.01)	0.006 (0.01)
Competition* diversity	-0.69 (0.55)	-0.8*** (0.26)	0.14 (0.24)	----------	----------	---------
Demand uncertainty*diversity	----------	----------	----------	-0.87* (0.48)	-0.18 (0.24)	0.2 (0.2)
Pseudo R^2	0.36	0.38	0.46	0.36	0.4	0.49

Note: *p<0.1; **p<0.05; *** p<0.01 - standard errors are in parenthesis. Dependent variable is new business decision making processes and new ways of organizing work responsibilities

Since quantile regression has the flexibility to estimate regression models at different percentiles of the response variable, it especially provides interesting insights for the analysis which is done at the industry level.

5.2.1 Search diversity and organizational innovation in different industries

All models (with all different levels) in Tables 3,4,5 demonstrate significant positive estimates (similar in all three levels, t=0.2, t=0.5, t=0.8) for knowledge diversity and significant negative ones for its non-linearity thus H1 a, H1 b and H1 c are supported.

5.2.2 Market conditions and organizational innovation in different industries

Although positive coefficients are estimated for competition intensity and demand uncertainty in three organizational innovation modes (support H2 a and H2 b) but these two plausible driving factors

of organizational innovation demonstrate volatility in their relationship with organizational innovation depending on the status of organizational innovation rates in the industry compared to that of external search diversity.

5.2.2.1 Competition intensity and organizational innovation in different industries

Comparing the coefficients of competition intensity at t=0.2 and t=0.5 (0.6 and 0.68, Table 3) the difference is not substantial and demonstrates that introduction of new business practices is highly sensitive to competition intensity when few new business practices are introduced to the industry (lower percentiles), such increase is positively affected with introduction of more and more of new business practices up to a threshold (median=0.5,Table 3) and then when there are many enterprises in the industry introducing or adopting new business practices (at 80^{th} percentile) the positive effect of competition intensity on introduction of new business practices lowers down (from 0.68 to 0.4, Table 3). Different findings are associated with establishment of new external relationships. When few enterprises have established new external relations in the corresponding industry (t=0.2, Table 4), competition intensity provides more synergies for establishment or arrangement of new external relations in comparison to industries in which more relations are founded (t=0.5, t=0.8, Table 4). This is different for the third organizational innovation mode, in that competition intensity does not show a statistically significant role in the new work assignment and decision making procedures when there are few of the trends in the industry, thus its effect is non-tangible at that level (Table 5, 0.52, statistically insignificant) but with more adoption of such procedures by more enterprises in the industry competition intensity promotes that trend positively (t=0.5, 0.6, Table 5), such association lowers down when more enterprises are adopting new decision making and work assignment procedures (t=0.8, Table 5).

5.2.2.2 Demand uncertainty and organizational innovation in different industries

Demand uncertainty is a significant and substantial driver of introduction or adoption of new business practices when there are few enterprises in the industry who are organizationally innovative in that mode (t=0.2, Table 3). This can be inferred by comparing the estimated effect of demand uncertainty on introduction of new business practices in Table 3. Similar behavioral pattern of demand uncertainty with establishment of new external relations and decision-making procedures are predicted in Table 4 and Table 5. With the emphasis that demand uncertainty cannot be a significant driver of introduction or adoption of new work assignment and decision-making procedures when there are many enterprises in the industry who are innovative in that mode (t=0.8, Table 5).

5.2.3 The diminishing effect of search diversity and competition intensity on organizational innovation in different industries

Interesting findings are obtained with the interaction effect of competition intensity and demand uncertainty with search diversity. The mitigating effect of search diversity on the relationship between competition intensity and introduction or adoption of new business practices is bigger in industries with lower rates of such innovation mode (t=0.2, Table 3) and has its biggest tole in industries with medium number of firms adopting or introducing new business practices (t=0.5, Table 3). That effect diminishes in industries with high number of enterprises being organizationally innovative in that mode. The moderating role of search diversity on the relationship between competition intensity and establishment of new external relationships is bigger in industries with few enterprises who are organizationally innovative in that form (t=0.2, Table 4). That is different with the effect of search diversity on the relationship between search competition intensity and new work assignments. It only has significant diminishing effect in industries with medium number of enterprises who have adopted or introduced that type of organizational innovation (t=0.5, Table 5). An interesting inference is in the situations where the positive linear and negative non-linear effects of search diversity get close. That is approximately where the downturn point in the inverse U-shaped relationship between search diversity and the organizational innovation type occurs. In that point the mitigating interaction effect of the market dynamism (either competition intensity or demand uncertainty) and search diversity on organizational innovation types is neutralized and turns into a positive but insignificant effect. In other words when the positive relation of search diversity with organizational innovation is deteriorating into a negative one there it does not exert an active compensating effect on the effect of market conditions. First case is found with the interaction effect of competition intensity and search diversity on new work assignment and decision-making procedures in industries who have high number of enterprises being organizationally innovative in that mode (t=0.8, Table 5).

5.2.4 The diminishing effect of search diversity and competition intensity on organizational innovation in different industries

Similar results are empirically obtained for the interaction effect of demand uncertainty and search diversity on new business practices in industries with high number of enterprises being organizationally innovative with introduction of new business practices (t=0.8, Table 3). Otherwise demand uncertainty has a significant effect on the relationship between search diversity and introduction or adoption of new business practices in lower percentiles (t=0.2, Table 3). Similar results are obtained with diminishing effect of search diversity on the relationship between demand uncertainty and establishment of new external relations and new deciosn making procedures which is neutralized in industries with higher rates of that type of innovation (t=0.8, Table 4, Table 5).

Otherwise search diversity deteriorates the effect of uncertainty in demand on latter modes of organizational innovation in industries with lower number of enterprises being organizationally innovative in those two types (t=0.2, Table 4, Table 5).

Altogether, in any situation where there is a statistically significant interaction effect of market conditions and search diversity on organizational innovation, it has a mitigating effect, thus fulfillment of H3 a, H3 b and H3 c can be concluded. As for control variables, industry size, total R&D intensity and machinery and software acquisition expenditures are employed in the models. Much automation in business disciplines might reduce firms' (industries') incentives for investing in innovative ways to implement their practices. Thus, this variable follows a negative relationship with organizational innovation. This result is contrary to the relationship analysis of machinery/ software acquisition with technological innovation where a positive trend is expected (Frank, Cortimiglia , Duarte Rebeiro & De Oliveira, 2016). Total R&D expenditure (including in-house and external sponsoring expenditures) is an important input into all types of innovation campaigns whether it is technological or non-technological according to the literature (Love & Mansury,2007, Ebersberger & Herstad,2013) and it has been shown that it follows a positive trend with organizational innovation. Training expenditure is also controlled in the models and it has an overall positive association with organizational innovation.

5.3 Robustness check

Generally, quantile regression is a robust analytical substitute for ordinary linear regression models. As mentioned in section 5 above, since it has the flexibility to model the relationships between independent and dependent variables in different percentiles of the response, it was an appropriate analytical model for our aim to analyze the organizational innovation dynamics in industry level. We checked the linear regression assumptions for our variables and normality, multicollinearity, and heteroskedasticity assumptions were fulfilled. There were autocorrelation impacts and generalized linear regression were performed and similar results were obtained. We incorporated industry size as one of the control variables in the evaluating models and the coefficients were statistically significantly close to zero. Therefore, we put that variable out for two reasons: 1. We used the percentage of enterprises in each industry who introduced organizational innovation during the time span of two years rather than the absolute number; 2. The total expenditure for innovative activities, expenditure for machinery and software acquisition and training expenditure could reflect a good proxy for the size of the industry. Thus, we conclude robustness in our findings.

6. Discussion and Conclusion

6.1 Theoretical and practical inferences

Validity support of the hypotheses throughout the whole discussion indicates that introduction of organizational innovation is a consequence of different internal and external factors which interact interdependently. The introduction of a new metric as a search strategy allows for capturing the diversity inherent in network of explored external sources in a more rigorous way than search breadth or search depth do. That helps with highlighting the importance of complementary knowledge in innovation processes, organizational innovation specifically as the subject of this study. We analyzed that there are three conducts for positive effect of search diversity on organizational innovation which turns down at some point into a negative effect caused by difficulties in processing too much diversity based on attention theory of the firms (Simon, 1947; Ocasio, 1997, 2011) which implies firms have limited capacities for processing different types of information due to restricted technological and non-technological resources and to exploit necessary information for their processes. (Garcia et al., 2000). Empirical findings support the statement that the diminishing effect of search diversity on organizational innovation happens in a slower pace than the positive linear association (see results in Table3,4,5). The interaction effect of market conditions and search diversity on organizational innovation proved to be mitigating. Out of 18 interaction effects in our models 10 were negatively interacting and statistically significant. In such cases, the overlap between the effect of the two driving factors (search diversity and market conditions) on organizational innovation are significant. The rest (4 of them) although not significant but showed the forecasted negativity. Only in cases where the positive linear and the negative non-linear effect of search diversity got close to be identical, some positive but insignificant interaction effect were found. In other words, in those few cases the mitigating effect of search diversity on the relationship between market conditions and organizational innovations was offset. We empirically indicated that the relation of knowledge diversity with different types of organizational transformations showed more stability than that of market conditions in respect to different rates of organizational innovations in different industries (different quantiles of the response). In other words, the positive and negative association of search diversity were not notably different in industries with lower number of organizationally innovative firms and industries with higher number of organizationally innovative firms (estimates of coefficients in Tables 3,4,5). This is different in case of market dynamisms and different types of organizational innovation modes. Results demonstrate that the footprints of market dynamisms (competition intensity and demand uncertainty) as synergy producing factors towards organizational innovation (introduction of new business practices, establishment of new external relations and new decision-making procedures) in industries are dependent on what percentage of enterprises in each industry are organizationally

innovative (in either of the three modes). Similar conclusion is decided for the interaction effect of market dynamism and search diversity. That effect is dependent on the distinct percentiles of the response variable in different industries. Special attention needs to be drawn to the situations where the downturn point in the effect of knowledge diversity on organizational innovation (U-shaped) happens where the interaction effect is neutralized and the market dynamism factors are active with less sensitivity on organizational innovation than in other percentiles. The dependency of the directing factors of organizational innovation on the intensity of organizationally innovative enterprises in industries is a significant contribution of this research in addition to illustration of the mediating effect between environmental forces and diversity in search. From a practical point of view, it provides insights about different roads for firms to economic performance including technological and non-technological innovation campaigns (organizational innovation in this review). Although the important and significant effect of diversity in search on organizational innovation is demonstrated, it is furthermore illustrated that such effect has different implications for managerial inferences. It does not follow a pure positive effect with organizational innovation and follows a negative pattern after a threshold. Secondly how it contributes to introduction of new organizational settings cannot be analyzed isolated but the consequence of its effect under the influence of environmental forces like competition intensity and demand uncertainty should be taken into account as well as the innovativeness of other enterprises in the corresponding industry.

6.2 Limitations and future research

One of the limitations of this research was its dependence on the surveyed data provided in CIS16 gathered from industries in Germany. Although different respondents gave answers to same designed questionnaire but still the responses could carry some social desirability bias. Furthermore, the analysis has been performed in the time span of 2014-2016 (covered in CIS16). It gives a good research opportunity if the implications could be analyzed in different time frameworks. Another interesting research opportunity could be to consider the relationship of other search strategies with organizational innovation modes (e.g., search depth) and make a comparison to results of this research. Finally, the empirical analysis has been performed using data from German industries. Findings embody the potential to be inferred for other industrialized countries with similar socio-economic characteristics like northern and western European economies. It might be possible to extend their applications to other industrialized countries in other parts of the world but to generalize the outcomes to developing countries which have differences in their jurisdiction can be supported by similar analysis with data related to those regions.

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