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Knowledge sharing among scientists: A causal configuration analysis

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ABSTRACT

Scientists are professionals who create knowledge, and academia is a place for creating and sharing knowledge. In this study, we examine the causal configurations that identify particular patterns that lead to knowledge sharing among scientists. Our examination uses a fuzzy-set qualitative comparative analysis. The data come from an online survey of 620 scientists in top Portuguese research centers in engineering, technology, health sciences, social sciences, and the arts and humanities. The results show that being a research team leader is an important condition for knowledge sharing. Productive scientists tend to share their knowledge, whereas unproductive ones tend not to share. The fear of losing power due to knowledge sharing restrains its use, while the scientists who are not afraid share their knowledge. The results do not identify the contribution of senior scientists. This finding indicates older or more experienced scientists are not related to the phenomena.

1. Introduction

Individuals gain knowledge from information, personal experience, and understanding (Alavi, Kayworth, & Leidner, 2006). Knowledge needs to be created before being shared. Since scientists are knowledge-creating and knowledge-sharing professionals (Sergeeva & Andreeva, 2016), as a consequence the research work depends on scientists sharing knowledge with each other. Academia is a place for creating and sharing knowledge; thus this paper reflects the relevancy of studying knowledge sharing (i.e., KS) among academics (Navimipour & Charband, 2016; Park & Gabbard, 2018; Saide et al., 2017; Zhang, Zhou, & Zhang, 2016).

The influences that encourage or discourage KS are poorly understood (Bock, Zmud, Kim, & Lee, 2005; Saide, Trialih, Wei, Okfalisa, & Anugrah, 2017). Although studies have addressed the antecedents of KS among scholars before (Ensign, 2009; Liao, 2008; Park & Gabbard, 2018; Saide et al., 2017; Smith et al., 2017), a gap exists in the literature regarding the use of the configuration theory to uncover alternative pathways that lead to KS and those that lead to its absence.

Research has so far not explored the effects of complex relations using configurations to identify particular patterns that lead to KS among scientists (Sergeeva & Andreeva, 2016) or to its absence (Ensign, 2009: 161). Our aim is to address the conditions and configurations leading to KS (and to its absence, ~KS) among scientists belonging to top Portuguese research centers funded by the national governmental funding foundation, Fundação para a Ciência e Tecnologia (FCT). The objective of the study is to identify the different configurations of conditions that lead scientists to share or to not share their knowledge. Because KS is so important to scientists, this research problem is worth addressing; thus we address the following research questions: Are there any patterns that lead to or inhibit KS? Which configurations generate this sharing?

2. Literature review

2.1. Knowledge sharing among scientists

Knowledge sharing plays an important role in improving a research team's effectiveness, gaining organizational success (Wang & Wang, 2012), and sustaining competitive advantage (Renzl, 2008). The KS of individuals influences the knowledge level of the team (Bock et al., 2005; Curado, Muñoz-Pascual, & Galende, 2017; Oliveira, Maçada, Curado, & Nodari, 2017; Wang & Noe, 2010) and therefore is of particular relevance. The team members' interpersonal relationships and social interactions affect their KS with the team (Ding, Ng, & Cai, 2007; Lin, Wu, & Lu, 2012; Zhang & Cheng, 2015). The social exchange theory (SET) (Emerson, 1976; Homans, 1958) proposes that social mechanisms control the exchange of resources that are not easy to value, like knowledge (Ensign, 2009). Social behavior involves the exchange of nonmaterial resources, such as symbols of approval and prestige. The cost and value of these resources can vary, but individuals always seek a maximum result from the transaction (Homans, 1958). Resources (i.e.,

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knowledge) give individuals who own them the capacity to reward other specific individuals that value such items. A reward is similar to a positive reinforcement that is associated with being socially controlled. Therefore, resources are attributes of the relationship between individuals. The more valuable the result of the behavior is, the more likely the individual is to act in that manner (Emerson, 1976).The view that social behavior is an exchange of resources means that its analysis involves different bodies of theory, like behavioral psychology and economics. The SET vocabulary comes from both such domains, for example, resource, reinforcement, cost, value, transaction, or profit (Homans, 1958). Scientists share (transaction) their knowledge (resource) when they perceive a gain or positive result from it (profit); thus KS is a series of transactions of resources that are based on the perception of the benefit that will come from that behavior (positive reinforcement).

Knowledge sharing is a labor-intensive process (Coleman, 1999; Davenport & Pruzak, 2000); thus an intrinsic motivation must drive individuals to share knowledge (Hung, Durcikova, Laia, & Lin, 2011; Ozlati, 2015; Park & Gabbard, 2018; Wang & Hou, 2015). Furthermore, it is an antecedent of innovation (Curado et al., 2017; Sáenz, Aramburu, & Blanco, 2012), especially for scientists (Ensign, 2009). For example, the technological significance of an innovation is a function of the significance of the knowledge shared (Ensign, 2009).

2.2. Knowledge sharing obstacles

Scientists face highly competitive research and publishing environments that can prevent them from wanting to share knowledge and expertise. As a result, they might opt to take a selfish attitude, such as just collecting knowledge (Park & Gabbard, 2018) and not sharing their own. The existence of economic, physical, and geographic constraints can demotivate scientists from KS. Furthermore, organizational constraints like established procedures and processes or limitations related to the requirement for the output of task performance can act as contextual drivers that inhibit KS (Kankanhalli, Tan, & Wei, 2005). KS involves some personal benefits, like obtaining expert status or getting public praise, but can have some individual costs too, such as a sense of personal vulnerability or the loss of a competitive edge. Depending on the individual's cost/benefit analysis, some researchers opt to protect their knowledge and keep it to themselves instead of sharing it (Cabrera & Cabrera, 2002).

The structured and explicit knowledge in data also poses restrictions to sharing; thus sharing is common in only a few fields, such as astronomy and genomics (Borgman, 2012). For example, the exponential growth of genomic data demands the use of new approaches to deal with “big data” sets (Park & Gabbard, 2018; Wang & Hajli, 2017; Wang, Kung, & Byrd, 2018). Given the highly complex data and emerging research processes, sharing knowledge and its storage, organization, and validation can help scientists (Park & Gabbard, 2018). Low levels of data sharing can be the result of the nature of data, research, rewards, economics, and public policy; thus sharing research data is an intricate and difficult problem (Borgman, 2012).

Many funding agencies advise researchers to share research data because it can increase citation rates (Piwowar & Chapman, 2010). Still, researchers can lack the expertise to share their data. Data might not exist in transferable forms, or it might not be sharable for ethical or legal reasons (Borgman, 2012).

2.3. Antecedents of knowledge sharing among scientists

To examine the individual antecedents of KS, we adopt the SET approach that uses economic assumptions to understand human behavior (Homans, 1958). The SET's premise is that individuals behave in such a way as to maximize their benefits and minimize their costs. This premise explains why a scientist on a research team expects to gain benefits from sharing knowledge. There is a different kind of “benefit” scientists might wish to maximize, the advancement of science (Park & Gabbard, 2018); thus some individuals might be intrinsically motivated to share knowledge and therefore, contribute to academia.

Knowledge leaders should apply knowledge sharing strategies and establish knowledge sharing environments (Lin & Lee, 2004; Liu & Phillips, 2011) to improve KS (Lakshman, 2005). A research team leader (i.e., TL) is actually a knowledge leader—an individual who has and shares knowledge, helps others to accomplish goals (Zhang & Cheng, 2015), and encourages knowledge management practices (Donate & Sánchez de Pablo, 2014). Knowledge leaders should support learning processes, create a climate for KS, and act as a model (Viitala, 2004). On the other hand, individuals can be afraid to share what they know because that might limit their struggle to differentiate themselves from their coworkers (Bock et al., 2005); thus the fear of losing one's unique value has a negative impact on KS (Renzl, 2008).

Social behavior involves the exchange of nonmaterial resources and social mechanisms to control the exchange of resources like knowledge. Therefore, we make several propositions:

P1: The loss of power that scientists sense from sharing their knowledge is a sufficient condition not to share it.

Conversely:

P2: The absence of the sense of loss of power is a sufficient condition for KS among scientists.

Regarding the fact that some scientists are a TL:

P3: Being a TL is a sufficient condition for scientists to share their knowledge.

By contrast:

P4: Not being a TL is a sufficient condition for scientists to abstain from sharing their knowledge.

Scientists' work involves knowledge sharing (Sergeeva & Andreeva, 2016), although they can only share it if they have scientific knowledge to share.

P5: Having knowledge to share is a sufficient condition for scientists to share their knowledge.

Whereas:

P6: Not having knowledge to share is a sufficient condition for scientists to abstain from sharing.

Regardless of age or research experience, the majority of scientists do not share their knowledge (Park & Gabbard, 2018). Therefore:

P7: Age and research experience are not sufficient conditions for KS among scientists.

In this research, the influence of the context (Sergeeva & Andreeva, 2016; Wang & Noe, 2010) depends on the characteristics of who and where the KS takes place, specifically, the position in the sharing context (being the TL or not), the seniority of the scientist, and the intensity of the preformed research work. KS behavior is influenced by intrinsic motivation (Hung et al., 2011; Ozlati, 2015; Park & Gabbard, 2018; Wang & Hou, 2015); thus this study considers the loss of unique value and power due to KS as having an association with the individual's cost of sharing knowledge (Kankanhalli et al., 2005).

3. Methods

A qualitative comparative analysis (QCA) is a technique that combines quantitative and qualitative methods (Roig-Tiernoa, Gonzalez-Cruz, & Llopis-Martinez, 2016). We use a fuzzy-set qualitative comparative analysis (fsQCA) because it exceeds its predecessors (crispy-set QCA and multi-value QCA) due to the advantages it offers for configuring conditions based on the degree of membership rather than on categorical membership (Roig-Tiernoa et al., 2016). The technique is based on Boolean logic, which is the logical combination of the established conditions after considering alternatives for the objective analysis of selected cases (Freitas & Neto, 2014). We apply fsQCA (Ragin, 2008; Rihoux & Ragin, 2009) to contribute to the literature on the conditions and causal configurations of KS among scientists, as well as its absence (i.e., ~KS). Such a contribution is only possible by using

Table 1
Statistics ($n = 620$) and calibration of causal conditions and outcome.

Conditions and outcome	Statistics	Calibration cuts (0.95; 0.50; 0.05)
TL (position in the team)	Not a leader – 80.65% Leader – 19.35%	Binary condition: Not a leader = 0; Leader = 1
Age (years)	μ = 44.13; σ = 9.80; min = 24; max = 81	(61; 43; 30)
Ten (years)	μ = 9.19; σ = 7.63; min = 0; max = 48	(22; 7; 1)
PRP (number of publications)	0–4.35% 1 to 5–33.39% 6 to 10–23.06% 11 to 15–13.87% 16 to 20–7.74% 21 or more – 17.59%	0 to 5–0 6 to 20–0.5 21 or more – 1
NPRP (number of publications)	0–28.87% 1 to 5–41.77% 6 to 10–15.81% 11 to 15–6.77% 16 to 20–1.94% 21 or more – 4.84%	0–0 1 to 15–0.5 16 or more – 1
BC (number of chapters)	0–27.74% 1 to 5–58.71% 6 to 10–8.23% 11 to 15–3.23% 16 to 20–1.13% 21 or more – 0.96%	0–0 1 to 10–0.5 11 or more – 1
NP (number of projects)	0–19.52% 1 to 5–74.03% 6 to 10–5.50% 11 to 15–0.32% 16 to 20–0% 21 or more – 0.63%	0–0 1 to 5–0.5 6 or more – 1
IP (number of projects)	0–35.16% 1 to 5–60.16% 6 to 10–3.87% 11 to 15–0.81% 16 to 20–0% 21 or more – 0%	0–0 1 to 5–0.5 6 or more – 1
LoP (Lickert scale from 1to 5)	μ = 1.62; σ = 0.71; min = 1; max = 5	(2; 1.5; 1)
KS (Lickert scale from 1 to 5)	μ = 3.96; σ = 0.72; min = 1; max = 5	(5; 4; 2.5)

fsQCA because it is more complete than the traditional quantitative statistical methods that merely offer a single estimated solution regarding the dependent variable in question (Rihoux & Ragin, 2009). By contrast, fsQCA accepts that variables can be related in one configuration and yet they can be unrelated or even inversely related in others (Meyer, Tsui, & Hinings, 1993). Conditions in this study are related to scientists' involvement in the scientific work.

Following Ragin (2008), we define the three different anchors that are necessary to calibrate the survey, or continuous data sets, to fuzzy-set values that establish the degree of membership of each score, 0.95 for full membership, 0.5 for the crossover point of membership ambiguity, and 0.05 for full nonmembership.

Table 1 shows the cuts used for the calibration for fuzzy-set conditions and outcomes. For each condition, it presents the statistics and the scores regarding the three different thresholds for calibration. Table 1 also presents the distribution of a binary condition and the cuts used for the conditions measured by the Likert scale. The transformation of the Likert scales into fuzzy sets is possible by calculating the average values of the item scores and adjusting the cut values by the number of items in each variable and its statistics (Woodside, Hsu, & Marshall, 2011; Woodside, Prentice, & Larsen, 2015).

3.1. Sample

The data come from a national online survey sent to 9800 scientists from 212 FCT-funded Portuguese research centers in the arts and humanities (19.5%), exact sciences (15%), health sciences (11.3%), natural sciences (13.9%), social sciences (18.5%), and technology and engineering (21.8%). The funded research centers are public organizations that contribute to the public welfare (Boer, Berends, & van Baalen, 2011). These research centers hold top classifications from FCT and have on average 104 members each. The sample data comes from 620 researchers' fully answered questionnaires (representing 131 research centers) from the arts and humanities (20%), exact sciences (16.2%), health sciences (8.2%), natural sciences (14.6%), social sciences (25.3%), and technology and engineering (15.7%). The scientists in the sample are registered with FCT as the most permanent and relevant in each center. Gender in the sample is quite balanced – 313 male scientists (50.48%) and 307 female scientists (49.52%).

3.2. Conditions and outcome in the study

The conditions in the study are:

Team leader (TL) is the condition of being (or not ~TL) the research team leader. This condition reflects if the scientist holds a leading position or not in the sharing context. The TL is a binary condition. We use this condition to examine the scientist's contribution to the KS in the research team (Wang & Noe, 2010).

Age of the scientist (Age) is measured in years.

Tenure of the scientist at the research center (Ten) is measured in years.

The conditions Age and Ten are transformed by using the fsQCA 2.5® into ***Seniority of the scientist*** (Sen) by means of the function of "fuzzy or" (stands for the mathematical logic operation in Boolean algebra "union") that means the scientist is either older in age or has been part of the research team longer. Age and Ten are commonly associated with knowledge accumulation over the years (Jung, 2012). We use this condition to determine how work experience (in number of years) contributes to KS (Wang & Noe, 2010).

Peer review publications (PRP) is measured by the number of published papers in peer review journals in the previous five years.

Non-peer review publications (NPRP) is measured by the number of published papers in non-peer review journals in the previous five years.

Book chapters (BC) is measured by the number of published book chapters in the previous five years.

National projects (NP) is measured by the number of participations in nationally funded research projects in the previous five years.

International projects (IP) is measured by the number of participations in internationally funded research projects in the previous five years.

The conditions PRP, NPRP, BC, NP, and IP are transformed by using fsQCA 2.5® into ***Intensity of the performed research work of the scientist*** (Int) by means of the operation of "fuzzy or" that represents the total level of scientific production of the scientist in the previous five years. With this condition, we consider the period of five years that is commonly used in the literature as a proxy for individual research productivity (Curado, Henriques, Oliveira, & Matos, 2016; George-Walker & Tyler, 2014; Zappa, 2011).

Loss of power (LoP) – The perception of power and unique value lost due to knowledge that is shared within the research team (adapted from Kankanhalli et al. (2005)). This lose is measured with a five-point Likert scale that ranges from one (totally disagree) to five (totally agree). Using this condition, we examine the contribution of the perception of knowledge as power to KS.

The outcome in the study is:

Knowledge sharing (KS) that is the degree to which scientists actually share their knowledge of professional tasks with their colleagues on the research team (adapted from Liao (2008)). The KS is measured with a five-point Likert scale that ranges from one (totally disagree) to five (totally agree).

4. Analysis and results

4.1. Necessity and sufficiency analysis

The condition's degree of necessity shows the extent to which it is needed to achieve the outcome, whereas the condition's degree of sufficiency indicates the extent to which it can be related to the explanation of the outcome (Fiss, Sharapov, & Conqvist, 2013). The sufficient condition sets are also designated as configurations of several conditions that lead to the outcome. Necessary conditions should present a consistency score that is over 0.80 (Ragin, 2000). There is a single necessary condition to the presence of the outcome (i.e., KS), the intensity of the performed research work of the scientist (i.e., Int). Regarding the absence (~means absence) of the outcome (i.e., ~KS), two necessary conditions exist, not being a team leader (i.e., ~TL) and the intensity of the performed research work of the scientist (i.e., Int). In order for a scientist to share knowledge, he or she needs to have knowledge to share. Since Int reflects an individual's research productivity, then an individual with Int is indicative of having knowledge to share, which is necessary for KS. Regarding scientists that do not share knowledge, they must have Int - even if they keep it to themselves - and not be team leaders (i.e., ~TL) because team leaders usually share their knowledge. Sufficient conditions for KS are TL, Int, ~Sen, and ~LoP. The results show two causal configurations in the intermediate solution leading to KS, whereas three causal configurations exist for the intermediate solution regarding the sufficient condition sets that lead to ~KS. The sufficient conditions that lead to ~KS are ~TL, ~Int, ~Sen, and LoP. There are more sufficient conditions than necessary ones (regarding both KS and ~KS) and they differ among themselves, which confirms that the presence or level of a condition can be necessary but it rarely is a sufficient condition to the outcome (Woodside, 2016). Table 2 presents the necessary and the sufficient conditions for KS and ~KS.

4.2. Causal configurations

Following best practice (Fiss, 2011;Fiss et al., 2013; Ragin, 2000, 2008), we report the configurations that lead to KS (Table 3) and ~KS (Table 4) along with their core and peripheral conditions. Core conditions are the ones included in both the parsimonious and intermediate solutions, while peripheral conditions are only part of the intermediate solution (Fiss et al., 2013; Ragin, 2000, 2008). The most parsimonious solution contains only conditions highly linked to the outcome. The intermediate solutions are more conservative and assume the most plausible simplifying assumptions (Ragin, 2008). Since fsQCA allows asymmetry, the conditions for KS differ from those for its absence (Fiss, 2011).

The configurations' consistency levels respect the threshold of 0.80 as per Ragin (2008) and Fiss (2011). Consistency reflects the extent to which sharing a given combination of conditions displays the outcome in question (Ragin, 2008). Coverage reflects how much of the variation in the outcome is accounted by a condition or a combination of them (Ragin, 2006) similar to the R^2 in linear regressions (Fiss et al., 2013). Specifically, unique coverage shows the relative importance of each particular configuration (Fiss, 2011). Regarding KS, the overall solution coverage value is 0.20 that is close to the suggested range of 0.25 to 0.90 (Ragin, 2008; Woodside & Zhang, 2013). Regarding the ~KS, the overall solution coverage value is 0.43 that is also within the suggested range.

Considering the sufficient causal configuration 1, the consistency level is approximately 0.82. This score means that in 82% of the cases where this configuration of conditions is present, KS occurs. Regarding the same sufficient causal configuration, the coverage level is a little over 0.18. Such a score means that 18% of the cases of KS occur because of this configuration, TL, Int, and ~LoP.

Considering sufficient causal configuration 2, the consistency level is approximately 0.81. Such a score means that in 81% of the cases where this configuration of conditions is present, ~KS occurs. Regarding the same sufficient causal configuration, the coverage level is a little over 0.40. Such a score means that 40% of the cases of ~KS occur because of this configuration, ~TL, ~Sen, and LoP.

The results confirm that conditions can be causally related in one configuration but they can be unrelated or even inversely related in others. The findings reproduce the characteristics of fsQCA (Fiss, 2011):

a) More than one configuration of conditions lead to KS and ~KS (equifinality);
b) Alternative causal configurations can produce the same outcome (results are not limited to a single configuration, which is the opposite from traditional quantitative statistical methods that only provide one estimated solution);
c) Conditions of the outcome differ from conditions of its absence (asymmetry).

Table 2
Necessary and sufficient conditions to KS and ~KS.

Conditions	Outcomes	
	KS	~KS
Necessary conditions	Int	~TL, Int
Sufficient conditions	TL, Int, ~Sen, ~LoP	~TL, ~Int, ~Sen, LoP

KS = Knowledge sharing; TL = Research team leader; Sen = Seniority of the scientist; Int = Intensity of the research work of the scientist; LoP = Loss of power.

5. Discussion

The results show that being a team leader (i.e., TL) is a core condition for sharing knowledge among scientists (i.e., KS). This is consistent with the role of leaders in relation to KS that we find in the literature (Zhang & Cheng, 2015). A high level of research intensity (i.e., Int) is a peripheral condition that is present in the two causal configurations that lead to KS among scientists. By contrast, the absence of a high level of research intensity (i.e., ~Int) is a condition that is present in two of the causal configurations that lead to ~KS among scientists, which clarifies the literature (Park & Gabbard, 2018) on the contribution of experience in the research on KS. One of the two configurations that lead to KS involve the absence of seniority (i.e., ~Sen) and the other one regards not being afraid to lose unique value and power (i.e., ~LoP) due to knowledge sharing. Therefore, the scientists that tend to engage in KS are team leaders, have high intensity in their performed research work, and either are not senior or are not afraid to lose unique value and power due to KS.

Regarding the causal configurations that lead to ~KS among scientists, three combinations exist; such result mean there are more alternatives that lead to ~KS than to KS. Such findings are consistent with the literature, since sharing knowledge is not easy or attractive but faces several obstacles (Liu & Liu, 2008; Wang & Hou, 2015; Yang & Wu, 2008; Zaglago, Chapman, & Shah, 2013; Zhang & Cheng, 2015;). Not being a team leader (i.e., ~TL) is a core condition that is common to the three configurations that lead to not sharing knowledge, which *in argumentum a contrario* corroborates the literature (Zhang & Cheng, 2015). The other core conditions are; a) not having a high level of research intensity (i.e., ~Int), b) not being senior (i.e., ~Sen) and, c) being afraid to lose unique value and power due to knowledge sharing (i.e., LoP). Configurations 1 and 2 involve not being a team leader (i.e., ~TL) and not being senior (i.e., ~Sen), but they vary in the third condition, either not having a high level of research intensity (i.e.,

Table 3
Intermediate solution to KS.

KS = f (TL, Sen, Int, LoP)							
Overall solution coverage: 0.196263					Overall solution consistency: 0.821251		
Configurations	Causal conditions				Coverage		Consistency
	TL	Sen	Int	LoP	Raw	Unique	
1	●		•	○	0.182087	0.129499	0.821618
2	●	○	•		0.066765	0.014176	0.865969

KS = Knowledge sharing; TL = Research team leader; Sen = Seniority of the scientist; Int = Intensity of the research work of the scientist; LoP = Loss of power; full black circles (•/●) indicate the presence of a condition, and white center circles (○) indicate its absence. Large circles indicate core conditions; small ones, peripheral conditions. Blank spaces indicate the condition does not contribute to the configuration.●○

~Int) or being afraid to loose unique value and power due to knowledge sharing (i.e., LoP). It seems ~KS is adopted by team members (not being the leader) that are not senior, do not have high intensity in their research work, or are afraid of losing unique value and power due to knowledge sharing. This configuration indicates that these scientists probably do not have much knowledge to share or are frightened of sharing their knowledge. Two out of the three configurations for ~KS involve the condition of being afraid to loose unique value and power due to knowledge sharing (i.e., LoP), which is in accordance with the literature (Renzl, 2008).

Configuration 3 in the ~KS solution is symmetrical to configuration 1 in the KS solution, not being a team leader (i.e., ~TL), not having a high level of research intensity (i.e., ~Int), and being afraid to lose unique value and power due to knowledge sharing (i.e., LoP), despite seniority. Although symmetry is not a characteristic of fsQCA, the results show that these two opposite configurations lead to opposite outcomes, KS and ~KS. The results from both solutions do not offer configurations with the presence of the condition of scientists being senior (i.e., Sen), which suggests that being older or more experienced does not lead to KS, nor to ~KS.

6. Conclusions

Regarding the research questions, our findings show that there are two patterns that lead to KS and three patterns that inhibit it. The two configurations that generate KS have in common the presence of a core condition (i.e., TL), whereas the three configurations that generate ~KS have in common the presence of a core condition (i.e., ~TL). Our findings support the propositions we have put forward:

1) The loss of power that scientists sense from sharing their knowledge is a sufficient condition not to share it.
2) The absence of the sense of loss of power is a sufficient condition for sharing knowledge among scientists.
3) Being a team leader is a sufficient condition for scientists to share their knowledge.
4) Not being a team leader is a sufficient condition for scientists to abstain from sharing their knowledge.
5) Having knowledge to share is a sufficient condition for scientists to share their knowledge.
6) Not having knowledge to share is a sufficient condition for scientists to abstain from sharing it.
7) Seniority is not a sufficient condition that leads to KS among scientists.

The study's first contribution is the discovery of two pathways that lead to KS among scientists. Being a team leader is a condition that leads to KS. There are two alternative configurations leading to KS among scientists, and they both include being a team leader as a core condition. Having different pathways leading to KS among scientists favors the scientists' work based on creating and sharing knowledge.

A second contribution concerns the discovery of several patterns that lead to the absence of KS. Three alternative configurations exist that prevent KS among scientists, and they all include not being a team leader as a core condition. These findings demonstrate there are more alternative pathways leading to ~KS among scientists than the ones leading to KS, which presents a challenge to the scientists' work. According to our findings not being a team leader is related to not sharing knowledge among scientists. Such results show that the team leader has a hard task in order to influence other team members to share their knowledge.

The KS among scientists is difficult, scientists that are not a team leader seem not to share knowledge and the less productive ones, and the ones that are afraid of losing power due to KS, also do not share. However, some scientists do share their knowledge, the team leader, the more productive ones, and the ones not afraid to lose power due to KS. Our findings lead us to conclude that research centers should adopt a multi-team structure to fully benefit from the potential of a team

Table 4
Intermediate solution to ~KS.

~KS = f (TL, Sen, Int, LoP)							
Overall solution coverage: 0.431288					Overall solution consistency: 0.813006		
Configurations	Causal conditions				Coverage		Consistency
	TL	Sen	Int	LoP	Raw	Unique	
1	○	○	○		0.056158	0.014004	0.929454
2	○	○		●	0.400214	0.358059	0.809892
3	○		○	●	0.059225	0.017070	0.942380

KS = Knowledge sharing; TL = Research team leader; Sen = Seniority of the scientist; Int = Intensity of the research work of the scientist; LoP = Loss of power; full black circles (●) indicate the presence of a condition, and white center circles (○) indicate its absence. All conditions in the solution are core conditions. Blank spaces indicate the condition does not contribute to the configuration.

leader regarding KS.

7. Limitations and future research directions

The response rate is not very expressive (7%) but this is not a limitation since the data show a proportionality between the number of male and female scientists from all areas of science. Although the results cannot be generalized beyond the Portuguese scientific community, this study provides an original contribution on the causal configurations that lead to KS and ~KS among scientists. Regarding the PRP condition used, we must acknowledge that one paper in a very prestigious journal equates to a paper in a lower quality journal, which may distort the results if the scientists follow different approaches regarding the balance between the quantity and quality of their research. Regarding the overall quality of the KS solution, the coverage is close to the suggested limits, but still we recognize it as a possible limitation to the results. We invite colleagues to replicate this study in other countries and to include conditions regarding environment factors, cultural dimensions, and the team's and the knowledge's characteristics.

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