Crowdsourcing of inventive activities: definition and limits

Julien Pénin*

BETA, CNRS-UMR 7522,
Faculty of Economic and Management,
University of Strasbourg,
Strasbourg, France
Email: penin@unistra.fr
*Corresponding author

Thierry Burger-Helmchen

BETA, CNRS-UMR 7522,
University of Strasbourg,
Strasbourg, France
and
EM Strasbourg Business School,
University of Strasbourg,
Strasbourg, France
Email: burger@unistra.fr

Abstract: The purpose of this paper is twofold: First we define the concept of Crowdsourcing of Inventive Activities (CIA) and we emphasise its differences with the crowdsourcing of routine activities and the crowdsourcing of content. Then we stress the advantages and limits of CIA by using two complementary theories of the firm: Transaction cost theory and the evolutionary theory of the firm. Specifically, we show that CIA may emerge only if knowledge is sufficiently codified and if a legal protection is possible (e.g. via patents). This work therefore builds theoretical predictions that can be tested in further works. Beyond this analysis, our work underlines issues for the traditional theories of the firm that will have to be clarified: for instance, does the emergence of crowdsourcing lead to rethinking the reasons why firms exist and the definition of their boundaries?

Keywords: crowdsourcing; knowledge; know-how; governance; transaction cost theory; evolutionary theories of the firm.

Biographical notes: Julien Pénin is a Researcher at BETA (UMR 7522 CNRS-UdS). His research interest is the economics and management of innovation and intellectual property rights. He is also an Associate Professor at the University of Strasbourg.

Thierry Burger-Helmchen is a Researcher at BETA, University of Strasbourg, France, and a Professor at the EM Strasbourg Business School. His research interests cover economics of innovation, real option and strategic management.

1 Introduction

Open innovation has received tremendous attention from scholars in economics and management in the last decade. According to Chesbrough (2003), in a context of open innovation firms must use knowledge developed elsewhere as well as external path to market in order to valorise inventions developed inside. Crowdsourcing is one of the multiple modalities of open innovation since it enables firms to lever knowledge and assets developed by other firms and individuals. Crowdsourcing is a business practice that means literally to outsource an activity to the crowd (Howe, 2006). Its emergence is strongly linked to the development of new technologies of information and communication, especially of the Web 2.0 that eases the connection among a large number of dispersed individuals.

We focus in this work on the crowdsourcing of inventive activities, as opposed to crowdsourcing of routine activities and crowdsourcing of content (mostly information). In the former case, the firm uses the crowd to solve problems (to bring ideas), while in the latter two cases the crowd does not provide the firm with knowledge but with information, time, computing capacities, etc. If the frontier between these different categories of crowdsourcing is often hard to draw, it is central to make a distinction since problems and issues at stake are very different.

Up to now, economic and management literature has mostly stressed the benefits of crowdsourcing as compared to other alternatives such as doing the activity inside the firm or outsourcing it to a single or to a network of identified suppliers (Pisano and Verganti, 2008). Crowdsourcing may increase the performance of the firm because the crowd may provide access to a reservoir of competences, ideas and resources much more important than what the firm can find internally.[1] It may also reduce the cost of performing some activities because, although some rewards are sometimes important, most of the time remuneration is low or even nil. Another advantage for the firm is that crowdsourcing may increase competition between solvers, since it puts the internal teams in competition with a worldwide reservoir of other teams, thus increasing incentives of internal research teams and decreasing the resistance to organisational changes. Finally, crowdsourcing is also a manner for the firm to deal with projects in which uncertainty and costs are hard to evaluate. Crowdsourcing obliges each contributor to reveal its cost, since only contributors with lowest cost (eventually the most skilled) accept to contribute. Linked to this point crowdsourcing also enable the firm to outsource the risk of failure, since the firm only pays the crowd for successful performance.

Yet, although crowdsourcing of inventive activities (CIA in the following) is appealing in theory and examples of practical use of this type of strategy are developing fast,[2] it is too early to say if those practices are sustainable on a larger scale. Discussions with practitioners suggest that CIA represents only a marginal fraction of firms' research activities and there is no reason to think that this share will increase. This paper aims therefore at (a) defining CIA and drawing a clear distinction with other types of crowdsourcing and (b) exploring the limits of CIA. For a firm, what are the problems

raised by this solution? What are the costs that it involves? What are the factors (appropriability conditions, more of less tacit nature of the knowledge, etc.) that affect its efficiency and thus the incentives for a firm to use CIA? This work departs therefore from other existing papers on crowdsourcing which, on the whole, largely ignore the problems and costs linked with CIA.

To do so we rely on two complementary theories, which dominated the management and economic approach of the firm over the last decades (Fransman, 1994; Coriat and Weinstein, 1995; Cohendet and Llerena, 1999): Transaction Cost Theory (TCT in the following) (Coase, 1937; Williamson, 1975) and the evolutionary theories of the firm (knowledge based) (Nelson and Winter, 1982; Cohendet et al., 2000; Augier and Teece, 2008). It is appealing to mobilise simultaneously those two theories because it has been acknowledged for long time in the literature that they are largely complementary, TCT dealing mostly with transaction as the unit of analysis and knowledge-based theories with resources (notably of knowledge). For instance, a similar approach was taken by Barney and Lee (2000) for comparing an investment situation. They show that the governance choices can vary dramatically following a TCT or knowledge-based reasoning and that the choice is not stable over the life cycle of the firm market. The cost approach of TCT is a necessary component but the variances depend on the type of learning that occurs. They also suggest that such a double analysis (TCT and knowledge based) can lead to good governance; outsourcing and investment choices on which the firm can build a competitive advantage.

The combination of TCT and evolutionary theories of the firm enables us to put forward contexts in which CIA may emerge and those in which it may not, because it would be too costly. TCT stresses major governance problems that may impede the success of CIA strategies, especially when crowdsourced problems and answers brought by the crowd are knowledge intensive and hard to codify. In this case, the opportunism of the individuals, information asymmetries, uncertainty and the specificity of the transaction make CIA very difficult to manage, increasing the shadow zones, and making this solution less attractive for a firm. Complementary to TCT, the evolutionary theories of the firm put forward problems of learning and transfer of knowledge between individuals as well as the importance of building routines and knowledge intensive communities (Cohendet et al., 2006; Nonaka and von Krogh, 2009). All those points strongly limit the performance of CIA and often render solutions internal to the firm or co-development with stable partners more appealing.

The next section provides a definition of CIA and insists on its differences with crowdsourcing of routine activities and crowdsourcing of content. Section 3 explores the performance of CIA in the light of TCT. Section 4 does the same but in the light of evolutionary theories of the firm. Section 5 compares our theoretical results with empirical cases of CIA and concludes.

2   On crowdsourcing in general and CIA in particular

2.1   Definition of crowdsourcing

Crowdsourcing means literally to outsource an activity to the crowd (Sawhney and Prandelli, 2000; Sawhney et al., 2005; Berthon et al., 2007; Nambisan and Sawhney, 2007).[3] It relies on two elements: an open call and a crowd. First, and conversely to usual practices, in the case of crowdsourcing the firm does not rely on a single supplier or on a

small number of suppliers, but launches an open call. The open dimension is here central. It means that everybody can answer the call. Not only individuals can participate but also firms, non-profit organisations or communities of individuals if they want to and are able to organise themselves accordingly. It is therefore the open dimension that makes it possible for the 'crowd' to participate. Schenk and Guittard (2011) define the crowd as a big number of heterogeneous individuals anonymous a priori. The heterogeneity of the crowd can affect many dimensions: knowledge, time to devote to the task, languages spoken, geographic situation, etc. Anonymity a priori means that the stakeholders (the firm requesting the aid of the crowd and the members of the crowd) are not individually identified. When it posts its problem the firm does not know the potential contributors. In other words, it does not rely on its 'own crowd', which helps to distinguish this notion from communities or groups. Remark that (if the firm wants to) anonymity can also sometimes be maintained a posteriori. In this case, an intermediary ensures the transaction between the firm and the contributors, thus making sure that they never know each other.

Practically, although the structure of the call and of the reward varies according to the firm and the activity, crowdsourcing always follows the following main lines: the organisation identifies an activity that it does not want to perform internally. Rather than outsourcing it to a predefined supplier, it posts a call on an internet platform (its website, or a platform run by an intermediation society) and fixes the terms for the participation of the crowd (agenda, reward, etc.). This allows a big number of individuals to perform the task. Here, two different scenarios can be envisaged: either each individual performs a small fraction of the activity, participants being therefore complementary (we call this 'integrative crowdsourcing', see Schenk and Guittard, 2011), or each individual tries to perform the activity as a whole, thus being in competition with the other individuals (we call this 'winner takes all' situation or 'selective crowdsourcing'). In the end, the firm assesses the contributions and distributes the rewards.

Most of the time crowdsourcing engages three types of actors, in a tripartite relationship: the organisation that crowdsources the activity; the individuals that attempt to perform it and an intermediation company that eases the connection between the two former. We will see later that the existence of high transaction costs may explain this tripartite relationship, the role of the intermediary company being mostly to decrease transaction costs.

It is worth noticing that any activity performed in a highly decentralised and/or community way is not automatically crowdsourcing. One must distinguish crowdsourcing from peer production Benkler (2006) or 'open source'. The main difference between the two deals with the strategic intention and the business model. Crowdsourcing is about firm or business organisations (including public). It relies on an explicit business model developed by the firm. It is not about a community of people exchanging on the web but about a firm that strategically decides to rely on the crowd to perform an activity. There is an explicit strategic intention in the case of crowdsourcing which is most of the time absent in peer production (for a comparison with other outsourcing strategies, see Albors et al., 2008). As underlined by Howe (2006): "*It's only crowdsourcing once a company takes the idea, fabricates it in mass quantity and sells it*".

To summarise, although the general idea is always to outsource an activity to a big number of unknown individuals, the benefits of crowdsourcing and the way it is implemented may vary greatly (Ågerfalk and Fitzgerald, 2008; Pisano and Verganti, 2008). Hence, it is necessary to distinguish between different categories of crowdsourcing.

2.2   A typology of crowdsourcing

We draw a distinction between three different types of crowdsourcing: CIA, on which we will focus in the remaining of the paper, crowdsourcing of routine activities and crowdsourcing of content (information most of the time).[4] The main characteristics of those three categories are summarised in Table 1.

Table 1   A typology of crowdsourcing activities

	Crowdsourcing of routine work	*Crowdsourcing of content*	*Crowdsourcing of inventive activities*
Role of the crowd	Bring low-skill workforce, time	Bring content, mainly data and information	Bring solutions, ideas, knowledge
Configuration	Integrative	Integrative	Selective (Winner takes all)
Type of reward	Micro-payments	Micro-payments or nil	Can be high
Size of the crowd	Very important	Very important	Important (but indirectly)
Diversity of the crowd	Not relevant	Very important	Very important
Examples	Interneteyes, ReCaptcha	The Great War Archive, openstreet-map, patent evaluation	InnoCentive, Wilogo

2.2.1   Crowdsourcing of routine activities

Crowdsourcing of routine activities deals with tasks that do not require specific competences in order to be performed. In this case, the crowd is attractive because the activity, although easy to perform, is time consuming. The firm would need to hire a large number of persons to fulfil it. The use of the crowd helps to decrease the cost and to increase the speed of execution of the task. The activity being repetitive and often boring, it is necessary to reward the crowd for its work. However, those rewards remain modest, consisting of micro-payments, since participants do not bring any rare resources.

In the case of crowdsourcing of routine activities, only the size of the crowd matters. Its diversity is not relevant, since the task can be performed potentially by everybody. It does not require specific competences. Thus, it does not matter if all the individuals are identical. Only their number is important for the firm. It is also worth noticing that the activity must be modular in order to be performed by the crowd. It must be possible to split the activity into a large number of sub-tasks, each being possibly performed independently by the individuals that compose the crowd. Indeed, the crowdsourcing of routine activities can only take the form of a collaborative game, where each participant complements the others. It can never take the form of a 'winner takes all' game because this would require that a single individual is able to perform the activity entirely. If this was true, the firm would draw no benefit from using the crowd. A single supplier could do it as well.

A peculiar example of crowdsourcing of routine activities is internet eyes (www.interneteyes.co.uk), a system of security video watch through the internet. The purpose of internet eyes is to allow the crowd to watch video camera owned by security firms and set up at various geographic locations (houses, firms, etc.). After having registered on the website each individual can watch, on his/her own computer, several

security cameras and as soon as he/she identifies an offence, alerts the website, which in turn immediately alerts the security firm in charge of the camera. Individuals are then rewarded according to the number of confirmed offences that they have signalled. This example meets all the conditions of crowdsourcing of routine activities: on the one hand, watching video camera does not require specific competences, only time and attention; on the other hand, in order to watch all their security cameras, security firms would have to hire hundreds if not thousands of employees, which would be prohibitively costly.[5]

2.2.2 Crowdsourcing of content

Crowdsourcing of content consists in using a crowd to feed a stock of data and information. For instance, it can contribute to the construction of a road map (www.openstreetmap.fr) or other documents that are geographically dispersed. The main difficulty in order to develop such informational goods is to achieve exhaustiveness. They are valuable only if the information they contain are diverse and complete, which makes it very difficult and costly to develop for one single entity. The interest for a firm to use the crowd lies therefore in its size and, most of all, in its diversity. Unlike crowdsourcing of routine tasks, where only the size of the crowd matters, in the case of crowdsourcing of content, the more heterogeneous the crowd (education, geographic location, centre of interest, experience, etc.), the more exhaustive is the indications collected. Furthermore, rewards in this case remain most of the time low, if not non-existent. Indeed, as for crowdsourcing of routine activities, we are in a configuration of division of labour and collaboration, not of 'winner takes all', each participant bringing only a very small part of the final content. Moreover, very often, the participants do have intrinsic motivations (they find that the fact of participating is in itself a reward because it is a source of fun for instance), or are directly users of the content they contribute to build, and thus accept to contribute for free.

A famous example of crowdsourcing of content is *The Great War Archive*, a project developed by the University of Oxford (from 2008 onwards) that asked the crowd to digitise any artefacts they held related to the First World War and to send them electronically to the project website. As a result, the site collected over 6500 items and stories online which can be freely downloaded and used for education and research.[6]

2.2.3 Crowdsourcing of inventive activities

CIA aims at allowing the crowd to solve problems (sometimes very complex) that the firm would not or could not solve internally. In this case, the crowd provides the firm, not only with time or information, but also with knowledge. Brabham (2009) gave a definition both simple and general of CIA: "A company posts a problem online, a vast number of individuals offer solutions to the problem, the winning ideas are awarded some form of a bounty, and the company mass produces the idea for its own gain".

The interest for a firm to use CIA is less in the size of the crowd than in its diversity. The problem being complex, it is more important for the firm to collect the knowledge of a small number of specialists in different fields than to lever the knowledge of a high number of profanes (Pisano and Verganti, 2008). Yet, as stated by 'Linus' law', the heterogeneity of the crowd is an increasing function of its size. Usually, the bigger the crowd, the more diverse it is, which means that the size of the crowd cannot be completely neglected. If this was not be the case, firms would not use an open call, but would direct their call towards a small number of experts previously identified.

Conversely to both earlier cases, CIA takes most of the time the form of a 'winner takes all' game, with rewards for the winner that can sometimes be very important (as compared to micro-payments in the earlier cases). A modular, collaborative solution is sometimes possible, but usually very difficult to implement, due to the specificity of the contest. The sole example of collaborative development that we are aware of is the case of open source software, in which the specific nature of the good (highly modular) and of participants' incentives (mostly non-pecuniary) allows an important division of labour and a collaborative development (Bagozzi and Dholakia, 2006; Pitt et al., 2006).[7]

InnoCentive, founded in 2001 by Eli Lilly, remains today the most famous example of CIA (http://www.innocentive.com). This platform connects firms that have a problem that they cannot or do not want to solve internally and a crowd of inventors who can devote time to solve those posted problems and are eager to find a solution. The sponsor (the firm) posts the problem online (describes it and sometimes also some of the properties of the expected solution) and offers a reward for a solution to this problem. Then, inventors in the crowd propose solutions and according to their successes win the prize or not.[8]

To summarise, CIA is a business practice that consists in outsourcing a problem to a crowd. Yet, the crowd only brings the solution and not the practical way to implement this solution (commercialisation or industrialisation phase). Thus, the cases of Wilogo or open source software are specific in the sense that the search for a solution is coupled with its practical implementation. In most of the other cases, it remains for the firm to industrialise the solution proposed by the crowd, to make it operational. It is thus the invention and not the innovation that is crowdsourced.

The fact that complex problems and creative activities can be outsourced to a crowd, or even outsourced at all, is a relatively new phenomenon (Chesbrough, 2003). In the remaining of the paper, we attempt to shed light on the limits of CIA by confronting it to two complementary stream of literature: TCT and the evolutionary theories of the firm.

3   A critical analysis of CIA by TCT

While Oliver Williamson has just been awarded the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2009 (Ronald Coase having already been awarded this prize in 1991), it may be appropriate to explore the lessons that this theoretical corpus can teach us with respect to CIA. After all, TCT considers the trade-off 'make or buy' and CIA is without doubt a specific case of outsourcing.

Developing further Coase's thought (1937), Williamson's analysis (1975, 1985) shows that the traditional market (anonymous and instantaneous) remains the best solution when a transaction is not too frequent and when uncertainty and, most of all, the specificity of the good are not too important. In such a context, transaction costs, which are risks linked to opportunistic behaviours, bounded rationality (Simon, 1945) and uncertainty, are limited. But when those conditions are not met, an internal solution, which implies more personalised and integrated relationships, is usually less costly than a market solution. It is therefore more attractive to 'make' than to 'buy'.

What are the transactions costs linked to CIA and, most of all, what are their determinants? To answer this question, we apply to the case of CIA the reasoning developed by Williamson. First, it is worth noticing that the hypotheses made by Williamson with respect to the behaviour of the actors still hold: the firm that posts a

problem online, the individuals that are in the crowd and the intermediation society are all opportunistic and have a bounded rationality. A contract of CIA is thus likely to be largely incomplete and it is therefore central to investigate how the nature of the transaction (frequency, uncertainty and specificity) affects transaction costs.[9]

Defining the frequency of the transaction in the case of CIA is tricky. On the one hand, it is a unique transaction since once the problem is solved (a solution has been found) it should not appear again. From this perspective, frequency is minimal, which may justify the use of an external solution, crowdsourcing for instance. Yet, this view supposes that the problem and the solution are so simple that they can be easily transferred, without further interaction between the solver and the sponsor. Once the solution has been found, it is transmitted to the sponsor who implements it. Problems linked to learning are here completely neglected. Usually, when a solution is know-how intensive, learning is slow and requires constant interactions between the sender and the receptor of a piece of knowledge. The transfer is therefore not instantaneous and we cannot speak properly about a unique transaction, since it needs time to be completed (Amesse and Cohendet, 2001). During this long phase of learning of the solution, the possibility of opportunistic behaviours by some actors of the transaction, coupled with the specificity of the good (knowledge), is often sufficient to explain why an internal solution or a solution, such as co-development with a well-known supplier, is less risky and less costly than crowdsourcing.

Uncertainty also raises important problems in the case of CIA. Uncertainty can not only be about the state of the world, which cannot be forecast exactly, but also about the behaviour of the actors of the economy, who are opportunistic and will not hesitate to cheat if it is in their interest. The fact that contracts are largely incomplete makes the problems raised by uncertainty still more relevant. Specifically, uncertainty is almost everywhere in the case of a transaction of inventive activity (knowledge): it is often very difficult to define exactly the unit of the transaction (Teece, 1986). What is exactly exchanged? How can we define a technology or a piece of knowledge and thus define exactly the boundary of the transaction? This problem of measuring the unit of the transaction is still increased by the fact that the real value of a technology depends on the system in which it is integrated (on the context in which it is used). The value of a piece of knowledge is thus very hard to define exactly, which increases legal uncertainty and risks of opportunistic behaviours, thus diminishing the attractiveness of CIA versus solutions that are more stable in time.

For instance, once solutions have been submitted by the crowd, how can the sponsor check the validity of all of them? How can it be sure that they will work, once applied? Similarly, once a problem is posted, how can the sponsor be sure that the information contained in the problem will not serve competitors? From the point of view of the crowd, once they have submitted solutions, how can individuals be sure that the firm will respect its commitments and reward them? This last problem is known in the economic literature under the heading 'Arrow's paradox' (Arrow, 1962).[10]

Arrow's paradox is specifically relevant when knowledge can be assimilated to information, i.e. when it is perfectly codified so that the transfer can be undertaken easily and instantaneously, without much learning. Conversely, when the problem is know-how intensive, this paradox is largely reduced. But in this case, the uncertainty linked to problems raised above (about the unit of transaction and the measure of the value of the transaction) is exacerbated.

Uncertainty and incomplete information also reduce the monitoring possibility of the sponsor. It is not possible to control the evolution of the project. When an invention is undertaken internally, the management can set up objectives, milestones, measure the risk and control if the objectives are fulfilled. Conversely, when the research is crowdsourced, the firm has no information about its progress. It does not know who is searching and in which direction and with which perspectives. This triggers monitoring issues that can be quickly insurmountable.

Problems raised by uncertainty are all the more important that the transaction is specific. And a knowledge-intensive transaction is usually very specific, in the sense that massive sunk investments must be undertaken in order to support the transaction. Its completion requires usually that senders and receptors build an emitting capability for the former and an absorptive capability (Cohen and Levinthal, 1990) for the latter. They must personalise the relationship, they must learn about each other in order to optimise the knowledge transfer. During the craft era, for instance the master and the apprentice succeeded to exchange knowledge only after a long period of learning about each other. And when the apprentice or the master changed, everything had to be built again with the new master or new apprentice. Hence, the specificity of a knowledge transaction, which means that the actors of the transaction are linked beyond the short run, can induce the sponsor to adopt an internal solution rather than a market one. The transaction can be neither instantaneous nor anonymous.

In the end, TCT puts forward the important costs that stem from CIA when the problem is know-how intensive. In this case, the problem and the solution are hard to codify and to transfer from one context to another. The transfer must therefore involve learning and frequent interactions between the sponsor and the solver. Conversely, when the technology is easy to codify these problems are reduced. The unit and value of the transaction is easier to define and measure so that the transfer can be made more easily.

However, in the case of codified problem and solution, the main problem remains Arrow's paradox, i.e. the possibility that the sponsor behaves opportunistically. The solution being easy to transfer, it is important for the solver to protect it in order to prevent free riding. Intellectual Property Rights (IPR), and in particular patents, are in this case central to allow the transaction (Arora et al., 2009). They protect the solver and force the sponsor to pay for the information he already holds. It is therefore important to draw a distinction between cases where protection via IPR is possible and the other cases. When a protection is possible, CIA may be a viable alternative for a firm. When it is not, CIA may not perform very well due to too high transaction costs.[11]

To summarise, TCT raises two main testable hypotheses with respect to the condition of emergence of CIA: transaction costs are low when knowledge can be assimilated to information (the problem and the solution are strongly codified) and when it is possible to secure the transaction via strong IPR (patents for instance). In the other cases, it is too costly to transfer the knowledge from the solver to the sponsor.

4   A critical analysis of CIA by the evolutionary theories of the firm

For TCT, the decisive criterion for the firm to decide whether or not to crowdsource a task lies in the possibility of setting up and enforcing a contract with the crowd. From the evolutionary point of view, CIA raises very different, but complementary issues.

Evolutionary theories put forward the strengths of the firm as a place to produce, exchange and store knowledge. The firm allows the building routines and group actions (communities) which make it a very efficient place for problem solving.

Evolutionary theories of the firm include several approaches: The one on knowledge creation and circulation (Nonaka and Takeuchi, 1995); resources-based theories (Wernerfelt, 1984) and competences-based theories and dynamic capabilities (Penrose, 1959; Teece and Pisano, 1994); and the one on the biological representation of the firm strictly speaking (Nelson and Winter, 1982). All those streams of literature are obviously not perfectly homogeneous but they converge on three core points, which are central to understand the notion of firm:

1 Resources and especially those formed by knowledge and competences (Penrose, 1959)

2 Routines that ease the coordination of different activities (Nelson and Winter, 1982)

3 Knowledge-intensive communities which constitute the special place where know-how is produced and stored (Cohendet et al., 2006).

First, whereas knowledge has received only limited attention from neoclassical scholars (Demsetz, 1995), within evolutionary theories it occupies the central place. Knowledge is the most important asset of a firm, the one which justifies its existence. Following Penrose's (1959) work, more recent contributions focus on the firm as being mostly a collection of knowledge and competences. For Nonaka and Takeuchi (1995) the firm is the special place where knowledge is produced, in particular because firms' environment is favourable to learning, either in simple loop or in double loop (Cowan et al., 2000). Knowledge being often tacit, it is hard and costly to exchange and transfer from one place to another, which explains the specificity of each organisation (Kogut and Zander, 1992).[12] Evolutionary scholars therefore view the firm as not a mere processor of information but as a processor of knowledge (Cohendet and Llerena, 1999).

Here, CIA raises clearly the problem of transferring knowledge between two entities which have not developed specific links and which do not know each other. The sponsor and individuals in the crowd do not share similar cognitive schemes, which complicates if not prevent the transfer of tacit knowledge. To overcome those difficulties, it is necessary to develop common routines, codes and processes (Ancori et al., 2001). But obviously, this takes time. This point is linked to the notion of firms' absorptive capacity (Cohen and Levinthal, 1990). It also raises the issue of the kind of knowledge that can be crowdsourced. From an evolutionary perspective, the crowd can only bring codified knowledge to a firm because only this type of knowledge can overcome the problems of learning that the firm would face otherwise. In all the other cases, the use of CIA is limited by this problem of being able to absorb the knowledge produced by the crowd.

Furthermore, within the evolutionary thinking, the development of a firm, its performance, lies mostly in its ability to generate specific knowledge. Now, is the crowd a specific resource owned by the firm? Apparently, all the firms have access and can use the crowd, which contradicts the vision of the crowd as a firm's specific asset. Thus, the core issue for firms is their ability to transform a resource that is available to all into a specific asset. This requires that the firm develops a privileged relationship with the crowd, targeting leaders and captivating them, developing routines that allow optimising communication and exchanges between the firm and the crowd. This takes time. It

implies transforming an undefined crowd into a well-known community that can be used only by the firm. Here, the ability to use the crowd, to submit problems in a specific way, to collect answers, to reward it, becomes in itself a competence that can be very important for certain firms.

Some firms have understood this point well and try to develop privileged links with the crowd [for instance in the case of user communities (von Hippel, 2006)]. To do so, they build specific knowledge. For instance, Dellarocas (2003) showed that ebay's ability to lever various groups of users is quite peculiar and that it enables ebay to overtake its main competitors. However, although quite interesting, the possibility to settle privileged relations between a firm and the crowd remains for the moment a hypothesis.

As soon as one considers the cognition as being the most important asset of a firm and one agrees on the fact that knowledge and competence are limited resources, CIA also raises a problem of selection of the most promising variations. CIA is obviously an extremely rich source of variation. Yet, most firms do not have the resources that make it possible for them to select these variations in an appropriate way. Virtually, CIA offers the firm access to an unlimited stock of information and knowledge. But this stock is only interesting provided that the firm is able to properly select the best elements, meaning that it must have the cognitive capability to treat all this information. This is usually not the case.[13] One of the reasons that explain the existence of firms is precisely the limited ability of individuals to treat knowledge.

The vision of the firm as a special place to produce knowledge also raises the issue of the coordination of productive activities. Since relevant knowledge is mostly tacit and distributed among individuals, it is central to ensure the coordination among these individuals. Here again, evolutionary scholars consider that firms are better than markets to ensure this coordination. According to them, the firm allows the development and securing of organisational routines, which are in a sense the genes of the organisation (Nelson and Winter, 1982). These routines represent contextual capabilities, mostly tacit, learnt in the past and usable easily when confronted to new situations. They are in a sense the element of continuity of the firm which, by building routines, creates a repertoire of prepared answers, thus economising on costly and repetitive search for solutions whenever a new problem appears.

Linked to the notion of routines, the evolutionary firm also strongly relies on the concept of knowing communities. Creation is not an individual process. It is the outcome of rich interactions among very different individuals. Knowledge production requires interactions and exchanges. Knowledge sharing is very often critical to achieve success (Nonaka and Takeuchi, 1995). Hence, knowing communities are genuinely the place where knowledge production, storage and circulation take place (Cohendet et al., 2006; Ferrary and Pesqueux, 2006). And, although evolutionary scholars agree on the fact that the boundaries of a firm do not usually coincide with those of communities, they also strongly agree on the fact that firms are usually more favourable places for the emergence of knowing communities than markets. In a sense, firms fertilise communities. Here again, the emergence of firms is considered as improving collective actions, collaborations and thus knowledge production and circulation. According to evolutionary scholars, the firm is therefore not a 'node of contracts' but a 'node of communities' (Brown and Duguid, 2001).

The emphasis put on communities and routines makes the use of CIA less attractive. Routines take time to be built. They are the outcome of long-lasting interactions. Similarly for communities, formation and survival require regular interactions, common

identity, trust and similar norms (often informal). This gives the internal solution or co-development with a well-known supplier a solid advantage over CIA. Crowdsourcing can hardly help build routines or trust.

To use the crowd means to rely first of all on individuals or teams who compete each other. Conversely to other forms of crowdsourcing, CIA leaves little room for collaboration. It is a 'winner takes all' competition, which hardly favours exchanges and collaborations. Despite the fact that open call means theoretically that everybody can participate, thus including communities, their construction is not favoured by the properties of crowdsourcing. Anonymity is the rule so that most of the time participants do not know each other and sometimes even the sponsor does not know the real identity of those who submit a solution. Only the intermediation society knows this identity, which is clearly not favourable to the construction of trust.[14]

CIA does not favour the creation of collective knowledge and the emergence of organisational routines and knowing communities. It is clearly in line with an individual process of knowledge production. Hence, if one agrees on the importance of routines and collective action in the act of creation, one must acknowledge that CIA can hardly be a credible alternative to a firm. The only case where this may be possible concerns is the development of peripheral knowledge, which may be easier to outsource (Amesse and Cohendet, 2001).

To conclude, evolutionary theories consider that the main advantage of CIA is to provide the firm with important sources of variations. However, they also show that firms can hardly select the most appropriate of these variations and that once a solution is developed outside the border of the firm it is almost impossible to transfer it properly within the firm. According to evolutionary theories, CIA also fails to develop the routines and communities that are so important in the process of knowledge creation and circulation. In order to use CIA, a firm must be able to clearly explicit the question and must be able to easily and quickly absorb the answers, which require that they have been formerly codified by the solvers within the crowd. Hence, CIA is limited to cases of codified knowledge. Furthermore, and also in line with this view, in order to launch the open call, the firm must be able to clearly express the problem, which confirms that it can only expect very precise answers. Never can the firm collect practices, routines and cognitive process to improve its search for a solution. Yet, evolutionary theories stress precisely that the main interest for a firm is not the answer in itself but the method used to obtain it.

5 Conclusion

The purpose of this paper was twofold:

1 To define CIA and specifically to draw the distinction with crowdsourcing of content and crowdsourcing of routines activities.

2 To explore the limits and costs of CIA by using two complementary theories: TCT and evolutionary theories of the firm.

More generally, this work aimed at feeding the debate on the nature of organisations and their boundaries (Thiétart and Forgues, 2006).

TCT and evolutionary theories largely converge in their analysis of the conditions favourable to the emergence of CIA. They show that CIA is a credible solution only when knowledge is strongly codified, thus reducing coordination and learning problems. The question must be clear and must call for an answer non-ambiguous, easy to evaluate, to assimilate and to reuse. Conversely, as soon as the domain is knowledge intensive, the use of CIA is far less attractive. In the case of strongly tacit knowledge, CIA faces insurmountable issues of governance and knowledge production and circulation. To these conclusions, TCT also adds the importance of the possibility of protection (via patents for instance) when knowledge is codified, in order to overcome problems of opportunistic behaviours. Without protection, CIA can hardly emerge. It is interesting to notice that these propositions with respect to conditions favourable to the raise of CIA are testable empirically.

This work has therefore many practical implications for practitioners who envisage implementing a strategy of CIA. It stresses the limits of such a strategy and most of all, the specific conditions that must be met for it to be successful. It shows that managers who decide to use CIA must pay a particular attention to IPR and to the codified nature of the task.

Our work tends to indicate that contexts favourable to the rise of CIA remain marginal. Opportunistic behaviours and the tacit dimension of knowledge imply that CIA will remain rare and will affect only small transactions (like in the case of Wilogo in which the amount of money at stake is weak). The few examples we have found in the literature (without pretending to any exhaustiveness) are in line with those theoretical predictions. For instance, it is well known that the success of open source software depends largely on the codified and modular nature of the technology, which allows for a decentralised and cumulative resolution of problems posted online. The nature of the incentives, which are mostly not directly pecuniary, also favours the emergence of collaboration and removes the burden of using IPR in order to design appropriate incentive schemes (in the case of software, IPR do not exclude but include).

Similarly, Wilogo works well especially because it meets the condition we have identified here. The unit of exchange is non-ambiguous since a proposition of logo is easy to identify. It is precisely one of the conditions of a good logo: to allow an easy recognition of the product or service. A logo is also easy to protect by copyright, limiting therefore risks of free riding. And finally a logo is easy to transfer. Issues of tacit knowledge or know-how that would limit the transfer possibility are not relevant here. Of course, one can wonder whether or not a collective production, that would imply several designers who would debate and exchange on different logos, would not perform better. But in any cases, it is easy to understand that most of the time the creation of a logo is an individual work.

The case of InnoCentive is also largely in line with our conclusions. Lakhani and Jeppesen (2007) studied a sample of representative posted problems on InnoCentive. In their huge majorities, those problems deal with chemistry and pharmaceuticals. Out of the 166 problems studied, three quarters are about analytical chemistry, polymer chemistry and synthesis chemistry. The remaining quarter is about biochemistry, biology and toxicology. Furthermore, still in line with our predictions, authors stress that: "Each scientific problem statement posted includes the problem's background and the solution

requirements, as well as deliverables which outside solvers are expected to provide". This shows clearly that for CIA to be operational and feasible, both problems and solutions must be clearly stated and delimited.

This work was only a first attempt towards a more global understanding of the issues linked with CIA. In the future, several research paths will still have to be explored. Among others, it is important to analyse the possibility of collective search for solutions for a problem posted online. Is it possible that the crowd organises itself in communities? For the evolutionary scholars, this point is one of the most important barriers for the success of CIA. Yet, in some cases it may be possible to turn the crowd into communities. Some recent examples tend to show that individuals in the crowd can sometimes manage to collaborate and to develop knowing communities.[15] It is thus critical to understand under which conditions this is possible.

Moreover, future research will also have to test empirically the theoretical elements raised here. In order to do so, it will be necessary to collect complete datasets on different cases of CIA. Data should cover the nature of the problem (more or less tacit dimension and appropriation condition), characteristics of the firm, of the crowd, etc. This empirical work is likely to be difficult and tiresome but it is critical to improve our knowledge of CIA.

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Notes

1   This can be illustrated by the example of free software development where the 'Linus' law' puts forward the efficiency of a crowd to identify and solve bugs ("Given enough eyeballs, all bugs are shallow", Raymond, 1998).

2   For a list of crowdsourcing projects, most of them being CIA, see: http://en.wikipedia.org/wiki/List_of_crowdsourcing_projects.

3   The word crowdsourcing has been popularised by Howe (2006) who defines it in the following way: "*Simply defined, crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by sole individuals. The crucial prerequisite is the use of the open call format and the large network of potential laborers.*"

4   Schenk and Guittard (2011) propose a typology of crowdsourcing activities slightly different than ours. They distinguish between crowdsourcing of simple tasks, crowdsourcing of complex tasks and crowdsourcing of creative tasks. However, since our two visions significantly differ, it is important to explain our typology in detail.

5   The case of ReCaptcha developed by Schenk and Guittard (2011) is also an example of crowdsourcing of routines activities (http://recaptcha.net). Without entering into too many details, it is enough to pinpoint here that: "The interest of the system is not that an individual may bring a specific, unique answer (any human being can in principle decipher a captcha) but it stems from the scale effect linked to the use of ReCaptcha all around the web: millions of series of characters are daily deciphered by the crowd" (Guittard and Schenk, 2009). In other words, the size of the crowd matters more than its diversity. Similarly, 'Humangrid' is another example, in-between crowdsourcing of routine activities and crowdsourcing of content (www.Humangrid.eu). Humangrid provides a website to connect firms who would like to outsource secretarial work (such as internet search for information, text correction or translation and files sorting) and the crowd who can perform this work. Rewards can go up to 10 euros per hour of work. Here, the tasks to be performed are not properly obvious. They require some competences, but at the same time they are not knowledge intensive. Any individual with a traditional school background can fulfil them. Again, what matters here is more the size of the crowd than its diversity.

6   Another remarkable example of crowdsourcing of content deals with the activity of patent examination. Traditionally, once a patent application is made, the patent office gives the responsibility of the examination to an examiner, who will then inform the applicant about his remarks, comments, etc. Then the applicant can reply and this process of bilateral bargaining can last until the patent application is accepted or rejected. This process is clearly inefficient and can largely be improved by enabling other individuals and firms to bring information to the examiner (Jaffe and Lerner, 2006). The latter may indeed not have the best information about the novelty or inventiveness of the invention. Competitors of the applicant are likely to have much better information and have strong incentives to communicate them to the examiner in order to invalidate the patent. The interest of crowdsourcing for the examiner here is to rely on a large and heterogeneous population in order to collect exhaustive information about the invention he must evaluate. Opening the process of patent examination to the crowd is therefore likely to shorten the delay of patent examination and to improve its quality. The crowdsourcing of a part of the examination of patent application is a project which strongly interests the USPTO.

7   Thus, unlike most other cases of CIA, in this case monetary rewards are usually non-existent. Another peculiarity of this example is that the solution brought by the crowd is usually not owned exclusively by the crowdsourcing firm. The latter must usually commit herself (through the adoption of specific licenses) to renounce the exclusive ownership on the developed software.

8   Another example of CIA is Wilogo (www.wilogo.com), which claims a community of 15,000 member designers, who can be mobilised to work on a specific logo or design. A firm, rather than outsourcing its design to a professional supplier can therefore rely on this community. Design creation, an activity acknowledged by all to be extremely creative, is therefore outsourced to a crowd. Again here, both the size of the crowd and its diversity ensure the firm that it will receive many very different and original proposals. Once it has chosen a proposal, the winner designer is rewarded.

9   Hart (1995, pp.20–23) argues that as long as a contract is 'comprehensive' it is somehow complete: the distortion in effort is due to the cost of observing variables rather than the inability to write contracts and there is no need for renegotiation since all future obligations are specified. However, following the survey of Spencer (2005), we consider here that a contract is incomplete as soon as it does not include all the possible realisation of the world and, in particular, when it cannot be written conditional on unobserved effort levels.

10   Arrow explains that it is hard to trade information on a market because no buyer would agree to pay anything for something he does not know. Hence, the seller must reveal the information in order to induce the buyer to pay for it. But if he does so, then the buyer does not need to pay since he already holds the information. A famous illustration of this paradox is the

invention of the intermittent windshield wiper by Robert Kearns. Tirole et al. (2003, p.23) explained that Kearns, the inventor, did not want to exploit the invention himself, so he contacted the main car manufacturers in the United States (Ford, GM and Chrysler). They expressed their interest, wanted to know more about the invention, and in the end refused the partnership. Yet, some time later they all had intermittent windshield wipers on their cars, very close to those proposed by Kearns.

11 It is worthwhile mentioning here that, according to TCT, tripartite relationships that are usually observed in most examples of CIA (where the transaction is supported by a society of intermediation such as InnoCentive) can decrease transaction costs and hence favour the emergence of CIA. Williamson explains indeed that the use of a referee (a third organisation) can bring flexibility to the contract and help reduce the shadow zones (i.e. the elements which are not explicitly written in the contract and which may therefore vary according to the interpretation of stakeholders). For instance, if a member of the crowd devotes huge efforts (time and resources) to find the answer to a CIA call, he wants to be sure that the crowdsourcing procedure is honoured. Therefore, a third party, repeatedly interacting with supply and demand of crowdsourcing, reduces such a type of uncertainty and allows probably the crowd to expand in size and quality. This is, for TCT, what firms such as InnoCentive are useful for.

12 For (Kogut and Zander, 1992): "what firms do better than market is the sharing and transfer of the knowledge of individuals and groups within an organization" (p.383). And later: "It is *the sharing of a common set of knowledge*, both technical and organizational that facilitates the transfer of knowledge within groups. Arrow (1974) views one of the advantages of the organization as its ability to economize in communication through a common code" (p.389).

13 The example of Dell illustrates this problem. Dell recently used the crowd (its customers) in order to collect ideas to improve its products. This initiative yielded more than 10,000 suggestions (see www.IdeaStorm.com). In other words, Dell collected a bulk of raw information that it was absolutely unable to manage, evaluate and store, although it established many subcategories and asked users to vote for the best proposals. This is one of the most perverse effects of CIA: it offers access to a bulk of information (this is one of the main reasons why firms use CIA) that can hardly be treated and exploited by the firm (it is the other side of the coin). Hence, a generalised use of CIA to solve problems that are not previously precisely defined and on which everybody can answer will provide the firm with too many vague answers. The crowd can help treat the answers by filtering them (for instance, Wikipedia), but very often it is not sufficient to resolve this problem of over information.

14 Conversely to TCT, evolutionary theories raise the issue of the strategic interest for firms to use intermediaries. What really matters in a-knowledge based view is the development of a direct relationship between the individuals in order to transfer tacit knowledge. The multiplication of intermediaries is clearly not favourable to the creation of collective routines and to the production and circulation of knowledge.

15 For instance, the *New York Times* dated 21 September 2009 described the case of Netflix, a movie rental firm, which launched an open call to the crowd in order to improve its system to predict the demand for movies. The winner of the 1 million US dollars was precisely a team of heterogeneous individuals who had competences in complementary disciplines: statistics, engineering sciences, computer sciences, etc.