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Analysing technological influence and dependance for competitive intelligence

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Abstract

In this paper we present a method that can be used for the assessment of the technological influence and dependance of players in a domain. Technological influence identifies the extent to which the technologies of a firm are used by other actors for their own innovation activities. Technological dependence measures how the focal firm uses technologies of other actors in order to innovate. Both dimensions are represented using a specific data-visualisation technique aiming to facilitate the analysis.

Measuring and visualising these dimensions helps decision makers with a variety of questions ranging from the identification of other applications for their technologies, the identification of potential partners to an assessment of litigation risk.

Keywords: Patent analysis; citations analysis; data visualisation; technological dependance; technological influence

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1. Introduction

It is no secret that innovation is vital for players' survival on the market (Duysters and Hagedoorn (2000), Penrose (1959)). The knowledge used to innovate is a strategic asset for players and therefor requires careful management and curating. The cumulative nature of knowledge results in the creation of a technological trajectory that is specific to the player. On this trajectory each innovation or invention is the result of a combination of new and old knowledge. The latter can be knowledge created by the company itself or found outside the bounds of the players structure (collaboration, books, publications, patents).

The management of this knowledge requires players to pay close attention the knowledge they use in their innovation process but also who is using the knowledge they created. We will refer to these two dimensions as technological dependance and technological influence respectively. The analysis of influence and dependance are important for any innovating player if she wishes to reduce risk and maximise opportunity.

Technological dependence, understood here as the extent with which a player uses other players knowledge reflects a risk. Using knowledge from others exposes a player to risk of litigation and a loss in bargaining power when a licence is needs to be negotiated (especially if the knowledge is already implemented in a sold product). In todays market, litigation is no longer a rare occurrence and some companies have specialised in litigation actions. These companies are called Non practicing entities and they are increasingly active Sterzi et al. (2021). The increased risk for litigation should push players to scan for their level of dependance upon technologies that go beyond the bounds of the company. It it therefor important to have detailed information on the knowledge used in the innovation and indeed, the production process. On the opposite side, the extend to which other players use one's knowledge is a valuable source of strategic information as well. The management of existing knowledge can require decisions related to selling licences, deciding wether or not to maintain patents, finding new avenues for revenue on other markets, keeping track on who might be infringing on one's IP. The analysis of the influence of ones technologies can help provide answers for many and more of these cases.

The study of technological influence and technological dependance is an activity that enters the domain of economic intelligence. More precisely it refers to a subdomain which is technology intelligence which aims to provide me-

thods and techniques that allow actors of the innovation landscape to better understand their environment. These methods and techniques are required
40 given the amount of information and data that is required to be treated for this type of analysis (Schneider and Veugelers (2010)) and should be part of any firms innovation process (Dodgson et al. (2008) Flamand (2016)). However, the number of companies proceeding to this type of analysis is too low Flamand (2016).

45 This paper contributes to the tools at the disposal of decision makers by providing a method for the analysis of technological influence and dependance. The method presented in this paper was developed at the VIA Inno platform of the University of Bordeaux. VIA Inno has been using this technique for several years to answer a variety of questions for a variety of decision maker
50 (multinationals, universities, government agencies, start-ups, regional agencies).

This paper is organised as follows, first we will present the type of data used for this type of analysis. Next we will show the logic of the method for influence and dependance respectively. The final section will provide a case
55 study.

2. Data & Methodology

The identification of influence and dependance requires data that contains information on which players are using knowledge of a given firm. Patents have the double advantage of containing both information on the knowledge
60 produced by a player (the claims of the patent) and the knowledge that was used to create it (the citations). Patents have been used for decades as a measure of innovation and for the technological analysis of players (Jaffe (1986), Verspagen (1997), Shapiro (2000), Tseng et al. (2011)).

Patent citations are come in two main forms, examiner and inventor citations.
65 The main difference between the two is that the examiner cites other documents to contain the claims of the assignee Organization (2004). This implies that examiner citations indicate a certain technological proximity between the citing and the cited patent (Benner and Waldfogel (2008) Alstott et al. (2017)). For this reason patent citations are also the a privileged datasource
70 for the analysis of knowledge flows (Alcacer and Gittelman (2006), Alcacer et al. (2009), Jaffe et al. (2000)). In fact, patent citations are even used for the purpose of evaluating the technological value of patent portfolios and the player holding them (Hall et al. (2005)).

For the purpose of this paper will use a citation of an indication that the citing play is building upon the knowledge produced by the cited player. Even
75 thought this hypothesis is widely accepted, we do have to specify that not every citation has a strategic value. Citations come in a variety of categories ranging from citation general knowledge (books, manuals, presentations) to citing knowledge that blocks part of the citing patent. The latter are identified in a patent by the category X or Y to signify that the cited patent
80 claims something that has already been achieved. These citations are therefor the strongest signal of technological proximity and are usually used for strategic analyses Shapiro (2000). However, in practice we have noticed that even inventor citations which are generally considered discarded can have
85 strategic value for some specific question especially those related to finding new markets for a technology. The method we will present here will start out including all citations, we will show how to highlight categories in order to answer specific questions.

3. Patent data for the identification of influence and dependance

90 3.1. Technological Influence

For our purpose we define technological influence as the extent to which players exploit the knowledge of a focal player. The latter can either be the player herself analysing her own portfolio, or another player (a competitor, potential buyout target, investment target etc.). In order to asses who is
95 using the knowledge we will use patent citations. For this purpose we will consider that a player citing the patent of the focal player will have used at least part of the knowledge held by the focal player. Using this information we aim to be able to answer a variety of use cases that arise in innovation and knowledge management. We show some of these cases in table 1.

100 Some of these indicators are quite basic but they are extremely powerful when presented in a clear manner. The number of citations is easily computed while patents cited together is more complicated to communicate. Beyond the simple measures of we require a method that has a powerful communication aspect to it. This is why we will present the different indicators visually
105 rather than a list with numbers, patents and players. We aim to provide a visualisation that is capable of instantly highlighting elements that are important for innovation management. The visualisation that we use is a graph that contains all layers of information that we have described, patents, citations and the citing players. In order to be able to highlight important

Aim	Indicator
Identification of highly valuable patents	Number of citations
Identification of players that depend upon the focal player	Number of citations coming from one player
Identification of groups of patents that have value when grouped	Patents cited together
Identification of potential partners	Who is citing specific patents
Identification of new potential markets	Player with a different core business citing the focal player

TABLE 1: Use cases and indicators used.

110 information we build the graph, which we will call the influence graph as follows :

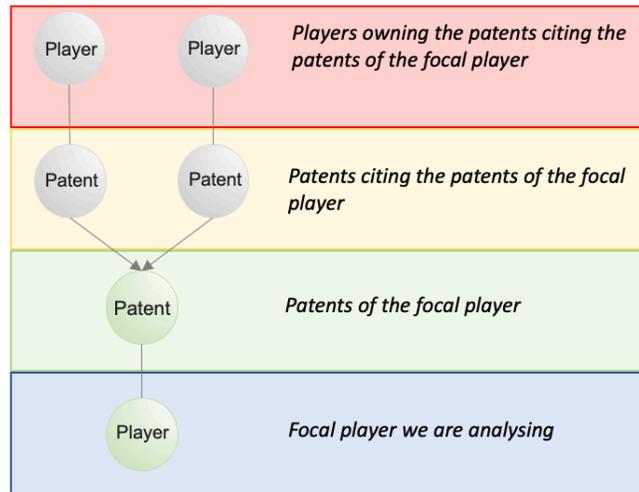


FIGURE 1: Concept of the influence graph, showing the different layers of information and how they are interconnected

The nodes represent either patents or players. The central node will represent the focal player to which we will connect all the relevant patents (this will be the first link, it will be undirected). Then are added the patents
 115 citing the patents of the focal actor. This is where the question of the technological influence will be visible at the patent level. We will be able to identify patents receiving many or few citations. In order to see if these citations come from one or multiple player we add the final layer which is the patent

owners. The last link is therefore an undirected link to highlight ownership,
 120 while the link in the centre is a directed citation link.

Using this data we build a graph connecting the different data sources which
 can be imported in any network analysis or visualisation tool (Gephi, payek,
 cytoscape, Tulip). The easiest way to create a dataset is then by a simple
 source-target list :

Source	Target	
EVE Rubber	US9758627B2	(connecting focal firm to patent)
WO2019094551A1	US9758627B2	(connecting citing patent to focal's patent)
WO2019094551A1	Cabot	(connecting citing firm to it's patent)

125 This table shows that patent US9758627B2 owned by EVE Rubber is
 cited by patent WO2019094551A1 which is owned by Cabot. This list is
 completed for all patent of the focal firm to allow the software to visualise
 the graph.

This is the basic logic of the graph of influence. When this is done for all
 130 patents citing a firm the result is a graph that has different layers (as we will
 show later in this paper in figures 5 and 6 for exemple). For now let us focus
 on the information that this kind of graph can highlight. In figure 2 we show
 some the of theoretical cases we can expect to find in an influence graph.

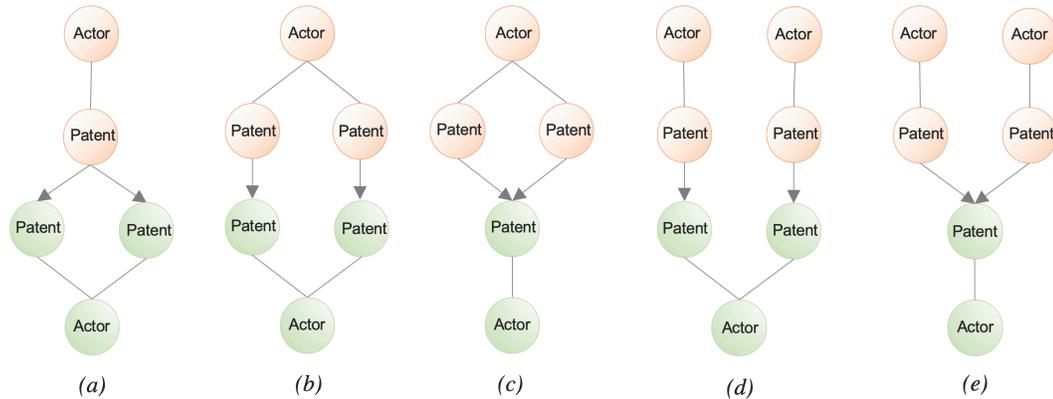


FIGURE 2

In the first of the cases, (a), we have one firms that owns one patent ci-
 135 ting two patents of our focal firm. This situation implies that the player has
 combined parts of both patents to somehow innovate. We deduce from this

type of citation that the focal firm has incentive to combine both its patents if it wishes to proceed to licence its patents. If the player wishes to continue its own innovation trajectory this citing player might cause a problem since
140 it combined some ideas and is therefore close from a technological point of) view. A thorough study of the freedom to operate is required for this patent. Case (b) shows more atomised citations, even though the number of citations is the same, they are distributed over multiple patents. The level of influence exerted by the focal company is lower at the patent level because of the dis-
145 tribution of the citations. At the player level however it is complicated to assess of the influence is higher or lower. On the one hand the citing firms cites with more patents which would signify increased influence of the focal player, but the influence is lower at the level of each patent. Only an in-depth analysis of the patents will allow for a conclusion.
150 case (c) highlights that the focal player has an important patent since it receives multiple citations. The technologies that the citing player is protecting with its patents depends upon a single patent of the focal firm. The influence of the focal firm is therefore high.

155 These theoretical situations are not exhaustive. In practise other cases might occur that are of interest for the question that one is trying to answer. Borderline cases can also exist. The force of this method is that it is able to highlight situations of interest and provides an easy-to-read visualisation.

160 3.2. *Technological Dependance*

Technological dependence analyses the extent to which a firm is dependent upon the knowledge of other players. The aim here is to identify high levels of dependance to reduce the risk of litigation or loss of negotiation power. An analysis of the technological dependance of the firm can be
165 used in a variety of use cases such as :

- Identify firms that can block my technological trajectory
- Identify litigating firms to which my patents are close
- Identify patents that rely too heavily on technologies of one specific player

170 The method we use for this purpose is the same as the method for the analysis of technological influence, the only modification required is to change the direction of the citations link as shown in figure 3.

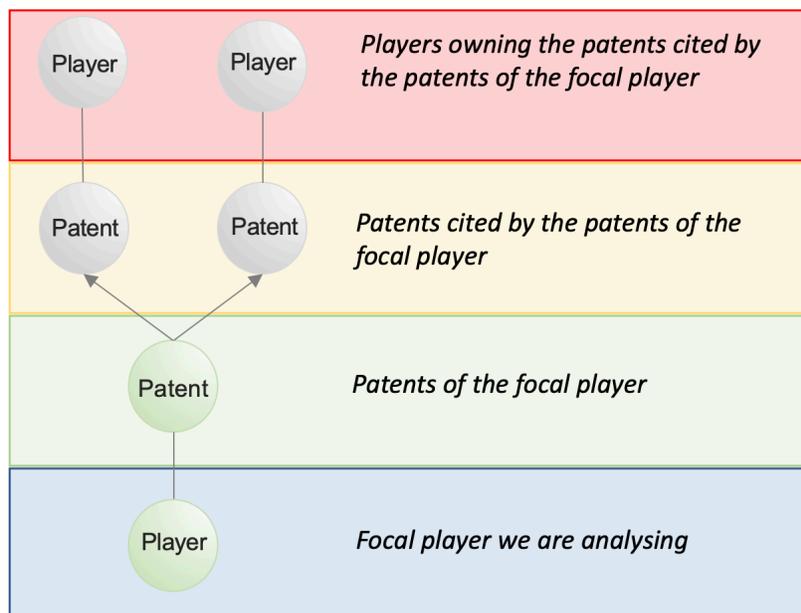


FIGURE 3: Concept of the dependance graph, showing the different layers of information and how they are interconnected

The focal node remains the player we are interested in. Connected to this
 175 player are its patents (or at least those that are relevant to the study) to
 which we then connect the **cited** patents. These citations are the first ele-
 ments to inform us about the dependance of the focal player. To complete the
 picture we add the assignees of the cited patents so we are able to identify the
 players holding the cited patents. The interconnection of these layers result
 180 in a structure that easily highlights different levels of dependancy as we shall
 illustrate later in this paper.

The particular structure we are searching for are those that highlight some
 level of concentrated citations from the focal firm to either patents or players.
 Figure 4 shows the type of structure we are searching for, these are identical
 185 the ones we search for in an influence graph, the interpretation is however
 reversed. In case (a) the player has multiple patents citing one patent of ano-
 ther firm implying that the player is dependant upon one particular patent
 of another firm. This gives more bargaining power the the cited firm and
 especially a higher risk of litigation.

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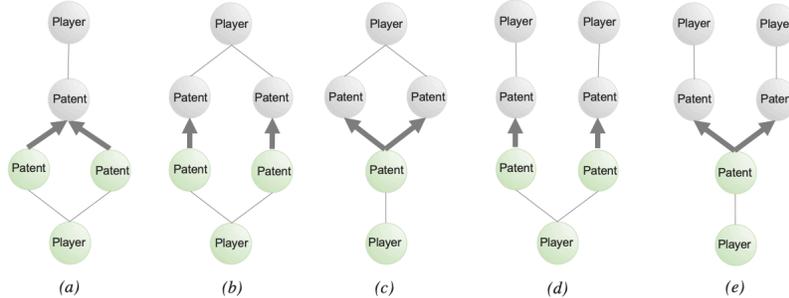


FIGURE 4: Citations structures we look for in a dependency graph.

4. Case study : EVE Rubber

To show how to use the method described in this paper we provide an example using EVE Rubber, a player in the rubber industry. We identified this player using a method for the identification of player with a particular collaboration strategy (van der Pol (2021)). This method uses dynamic network analysis to identify a players that have a behaviour that is a deviation of the average in addition to providing a classification of player into a topology of strategies. EVE Rubber is particular because it is relatively you while having collaborations with large corporations. With the aim of understanding the technological trajectory of the company we look into its technological dependance and influence using the method presented in this paper. For a more extensive study of this player see Brunet et al. (2020). Patent information was obtained from the Questel Orbit database¹ and Gephi (Bastian et al. (2009)) was used for the visualisation of the graphs.

4.1. EVE Rubber's Influence Graph

Figure 5 shows the influence graph of EVE Rubber. The different levels of the graph have been coloured to highlight their origin. Green nodes are the patents of EVE Rubber, blue nodes are the patents citing EVE Rubber and the purple nodes the assignees of the citing patents.

1. see <https://www.questel.com> for more information on this worldwide patent database

Within this graph we highlight different cases of interest linked to the theoretical cases we have previously identified. The letters next to the circles relate directly to those theoretical cases.

215 We can start this analysis by highlighting Qingdao Tailan, a Chinese company that cites three patents of EVE Rubber with one of their patents. This situation created negotiation power for EVE Rubber if they have proof that Qingdao Tailan uses its patent for production purposes. This also shows that the three patents can be grouped together and used as a bundle of patents.
220 This idea is reinforced by the observation that Shandong Yanggu Huatai Chemical cites the same group of patents with one of its own. In addition, the latter has a second patent citing EVE Rubber increasing its dependence on EVE Rubber.

Other interesting cases, such as Petrochina which cites one patent with two of its own shows that patent CN103205001 attracts a lot of attention and therefor has potential value for EVE Rubber.

Patent numbers CN10523783 and CN103224659B, illustrated by (e) in the graph, is cited by two different companies. This patent can therefore also be of interest for EVE Rubber if it wishes to valorise its patents.

230

Adding more information to the graph. Citations are very informative but they come in many categories, some of which are of more interest than others. We focus here on two categories : X and Y citations. These citations are added by the patent examiners to indicate that the cited patent blocks at least one claim of the citing patent. These citations therefor indicate a high technological proximity Shapiro (2000) which is what we are searching for.

Using the same graph as previously we add two indicators to the graph, one that indicates whether the citation is blocking (either a category X or Y citation) and whether the patent itself is in the top 5% according to its influence in the domain. This indicator is computed by counting the number of direct and indirect citations a patent has received. This is computed at the end of the period according to the year of filing. The top 5% is computed and retains those patents with the most direct and indirect citations when compared to other patents filed the same years in the same domain.

245 In figure 6 we visualise these two indicators : red links represent a category X or Y citation, green patents indicate patent that are in the top 5% of the domain in terms of indirect and direct citations.

This additional information shows some of the patents citing EVE Rubber

The added value of this approach is that the visualisation makes it easy to identify patents and players that present either risks or opportunities for a player. Any additional information can easily be added by adding colours or images of the technologies behind the patents.

265 4.2. *EVE Rubber's Dependance Graph*

We now look at the inspiration of EVE Rubber used for its patents. We search for companies and patents that receive many citations to identify what the firm is dependant upon.

270 Figure 7 shows the dependance graph of EVE Rubber. The graph highlights the importance of tire manufacturers as an influence (Michelin, Bridgestone, Yokohama, Sumitomo). The highest number of citations point towards Michelin and Cabot, which can make sense since Cabot is a supplier of Silica for Michelin. A more in detail analysis actually shows that the founder of EVE Rubber as worked for Cabot in the past, explaining this high proximity
275 between the firms.

The structure of the graph also highlights that groups of patents appear to cite particular firms. 7 patent to the north of the graph cite JSR and Bridgestone while patents in the south east tends to focus on Cabot and Michelin. The dependance of EVE Rubber on the technologies of these firms is directly
280 visible and contrasts with the influence graph. While EVE Rubber seeks its technological inspiration mainly through tyre manufacturers, none of them cite the patents of EVE Rubber. Actually, mainly Chine players cite their patents.

Just as we did for the influence graph, we add two indicators in the
285 graph to asses in more detail the type of citation. Figure 8 shows that EVE Rubber cites two of Michelin's patents that are in the top 5% with a blocking citation. Therefore, The patents filed by EVE Rubber are close to those of Michelin since part of the claims made by EVE have been blocked by Michelins Patents, there is hence a high proximity between these documents.

290 4.3. *A tool to help decision making*

The type of graph presented in this paper was initially developed at the VIA Inno platform where it is now a tool currently used for the strategic analysis of player in a technological domain. It has been used to answer a variety of questions, ranging from finding opportunities for selling a technology in another domain, to finding partners to develop a technology further,
295 identifying litigation treats, identifying patents to sell or maintain.

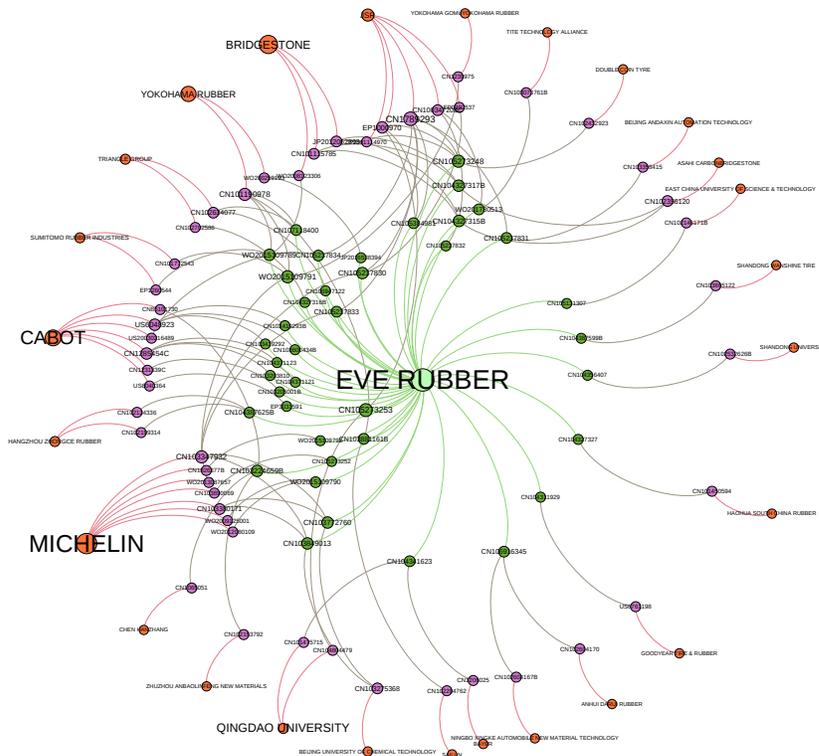


FIGURE 7: Dependance Graph of EVE Rubber for its patents in the domain of silica for rubber (patents filed before June 2019)

The graph allows the analyst to accentuate the elements that answer the question she/he is trying to answer. Experience has shown that the visual of the graph makes communication with decision makers easier. For the analyst building the graph allows for easy identification of elements of value. It is possible to add additional layers of information relevant to the question asked by the decision maker. We do however recommend to not add too much information in one graph but rather provide multiple graphs with less information.

5. Conclusion

In this paper we have shown a method for the measurement of technological influence and dependance. There are multiple use-cases for this type of analysis, ranging from a simple analysis of the patents and player on which

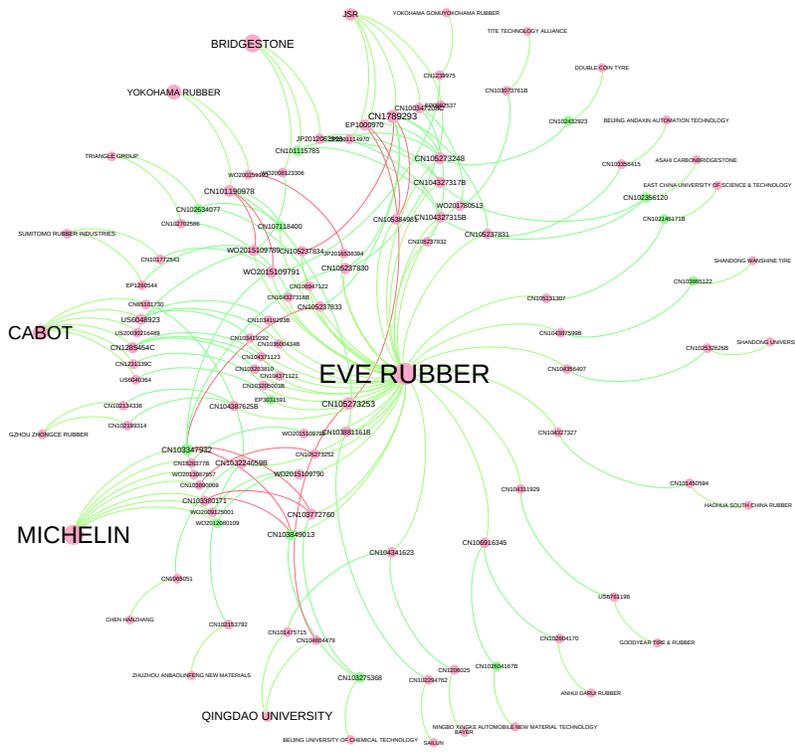


FIGURE 8: The dependance graph complemented with Red links representing a category X or Y citation, green patents indicating patents that are in the top 5% of the domain in terms of indirect and direct citations.

310 a player is highly dependant to the more complex question of finding new applications for a given technology.
 What we present in this paper is the logic of the method. We have used this method in many different settings and for many different questions over the

past years and is broadly very well received. The visual facilitates the discussion with experts and facilitate the decision making process for decision makers. The method can be used by intellectual property experts to assess the risks of certain patents (for instance a pool of patents highly dependant on one player), by engineers to assess what other applications might exist for a technology, for competitive intelligence analysts to better understand the technological proximity between players and so on.

We have shown here a basic version of the graphs, but they can be complemented with additional information. For instance one can add information relative to the IPC classes, the dates of the patents, the inventors, images from the patents or even add a dynamic perspective.

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