Proposal of a global product development strategy assessment tool and its application in the Italian industrial context

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Abstract: The paper describes the construction of a new GPD strategy assessment tool. To better comprehend the current state of knowledge on GPD, a wide state-of-the-art analysis was implemented. Starting from the evidenced lacks, a specific questionnaire was structured, trying to recover information from the field. This allowed to assess the current Italian situation on a sample of 20 companies, equally distributed among SMEs and MNCs. Data were inserted into a database and classified both with cluster and qualitative analyses. Results were used to define the triad of classification axes constituting the final GPD strategy assessment tool. This new tool is able to acquire both technical, geographical and strategical information. Furthermore, it can map the suitability of organisational structures, IT infrastructures and GPD strategies evolution. The assessment is virtually supported by a 3D representation and it could be useful to evaluate both 'as is' and 'to be' states.

Keywords: global product development; GPD; product lifecycle management; PLM; strategy assessment tool; Italian industrial context.

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1 Introduction

Globalisation is the process of international integration arising from the interchange of world views, products, ideas and other aspects of culture (Geneva Centre for Security Policy, 2006). With its multidimensional and multidisciplinary characteristics, it directly affects R&D and marketing strategies (Guerini, 2006; Kumar et al., 2009) and, indirectly, education (Bilén et al., 2002). Globalisation began to spread in the 1980s, but its effects appeared only in the second half of the 1990s when new international competitors from new geographical areas entered the market and innovative collaboration processes were discovered. Originally, globalisation was intended as the outsourcing of production infrastructures, by shifting some activities in cheaper labour markets. Later, with the internet revolution and the rise of web-based architectures, some multinational companies (MNCs) started to move value-added intellectual activities (e.g., software development) to emerging low-cost nations, such as China and India. Gradually, other companies abandoned their reluctance to globalisation (gaining valuable economic achievements) for a series of reasons:

- fear of losing their competitive advantage
- lack of talents in countries traditionally recognised as centres of expertise
- ethnocentrism of their organisation.

With the evolution of technology and a better understanding of the industrial context, the new paradigm of global product development (GPD) was defined. This led, on the one hand, to great interest in understanding reasons underlying this new phenomenon and its effects on the global economic system. On the other hand, experts tried to build a series of classification models to identify new GPD strategies. However, these models did not take account of the relation between strategies and technologies. For that reason, a new assessment tool was proposed by the authors. This paper is structured as follows:

- Section 2 presents a review of the GPD literature, analysing papers from different perspectives. The literature analysis was used to define new research areas and to develop a detailed questionnaire.

- Section 3 focuses on Italian companies. A sample of 20 small, medium and large enterprises was interviewed (by phone or e-mail). The empirical data were transferred to a database (Flynn et al., 1990), and cluster (Kaufman and Rousseeuw, 2009) and qualitative analyses were implemented.
- Section 4 describes the new assessment tool, based on the results obtained in the previous Section 3 and discusses the application of the tool to a set of five additional companies (used as a tuning sample).
- Section 5 discusses limitations and benefits and provides some concluding remarks.

2 Literature state-of-the-art analysis

The scientific literature analysis was implemented as follows. First of all, a sample of 133 papers was classified into four (notional, organisational, technological and strategical) perspectives. These views, which were extracted directly from the papers, represent (from the author's personal point of view) the main perspectives supporting the definition of new GPD strategies. These views are described in detail in the four sub-sections below. Sub-section 2.1 presents some definitions of GPD and the main reasons driving its expansion. The next sub-section (2.2) analyses some important aspects of GPD related to organisational culture and distributed team management. Sub-section 2.3 presents some innovative GPD collaboration supporting tools. Sub-section 2.4 expands on the main factors influencing GPD strategies and briefly presents current classification models available in the literature. Finally, Sub-section 2.5 presents the literature analysis on which the paper is based.

2.1 Notional view

Many experts use different terms to address the concept of GPD, such as distributed product development (Dustdar et al., 2003), global/international R&D (von Zedtwitz and Gassman, 2002), global collaboration (MacCormack et al., 2007) and global innovation (Cleveland, 2006). However, a definition that offers a good idea of the phenomenon is: "GPD is a unified product development process where multi-disciplinary design teams work collaboratively on a single process or product across multiple geographic locations" (Eppinger and Chitkara, 2006). In recent years, many manufacturing sectors have experienced increased global competition in product development processes, requiring them to:

- improve competences (e.g., quality and innovation) (Barczak et al., 2009)
- reduce costs (Subramaniam et al., 1998)
- compete in different markets (e.g., with shortened time-to-markets and lifecycles) (da Silveira, 2014)
- react to rapid changes in the environment (e.g., to customer needs or new services provision) (Garetti et al., 2012).

Faced with these competitive forces, a number of analysts (Alves et al., 2011; Hojlo et al., 2007; Jacobs and Singhal, 2014) found that many manufacturing firms were interested in GPD opportunities. However, this rapid adoption of GPD by companies has not to be considered as a pure fashion effect, but a calculated balance between product development risks and the need to maintain a global market competitivity.

2.2 Organisational view

GPD has also organisational-wide implications. On this side, it is named as collaborative/concurrent product development (CPD). CPD means: "organizing distributed teams to better exploit GPD network potentials" (Li and Roy, 2007). This evidences two critical challenges, the organisational culture and distributed team management, that must be addressed in CPD (Andersen and Drejer, 2009; Plotnick et al., 2011; Santos et al., 2004; Tripathy and Eppinger, 2013).

In general terms, the issue of organisational culture has been addressed in detail, as evidenced by the literature (Frank et al., 2014; Glier et al., 2011; Silveira and Sbragia, 2010; Sivakumar and Nakata, 2003; Sosa et al., 2002; Stahl et al., 2012). Different cultural values can create conflicts, misunderstandings and inefficiencies among team members, causing problems even in well-organised structures. However, if correctly managed, cultural heterogeneity can have a positive effect, encouraging the generation of new ideas and enhancing the creativity level. The correct management of (Jin and Hong, 2007; Mudambi et al., 2007; Waddell et al., 2011):

- collaboration
- integration,

in addition to (Poole, 2004; Reich et al., 2009; Ruy and Alliprandini, 2008; Yam et al., 2007):

- communication
- training
- education,

can improve problem-solving skills of project team members in a distributed environment and enhance the pursuit of knowledge within distributed organisations. Many authors have provided advice on the practical implementation of CPD (Chu and Cheng, 2005; Graber, 1996; Hsu, 2009; Ichijo and Kohlbacher, 2008; Rodriguez and Al-Ashaab, 2005; Wu, 2007). However, for the achievement of high performance in distributed environments, three soft dimensions are more important than points 1 to 4 above (Salomo et al., 2010). These are:

- the company's culture
- commitment of resources
- top management involvement.

Results show that low performers tend to emphasise just two of these dimensions and that the best performers are able to balance all of them.

From the distributed team management point of view, many types of collaboration teams were proposed. First of all, cross-functional teams (Pitta, 2005; Yelkur and Herbig, 1996). Still present in many enterprises, they are a lever for new product development (NPD) processes, performing different tasks simultaneously and, at least, as fast as possible, greatly reducing the development time. For temporary collaborations, virtual teams seem to be the best solution (Gordon and Curlee, 2011; Harvey and Griffith, 2007; Siebdrat et al., 2009; Tavčar et al., 2005). Virtual teams are culturally different, geographically dispersed and electronically communicating teams who think and act in concert. Instead, for more continuative collaborations, communities of practices represent the only way for the development of global business processes, understood as a balance between negotiation and learning among local practices and global planning (Molina et al., 2005; Smeds and Alvesalo, 2003).

Despite these problems about culture and team management, distributed teams remained widely diffused in the second half of the 1990s. Among 103 American companies analysed, 54 had used or were using global teams for their NPD processes (McDonough et al., 2001). In Europe, 49 German companies leading their industries employed international teams as a means of coordination in projects, with the use of such teams increasing over time (Ambos and Schlegelmilch, 2004). Later, in 2006, a study of 1,157 manufacturing firms across a different arrays of industries and nations (65% from the USA, 17% from Europe and 18% from Asia) showed that they were formally examining the use of distributed teams (Eppinger and Chitkara, 2006).

2.3 Technological view

Today, less and less finished products and more and more valuable services (e.g., problem-solving, brokerage and some parts of routine services) are traded between nations. This means that end products can be seen as the result of intense cross-border collaborations. In this context, product development becomes virtual, and e-collaboration systems play a fundamental role (Durmuşoğlu and Barczak, 2011; Taisch and Terzi, 2009). These systems not only replace traditional collaboration systems, they allow:

- transactions and coordination in real-time on various decisions and activities
- capitalisation of cross-national, organisational and professional knowledge
- remote collaborations among distributed teams.

The level of use of e-collaboration tools seems to depend strongly on people-related factors (e.g., languages, training and professional experience). The substitution of in-person meetings with e-collaboration tools gives rise to various challenges. For example, e-collaboration tools are not entirely focused on knowledge management optimisation among team members. Furthermore, although they have evolved over the years, they have inherited some technical problems in terms of software compatibility (not allowing the construction of unified 3D platforms) and co-existence between 3D and 2D tools. Finally, the overall impact of these tools on business performance is not significantly correlated with a reduction of costs (Lefebvre et al., 2006). To ensure the best use of these tools, it is very important that people are trained how to employ them to enhance coordination, communication and collaboration methods.

In chronological order, product data management (PDM) was the first technology used for e-collaboration. According to Abramovici et al. (1998), PDM is a suitable instrument to support product development teams due to its data management and real-time control of the entire development process. Even if there are many types of PDM systems, they are not immune to problems (Hameri and Nihtilä, 1998). In fact, these systems:

- do not cover the entire life cycle of a product
- use routines to map the whole development process
- do not consider managerial actions when monitoring and measuring performances
- have some difficulties in exchanging data among systems
- present many actions without a value.

However, new PDM software have fixed many of these problems. The evolution of PDM systems is represented by groupware (Wedlund, 2000). Groupware refers to the global sharing of real-time information through physical and virtual networks among different distributed working groups. Due to their potential, groupware tools have become the starting point for network expansion outside companies. Such tools allow companies (Dustdar et al., 2003; Michalos et al., 2011; Ozer, 2004):

- to transcend physical barriers
- to reply functions in real time and maximise productivity
- to increase the number of mobile-workers
- to enable multilevel security by guaranteeing the certainty of data.

The literature contains various examples of the practical application of groupware systems (Farshchian, 2001).

GPD technologies are not limited to e-collaboration tools. They influence computer graphics display systems for managing distributed information and virtualisation (Maropoulos, 2003; Wang and Chou, 2008). Furthermore, GPD technologies allow the integration of distributed product development operations, enabling dynamic responses to market changes through object-oriented (or feature-based) systems (Bertoni and Chirumalla, 2011; Bradfield et al., 2007; Lee and Kim, 2007; Mi et al., 2006; Rodriguez and Al-Ashaab, 2005; Sadeghi et al., 2009; Völz et al., 2010). Many examples of implementation are presented by the experts. Some of them are focused on MNCs collaboration platforms (Molina et al., 2005; Montoya et al., 2011; Salhieh and Monplaisir, 2003), others on small and medium enterprises (SMEs) support (Li et al., 2005). Finally, GPD technologies support distributed supply chain management (Albizzati et al., 2012; Liu et al., 2006; Yang et al., 2006).

2.4 Strategical view

To better comprehend how a company defines its GPD strategies, it is important to understand the typical organisational response to any kind of change, for example, with respect to innovation (Chesbrough, 2003; Hansen and Ahmed-Kristensen, 2012; Ichijo and Kohlbacher, 2008; MacCormack et al., 2007; Townsend et al., 2009; Wang, 2010; Zhang and Gregory, 2011). However, a GPD strategy depends also by other trends, only partially controllable by companies, as R&D outsourcing or mobile working needs

(Coe et al., 2004; Hojlo et al., 2007; Lynn and Salzman, 2005). These exogenous factors can have a strong influence on a GPD strategy, especially working in inter-firm networks, going to link independent organisational structures in a common distributed environment. Problems related to poor implementation of GPD strategies have been widely described in the literature (Ledwith and Coughlan, 2005; Palpacuer and Parisotto, 2003; Rundquist and Halila, 2010). GPD is not suitable for all companies and its implementation requires a well-balanced decision about the level of distribution (or concentration) of R&D activities in both owned or external centres, together with an appropriate management of localisation risks (Amaral et al., 2011; Crick, 2009; de Brentani et al., 2010; Harvey and Griffith, 2007; Leung et al., 2008; von Zedtwitz et al., 2004). These choices may depend on different factors, as outlined below:

- external factors: context characteristics (Yang and Coe, 2009), types of governance (Boehe, 2008), operational allocation (Vos and van den Berg, 1996), standards, laws and local rules (Gunzenhauser and Bongulielmi, 2008)
- internal factors: native country, product management group, prevailing culture and practices of management and organisation (Gerybadze and Reger, 1999), commitment of management, modularity of products/processes, competencies, intellectual property, data quality, infrastructures and governance (Eppinger and Chitkara, 2006; Lasserre, 2007).

A proper evaluation of all these factors can allow companies to define:

- better GPD strategies
- exploit economies of scale
- reduce time-to-market (TTM) and development costs
- balance communication and coordination among distributed teams.

The assessment of GPD strategies is a well-researched topic in the international GDP literature. Authors have proposed a number of interesting classification models during the last two decades. Early models focused on a specific feature of distributed R&D centres, such as their role within the development chain (Chiesa, 2000) or their location (von Zedtwitz and Gassman, 2002), trying to identify a series of GPD approaches followed by companies. More recent models are based on just two features, such as location versus ownership (Eppinger and Chitkara, 2006) or location versus integration (Lasserre, 2007), of R&D centres. However, these models do not assist companies in the practical implementation of GDP strategies or incorporate a technological perspective.

2.5 Literature analysis

To illustrate the weaknesses of current classification models and fill existing gaps, the previous four (notional, organisational, technological and strategical) views were divided into several more specific views (context and scope of application, roles and structures, technological IT systems, practical guidelines and locations selection). This additional step confirmed initial assumptions about current classification models, and identified two other weaknesses of these models: lack of GPD management roles and available collaborative technologies. All these points were enhanced by some summarising tables (e.g., see Tables 1–2). Table 1 shows the different components of GPD strategies and Table 2 presents the results of the literature analysis.

Table 1 Example of paper classification based on different GPD strategies components

Notional view	*Organisational view*		*Technological view*			*Strategical view*	
Author	*Context*	*Scope*	*Roles*	*Structures*	*IT systems*	*Guidelines*	*Locations*
Lee and Kim (2007)	x				x		x
Kumar et al. (2009)		x		x			
Bradfield et al. (2007)	x	x		x	x		
Liu et al. (2006)		x			x		x
Ghosh and Varghese (2004)		x					x
Gunzenhauser and Bongulielmi (2008)	x			x			x
Johnson and Filippini (2010)	x	x		x			x
McDonough et al. (2001)				x			x
Vos and van den Berg (1996)		x					x

Table 2 Results of the paper classification

Notional view	*Organisational view*		*Technological view*			*Strategical view*	
Results	*Context*	*Scope*	*Roles*	*Structures*	*IT systems*	*Guidelines*	*Locations*
Selected papers	50	92	11	45	18	14	42
Total							

From an industrial point of view, the authors considered that a lack of strategic GPD guidelines is most likely to negatively influence new GPD implementation among SMEs. To comprehensively investigate the effect of a lack of strategic GPD guidelines, a series of correlated phases of analysis were implemented. First, the literature analysis allowed to construct a questionnaire aimed at gathering lacking literature data directly on the field. These data, once adequately translated into a binary code, were transferred to database. Subsequently, the great amount of information was assessed through a cluster and qualitative analyses to discover important behaviours of companies (from clusters) or relations among variables (from qualitative diagrams). Once mixed with correlated ones, more interesting variables were used to construct the definitive GPD strategy assessment tool. Finally, it was possible to test the reliability of the tool on a tuning sample of companies.

3 Empirical research

The literature analysis revealed the main gaps in GPD research that need to be addressed in the near future. Starting from this point, a specific questionnaire focused on the lack of strategic GPD guidelines was developed, trying to gather lacking information directly from Italian companies. This section presents the results of the empirical analysis, conducted in Italy in 2009, on GPD practices. Among 93 respondents, 82 companies declared that they regularly use GPD technologies. However, only 20 companies agreed to take part in interviews. For the interviews, a reference questionnaire, with open questions, was developed. The questionnaire was structured into three sections:

- general information (i.e., organisation, markets, products and processes) on the companies
- NPD process analysis
- GPD network assessment.

Phone and e-mail interviews were conducted. R&D managers, chief information and executive officers were interviewed. The main results of the interviews are detailed in the following sub-sections.

3.1 General information on the companies

The first section of the questionnaire focused on the characterisation of the companies (e.g., size, industrial sector, headquarter location, etc.). As can be seen in Tables 3–5, the Italian sample is mainly made up of large companies (60%) from different industries (principally automotive) and SMEs (40%).

Table 3 Size of companies

Company's size	*Relevance (%)*
Small (< 250 employees, revenue < 100 M€)	25%
Medium (< 1,000 employees, revenue < 500 M€)	15%
Large (> 1,000 employees, revenue > 500 M€)	60%

Table 4 Industrial sectors

Industrial sector	*Relevance (%)*
Aerospace	10%
Automotive	30%
Design	5%
Electrics	10%
Furniture	10%
Mechanics	25%
Thermo-hydraulics	10%

Table 5 Location of headquarters

Headquarters' location	*Relevance (units)*
Italy	16
Outside Italy	4

3.2 NPD process analysis

The second section of the questionnaire focused on the assessment of the importance of NPD units within the company (e.g., in terms of engineers in the NPD department, product complexity, IT supporting technologies, etc.). Examples of related research questions from the literature are:

- How many engineers (of any kind) work in the NPD department?
- How complex (e.g., in terms of families, components, embedded technologies) is the product?
- What are the available technologies supporting NPD activities?
- What are future provisional IT changes?

Tables 6–8 show that half of the sample has more than 100 employees in NPD units. In the majority of the companies, the complexity of the product is medium-high. Furthermore, PDM and CAx tools are widely used. With regard to future perspectives, the global crisis influenced both GPD budgets and technology investments in recent years. For example, companies owning distributed R&D centres reduced investments for the improvement of IT collaboration systems and companies planning on implementing new GPD strategies decided to postpone them for the near future. This result leaves a great deal of uncertainty about new GPD trends.

Table 6 Engineers in NPD departments

No. of engineers (any kind) in NPD dept.	*Relevance (%)*
Less than 25	30%
From 25 up to 100	20%
More than 100	50%

Table 7 Product complexity level

Product complexity level	*Relevance (%)*
Low complexity	30%
Medium complexity	25%
High complexity	45%

Table 8 Available NPD supporting technologies

Available NPD supporting technologies	*Relevance (%)*
CAx	15%
PDM + CAx	85%

3.3 GPD network assessment

The third section of the questionnaire focused on the characterisation of GPD systems (e.g., in terms of GPD network extension and composition, GPD representatives, etc.). Examples of related research questions from the literature are:

- How much is the GPD network extended (e.g., in terms of countries)?
- What is the composition of the GPD network (e.g., in terms of owned centres)?
- Who is responsible for the management of GPD technologies and strategies?

Tables 9–10 shows that GDP is widely used, within the sample, especially to collaborate with low-cost nations. Furthermore, the GPD network consists mainly of owned distributed centres.

Table 9 Distributed product development network extension

GPD network extension	*Relevance (%)*
Italy	5%
Europe	20%
Europe + USA	10%
Europe + India/China	40%
Worldwide	25%

Table 10 Distributed product development network composition

GPD network composition	*Relevance (%)*
Owned distributed centres	65%
External partners	20%
Owned distributed centres + external partners	15%

An interesting information comes from the role of GPD managers (see Table 11). By definition, GPD managers are senior managers responsible for:

- providing a vision to guide NPD programmes
- managing the distributed network of R&D partners
- participating and controlling day-to-day activities of international ventures.

However, there was a clear correspondence with NPD directors only in 20% of cases. In Other cases, the GPD responsibility was given to different roles or third parties.

Table 11 GPD management representatives

GPD manager	*Relevance (%)*	*GPD manager*	*Relevance (%)*
NPD director	20%	Tech office manager	10%
Design manager	15%	Marketing manager	5%
IT manager	15%	Operations manager	5%
R&D manager	10%	Product manager	5%
CAD manager	10%	Systems manager	5%

3.4 Cluster and qualitative analyses

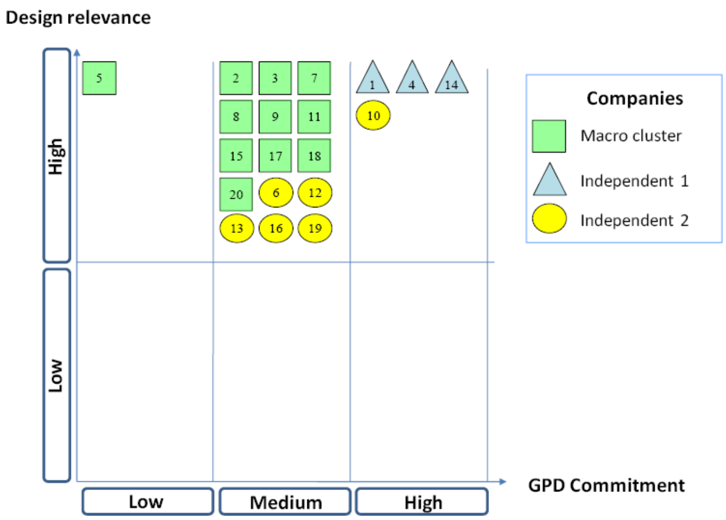
The collected data were condensed in a database and translated into a binary code. Cluster analysis was then implemented with a proper MATLAB function. The results pointed to the presence of three distinct groups of observations:

- ‘macro cluster’, or data consistently linked together, even after many levels of clustering
- ‘independent 1’, or data that, first than others, got out from the ‘macro cluster’
- ‘independent 2’, with data got out from ‘macro cluster’ only after many levels of clustering.

However, the clustering analysis did not shed light on the kinds of dimensions that influenced the distribution of the data Thus, the data were subjected to qualitative analysis, and a number of variables (both directly extracted from the questionnaire and specifically constructed from a mix of the previous ones) were directly compared. In the end, only four variables were able to explain the distribution of the data in a significant way. The variables are described below, and their interactions are shown in Figures 1–3.

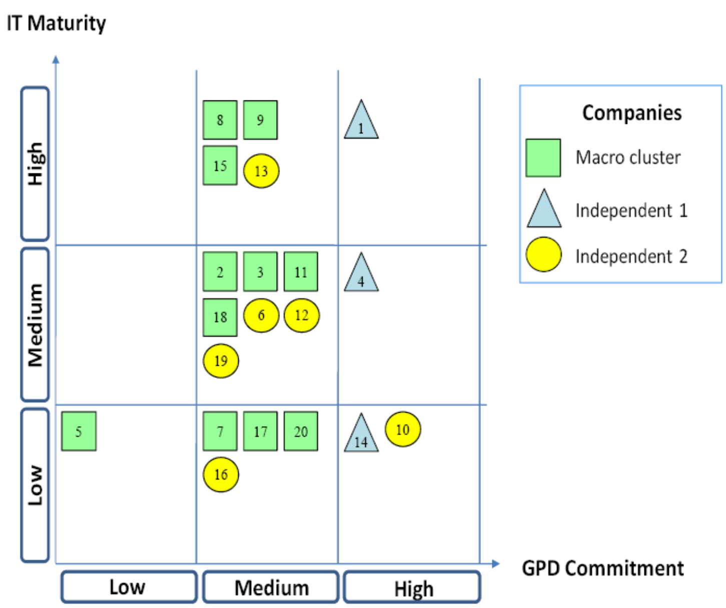
- *Design relevance:* This maps the importance of the design phase within the normal development cycle. As shown in Figure 1, the design relevance is high for all the companies within the sample due to the weighted sum of different product-related factors (e.g., complexity, size, value, etc.). Differences are due to the GPD commitment level, which is higher for the ‘independent 1’ cluster and medium-low for the ‘macro’ and ‘independent 2’ clusters.
- *GPD commitment:* maps the presence of an adequate organisational structure to exploit all the GDP potentialities and assesses the rules for distributed resources and facilities relocation management. Furthermore, it evaluates the GPD vision and the presence of a collaborative culture inside the company. As shown in Figures 1–2, GPD commitment is a good behaviours classifier. In fact, it is able to distinguish the ‘independent 1’ cluster positioning with respect to that of the other ones.
- *IT maturity:* This maps the presence of GPD systems within a company and classifies technologies used in normal business operations among those listed in the questionnaire (e.g., 3D CAD and PDM systems). The aim of the IT maturity variable is to assess progresses in GPD technologies. As shown in Figure 2(a), IT maturity is equally distributed among all the companies.
- *Partner localisation:* This maps the presence (or not) of R&D partners or distributed centres in low-cost or high-cost labour markets. As shown in Figure 2(b), the R&D partners of most of the companies are located in developing countries (13 of 20). Seven of the 20 continue have R&D partners only in developed countries.

Figure 1 Design relevance versus GPD commitment (numbers represent the company ID) (see online version for colours)



Note: Numbers represent the company ID.

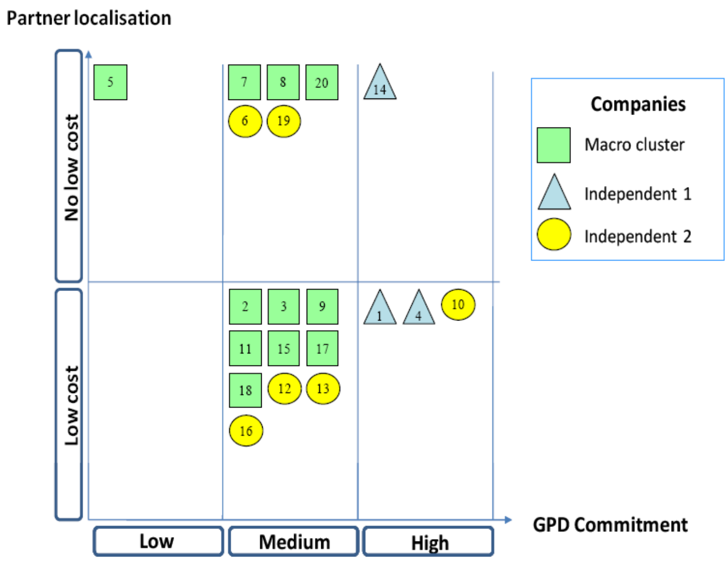
Figure 2 (a) IT maturity and (b) location of partners versus GPD commitment (see online version for colours)



(a)

Note: Numbers represent the company ID.

Figure 2 (a) IT maturity and (b) location of partners versus GPD commitment (continued) (see online version for colours)



(b)

Note: Numbers represent the company ID.

The GPD analysis in Italian companies revealed – but it might be evaluated with more detail and a wider sample – the following salient points:

- GPD drivers and strategies are not directly correlated to industries, but to company size (e.g., in automotive, electric and aerospace sectors).
- Technologies are not directly correlated to industries, but to product size and complexity. Most sophisticated GPD technologies are found in large companies making complex products, whereas there are fewer such technologies (both in number and functionalities) in SMEs.
- Organisational structures are not directly correlated to industries, but to company size and market responses, excluding the electric sector (that presents these correlations).
- Companies, during the implementation of GPD technologies, do not look at best practices. Only seven companies out of 20 claimed to do that in their industry. Other companies are usually driven by vendor advises, selected after a standard evaluation of IT investments.
- There is a direct correlation between the production of highly complex products and the location of R&D centres. The high complexity level pushes, in some way, companies to follow technological excellence. There was no correlation only in some cases (e.g., furniture and aerospace sectors), and different size-dependent behaviours were evidenced.

Starting from all these information, a new GPD strategy assessment tool was developed. This new tool is deeply described in the following Section 4.

4 Proposal of a new GPD strategy assessment tool

The literature review subsection on strategical views (see Section 2.4 for details) demonstrated that current GPD strategy classification models focus only on organisational and geographical factors, without considering the influence of technology. Hence, there is a clear need to create a new kind of GPD strategy assessment tool, which can take this additional side into consideration (better with a 3D representation).

4.1 Construction of the GPD strategy assessment tool

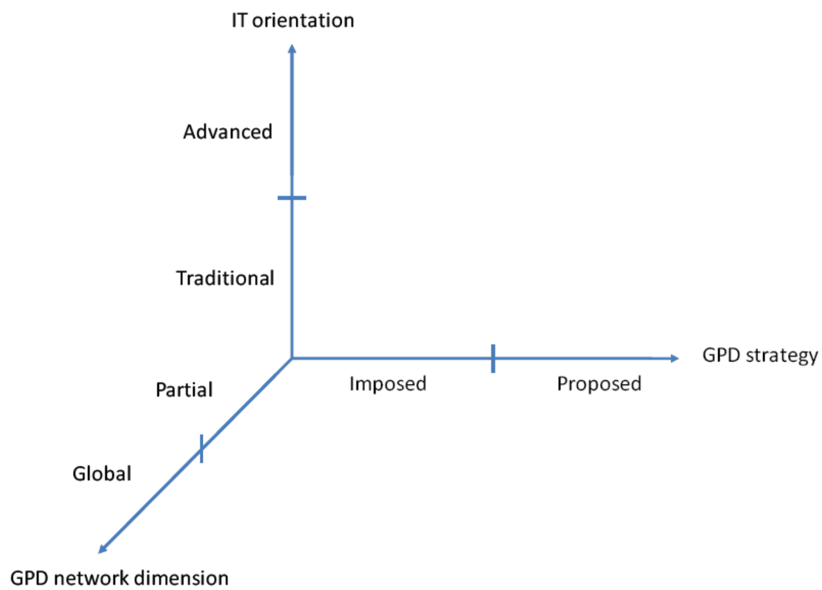
Important information for the creation of the GPD strategy assessment tool were obtained both from cluster and qualitative analyses (see Section 3.4 for details). The four variables identified as good classifiers were grouped into three new categories, as follows:

- *IT orientation:* It was derived from the IT maturity variable. It highlights the GPD technological innovation level within the company and the propensity towards new ways of collaboration. A rating scale was used to distinguish between 'advanced' and 'traditional' companies. Advanced companies have a strong and deeply rooted culture in distributed collaboration, supported by the latest technologies. Traditional companies remain tied to their cultural origins, using reliable, but outdated, collaboration technologies.
- *GPD strategy:* It was derived from the mix of GPD commitment and design relevance variables. It highlights the ability of firms to implement good GPD strategies by assessing:
  1. distributed organisational structures
  2. availability to cooperate with third parties
  3. strategic objectives
  4. role within the R&D chain.

  A rating scale was used to distinguish between 'proposed' or 'imposed' strategies. In the first case, companies accept the use of external inputs heading the distributed R&D chain. In the second case, companies are exclusively engaged in distributed R&D chains (as partners or de-located centres), taking GPD directives from others.
- *GPD network dimension:* It was derived from the partners' localisation variable. This dimension considers not only the presence of distributed sites in high- or low-cost labour markets but also the number of owned distributed R&D centres and external collaborators. A rating scale distinguishes between 'global' and 'partial' networks. In the first case, R&D centres (both owned and independent) are located around the world and constitute a very complex network. In the second case, R&D centres are located only in developed countries, and the cooperation network is limited.

These three dimensions can be useful (both in pairs and together) to assess the GPD strategy of a company based on multiple points of view and to define a hypothetical 3D assessment space (see Figure 3).

Figure 3 The new GPD strategy assessment tool (3D view) (see online version for colours)



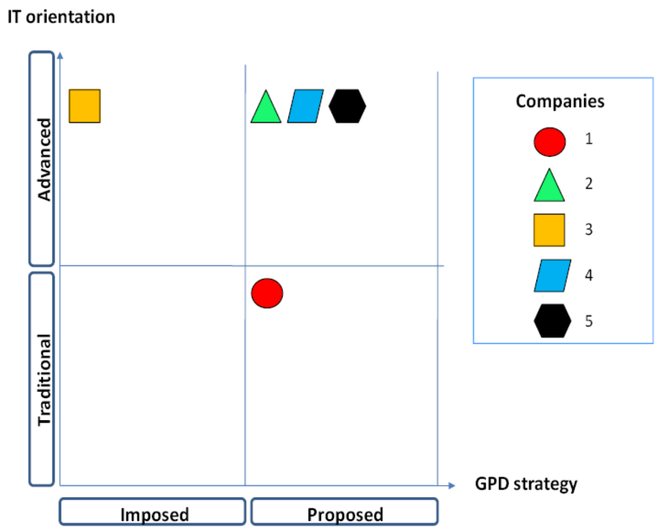
Note: Numbers represent the company ID.

4.2 Application of the GDP assessment tool to a tuning sample

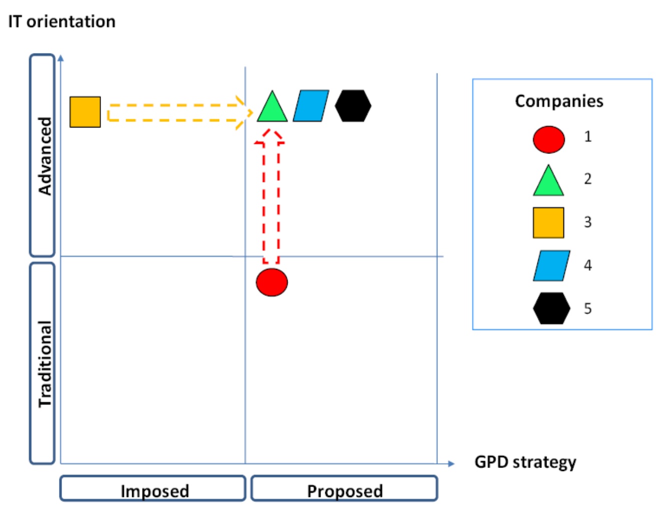
After defining the triad of classification axes, the new assessment tool was applied to a tuning sample to test its reliability. This sample was composed of an additional set of five companies (not considered before). To better comprehend its functioning, it was decided to adopt a 2D (rather than a 3D) view, each time considering just two of the three classification axes. Figures 4–6 show the current state of the tuning sample within the assessment tool and a list of possible future transitions.

Figure 4(a) shows the 2D view comparing IT orientation versus GDP strategy. The results show the presence of three companies (actors 2, 4 and 5) with high IT orientation and active participation in GPD strategies. Actor 3 has the same IT orientation but an imposed strategy. In contrast, Actor 1 has a low IT orientation but an active role in strategies definition. The first set of transitions [see Figure 4(b)] considers the position of Actor 1 and 3 in terms of IT orientation and the company's role within the GPD chain. The first case requires an investment in collaboration technologies. The second case depends on the negotiation power of a GPD partner within the network (not assessed with this tool).

Figure 4 (a) GPD strategy assessment tool first 2D view and (b) possible transitions (see online version for colours)



(a)



(b)

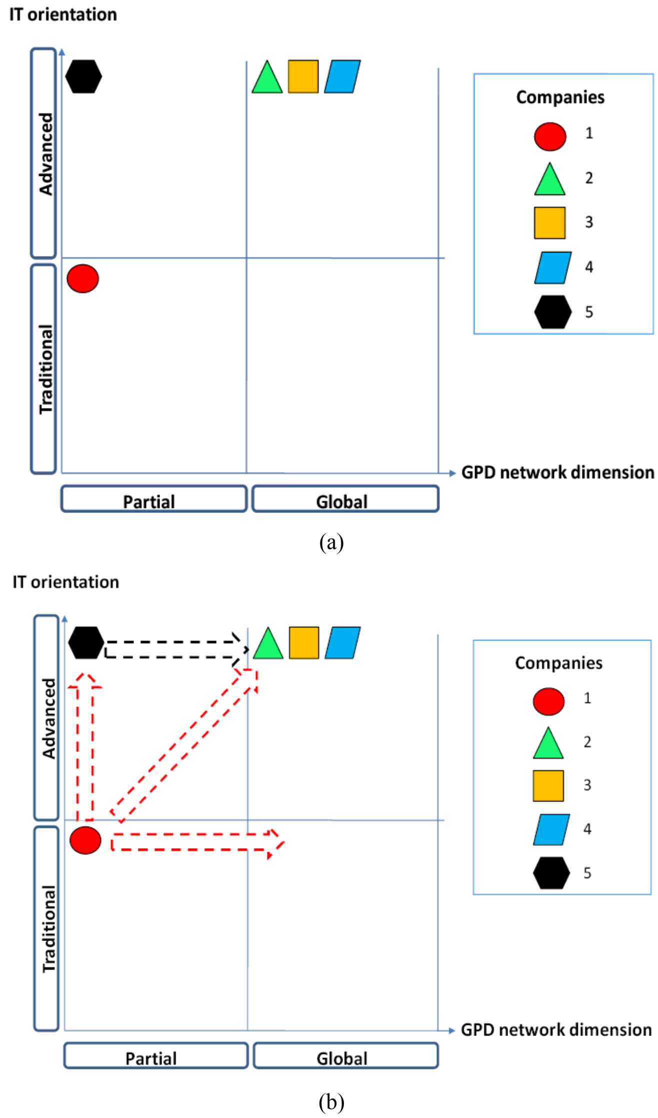
Figure 5(a) shows the 2D view comparing the IT orientation versus the GDP network dimension. The results demonstrate that only three actors (2, 3 and 4) have an extended network and high IT orientation. Actor 5 has the same IT orientation but a limited network. In contrast, Actor 1 has both a limited network and low IT orientation. A second set of transitions [see Figure 5(b)] considers the position of Actors 1 and 5. Actor 1 can:

- invest in collaboration technologies

- extend the network
- both.

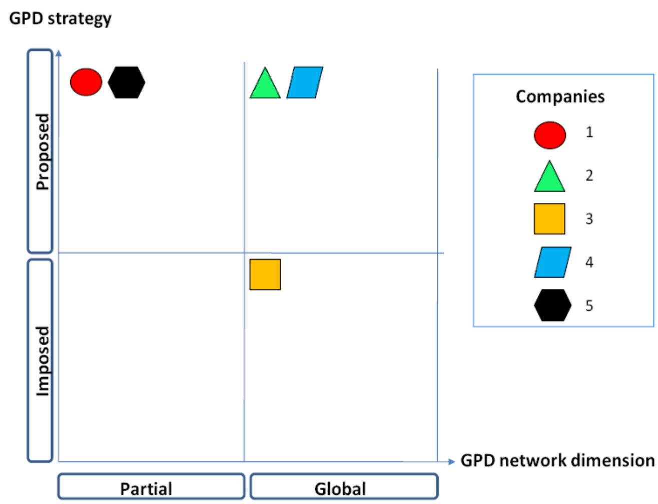
Actor 5 can only extend its network.

Figure 5 (a) GPD strategy assessment tool second 2D view and (b) possible transitions (see online version for colours)

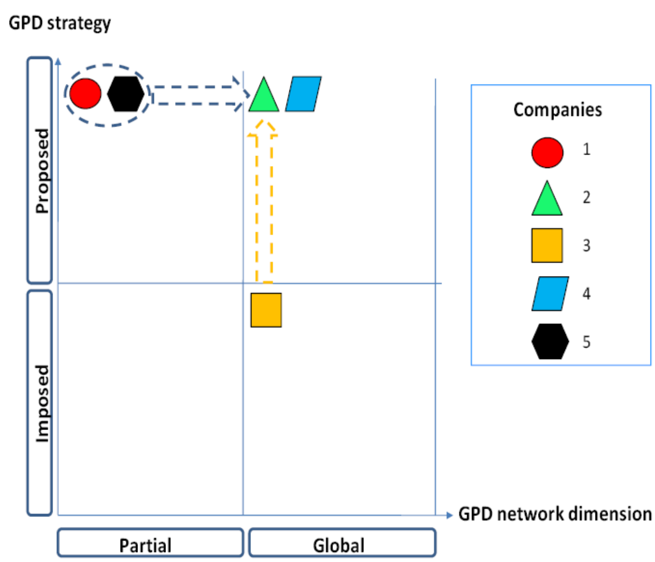


Lastly, Figure 6(a) shows the 2D view comparing GPD strategy versus GDP network dimension. The results show that Actors 2 and 4 have a wide GPD network, together with active participation in GPD strategies. Actor 1 and 5 have the same active role, but they have a limited network. Actor 3 has a passive role in GPD strategies, but it has an extended network. A third set of transitions [see Figure 6(b)] considers the position of Actors 1, 3 and 5. Actor 1 and 5 can act to extend their collaboration network. Instead, Actor 3 can only try to modify its position within the GPD chain based on its negotiation power.

Figure 6 (a) GPD strategy assessment tool third 2D view and (b) possible transitions (see online version for colours)



(a)



(b)

Summarising all the proposed available transitions, a list of the most interesting ones is present in Table 12.

Table 12 Some examples of GPD strategies assessment

Type of company	*GPD strategy*	*IT orientation*	*GPD network dim.*	*Description*
Newcomers	Imposed or proposed	Traditional	Partial	SMEs or MNCs entering a GPD network for the first time. Evolutions are available in all dimensions indistinctly.
Independent partners	Imposed	Traditional	Global	SMEs or MNCs engaged in a GPD network. Evolutions in IT orientation and GPD strategies are available. Strategic changes related to decisional powers are possible.
Distributed centres	Imposed	Advanced	Partial	MNC-owned distributed R&D centres. Evolutions in GPD network dimension or strategies are available. Strategic changes related to decisional powers are possible.
Global firms	Proposed	Advanced	Global	MNC headquarters leading the GPD strategy worldwide. As the MNCs have advanced in all dimensions, they can only improve their position by following best practices.

5 Conclusions

This paper described the construction of a new assessment tool, which can be useful to support the implementation of new GPD strategies by customising available technologies to specific needs. To better comprehend the current state of knowledge on GPD and identify knowledge gaps, a wide literature analysis was implemented. Starting from the evidenced lacks, a specific questionnaire was constructed, trying to gather information directly from the field. This study allowed to assess the current state of 20 Italian companies on GPD. Data were inserted into a database and classified both with cluster and qualitative analyses. The results identified three classification axes constituting the assessment tool. The limitations of the tool are the impossibility to specify the following:

- types and locations of R&D centres
- ownership of resources
- local needs sensitivity.

However, these three areas were implicitly considered within the axes. The benefits of the tool are the possibility:

- to compare GPD organisations, technologies and strategies at the same time
- to exploit a virtual 3D representation

- to evaluate 'as is' and 'to be' states (even if the tool cannot directly measure the accomplishment of future transitions).

Future developments will consider the assessment tool application on a wider sample.

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