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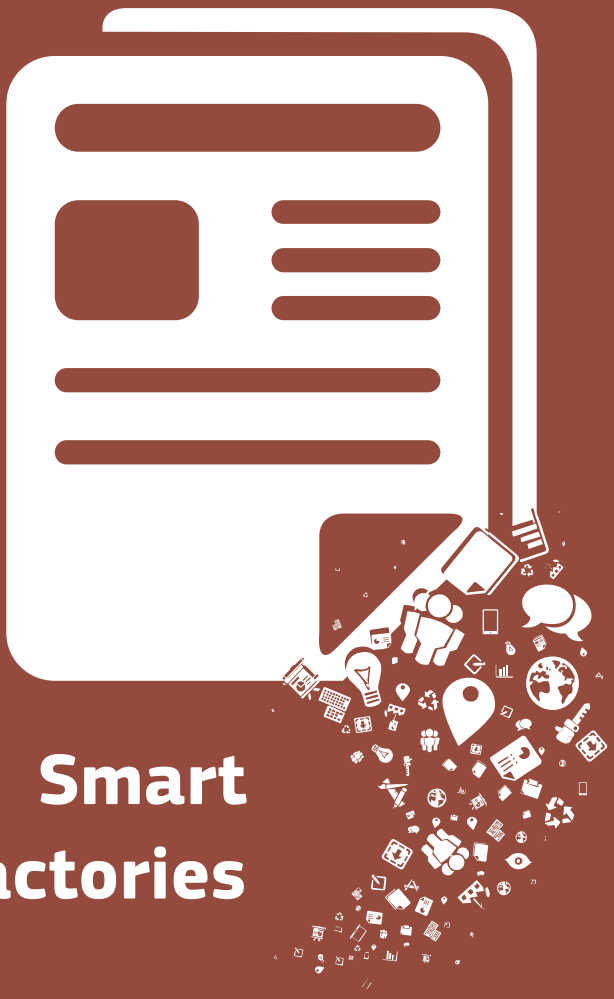
Business Innovation Observatory



Smart Factories

Crowdsourced manufacturing

Case study 27

Enterprise and Industry

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Smart Factories

Crowdsourced manufacturing

Business Innovation Observatory
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Authors: Diederik Verzijl, Kristina Dervojeda, Fabian Nagtegaal & Jorn Sjauw-Koen-Fa, PwC Netherlands, and Laurent Probst & Laurent Frideres, PwC Luxembourg.

Coordination: Directorate-General for Enterprise and Industry, Directorate B "Sustainable Growth and EU 2020", Unit B3 "Innovation Policy for Growth".

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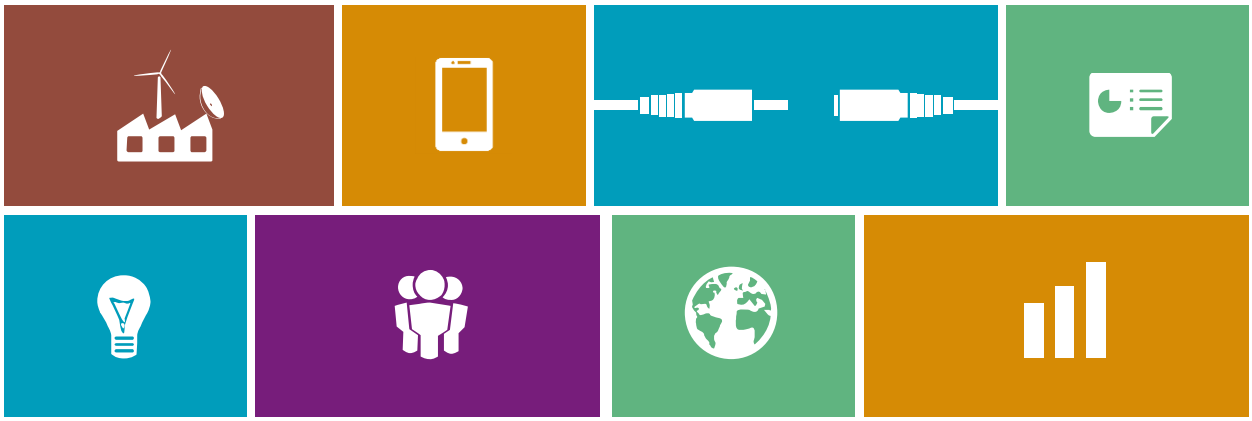


1. Executive summary

Crowdsourced manufacturing is the process by which **manufacturers complement and expand their processes** with capabilities, tools, equipment, and ideas from a **large group of people rather than from their own employees or their commissioned suppliers**. Crowdsourced manufacturing covers various forms of interaction (such as online contests, interactive forums, online design), between manufacturers and a community (online) of consumers, specialists and intermediaries such as crowdsourcing platforms.

Crowdsourced manufacturing offers a variety of benefits. It offers **quick access to specialised human resources** and benefits from the innovative strength of idea generation outside an organisation rather than draw from internal ideas. Crowdsourced manufacturing can also decrease production cost through better alignment of consumer needs with product specifications, less need for in-house R&D, and shorter time to market.

The market potential of crowdsourced manufacturing is stretches **all along the manufacturing value chain and across different sectors,** including advanced manufacturing and consumer goods. By 2017, more than half of consumer goods manufacturers are expected to receive 75% of their new consumer product development inputs from crowdsourced solutions rather than in-house R&D capabilities.

The companies that are showcased in this case study are offering innovative solutions to enable crowdsourced manufacturing. The common denominator of these companies is the way in which they leverage communication technology to spread the request for assistance around the world, and through which they manage to collect huge numbers of ideas and solutions. Companies like Quirky and Shapeways show that they are able to create manufacturing jobs in advanced economies. Their business models enable close proximity between a manufacturer and an online community of experts. Crowdsourced manufacturing is able to spur productivity and has great potential to revolutionise manufacturing by reshoring parts of the manufacturing value chain to Europe.

Three major obstacles need to be overcome before crowdsourcing can become mainstream: fear of change and unawareness by organisations adopting crowdsourced manufacturing solutions, intellectual property issues, and a lack of design sharing technologies.

The growth of crowdsourced manufacturing has been **driven by rising production cost in traditional production economies**, by the emergence and benefits of additive manufacturing, and by the growing maturity of different crowdsourcing platforms such as eYeka, Hypios and the platform that has been developed by General Electric (GE), Massachusetts Institute of Technology (MIT) and an American defence institute, Defense Advanced Research Projects Agency (DARPA). Moreover crowdsourced manufacturing has gained a lot of attention and awareness in the press in the last years. However there are also some reported obstacles for further upscaling such as gaining and maintaining an online community of experts by platforms.

Policymakers can facilitate and stimulate the growth of crowdsourced manufacturing. Crowdsourced manufacturing is redefining the labour **relationships between online communities as labour force and platforms and manufacturers as employers**. This might require a new regulatory framework for flexible labour contracts. Moreover, policymakers could help developing standards for sharing open data. From a client side, further adoption could be increased by R&D tax breaks for users. It is also recommended that governments participate in crowdsourced manufacturing.

2. Crowdsourced manufacturing

Traditionally, manufacturing companies have sourced ideas exclusively from their employees, suppliers and business partners. As market conditions change and modern digital technologies have created new possibilities, companies in the manufacturing sector are exploring the **potential of tapping into the broader community**, to solve a problem or design a product in a co-creative spirit.

The explosion of social media, smart phones, and apps has provided the opportunity to create online platforms through which workers and tech-savvy consumers communicate. Crowdsourcing enables a company to **broadcast an issue to a diverse audience** — using a variety of social media and collaborative software solutions — and ask them to contribute ideas to solve the problem.[1] Organisations that have embraced crowdsourcing have experienced surprising solutions to internal problems and innovation needs, particularly in the manufacturing sector.

Crowdsourcing in manufacturing is defined as the process by which manufacturers complement and expand their manufacturing processes with manufacturing capabilities, tools, equipment, processes and ideas from outside their organisational boundaries tapping into a larger mass of people, typically by means of internet-enabled solutions There are **four categories in which manufacturers apply crowdsourcing,** from research & development to design (Table 1): crowdsourcing to innovate, crowdsourcing to research new concepts, crowdsourcing to design new products, and crowdsourcing to fine tune design and concepts.[2]

Table 1: Typologies of crowdsourcing within the manufacturing industry[3]

Type	Description
Crowdsourcing to innovate	While employees have historically been the force behind innovation, an online community of users give manufacturers a way to think outside the box. Crowdsourcing allows businesses to tap into a broader supply of talent instead of letting innovation be restricted by the ideas, concepts and abilities of in-house employees. 'Crowd workers' give a new perspective and new ideas come with that perspective.
Crowdsourcing to research new concepts	No business can continue to thrive in today's marketplace without creating new products or services, simply because whatever they do not provide, competitors will. Using an online community of users to evaluate new concepts helps any manufacturer learn more about the viability of taking something from the idea phase to the development phase. Within the crowd, these evaluations come from the very people who are likely to use a company's products.
Crowdsourcing to design new products	No one knows what consumers want better than consumers themselves. By tapping into the power of an online crowdsourcing community to design products with existing concepts in place, manufacturers position themselves to create much more market-friendly products. Using an online crowdsourcing community to design the look and feel of a product creates a product that is more in tune with what consumers want.
Crowdsourcing to fine tune design and concepts	Once a product has gone through the idea phase and progressed past the initial development phase, it is likely to require many adjustments before going to market. Crowdsourcing products at this stage lets manufacturers get feedback from potential customers. Like the benefit that crowd workers provide in the initial design phase, they can offer suggestions on everything from material choice to the location or function of product features.

One of the first multinationals to venture into crowdsourcing was Procter & Gamble, which tried out crowdsourcing in 2002 to find a way to print images onto Pringles cans. Their search led them to a small Italian bakery that had figured out how to print images onto pastries. Proctor & Gamble licensed the technology and was able to bring their idea to the market in a timespan of little less than a year[4].

Today, engineers, scientists, IT professionals and marketers are engaging online crowds much more aggressively and with increasing frequency.[5] Using digital channels to reach a larger and more anonymous pool of intellect and opinion, manufacturing companies can leverage the online crowdsourcing community effectively because online technology has matured. In fact, after the initial success with Pringles, Proctor & Gamble decided to expand their crowdsourcing efforts, and they currently rely on outside collaboration for a full 50 percent of their innovations. Technology research company Gartner sees a massive, technology driven shift towards applications of crowdsourcing, such as online advertising, online communities, scientific problem solving, internal new product ideas, and consumer-created products.[6]

An American SME called Quirky is heavily engaged in a crowdsourced manufacturing process in cooperation with GE, leveraging a registered pool of crowdsourcing users of 500,000 people to come up with creative new products based on GE patents, such as the Aros – the smart air conditioner that was developed in partnership between Quirky and GE. In fact, GE announced it will invest EUR 21.5 million into Quirky and launch 30 new products through this collaboration over the next five years.[7] GE believes its partnership will drive faster innovation and scale.

GE is not the only large company that embraces crowdsourced manufacturing. Other large multinationals, like Unilever, Philips, L'Oreal and BMW are adopting crowdsourced manufacturing to gather ideas, inventions and patents in order to innovate, research and adapt design using an online crowdsourcing community.[8]

Relying on crowdsourcing in the manufacturing industry, companies can **bring products to the market faster and at a lower cost** and thus speed up innovation. *The Economist* goes as far as mentioning that as the manufacturing industry goes digital, it could revolutionize the way things are done today completely.[9] By combining the , and how policymakers can further encourage the adoption of crowdsourced manufacturing.

insight of people outside of a company with the smart people inside it, solutions are created faster than they otherwise would have been. Crowdsourcing allows cost-effective production of much smaller batches, with more flexibly and with a much lower input of labour, thanks to collaborative manufacturing services. In combination with new materials and 3D printing, crowdsourced manufacturing could move companies away from mass production and towards much more individualised manufacturing.[10] By engaging with an online crowdsourcing community early and by prototyping small quantities, large conglomerates can cut down on the risk of mass producing an unwanted product, but it also means these companies can scale up once a product proves itself in the market. And that in turn could bring some of the jobs back to advanced economies that were outsourced to the emerging economies.[11]

This case study will explore how companies have developed crowdsourcing opportunities in the manufacturing sector. Taking the perspective of six case companies that are specialised in crowdsourced manufacturing solutions, this study will examine the impact of innovations in this area, the drivers of market uptake of their products

Figure 1: Aros, the smart air-conditioning developed by GE and Quirky

Source: Quirky

3. Socio-Economic Relevance

Crowdsourced manufacturing is a social-economic relevant trend for reasons that include improving the exchange of ideas between consumers and manufacturers and increasing the time-to-market of new product development and the impact it has on the organisational structure of firms.

Adoption of the trend by the manufacturing industry allows specialised skills to be dynamically sourced — from anyone, anywhere, as needed — for everything from data entry and coding, to advanced analytics and product development. The potential for disruptive impact on cost alone could make early experimentation worthwhile, yet there are broader implications for innovation in the enterprise and for society, as will be further elaborated upon in the sections below.

3.1. The benefits of crowdsourcing for the manufacturing market

As Sun Microsystems co-founder Bill Joy noted already in 1990: "No matter who you are, most of the smartest people work for someone else."[12] Today, more and more enterprises in the manufacturing industry are harnessing the "crowd" to help with a wide mix of challenges, ranging from **easy tasks to complex challenges requiring specialised skill sets, as well as creative endeavours and even strategic planning**. The idea of open source talent via crowdsourcing is becoming industrialised and growing in scale, sophistication, and importance as an alternative staffing model. The goal is not just cost savings but also to benefit from quick access to specialised resources, from the ability to dynamically scale up (and down) around workloads, and from improved geographic coverage in quickly changing markets.

*"No matter who you are, most of the smartest people work for someone else" – **Bill Joy (Sun Microsystems)***

Businesses, and also manufacturing companies, have a rich history of trying to tap into different crowds, such as consumers, suppliers and experts from outside of the organisation. To this end, these companies used and still are using consumer surveys, focus groups, and experiential marketing to provoke customer engagement. Product R&D in particular has seen significant activity, with open innovation campaigns launched by many large companies, including 3M, BMW, General Mills, and Stanley Black & Decker. More recently, companies have flattened their organisations and reorganised their structures in a way that makes it easier for people within the organisation to connect with information and specialists that allow them to grow ideas and solve pressing problems across a wide spectrum of domains.

*"By 2017, Gartner estimates more than half of consumer goods manufacturers will receive 75 percent of their consumer innovation and R&D capabilities from crowdsourced solutions" - **Gartner**[13]*

Beyond improving the exchange of ideas, crowdsourcing can also be useful for **keeping companies in touch with the market**. Procter & Gamble is not the only large company seeking the wisdom of crowds for product innovation. Clorox, Siemens, L'Oreal and Philips and others regularly rely on networks such as Hypios and eYeka to crowdsource their product ideas.

A third important beneficial feature of crowdsourced manufacturing is that it can drastically **reduce the time to market** of product development by manufacturers. Product development and innovation can take years for large companies to develop from initial idea to an item available on retail shelves.[14]

Start-up Company Quirky, which will be introduced further on, is challenging current wisdom by crowdsourcing the product development process, shortening the invention timeline of new products from years to weeks. In 2012, Quirky received the attention of GE during its launch of 121 new products and sale of 2.3 million units. The short development schedule is deployed made an impression on the board of GE, so much so that the company opened its patent library to the Quirky community to enable development of new consumer products. Products developed by Quirky begin as one of approximately 3,000 ideas submitted weekly by the Quirky community. As ideas are submitted, community members vote for the ideas they like. Those with the most votes are reviewed by industry specialists and community members who select products for production. During development, the community influences the product roadmap by voting on issues ranging from colour and price to specific engineering requirements.

In another example which will be showcased below, the first U.S. crowdsourced military vehicle has been developed and produced in less than six months through crowdsourcing (Table 2 on page 6 and 7).

3.2. The market potential of the trend

The conditions for a high market potential of crowdsourced manufacturing solutions are favourable. From the supply side, the number of people online is projected to increase from 2.4 billion today to 5 billion by 2020[15]. These minds, armed with ever more affordable tablets and devices, will dramatically increase the general availability of intellectual capital. The technologies and resources now exist for virtually anyone to become skilled in anything very quickly.

The demand for solutions to enable crowdsourced manufacturing will also increase. By 2017, more than half of consumer goods manufacturers are expected to receive 75% of their new consumer product development inputs from crowdsourced solutions rather than in-house R&D capabilities.

The added value of this trend impacts the entire manufacturing value chain, from product development to business support functions and customer service. Moreover, this applies to a variety of manufacturing sectors, e.g. consumer goods, and advanced manufacturing, e.g. semiconductors, automotive, and aerospace and defence.

According to research company Gartner, consumer goods companies that employ crowdsourcing in marketing campaigns or new product development will boost their revenue by 1% compared to "non-crowdsourced competitors" by 2015.[16] So crowdsourcing does bring companies a competitive edge, according to Gartner. The research company also sees a massive shift toward applications of crowdsourcing, driven by technology, such as: advertising, online communities, scientific problem solving, internal new product ideas, and consumer-created products.[17]

Table 2: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
Shapeways	Netherlands and United States	A printing marketplace and service start-up company. Users design and upload 3D printable files, and Shapeways prints the objects for them or others. Users can have objects printed from a variety of materials, including food-safe ceramics, in a variety of locations.	In 2013, Shapeways employed over 90 people. Shapeways is a spin-out of the lifestyle incubator of Royal Philips Electronics. The company has a community of 300,000 members and three million products in its online catalogue. They also have 10,000 shops selling designs and items. Each month, the company receives prints and ships 60,000 orders to customers all over the world.
Quirky	United States	When a user submits an idea and if enough people like it (as on Facebook), Quirky's product-development team makes a prototype. Users review this online and can contribute towards its final design, packaging and marketing, and help set a price for it. Quirky then looks for suitable manufacturer world-wide and often in close proximity of its customers.	The company has brought more than 100 new products to the market so far, selling to big-box stores like Target, Bed Bath & Beyond, and Best Buy. It has attracted close to EUR 70 million in investments, and secured a contract with General Electric.
Hypios	France	Hypios uses software that allows users to find experts for specific challenges on the world wide web. This ensures that problems are not broadcasted to the entire world, but instead are 'narrowcasted' to relevant expertise in a pre-selected range of scientific discipline. This helps maximise the number of relevant solutions by applying 'intelligent crowdsourcing'.	Hypios, which draws from a network of over 950,000 experts across the world, has been solving R&D problems for global companies since 2008.
Vehicleforge.mil by General Electric	United States	GE and MIT are working to build and demonstrate a crowdsourcing platform to support DARPA's Adaptive Vehicle Make (AVM) portfolio. The crowdsourcing platform is a key part of GE's efforts to build the Industrial Internet. It will connect data, design tools and simulations in a collaborative environment to accelerate the design of highly complex industrial systems.	GE has won a Manufacturing Leadership 100 award in recognition of its work to build a new, cloud-based, software platform that enables a global community of experts to share ideas, design, and build complex cyber-physical systems securely on the Internet

eYeka	France	eYeka enables manufacturers to directly involve their customers into the design of new products by leveraging creative ideas developed by a community of 250,000 creative individuals in 154 countries.	40 large brands such as P&G, Kraft, Coca-Cola, Unilever, Nestle, Danone, Hyundai, Citroen and Microsoft are tapping into eYeka's community.
InnogetCloud	Spain	InnogetCloud is an open innovation tool that is marketed as "Software as a Service" (SaaS). With InnogetCloud, clients are able to build an open innovation marketplace where their organisation's members can interact and collaborate by posting technology offers and requests. The service is aimed at companies, universities, science parks, technology clusters, business associations, public institutions that promote innovation.	Innoget.com has currently more than 40,000 users and a global community from 16 different industry areas formed by large companies, universities, SMEs, spin-offs, research centres and scientists.

3.3. Companies offering innovative solutions to enable crowdsourced manufacturing

The companies in this case study offering or adopting solutions to enable crowdsourced manufacturing demonstrate the scope of activities to which crowdsourced manufacturing can be applied. The companies in this case study are Shapeways (The Netherlands), Quirky (USA), Hypios (France), General Electric (United States), eYeka (France) and Innoget (Spain).

The current section shows how the solution developed by the showcased companies solves common development, production or marketing problems in the manufacturing industry. The common denominator between the companies is the way in which they leverage information and communication technology to spread requests for assistance around the world and to garner huge numbers of options and ideas.[18]

Problem 1 – Small-batch production of individual designs is expensive and manufacturing companies that are willing to produce single items or small batches are rare and hard to find.

Innovative solution 1 – **Shapeways** is the link between a **3D printing firm and a consumer-facing marketplace**. The website of The New York City-headquartered company allows product designers to upload 3D designs and sell them to online customers, who can choose a plastic, ceramic or metal material and sometimes also customise or personalise the product. Shapeways then prints the object in one of its factories in New York, USA or Eindhoven, The Netherlands, and mails it to the customer.

Shapeways is not the only company that applies this approach, but it currently is the largest company providing these services. Some 10,000 people are selling 1,000,000 designs to 150,000 customers so far. Shapeways informs designers on the manufacturing cost of the product they designed, after which the designers can set the sales price.

Shapeways' 3D printing concept

Source: Shapeways

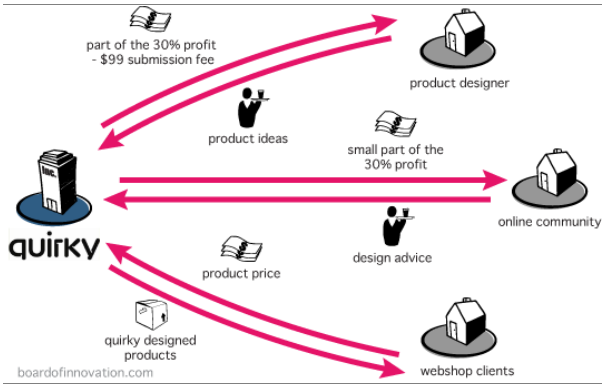
Problem 2 – It is expensive to manufacture a prototype based on an idea, and time consuming to gauge whether this prototype has any market potential. After that, getting a prototype of a good looking product into mass production is complex. Product development and innovation can take years for large manufacturing companies to develop from initial idea to an item available on retail shelves.

Innovative solution 2 – Start-up company **Quirky** enables crowdsourcing of the product development process, managing to shorten the invention timeline of new products from years to weeks.

The concept of Quirky is relatively simple. First, the platform allows inventors to share an idea with the community. The **community, in turn, offers feedback and suggestions for refinement**. Every week, the community rates idea that it thinks have a shot of becoming commercially viable, and offers pricing suggestions. The Quirky team meets each week to decide which ones will move forward.

Quirky's founder, Ben Kaufmann, created the site tapping into his own experience of getting a product to the market. The crowdsourcing community now green lights approximately one product every few days. The site receives thousands of submissions every week, many of them from inventors with multiple ideas. Approximately 40 percent of the community comes from outside of the United States. Products that move forward are marketed under the Quirky brand name; the company focuses not so much on flash branding but on highlighting the specific problem that the invention solves. Products are shipped to more than 20 different countries; consumers can buy them online and Quirky has now forged relationships with large retailers to increase their distribution possibilities.

Quirky's business model based on selling product ideas



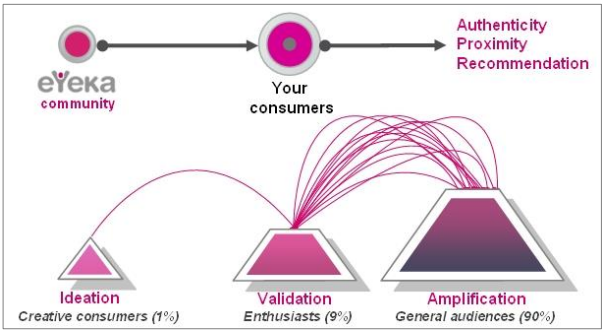
Source: Board of Innovation, Quirky, get paid to influence product designs[19]

Problem 3 – Failure rates when a product hits the market remain too high. This is because consumers are mostly involved periodically as validators, and not as co-creators.

Innovative solution 3 – By facilitating the co-creation of new products with help of customers, **eYeka** helps leading companies to create new categories and new products, or to transform existing ones.

One of the many examples is Oral-B (Procter & Gamble). This manufacturer of dental care products has launched a product based on idea generation that was made possible by eYeka. To accelerate the development of the world's first bluetooth connected toothbrush, Oral-B launched an unbranded contest on eYeka's crowdsourcing platform to seek original ideas on what such a product could offer consumers. In just 22 days, Oral-B received 67 unique and innovative ideas from community members in 24 countries across the globe. Stephen Squire, BFO Marketing Director, Procter & Gamble commented, "We knew time was critical and the company that could launch the first product would have a huge first mover advantage." The eYeka community gave them the head start needed and helped them anticipate some of the problems that Oral-B had to consider in the development of the product; in particular the importance of content, gamification, family interaction and socialisation. Out of these 67 creative ideas, Oral-B selected three winning ideas that came from Yao Peipei from China ("YPPP1117" on eYeka), Javier Alcázar from Spain ("Moebius" on eYeka) and Thibault Berrido from France ("Thaubyas" on eYeka). The three winners shared EUR 2,500 of prize money.

eYeka's proposition is based on commoditising, not of the creative process but of its own community. In terms of Forrester's 90-9-1 rule, eYeka's community is a mercenary 1%, a creative hydrogen bomb for hire, exploding content into social media channels, then disappearing without trace.



Source: eYeka

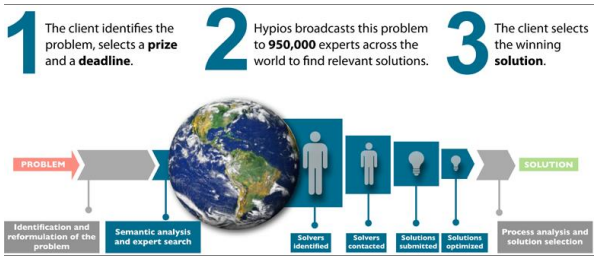
Problem 4 – Many R&D crowdsourcing platforms present their challenges to individuals from all scientific disciplines. In such a process, individuals interested in the details of the challenge need to sign up to receive additional information. Also, they themselves determine whether they can offer a valid solution. Therefore, the ability to broadcast (in this case 'narrowcast') problems to solvers in relevant fields, bypassing the last filter mechanism (the solver's own 'self-censorship' on whether or not he/she can provide a solution) is key in enhancing successful problem resolution.

Innovative solution 4 – **Hypios** combines intelligent crowdsourcing, competency discovery technology, and human outreach, to deliver an optimal open problem-solving service. 'Seekers' post R&D problems to the network and select a deadline and a price for the successful 'Solver'. Hypios, then, 'narrowcasts' this information to all experts it deems best capable to engage the problem. Hypios draws from a network of over 950,000 experts across the world, and has been solving R&D problems for global companies since 2008.

To identify the disciplines and people best capable of providing novel solutions, Hypios has developed patented semantic technology called hy.Proximity. The standard procedure when they have a new innovation challenge on Hypios is to feed the problem statement into hy.Proximity which suggest keywords related to the problem, and look for experts in their large, cross-domain, 950,000 expert database. Finding keywords relevant to the problem and that do not appear in the problem text is important in order to reach the relevant experts in most diverse domains, who might be able to bring an innovative solution.

Since 2009, 189 solutions have been submitted to clients in 10 different areas of expertise. The average time between problem submission and acquired solution is three months.

Hypios crowdsourcing process



Source: Hypios

Problem 5 – Designing and building things for the United States military is a notoriously slow-moving and costly endeavour. The time from idea to manufacturing for a new armoured personnel carrier or a tank is typically 10 to 20 years.[20] The Defence Advanced Research Projects Agency (DARPA) wants to change that, and drastically so. It seeks to cut the design-to-production cycle to two to four years.

Innovative solution 5 – Crowdsourcing and prize contests are crucial ingredients in order to speed-up new product development. The crowdsourcing effort relies on a software initiative, called **Vehicleforge.mil**, which will be a Web portal for gathering, sharing and testing ideas. The project is a collaboration between GE, MIT and DARPA.

The software is designed to allow DARPA to solicit and attract new ideas and concepts that could shape the design and manufacture of military vehicles and other complex defence systems. Scientists, engineers, and others can use the software to team up on projects and freely submit, re-use, re-shape, or build upon designs that have been shared by DARPA. As they evolve, designs can be tested and vetted by those in the crowd.

What stands out about the Vehicleforge.mil project is that it is essentially a software "engine" that contributors use to plug in simulated components. Then, the new part or subsystem can be tested virtually.

The Vehicleforge.mil program will allow solo inventors or small teams to tap into the capabilities of Vehicleforge online. For example, a vehicle body and chassis design, submitted as code, could be plugged into the Vehicleforge.mil platform and tested for aerodynamics in a virtual wind tunnel.

A template for how teams competing in DARPA's online challenge can design a vehicle in an online foundry called VehicleFORGE

Source: WIRED[21]

Problem 6 – In every organisation, innovative ideas and solutions are distributed amongst the members of that organisation. A lot of organisations are neither taking enough advantage of the innovative power hidden in its own workforce, nor of that present outside its workforce in an online crowd of experts.

Innovative solution 6 – InnogetCloud is an open innovation portal that is marketed as Software as a Service which implies that its users can use software offered by Innoget to program their innovation portal over the internet. With InnogetCloud, clients are able to build an open innovation marketplace where their organisation's members can interact and collaborate by posting technology offers and requests. Among others, it is aimed at companies, technology transfer offices at universities and science parks (TTOs), technology clusters, business associations and economic promotion agencies. With InnogetCloud they have their own exclusive open innovation marketplace, with the organisation's own branding and 'look and feel'. They can generate internal collaborative opportunities in R&D and innovation, and will be connected to innoget.com in such a way that they can control and manage the flow of information (offers, requests, solutions, contact requests) between users of their open innovation platform and innoget.com.

"Usually you have months of freight time to ship from China. But for Crates we knew we couldn't afford the luxury of weeks on the water." – ***Ben Kaufman, Quirky***

The open innovation model behind Innoget Cloud

Source: Innoget Cloud

3.4. The creation of new markets and jobs

Over the past decades, often low-skilled manufacturing jobs have been relocated from advanced, knowledge intensive economies towards low cost countries, e.g. to Asia. Crowdsourced manufacturing has the potential to attract some of these jobs back to Europe, by transforming the job tasks involved in manufacturing from low-level ones that can easily be outsourced into highly skilled job tasks that can best be performed in the proximity of high-tech clusters as illustrated in the examples below.

Shapeways for example has hired 50 engineers, distribution specialists, and machine operators to staff the factory that they opened in 2011 and plans to hire more employees at even bigger factories after that.[22]

Another example of the way crowdsourced manufacturing creates jobs and reduces production and delivery times drastically is illustrated by a case from Quirky. In February 2013, Jenny Drinkard, an industrial designer and recent Georgia Institute of Technology graduate, proposed an idea to Quirky to turn modified milk crates into a home storage system. Then 1,791 Quirky community members around the world refined his design, suggesting accessories and ranking them in order of preference on the site. The result: plastic cubes that can be stacked, connected, and customized with drawers, slide-in wooden shelves, cork bulletin boards, wooden feet, and rollers — fit for a college dorm room.[23]

Quirky needed to ship a million units of the product, simply called Crates, to retailers in the USA by July to capture back-to-school shoppers. To hit that deadline, the company would have to do what it has never done before: manufacture in the USA. “Usually you have months of freight time to ship from China,” says Quirky founder Ben Kaufman. “But for Crates we knew we couldn’t afford the luxury of weeks on the water.”

With labour and shipping costs rising in China, companies are looking for local factories to make certain goods, especially when production can be largely automated, as in the case of the milk crates. When labour is a smaller chunk of the total cost, the benefit of China’s lower wages diminishes. In this particular case another factor was favouring the return of plastics manufacturing in particular: the low cost of natural gas in the U.S., which is a feedstock for plastic polymers.

The example illustrates that many businesses do not realise that China is not always the cheapest place to manufacture. Most companies assume that because wages in China were at EUR 0.50 an hour in 2001, that wages are still low[24]. However, productivity also needs to be part of the equation, because labour productivity in Europe is higher on average than in China[25], which can be explained to a large extent by more advanced automation and better manufacturing techniques in Europe as compared to China

Product quality and accountability on production conditions can also constitute job related advantages of crowdsourced manufacturing. Sometimes when products are manufactured abroad, consumers do not know what product they are getting back and what the local labour conditions are.. Consumers are willing to pay a premium if they feel they are getting better, higher quality and more honest products. Quirky, for example, has started to work with local manufacturers. It is not easy according to the company, and it is a lot of work. The initial costs in tooling and labour are higher, but the trade-off is that it results in a better quality product. The advantage of close proximity is also that the representatives of the company can drive a few hours and actually have a face-to-face meeting with their manufacturers and solve issues. Manufactures want to keep their factories at home and they want to hire more people locally.[26]

3.5. Client perspectives and challenges related to the uptake of the trend

Companies that offer solutions that enable crowdsourced manufacturing report a variety of challenges related to the use of crowdsourced manufacturing by their clients. Broadly, there are three obstacles that need to be overcome before crowdsourcing can become mainstream: fear of change and unawareness, intellectual property issues, and a lack of design sharing technologies.

Fear of change can be historically explained, as many manufacturers have taken the attitude that if something was not invented within their ‘four walls’, it did not merit consideration. Closed innovation processes that barely involved outsiders were the standard for decades within most companies. The change to open innovation models can be a tough change management issue to tackle. According to the interviewed companies, manufacturers can start using crowdsourcing with a fringe product that is not core to their business. These products can be used as a training ground for managers to get used to the approach. After a few successes, they might get bolder about introducing more products through crowdsourcing.

Another concern that manufacturing organisations raise against crowdsourced manufacturing approaches pertains to the possibility of intellectual property (IP) theft. Crowdsourced manufacturing constitutes also a risk to an organisation as it shares potential valuable information (IP) on for example product designs and specifications which may also be of interest to competitors. To protect the IP of a car design, manufacturers can limit information by narrowly defining crowdsourced project roles and information access. Splitting up roles in the project can help limit the problem of information sharing. For instance, a manufacturer may want to crowdsource just the fuel cell for a car, and keep the rest of the car design proprietary.

Yet another challenge often mentioned by clients is the need for a sharing platform that allows for exchange of information without too much transaction complexity and cost. This can be overcome for example by creating a single file sharing system for design files. There is a broad ecosystem of computer-aided design (CAD) software available, with each system running its own flavour of XML code. This makes it difficult to share design files with collaborators. While creating a universal standard for CAD programs is beyond the reach of any one manufacturer, the industry as a group could push for format standardisation. Creating a standard format and standard environment would, if used by all, go a long way toward enabling more crowdsourcing projects in manufacturing.[27]

4. Drivers and obstacles

There are a number of drivers encouraging and obstacles hampering the application of crowdsourced manufacturing. These drivers and obstacles impact both the companies developing crowdsourcing solutions and the use of these solutions by users in a range of different target sectors. Further detail on such drivers, as well as obstacles, are provided in this section.

4.1. Trend drivers for crowdsourced manufacturing

A few drivers that will be presented in this section positively influence the uptake of crowdsourced manufacturing solutions: the emergence of 3D printing, the growing use of social technologies, the strength of crowdsourced manufacturing as a marketing tool and shortened product life cycles.

One of the largest drivers for crowdsourced manufacturing is the emergence of **3D printing or additive manufacturing**. This is the driving force behind the success of Shapeways and Quirky. Additive manufacturing is any of various processes of making a three-dimensional object from a 3D model or other electronic data source primarily through additive processes in which successive layers of material are laid down under computer control.[28] By linking crowd-sourcing, digital product certification, and additive manufacturing, a company could transfer completed digital models to computer-numerically controlled machines around the world whereby a schedule would be produced to determine which factories have the capacity to produce which parts at which times. A lot of manufacturers, such as GE and Siemens are exploring possibilities in this area with a number of researchers, start-up companies, and suppliers.

Additive manufacturing technologies, which produce almost no material waste, have opened the door to an **entirely new model for manufacturing** in which parts and products are produced when and where they are needed, thus reducing the need for mass production, warehousing, and distribution, all while bringing production closer to the user.[29]

Additive manufacturing changes the manufacturing process in at least two ways: 1) It allows for the creation of incredibly intricate designs (such as a pre-assembled chain of links), and 2) it makes it easier and less expensive to create one-off or limited-run creations. The design software acts as a conduit between the designer's brain and the printer, limited only by her imagination and the laws of physics.[30]

A second important driver is the **growing use of social technologies** that connect companies, sometimes via intermediaries such as eYeka and Hypios, to a community of experts. This growing use has been facilitated by the accelerated pace of IT change and the adoption of internet around the world. As a result there is an increasing pressure to rapidly deploy new technology in order to gain market insight and search for highly specialized skills, as companies have much faster access to this data and skills than before the emergence of social technologies. These are areas for which crowdsourcing solutions are well suited. In relation to this, a lot of crowdsourcing platforms such as eYeka and Quirky are maturing; communities of shared interest have organically formed or are forming around ever more products, services, and ideas.

Moreover, the press is covering strong case studies from early adopters; some of the biggest market disrupters, such as Facebook and Google as well as large enterprises including Siemens, GE, and L'Oreal are currently using crowdsourcing services to solve their most complex manufacturing problems, and are receiving additional media coverage as a result.

Another driver for the further adoption of crowdsourced manufacturing is that **it is an effective marketing activity in itself,** as it also is a method of communicating with customers and making customers feel valued. Customers who engage in crowdsourcing activities performed by a firm or who participate in a crowdsourcing activity are more likely to have a good impression of the innovative activities of the firm, and they feel that the firm pays attention to their opinions and needs. This results in customers' positive attitude toward the firm and, in turn, it is able to enhance the customers' loyalty.

Furthermore, **product life cycles have shortened in the past decades.**31 This shortening of life cycles implies that replacing a product or service line every two to three years is becoming the norm across many industries[32]. Consequently, if a business is not quick enough to introduce a product to market, it risks launching goods that have already been outperformed by competitors. Crowdsourced manufacturing is able to drastically shorten some parts of the innovation chain from idea to product as ideas are gathered and processed much faster.

4.2. Obstacles to crowdsourced manufacturing

Manufacturing needs to be agile and receptive to technological change and evolving customer demand. The shift to crowdsourced manufacturing requires new software to attract and manage an online community, new skill sets to plan and organise novel work processes, and new ways of thinking to understand and benefit from the advantages crowdsourced manufacturing has to offer.

Attracting and managing an online community can be an obstacle in scaling up crowdsourced manufacturing. There is no shortage of people willing to participate in online experiments, contests, challenges, and more. Individuals are surprisingly ready to work for little or no money if they get other rewards: prizes, recognition, fame, or the sense of pride that comes with creating something. But how do business leaders then effectively manage the flow of talent and ideas? How do they effectively keep control when their workforce moves from hundreds or thousands of on-site employees to an 'expanded workforce' of tens of thousands of online contributors? The answers to these questions have not been fully discovered yet.

Given the still relative immaturity of these crowd-based services and platforms, there is still much to be learned. The strengths of these services can also be their limitations. However, although there are no clear lines or absolutes when employing the expanded workforce, there are already some useful guiding principles for planning and implementing platforms for crowdsourcing.

The use of the expanded workforce demands very **careful planning**. There have to be clear, shared objectives for the crowdsourced exercise, whether the requirement is for new approaches to tough engineering challenges or for funds for new-product development. Also, complex tasks must be clearly and logically broken down into a series of independent subtasks that can be parcelled out to the user community in a way that allows the crowdsourced efforts to be reintegrated into the overall product or project. In the case of labour market exchanges, there can be no subtlety in the work description; amplified across hundreds or perhaps even thousands of "workers" in the expanded workforce, inexactness will produce meaningless results or work that cannot be re-aggregated.

The use of an expanded workforce for crowdsourced manufacturing, and being an enterprise without borders as regards human resources on the payroll of a legal entity and 'freelancers', bring their own challenges. For instance, the inherent anonymity of the expanded workforce places sharp **limits on traditional human resources activities such as job training**. And it raises many complex questions about the security of intellectual property. This need for structure requires more than just planning; typically, it will also require a technology solution to drive users through the process, as well as business processes adapted to this reality.

Another obstacle is the still relatively low level of awareness of the trend at 'c-level' within organisations. Although many organisations are experiencing the benefits of digitally enabled forums such as innovation exchanges and crowdsourcing platforms, few executives yet fully grasp the idea of being able to access a truly liquid workforce — pools of premier talent gathered in virtual communities and coalescing around specific business problems. This expanded workforce likely offers not only expertise that is not immediately available in-house, but it can also be leveraged to solve problems that may be too large or too expensive to solve internally.

Despite these challenges and obstacles, the market conditions for enterprises that are willing to step up, are favourable. The companies that get it right will find themselves with more innovative products and services, and with better insight into their customers.

5. Policy recommendations

As crowdsourcing is growing larger, governments have a role to play in increasing further uptake and up scaling of crowdsourced manufacturing, as well as in guarding the potential risks and market failures that are associated with crowdsourced manufacturing. In safeguarding potential risks, such as ordinary people printing 3D-guns from home, governments need to strike a balance between guaranteeing public safety on one end and unleashing the full economic potential of the trend on another.

5.1. New regulatory framework for flexible labour contracts

Crowdsourced manufacturing is based on a model of flexible labour input from an online community of professional and amateur experts. This combination of flexibility and low transaction cost is also what makes crowdsourced manufacturing attractive to traditional manufacturers. Legal scholars point out that with such flexibility come a few distinct potential disadvantages.[33] The reason firms and vendors currently are so willing to cede control over who accepts their tasks, and over how those tasks are performed, is that as yet only little money is at stake. Crowd workers tend to receive extremely low compensation for their products and efforts. They usually enjoy no job security and earn no benefits, and in fact the intermediaries may even seek to prevent them from doing so. Crowdsourced labourers do not enjoy true legal protection on the job as is the case with regular labour, and the cyberspace in which they work remains essentially unregulated for employment and labour law purposes.

*"We feel that the current contests don't need additional regulation since our community is not full time involved in crowdsourcing and are enthusiasts. But we are keeping a close eye on the need for this" – **eYeka***

It seems that currently this inequality in the relationship between manufacturers and the online crowdsourced community does not pose a large issue as a lot of people engaging in crowdsourcing do not depend on these contests for a living. Apparently the advantages of engaging in crowdsourcing currently outweigh the disadvantages.

However, the fact that crowdsourcing platforms can offer access to an almost unlimited global labour supply may prevent normal competitive effects as present in traditional regional labour markets from taking place for quite some time, if at all. The European Commission might need to identify and assess market failures in this respect and provide a regulatory framework for crowdsourced labour if needed.

Websites such as Hypios and eYeka also have a large role to play and can be stimulated to set mandatory wage floors, create default rates or simply build into the job posting process a method for firms to tailor their compensation to meet minimum wage. They can establish mechanisms for dispute resolution, perhaps staffed by platform participants. They can enhance transparency and institute mandatory disclosures to address the information asymmetries that tilt the scales

5.2. Governments can help develop standards for sharing open data

In order to stimulate the adoption of crowdsourced manufacturing, governments might take part in or stimulate the creation of technical standards concerning data quality and format, since these can significantly increase and scale the benefits of open data.[34] Public-sector leaders might consider seeking the advice of experts to help design standards that will facilitate use across different computer systems. For instance, they could follow the example of some private organisations by promoting the use of Data Catalogue Interoperability Protocol (DCIP)[35], which specifies design criteria for data catalogues published on the web. Among other recommendations, the DCIP promotes the use of JavaScript Object Notation, an easy-to-use data-interchange format. As tools and technologies become more sophisticated, leaders might consider revisiting existing standards, since better methods for organizing and sharing data may emerge. Governments could also re-evaluate the level of detail contained within open data, the frequency of its release, and the ease with which data can be integrated across systems.

5.3. Further adoption could be increased by tax breaks for users

In several interviews the representatives of the companies offering crowdsourcing platforms have suggested to offer users R&D tax breaks for using their platforms. In the countries where these companies operate, tax breaks are offered for in-house R&D personnel, but not for crowdsourcing solutions. According to the interviewees, tax breaks might spur the adoption of crowdsourced manufacturing solutions. This notion could benefit from a data-driven econometric analysis to review its merit.

5.4. Governments can participate in crowdsourced manufacturing

Similar to the concept of public procurement of innovation, governments can spur the development and uptake of crowdsourced manufacturing approaches by adopting these approaches in their own processes, and by deliberately procuring from companies that deploy crowdsourced manufacturing approaches. The sheer size of government activity in Europe ensures that even a relatively small procurement preference for crowdsourced manufacturing can have a significant positive impact on the development and uptake of the trend in Europe.-

The case on the development of a military vehicle by DARPA illustrates the possibilities for governments to engage in crowdsourced manufacturing themselves. Not only does this engagement drastically decrease time-to-market for developing and building a military vehicle, it also offered the government the chance to learn about crowdsourced manufacturing and to co-fund the development of a revolutionary software platform which enables crowdsourced manufacturing.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
Shapeways	Peter Weijmarshausen	CEO
Quirky	Ben Kaufman	CEO
Hypios	Sam Musacchio	VP Communications
eYeka	Francois Petavy	CEO
InnogetCloud	David Rafols	Director

6.2. Websites

Shapeways	www.shapeways.com
Quirky	www.quirky.com
Hypios	www.hypios.com
eYeka	www.eyeka.net
Vehicleforge.mil	www.vehicleforge.org
InnogetCloud	www.innogetcloud.com

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[24] http://www.economist.com/node/21549956

[25] http://www.sfgate.com/business/article/Manufacturer-Quirky-finds-China-not-always-3675966.php

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