The Role of Aggregators and Hubs in Collaborative Prosumer Networks

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Abstract. Prosumers are consumers that also produce goods, services, or information. Prosumers may form networks where they exchange goods, services, and information. They can use the network to share knowledge, resources, and expertise. Prosumers can create new value that benefits themselves and others in the network. Collaborative prosumer networks can take many forms, from online communities to physical spaces, and can be driven by various motivations, such as social, economic, or environmental. This paper examines the role of the prosumer and provides examples of collaborative prosumer networks. Prosumer networks can be organized in different ways. A network can be completely decentralized or have some hub or an aggregator connecting the prosumers. Here, the focus is on networks with an aggregator or a hub. The paper also briefly discusses the ownership and organization of the networks and how such networks can be resilient and responsible.

Keywords: prosumer · prosumer networks · collaboration · aggregator

1 Introduction

A prosumer is an individual who both produces and consumes goods, services, or information. The concept was introduced in 1980 by Alvin Toffler in his book "The Third Wave" [1]. The term "prosumer" is a combination of "producer" and "consumer," and it refers to the blurring of traditional lines between production and consumption.

In a *prosumer network*, prosumers exchange goods or services. Such networks can take many forms, from online communities to physical co-working spaces. In a *collaborative prosumer network*, prosumers collaborate to share knowledge and resources, reduce costs, and increase efficiency. These networks can take various forms, from self-support networks to renewable energy prosumer networks, and are often facilitated by online platforms that allow prosumers to connect and interact.

A prosumer network may be completely decentralized, but in most cases, the network has a hub or an aggregator that keeps the network together. The aggregator is a role that aggregates the goods, services, or information produced by a network of prosumers. The aggregator also represents the network in its relation to the outside world. The aggregator

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can also facilitate the exchange of goods, services, or information inside the network. The aggregator may negotiate with the outside world on behalf of the prosumers or provide infrastructure elements that enable exchanging goods, services, or information, e.g., a portal for a self-support network or a settlement service for renewable energy prosumers. Figure 1 illustrates the role of the aggregator.

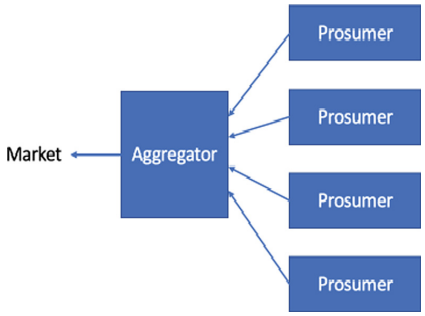

Fig. 1. The aggregator role.

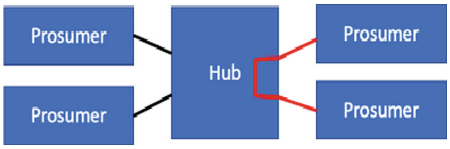

Fig. 2. The hub role.

A hub connects the prosumers without aggregating the goods, services, or information. Figure 2 illustrates the role of a hub.

This paper examines the role of the prosumer and discusses collaborative prosumer networks, both from a conceptual perspective and through practical examples. Collaborative prosumer networks can take many forms, from online communities to physical spaces, and can be driven by various motivations, such as social, economic, or environmental. The methodological steps of the paper are the following: identification of key concepts and an analysis frame from the literature (Sect. 2), analysis of the advantages of having an aggregator or a hub in the network (Sect. 3), presenting some practical cases of collaborative prosumer networks (Sect. 4), and a discussion of how these cases relate to the advantages described earlier (Sect. 5). The paper ends with conclusions, including research limitations and future work.

2 Background

Most scientific literature nowadays associates the term prosumer with persons who have invested in solar panels to produce energy. When Toffler introduced prosumers in his book "The Third Wave" [1], he did not write about electricity. He wrote about societal changes. Toffler suggested that the following trends would characterize the rise of the prosumer:

- Increased customization: Advances in technology would make it easier for individuals to create their own products, leading to an increase in personalized, tailor-made goods.
- Greater self-sufficiency: With the spread of new technologies, people could produce more of what they consumed, reducing their dependence on large-scale, centralized production systems.
- Decentralization of production: The shift toward prosumerism would lead to the decentralization of production, as individuals and smaller groups took on roles traditionally reserved for large-scale manufacturers.

- Democratization of technology: The availability and affordability of new technologies would empower individuals to take on the roles of both producers and consumers, resulting in a more democratic and participatory economic system.
- The blurring of traditional economic roles: As individuals became producers and consumers, the traditional distinctions between these roles would become less meaningful.

Toffler's concept of the prosumer has significantly impacted various fields, such as economics, sociology, and business management. It has been used to describe the rise of the "maker" culture [2], the growth of the sharing economy [3], and the increasing importance of user-generated content [4] in the digital age. While Toffler's predictions have not unfolded exactly as he envisioned, the idea of the prosumer continues to be relevant and influential.

Other authors discuss prosumers with a focus on developments of the Internet and social media:

Benkler [5] argues that the rise of networked information environments, facilitated by the Internet and digital technologies, has led to new production and distribution models based on collaboration and non-market interactions. He refers to this phenomenon as "social production" or "commons-based peer production." Such production includes open-source software, collaborative knowledge creation (like Wikipedia), and user-generated content on social media platforms. Benkler is not using the term prosumer, but he discusses the combination of producers and consumers.

Benkler also argues that the shift toward social production has profound implications for society, including:

- Economic implications: The rise of social production challenges traditional market-based economic models and offers new opportunities for innovation, creativity, and more equitable distribution of resources.
- Political implications: Information production and distribution decentralization empower individuals and grassroots organizations, potentially leading to increased democratic participation and more responsive governance.
- Cultural implications: Social production encourages the development of diverse cultural expressions and fosters a more inclusive and participatory culture.
- Legal implications: The new modes of production necessitate reevaluating intellectual property laws and regulations to ensure that they promote, rather than hinder, the potential benefits of social production.

Tapscott and Williams [4] describe collaborative prosumer networks as driving the new Internet economy. They argue that the Internet and other digital technologies have enabled individuals to participate actively in creating, consuming, and distributing content, products, and services. The authors emphasize the shift in power dynamics from traditional organizations to these decentralized networks, which leverage mass collaboration and collective intelligence. By tapping into the knowledge and expertise of diverse individuals, these networks can innovate and solve complex problems at a rapid pace, disrupting traditional industries and reshaping the way value is created in the global market. By embracing principles such as openness, peering, sharing, and acting globally, businesses, industries, and governments can leverage prosumer networks' collective

intelligence and diverse expertise, leading to rapid innovation, problem-solving, and value creation in the digital age.

Shirky [6] focuses on how social media and internet technologies have changed how people collaborate, organize, and distribute power. The book analyses the transformative effects of these technologies on the social, economic, and political landscape. Shirky argues that collaborative production, where people have to coordinate with one another to get anything done, is considerably more challenging than simply sharing, but the results can be more profound. He uses Wikipedia as an example of collaborative production without explicitly using the term prosumer. He also introduces collective action as the next step, where the prosumers gain political power from collaboration.

Leadbeater [7] explores how mass collaboration and collective intelligence transform how we create, consume, and share knowledge, products, and services. Leadbeater argues that the Internet and digital technologies have enabled a participatory culture where individuals co-create and collaborate on ideas and projects. This democratization of innovation empowers prosumers to drive change, disrupt traditional industries, and challenge established hierarchies. "We-Think" highlights the potential of collaborative networks to foster creativity, inclusion, and a more open and interconnected society, emphasizing the transformative power of collective action in the digital age.

Most of the cited work from this section focuses on something other than the aggregators or hubs as we do. The aggregator role is often used in the context of energy prosumers [8]. Still, we aim to show that the aggregator role is essential in other collaborative prosumer networks.

3 Advantages of an Aggregator or a Hub

The introduction defined the aggregator as a role in aggregating the goods, services, or information produced by a network of prosumers. The aggregator also represents the network in its relation to the outside world. A hub facilitates communication between prosumers but does not aggregate. An aggregator or a hub can offer several advantages to a collaborative network, as evidenced by various studies and examples:

- Legal and regulatory compliance: A hub or aggregator can help ensure that the network complies with relevant laws and regulations, such as intellectual property rights or data protection rules, by centralizing the responsibility for these issues within the network [4].
- Simplified access: A centralized platform makes it easier for users to find, access, and contribute to projects, as they have a single point of entry and can quickly discover relevant content or initiatives [4]
- Coordination: A hub or aggregator can help coordinate and manage the efforts of multiple participants, streamlining the collaborative process and reducing the potential for chaos or duplicated work [5].
- Reputation and trust: By establishing a trusted brand or identity, a hub or aggregator can attract more participants to the network and foster a sense of credibility and reliability [5].
- Data aggregation and analysis: By collecting and analyzing participant data, a hub or aggregator can identify trends, patterns, and insights, which can inform decision-making and drive innovation [5].

- Networking opportunities: Centralized platforms can facilitate connections among participants, allowing them to network, share ideas, and collaborate more effectively [6].
- Scaling: A centralized platform can facilitate the growth and expansion of the network by providing the necessary infrastructure, support, and resources for scaling the collaborative efforts of prosumers [6].
- Quality control: By centralizing the evaluation and approval of content, products, or services, a hub or aggregator can help ensure consistency and maintain high-quality standards across the network [6].
- Resource allocation: A hub or aggregator can more effectively allocate resources, such as funding or expertise, to the network's most promising or high-impact projects [7].
- Monetization: For networks aiming to generate revenue, a hub or aggregator can help manage and distribute income streams, such as advertising, subscriptions, or donations [7].

4 Practical Examples of Collaborative Prosumer Networks

This section presents eight different examples of collaborative prosumer networks. The aim is to show the wide range of problems collaborative prosumer networks address and what roles an aggregator or a hub can take. The eight examples discussed here are based on previous research and project involvements by one of the authors.

4.1 Self-Support Network

One of the authors was involved in developing and maintaining a collaborative self-support network initiated by the Norwegian municipality Nøtterøy. The network, Tryggghetsnett (Safety net), was established in 2002 as a pilot project to support spouses of citizens who have suffered strokes or dementia. Since then, the project has been extended to more municipalities and new user groups, e.g., parents of children with developmental disorders or teenagers with drug problems [9]. A nurse was part of the network but did not offer medical advice (in that case, the network would be subject to health laws). The nurse only provided contact information to specialists and references to relevant literature.

The network used a platform consisting of a video call service, a discussion forum, and a document library. The original platform has been retired due to the emergence of new technologies. Today the network uses Skype and social media. From the beginning, the network has organized physical events so users can meet face-to-face.

The collaborative network consists of prosumers. The participants produce by sharing their knowledge and experiences and consuming advice from other participants. The network uses both a communication platform and physical gatherings. It would be no clear aggregator function, even if the platform used a discussion forum and later social media. The focus was on one-to-one conversations. The platform acts as a hub keeping the participants together without aggregating the information.

4.2 Genealogical Records

Genealogy is the study of families, family history, and the tracing of their lineages. Genealogy research is based on written sources, such as civil registry documents, church records, census records, wills and probate records, and land records. The problem is that older records are handwritten and not searchable. Transcribing and digitizing such records is a time-consuming process. In Norway, the National Archive maintains "Digitalarkivet" (the digital archive). Digitalarkivet contains digitized versions of many relevant records for genealogists. However, many more documents exist as images. One of the authors used this as an example of a collaborative prosumer network [10].

The National Archive asked genealogists to help with the transcription to get more records transcribed and digitized (Fig. 3). Genealogists consume the material from the digital archive and produce newly digitized material from non-digitized sources. A genealogist can get a room in what is called the Digital Inn. The "room" is a personalized page to submit transcribed materials. The Digital Inn is used to honor the contributors. The data is transferred into the Digital Archive and becomes accessible to the public.

The contributing genealogists constitute a collaborative prosumer network. The infrastructure is maintained by the National Archive, which functions as an aggregator for the prosumers.

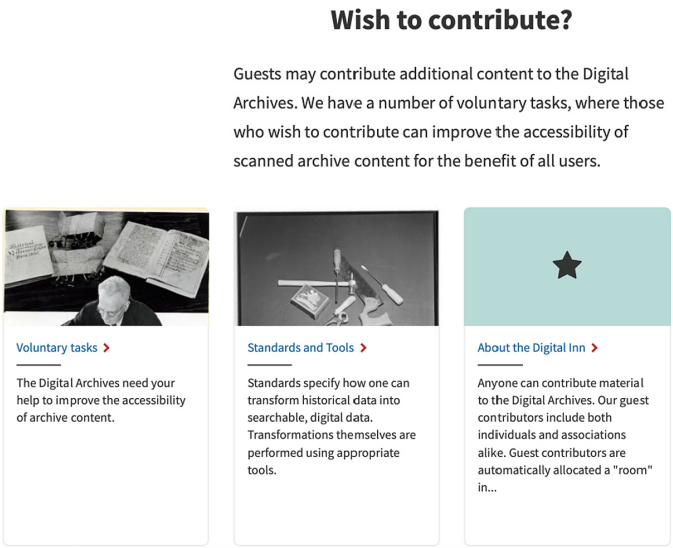

Fig. 3. The Digital Inn homepage

4.3 Map Sharing

In 2006, one of the authors created a solution for a collaborative prosumer network to make application-specific maps [10]. The service used the GIS platform of the municipality. This GIS presentation server could merge overlays with the existing maps. Inspired

by the "Digital Inn," the overlay database was called the "Map Hostel," as shown in Fig. 4.

The overlays could contain different symbols. Interest groups and individuals could then construct their own maps and share them with other citizens [11].

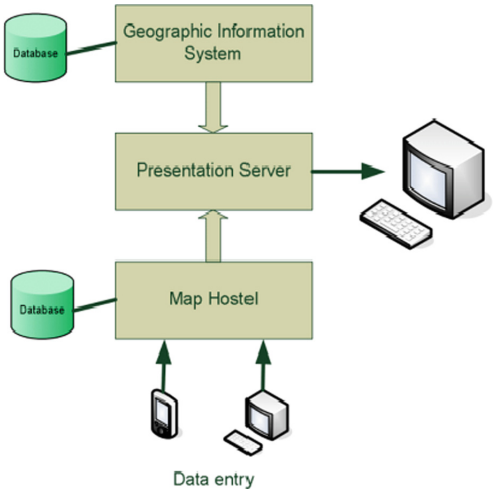

Fig. 4. The collaborative map solution

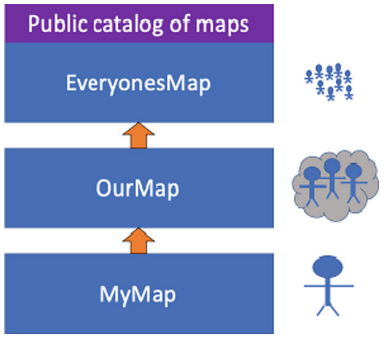

Fig. 5. Different levels of sharing

The system had three levels, as shown in Fig. 5. On the first one, MyMap, an individual could create a map for personal use. On the next level, OurMap, the map could be shared within a group. The third level, EveryonesMap, shared the map with the public. The map creators are producers, and the users are consumers. But producers also consume map overlays created by others and become prosumers. Here the municipality took the role of aggregating the results from the prosumers. The network of map prosumers existed until the city changed to a new GIS platform.

4.4 Open-Source Development

A classic example of collaborative consumer networks is open-source development [12]. Open-source software and hardware is available to the public and can be modified and shared by anyone, allowing prosumers to collaborate on projects and build upon each other's work. Collaboration within a network of prosumers allows for developing more sophisticated and efficient software and hardware products. Open-source development also promotes transparency and community-driven innovation, as users can report bugs and suggest improvements to the codebase or the schematics.

One of the benefits of prosumer collaboration in a network is the diversity of skills and perspectives that can be brought to a project [12]. These skills and perspectives can lead to more innovative solutions and efficient problem-solving. Prosumers can also benefit from the network by learning from one another and developing their skills. Additionally, prosumer collaboration in a network can provide a sense of community and support for those working on similar projects.

Someone needs to organize and distribute tasks and handle quality control, e.g., the voting among participants to include new functionality. So an aggregator or hub role should be present.

4.5 Social Media

Social media platforms have become a space for prosumers to showcase their talents, express their opinions, and connect with others with similar interests. The opportunity to express views and relate to others creates a sense of community among prosumers who can interact with and follow others and gain a following for their content [13].

Social media can also be seen as collaborative prosumer networks. The users produce content and consume content made by others. Facebook and Instagram want users to share their stories with the network. YouTube lets users create videos and distribute them through the YouTube platform. Twitter shares shorter messages with the network. Prosumers have access to a wide range of content from other users, which can provide them with inspiration and ideas for their own content. This exchange of ideas and information between prosumers can lead to a more diverse and engaging social media experience.

Blogs are another type of social media where producers create content for followers. In most cases, the followers can react through comments, emojis, etc., contributing to co-creation. Social media platforms work as aggregators collecting and distributing the content individuals produce. Someone obviously needs to monitor social media to ensure the content does not violate laws, etc. This moderator function is essential.

4.6 Wikipedia

Wikipedia is an open, multilingual, online encyclopedia. It is maintained by a community of volunteers known as Wikipedians through open collaboration. Wikipedia was launched on January 15th, 2001. In April 2023, Wikipedia had more than 6.6 million articles in English. It is available in 333 languages and has 308.380 active editors and 107,484,380 registered users.

All content is created by prosumers writing about their fields of expertise. The aggregator function is mostly about presenting the collective output of the prosumers. The aggregator also contributes to quality control and running software robots to add cross-reference links.

4.7 Renewable Energy

Traditionally, the electric energy market has consisted of large energy producers operating power plants that sell electricity to consumers. New emerging renewable energy sources like solar panels have allowed consumers to produce their own electricity. They have become prosumers. A smart grid is an electricity grid where smart meters keep track of consumption from the grid but also production to the grid [8].

A single prosumer has limited bargaining power in the market. However, if an aggregator organizes the prosumers, it can negotiate flexibility and tariffs in the energy market (Fig. 6). The aggregator may be independent, connected to a distribution system operator, or the prosumers can own it. The critical point is that the prosumers collaborate in a network and use the aggregator to represent themselves to the outside world.

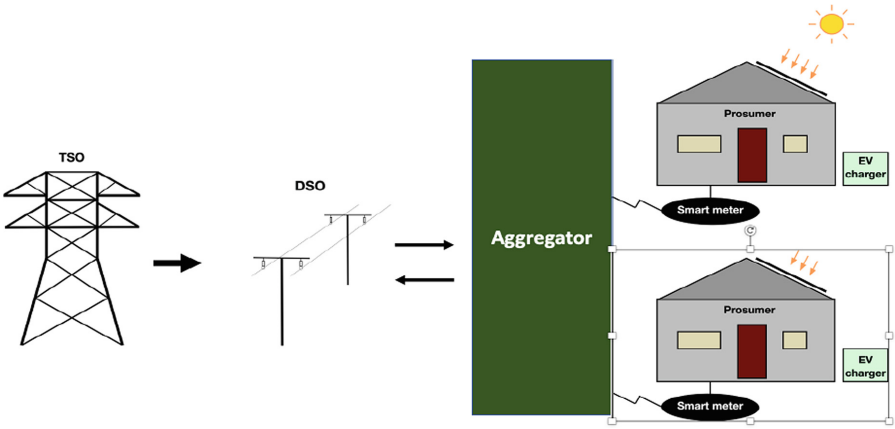

Fig. 6. The aggregator in a collaborative network of prosumers.

4.8 REKO-Rings

A REKO-ring is a food distribution system that originated in Jacobstad, Finland and has become increasingly popular in other countries [14]. The word "REKO" is an abbreviation for "rejäl konsumtion," which means "sincere consumption" in Swedish. The system involves a group of consumers who form a network with local producers and farmers, enabling them to purchase food directly from the producers without intermediaries like supermarkets.

The REKO-ring system typically operates through a closed Facebook group, where producers post what products they can deliver, and consumers can place their orders by commenting on the post. The producers then have the ordered products delivered to a designated location, where the consumers pick them up on a set date and time. This system enables consumers to purchase fresh, locally sourced food directly from the producer, allowing them to support local agriculture and have a more transparent food supply chain. It also creates a sense of community between producers and consumers and fosters a more sustainable and environmentally friendly food system. The producers also buy from other producers and thereby become prosumers.

The REKO-ring can be considered a collaborative prosumer network, but most participants are not producing, just consuming. The network has no aggregator but a hub (the Facebook group). An aggregator would collect the production from each producer and be the contact point for the consumers.

The Facebook group needs to be maintained. A few volunteers usually do this, which requires minimal work: To approve new members and decide when and where to meet to exchange goods.

5 Discussion

This section presents a confrontation of the pragmatic pieces of knowledge to a conceptual analysis frame.

5.1 Digitalization's Impact on Collaborative Prosumers Networks

Toffler's "The Third Wave" [1] and Benkler's "The Wealth of Networks" [5] both address the transformations of society and economy driven by advancements in technology. Toffler's concept of prosumers describes a new class of individuals who produce and consume goods and services. He argues that the shift from industrialization (the Second Wave) to an information-based society (the Third Wave) is characterized by this blurring of boundaries between producers and consumers, enabled by new technologies that democratize access to the means of production.

While Toffler's prosumers concept laid the groundwork for understanding these societal shifts, Benkler's "The Wealth of Networks" expands upon and enhances this framework by focusing on the role of networks in the digital age [5]. Benkler argues that the rise of the Internet and digital technologies have facilitated the creation of decentralized, peer-to-peer networks that harness collective intelligence and collaboration. These networks empower individuals and communities to create, share, and access knowledge and resources more efficiently than traditional hierarchical structures. In this sense, Benkler builds upon Toffler's ideas by providing a more detailed exploration of how prosumers collaborate and engage in the digital age, highlighting the transformative potential of networks in reshaping social, economic, and political dynamics.

While Benkler's "The Wealth of Networks" [5] and Shirky's "Here Comes Everybody" [6] explore the transformative effects of digital technologies and the Internet on society, they differ in their focal points. Benkler primarily concentrates on the rise of decentralized, peer-to-peer networks and their potential to harness the collective intelligence, addressing the broader implications in areas such as culture, economics, and politics. In contrast, Shirky focuses on the power of organizing without organizations, emphasizing the role of social media and other internet technologies in enabling collaborative prosumer networks. He delves into the impact of social media on new forms of collaboration, using specific case studies and examples to illustrate his points.

While both Shirky's "Here Comes Everybody" [6] and Tapscott and Williams' "Wikinomics" [4] explore the transformative effects of digital technologies on collaboration and organization, "Wikinomics" offers a broader perspective on the economic implications of mass collaboration. Introducing four core principles—openness, peering, sharing, and acting globally—Tapscott and Williams analyze how businesses, industries, and governments embrace these principles to succeed in the digital age. While Shirky focuses on organizing without organizations and the role of social media, "Wikinomics" emphasizes the importance of adaptability, transparency, and leveraging collective intelligence, providing additional context and guidance for thriving in the changing landscape.

5.2 Case Study Insights

The examples provided in Sect. 4 show different kinds of prosumer networks, and the idea was to show that some aggregator often, but not always, plays an essential role in the network. Table 1 summarizes the eight case studies.

Six of the examples shown have an aggregator role. An aggregator needs to aggregate the production from each prosumer into a more extensive offering. This is the case for the genealogy example, where all the prosumers' combined efforts are the final product. The

Table 1. Aggregator or hub?

	Collaborative network	Prosumers	Aggregator or hub?
Self-support network	Yes	Yes	Hub
Genealogy records	Yes	Yes	Aggregator
Map sharing	Yes	Yes	Aggregator
Open source development	Yes	Yes	Aggregator
Social media	Yes	Yes	Aggregator
Wikipedia	Yes	Yes	Aggregator
Renewable energy	Yes	Yes	Aggregator
REKO-rings	Yes	Yes	Hub

same holds for map sharing, open-source development, social media, and Wikipedia. In the renewable energy prosumer network, the aggregator aggregates the output from the prosumers but also represents the prosumers to the outside world, e.g., by negotiating tariffs.

Two examples are hubs, where the production is not aggregated but offered on a peer-to-peer basis. The self-support network is based on one-to-one communication between next-in-kins. The REKO ring is based on one-to-one sales, even if a customer may receive goods from several producers at the same event.

Section 3 presented some advantages of having an aggregator or hub in a collaborative prosumer network taken from literature. The authors tested these presumed advantages on the examples given in Sect. 4. Table 2 shows the results.

Dark green suggests very high relevance, light green suggests high relevance, light red means some relevance, and white indicates no relevance. The results are based on a discussion of each example. Future work will validate the results with a larger group of experts.

The collaborative prosumer network dealing with renewable energy focuses on data aggregation, analysis, and monetization. For the social media providers, these aspects are important for the platform provider but not for the individual prosumer. Reputation and trust, simplified access, networking opportunities, and scaling are important for all examples. Resource allocation is less important, and monetization is not an issue in most examples.

5.3 Ownership and Organization

A collaborative prosumer network consists of individual entities. When an aggregator or hub is introduced into the network, ownership and organization questions arise. The examples show several possibilities:

- The aggregator or hub is an independent business. It can collect membership fees from the network members to provide services or gain revenues from other channels. A typical example is social media, which offers infrastructure to its prosumers and

Table 2. Using the advantages presented from theory on practical examples.

	Self-support network	Genealogy records	Map sharing	Open source dev.	Social media	Wiki-pedia	Renewable energy	REKO-rings
Legal and regulatory compliance								
Simplified access								
Coordination								
Reputation and trust								
Data aggregation and analysis								
Networking opportunities								
Scaling								
Quality control								
Resource allocation								
Monetization								

receives its income from advertising. Membership fees could be an option for the renewable energy prosumer network, but the independent business could also take a cut of the revenues made from negotiating.

- In the renewable energy prosumer network, an alternative would be to establish a cooperative where the prosumers own the aggregator.
- The network can be sponsored by an organization sharing the goals of the network. One example is the self-support network. The municipalities want to encourage such networks because support from others with the same experience helps the participants cope with their problems. Another example is the genealogy records, where the national archive found it necessary to rely on volunteers to increase the number of historical records transcribed.
- The network can be managed by a foundation based on voluntary contributions. Wikipedia is a typical case. We see the same for many open-source development projects.
- The REKO-rings are self-contained, relying only on a (free) social media platform.

5.4 Resilience and Responsibility

Multiple global challenges like pandemic, geopolitical tensions, natural disasters, and energy or water shortage taught us the necessity to be resilient and reactive. The resilience of energy production is also in question and network of prosumers provide key perspectives.

Our examples of collaborative prosumer networks show that reputation and trust rank high on the advantages of having an aggregator. An aggregator needs the trust of the prosumers to be able to work. Also, the aggregator can take care of compliance. In our examples, ensuring reputation and trust were seen as very important functions of

the work of the aggregator. Trust in network partners is very important. Each member must be convinced that the other members will act in a trustworthy, honest, and cooperative manner, even when uncertainty or vulnerability is involved. If there is trust in collaborative networks of prosumers, then the need for formal contracts, monitoring, and enforcement is reduced and allows for communication, learning, and problem-solving much more efficiently.

6 Conclusion

This paper is based on some of the most influential books about networks in the digital era. After presenting ideas about prosumers, collaborative networks, and collaborative prosumer networks, we provided a list of benefits of having an aggregator or a hub as part of the network. We then gave some varied examples of collaborative prosumer networks. The benefits were tested on the case studies, and some were found more important than others.

Our examples mainly focus on how networks can contribute to a better society rather than how to earn money. That may be why we found monetization and resource allocation less critical for our cases, except for the renewable energy prosumer network, where money is an incentive for the individual prosumer.

This paper aims to shed light on the often-overlooked role of the aggregator or hub as what keeps the network together. We have shown the importance of the aggregator or hub function by examining the most influential books on network economy and prosumers combined with practical examples.

6.1 Limitations and Future Work

This work has some clear limitations. The theory was mostly taken from influential books discussing different aspects of networks, collaboration, and prosumers. We have plans to do a more thorough review of journal articles and conference papers in the future.

Also, the case studies were chosen based on familiarity. Some were selected because of earlier involvement in real projects with practical experience and detailed knowledge. Others were chosen because they are often used as examples of prosumer networks (social media, Wikipedia). Future work will also look for new case studies, broadening the specter of collaborative prosumer networks. Table 2 can be expanded with more cases and be validated by more experts.

We also need to work on the typology of different collaborative prosumer networks. The aim is to find a set of indicators to measure the impact of the aggregator in a collaborative consumer network.

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