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Bastås, L., Johansson Mignon, I. (2025). Comparing public and private intermediaries co-existing in ecologies of intermediation. *Environmental Innovation and Societal Transitions*, 56.
<http://dx.doi.org/10.1016/j.eist.2025.100972>

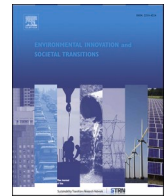
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Environmental Innovation and Societal Transitions

journal homepage: www.elsevier.com/locate/eist

Research article

Comparing public and private intermediaries co-existing in ecologies of intermediation

Lisa Bastås, Ingrid Mignon*

Chalmers University of Technology, Department of Technology Management and Economics, Gothenburg, Sweden

ARTICLE INFO

Keywords:

Intermediaries
Ecologies of intermediation
Public
Private
Solar PV
Adoption process

ABSTRACT

Ecologies of intermediation are important in facilitating the adoption of renewable electricity technologies by supporting adopters. However, previous research has suggested that this support is fragmented and uncoordinated. This paper draws attention to the support provided by two actor-types co-existing in an ecology of intermediation: public and private intermediaries. While differences between these intermediary types have earlier been suggested, these assumptions have not been tested on a larger sample. The analysis of novel survey data shows that public and private intermediaries co-existing in the studied ecology exhibit complementarities regarding target groups, activities, and timing of the provided support. The extent of these complementarities and potential reasons are finally discussed, raising the question of innovation system maturity and well as additional characteristics of the ecology of intermediation in the specific context of solar PV technology.

1. Introduction

Despite the widespread availability of renewable electricity technologies (RET), there is an urgent need for increased adoption to achieve a sustainable energy transition (IEA, 2023). Studies have shown that RET adoption processes can be facilitated by intermediation support in the form of e.g., provision of information and advice, mediation between adopters and other actors, and facilitation of administrative processes (Aspeteg and Mignon, 2019; Bergek, 2020; Kivimaa, Boon, et al., 2019). This intermediation support is often provided through ecologies of intermediation that encompass the entirety of intermediation activities performed by a variety of (intermediary) actors in a given context (Hyysalo et al., 2022; Kivimaa et al., 2020; Kivimaa, Boon, et al., 2019). In the context of RET adoption support, ecologies of intermediation include e.g., public advisors, private consultants, suppliers, industry associations and peer to peer internet forums (Aspeteg and Mignon, 2019; Glaa and Mignon, 2020; Hyysalo et al., 2018; Kivimaa et al., 2020).

Ecologies of intermediation mainly emerge and evolve dynamically in response to the development of technologies, markets, and institutions (Hyysalo et al., 2022). Often, ecologies of intermediation struggle to coordinate and synchronize, hence resulting in fragmented and uncoordinated intermediation support (Glaa and Mignon, 2020; Hyysalo et al., 2022; Kivimaa et al., 2020). Such issues of fragmentation and lack of coordination in intermediation support have strong implications for transition processes, as a weak knowledge and support infrastructure slows down the diffusion of new technologies and practices (Kivimaa et al., 2020). This calls for attention to what constitutes specific ecologies of intermediation and how different intermediary actors co-exist within these ecologies. For that, understanding potential overlaps and tensions among intermediaries is necessary.

* Corresponding author.

E-mail addresses: lisa.bastas@chalmers.se (L. Bastås), ingrid.mignon@chalmers.se (I. Mignon).

<https://doi.org/10.1016/j.eist.2025.100972>

Received 12 June 2024; Received in revised form 9 February 2025; Accepted 17 February 2025

Available online 22 February 2025

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In the intermediary literature, a common dichotomy is the distinction between public and private intermediaries. Indeed, while public and private intermediaries often co-exist in ecologies of intermediation, they also display characteristics that may interfere with each other and create tensions (e.g., [Glaa and Mignon, 2020](#); [Intarakumnerd and Chaoroenporn, 2013](#); [Mignon and Kanda, 2018](#)). For instance, public intermediaries often have specific policy missions to fulfill (e.g., [Caloffi et al., 2023](#); [De Silva et al., 2022](#); [Rossi et al., 2022](#)), whereas private intermediaries emerge as a response to market opportunities and constraints (e.g., [Hyysalo et al., 2022](#); [Mignon and Broughel, 2020](#)). Likewise, they seem to be driven by different objectives and to focus on different target groups ([Glaa and Mignon, 2020](#); [Klerkx and Leeuwis, 2008a](#); [Mignon and Winberg, 2023](#); [Polzin et al., 2016](#)). Nevertheless, at this stage, there is still a lack of understanding about how public and private intermediaries co-exist in the same ecology, e.g., what support they provide and if this support overlaps ([Glaa and Mignon, 2020](#); [Mignon and Winberg, 2023](#); [Polzin et al., 2016](#)).

This paper addresses this gap and intends to answer the question of how public and private intermediaries co-exist in the context of solar PV adoption support in Sweden. It proposes to inform the transitions research on knowledge and support infrastructure in accelerating transitions, by providing a better understanding about ecologies of intermediation. In order to test a number of similarities and differences between public and private intermediaries suggested in previous qualitative studies, a survey was developed and sent to public energy advisors (public intermediaries) and solar PV installers and retailers (private intermediaries).

This study has several important implications. First, it sheds light on actors within ecologies of intermediation by exploring how public and private intermediaries co-exist within the same ecology of intermediation. Second, the study contributes to new insights into the temporality of ecologies of intermediation, by suggesting characteristics of a maturing ecology of intermediation. Third, the study provides a new methodological approach in the growing intermediary research, by using quantitative methods to test assumptions previously developed in qualitative research. Finally, the paper contributes with a conceptualization of attributes distinguishing public and private intermediaries, i.e., funding, organization, and governance.

The paper is structured as follows. In [Section 2](#), we present an overview of the literature on ecologies of intermediation as well as key differences between public and private intermediaries, leading to the formulation of seven propositions. [Section 3](#) outlines the methodology and [Section 4](#) presents and discusses the analyses and results. Finally, we conclude the study in [Section 5](#).

2. Theoretical framework

2.1. Ecologies of intermediation in transitions

Over the last decade, intermediary actors and their intermediation support have received major interest in the transitions literature ([Kivimaa et al., 2020](#)). Indeed, transition contexts often require new types of mediation, e.g. between new and established actors and between national, regional, and local levels of transitions (e.g., [Gustafsson and Mignon, 2019](#); [Hodson et al., 2013](#); [Hyysalo et al., 2022](#); [Klerkx and Leeuwis, 2009](#); [Mignon and Winberg, 2023](#)). In the transitions literature, transition intermediaries are conceptualized as actors and platforms contributing to sustainability transition processes by connecting different actors, activities, and visions ([Kivimaa, Boon, et al., 2019](#)).

From studying individual actors performing intermediation activities and roles (e.g., [Kivimaa, Boon, et al., 2019](#)), transition scholars have in recent years started to show increased attention to ecologies of intermediation. The underlying argument for this attention shift is that intermediation in transitions is not performed by single intermediary actors and that intermediation should be seen as a function rather than as an actor or a role ([Hyysalo et al., 2022](#); [Kivimaa, Boon, et al., 2019](#)). Hence, considering intermediation as context-specific ecologies of actors decreases the risk of assuming unrealistic capabilities among intermediary actors.

Studying intermediation through the lens of ecologies of intermediation offers new insights into many challenges associated with intermediation, as highlighted in previous studies. These challenges include issues related to coordination and alignment among intermediaries (reported e.g., in [Glaa and Mignon, 2020](#); [Hyysalo et al., 2022](#); [Klerkx and Leeuwis, 2008b](#); [Soberón et al., 2022](#)), tensions due to competition among intermediaries (e.g., [Hyysalo et al., 2022](#); [Klerkx and Leeuwis, 2008b](#)), unclear or changing mandates of intermediaries (e.g., [Klerkx and Leeuwis, 2008a](#); [Moore et al., 2012](#)), overlaps in target groups (e.g., [Klerkx and Leeuwis, 2008b](#); [Mignon and Winberg, 2023](#)), or issues related to a lack of vision and objective alignment ([Soberón et al., 2022](#)). Consequently, studying ecologies of intermediation highlights new needs and solutions such as better orchestration and coordination, activity and relationship alignment, lower competition, increased credibility and impartiality, and better access to intermediation services for the actors in need of intermediation ([Glaa and Mignon, 2020](#); [Klerkx and Leeuwis, 2008a](#); [Soberón et al., 2022](#)).

Furthermore, studying ecologies of intermediation provides an opportunity to understand the temporality of intermediation, i.e., how transition intermediation and intermediation support evolves over time as changes in the emergent socio-technical system happen. As suggested by [Kivimaa, Boon, et al. \(2019\)](#), transition processes imply that socio-technical system configurations evolve, which may lead to the emergence of new intermediaries, changes in some intermediary roles, and the termination of others. These changes are difficult to study when focusing on one specific intermediary, because intermediation within transition processes is rarely the responsibility of one single intermediary ([Kivimaa, Hyysalo, et al., 2019](#)). Nevertheless, considering the whole ecology of intermediation enables the study of changes in intermediation over time, potentially going from an undeveloped (e.g., fragmented and uncoordinated) to a more mature (e.g., coordinated, less conflictful, and more efficient) ecology of intermediation.

2.2. Understanding the composition of ecologies of intermediation

One step towards a better understanding of ecologies of intermediation is to grasp key attributes of actors composing ecologies and identify attributes that may lead to tensions. In the intermediary literature, many attempts have been made to describe and classify the

large variety of intermediary actors which compose ecologies of intermediation (e.g., [Bergek, 2020](#); [Kivimaa, Boon, et al., 2019](#); [Mignon and Kanda, 2018](#)). When reviewing the literature, three main distinctions can be made between intermediaries: whether they are professional or informal (and self-organized), project- or system-level, or public or private.

In general, in most studies about intermediaries or intermediation, the focus is on professional organizations or individuals with a formal function or role, either as intermediary or as something else ([Bergek, 2020](#); [Kivimaa, Boon, et al., 2019](#)). They may be professional innovation networks, innovation and/or knowledge centers, research foundations or institutes, chambers of commerce, advisors, civil servants, etc. (e.g., [Kivimaa, Boon, et al., 2019](#); [Klerkx and Leeuwis, 2009](#)). Nevertheless, some authors also put forward the existence of more informal (or self-organized) types of intermediaries, e.g., peer users, communities and advocacy groups (e.g., [Bushouse and Mosley, 2018](#); [Hargreaves et al., 2013](#); [Kanger and Schot, 2016](#)). Some of these actors function as transition intermediaries, although they are not aware of it, e.g., architects, project managers (e.g., [Hodson et al., 2013](#); [Martiskainen and Kivimaa, 2018](#); [Moss, 2009](#)). In some cases, the intermediaries are not organizations or individuals, but rather a platform, a network or an internet forum (e.g., [Hyysalo et al., 2013](#); [Hyysalo et al., 2018](#)).

Intermediary actors have also been distinguished in terms of specialization ([Bergek, 2020](#); [Howells, 2006](#)) and level of aggregation (project- versus system-level) ([Aspeteg and Bergek, 2020](#); [Kanda et al., 2020](#); [Mignon and Kanda, 2018](#); [van Lente et al., 2003](#)). This has led authors to differentiate, for instance, between pure intermediaries – that are entirely devoted to intermediation activities – and diversified intermediaries – that perform different activities apart from intermediation and have different missions, knowledge bases, and interests ([Bergek, 2020](#); [Mignon and Broughel, 2020](#)). There is a consensus that system-level (or systemic) intermediaries are more suitable to take broader roles that benefit entire innovation systems, while project-level intermediaries are more adapted to perform tailored activities for clients ([Kanda et al., 2020](#); [Mignon and Kanda, 2018](#)).

Finally, the distinction between public and private attributes has been considerably discussed, particularly when highlighting potential sources of tension ([Glaa and Mignon, 2020](#); [Kivimaa, 2014](#); [Klerkx and Leeuwis, 2008a, 2008b](#); [Mignon and Kanda, 2018](#)). In this context, scholars use different attributes to make the distinction between public and private (see [Fig. 1](#)). Some authors distinguish between public and private intermediaries based on organizational form, i.e., whether the intermediary is a public organization (e.g., [de Wilde and Spaargaren, 2019](#); [Mignon and Winberg, 2023](#)) or a company (e.g., [Aspeteg and Bergek, 2020](#); [Aspeteg and Mignon, 2019](#)).¹ Others categorize intermediaries based on source of funding, delineating whether funding for intermediary activities comes from public or private sources (e.g., [Glaa and Mignon, 2020](#); [Kivimaa, 2014](#); [Kivimaa, Boon, et al., 2019](#); [Klerkx and Leeuwis, 2008a, 2008b](#); [Mignon and Kanda, 2018](#); [Rossi et al., 2022](#)). Less frequently, authors classify intermediaries as public or private based on governance structure, considering whether the organization(s) deciding the intermediary's mission is public or private (e.g., [Klerkx and Leeuwis, 2008a](#); [Klewitz et al., 2012](#); [Talmar et al., 2022](#)) and whose interests the intermediary is serving (e.g., [Mignon and Broughel, 2020](#); [Page and Fuller, 2021](#)). If the governing institution comprises both public and private organizations, the intermediary may be referred to as hybrid (e.g., [Duan and Jin, 2022](#); [Williamson, 2014](#)).

2.3. Distinguishing between public and private intermediaries

Although only few studies compare public and private intermediaries (selected exceptions include [Glaa and Mignon, 2020](#); [Klerkx et al., 2009](#); [Mignon and Kanda, 2018](#)), public and private intermediaries have often been distinguished according to different, but recurrent, themes, with potential implications for the activities they perform and the role(s) they play in an ecology of intermediation. In particular, public and private are assumed to differ with regard to their rationale for providing adoption support, the value provided to adopters, their target groups, the support activities, and the degree of influence on adopters' choices during the adoption process. This section elaborates on these aspects based on previous qualitative research and suggests propositions for differences between public and private intermediaries that may be tested empirically.

2.3.1. Rationale for providing adoption support

In studies about intermediaries, public intermediaries are often described as being driven to contribute to the common good, often as a result of their policy missions (e.g., [Glaa and Mignon, 2020](#); [Mignon and Winberg, 2023](#)). Examples have been highlighted of public intermediaries established as a policy measure to address grand challenges in society ([Schot and Steinmueller, 2018](#); [Selviaridis et al., 2023](#)), such as accelerating the energy transition towards sustainability ([Polzin et al., 2016](#)). Consequently, public intermediaries are assumed to contribute to overall system goals, by e.g., building and maintaining networks that connect different stakeholders (e.g., [Kanda et al., 2020](#); [Rossi et al., 2022](#); [Talmar et al., 2022](#)) or translating national policies to the local context ([Mignon and Winberg, 2023](#)). Since such activities are seldom profitable endeavors, private intermediaries are less likely to pursue them. Hence, authors stress that public funding is crucial to ascertain that such intermediary functions are covered in the ecology of intermediation ([De Silva et al., 2022](#); [Klerkx and Leeuwis, 2008a, 2009](#)).

In contrast, private intermediaries are assumed to prioritize their own survival and growth, sometimes at the cost of their client (e.g., [Mignon, 2017](#); [Mignon and Broughel, 2020](#)). This is a consequence of their for-profit structure and the need to generate revenues to survive ([Klerkx and Leeuwis, 2008a](#)). Private intermediaries are often pictured as project-oriented, i.e., supporting users and clients by customizing the support and adapting to each client's demands and needs (e.g., [Aspeteg and Mignon, 2019](#)). The profit orientation of

¹ Note that we are aware that there are more nuanced distinctions made with regard to the organizational form of intermediaries, e.g., non-governmental organizations or associations. Nevertheless, since the purpose of the study is to compare public and private intermediaries, we focus on the distinctions between these two types of organizations.

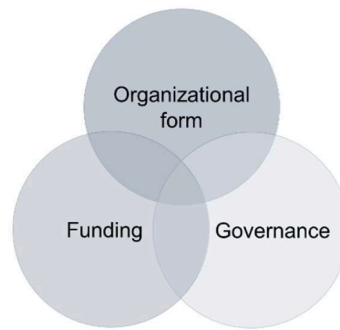


Fig. 1. Characterization of attributes for distinguishing public and private intermediaries.

private intermediaries also provides strong incentives for efficient and effective support, as the dependence on revenues increases the sense of accountability in their adoption support (Klerkx and Leeuwis, 2008a).

This results in the first proposition:

P1. *Public and private intermediaries have different rationales for providing adoption support.*

2.3.2. Value provided to their recipients

When reviewing the previous literature, it is also possible to distinguish differences related to the value provided to the recipients of adoption support from public and private intermediaries. In their study of project developers and consultants supporting solar PV adoption in Sweden, Aspeteg and Mignon (2019) have suggested that the value can either be tangible (i.e., measurable and objective) or intangible (i.e., abstract and subjective). Similar types of values have been identified in other studies covering a broader range of intermediaries (e.g., Klerkx and Leeuwis, 2008a, 2008b; Rossi et al., 2022).

Tangible values associated with private intermediaries include price competitiveness, responsiveness, content of the service package, and proximity (Aspeteg and Mignon, 2019). Meanwhile, authors have highlighted that it can be difficult for intermediaries working towards long-term goals and less visible end-products (e.g., associated with the common good) to be considered as competitive or valuable from a market perspective (Klerkx and Leeuwis, 2008a). For this reason, public intermediaries often provide services free of charge (Klerkx and Leeuwis, 2008a; Mignon and Winberg, 2023).

Intangible values are more subjective and depend on perceptions, e.g., service-mindedness, expertise, legitimacy, commitment, and quality (Aspeteg and Mignon, 2019). Being service-minded and adapting support to the needs of the adopter is highlighted as important for both public and private intermediaries (Rossi et al., 2022). Legitimacy is also important for all types of intermediaries, since intermediation builds on mutual trust (e.g., Kant and Kanda, 2019; Karhinen et al., 2021; van Lente et al., 2020). For instance, legitimacy is important for maintaining a market position and ensure future revenues, which is particularly relevant for private intermediaries (Bush et al., 2017). Meanwhile, it is assumed that public intermediaries have formal legitimacy due to their policy mandate (Rossi et al., 2022; Selviaridis et al., 2023). Yet, it is sometimes questioned whether public intermediaries are relevant to stakeholders outside of their remit (De Silva et al., 2022).

As these attributes seem to differ for public and private intermediaries, the second proposition is formulated as:

P2. *Public and private intermediaries provide different values to their recipients.*

2.3.3. Target groups and support activities

When studying the interactions between intermediaries and technology adopters, there is an underlying assumption that public and private intermediaries target different adopters and provide different types of support activities (e.g., Glaa and Mignon, 2020; Klerkx and Leeuwis, 2008a; Mignon and Kanda, 2018). To fulfill their policy missions and contribute to the common good, public intermediaries are missioned to target certain adopter groups with their broad activities, such as households, SMEs, or the general public (Caloffi et al., 2023; Mignon and Winberg, 2023). In contrast, private intermediaries are more likely to target companies and private investors that pursue larger investments (Mignon and Broughel, 2020). The third proposition is thus as follows:

P3. *Public and private intermediaries target different adopter groups.*

Moreover, previous studies have suggested that intermediaries may provide different support activities at different points of time (Broers et al., 2023; Glaa and Mignon, 2020). The intermediary support can also be either functional (technological, investment, or administrative support) or psychological (behavioral support) (Aspeteg and Mignon, 2019). Public intermediaries seem to be better suited for activities such as general information, network creation, needs articulation, and network brokerage roles (Glaa and Mignon, 2020; Klerkx and Leeuwis, 2008a; Rossi et al., 2022). For instance, Rossi et al. (2022) demonstrate the important role played by public innovation intermediaries in articulating demands of firms adopting new digital technologies. In contrast, it is assumed that private intermediaries are more suitable in helping their clients formulating their needs and designing their investments (Glaa and Mignon, 2020; Klerkx and Leeuwis, 2008a). Given their for-profit aspirations, it is expected that private intermediaries focus on providing services that generate profit, e.g., project management and coordination, installation (Glaa and Mignon, 2020). Authors have also

suggested that public intermediaries are suited to support the early phases of the adoption process (i.e., the pre-decision and decision-making processes), while private intermediaries are more suited for the in- and post-decision phases (Glaa and Mignon, 2020; Klerkx and Leeuwis, 2008a). Based on this, we formulate two propositions:

P4. *Public and private intermediaries target adopters at different stages of their adoption processes.*

P5. *Public and private intermediaries provide different types of support activities.*

As seen above, intermediaries have different domains of expertise and activities (Bergek, 2020). Some intermediaries are considered narrow, i.e., they specialize in one specific sector, or broad, i.e., they also provide services connected to several sectors, e.g., energy efficiency, electric vehicles and charging, energy storage and batteries, heating systems and ventilation, insulation and renovation, lighting, and electricity consumption steering (Bergek, 2020). While the study by Bergek (2020) focuses on private intermediaries only, it is not clear at this stage if public or private tend to be narrow or broad. Moreover, Talmar et al. (2022) highlight that ecologies of intermediation must pay attention to the trade-off between broad and narrow intermediaries, in particular in relation to public intermediaries and their policy mission. Consequently, the sixth proposition is:

P6. *Public and private intermediaries have different degrees of specialization in their adoption support.*

2.3.4. Degree of neutrality

Lastly, previous studies diverge in the importance they give to neutrality in the role of intermediaries (Kant and Kanda, 2019; Klerkx and Leeuwis, 2009). Some authors stress the importance for intermediaries of being independent from political (Kivimaa, 2014) or commercial interests (Rossi et al., 2022). Nevertheless, other empirical studies suggest that intermediaries may have hidden agendas when providing support and advice (Mignon, 2017). There is indeed a consensus on public and private intermediaries not being equally neutral. Yet, opinions seem to diverge on how neutral public intermediaries are (or if their public position in fact implies a lack of political neutrality).

It has been highlighted that private intermediaries, due to their business model, have to prioritize their own survival, sometimes at the cost of their clients (e.g., Klerkx and Leeuwis, 2009; Mignon and Broughel, 2020). Due to their market position, private intermediaries have to foster their networks, which may result in them prioritizing specific technologies or suppliers, even if these choices are not the optimal ones for the system or for their clients (e.g., Mignon, 2017; Mignon and Broughel, 2020).

When it comes to public intermediaries, this is not as clear. On the one hand, public intermediaries are often required to remain technology- and supplier-neutral, which implies that they are not allowed to recommend a specific brand, technology or contractor (e.g., Kivimaa, 2014; Mignon and Winberg, 2023). Being commercially independent, public intermediaries are thus often expected to be impartial and trustworthy (Rossi et al., 2022). Studies have shown that public intermediaries can be assigned long-term objectives, contributing to the common good and not just individual interests (De Silva et al., 2022; Rossi et al., 2022). On the other hand, it has also been stressed that public intermediaries may be perceived as biased (i.e., hidden messengers from public governments) from the actors that need their services (Kivimaa, 2014; Klerkx and Leeuwis, 2009). In line with this understanding, authors have underlined that when intermediaries receive public funding to finance their activities, they become dependent of public institutions, which limits their agency and freedom, and forces them to pursue funding that may damage their neutrality and legitimacy (Kant and Kanda, 2019; Mignon and Kanda, 2018). The seventh proposition is thus:

P7. *Public and private intermediaries have different degrees of neutrality in their advice to adopters during the adoption process.*

3. Method

To test the propositions presented in Section 2.3, this study takes an exploratory quantitative research approach. By comparing items reflecting intermediation support from public and private intermediaries using Mann-Whitney *U* tests, the study provides a snapshot of the function of the ecology of intermediation for solar PV support in Sweden.

3.1. Study context

The context of this study is the ecology of intermediation providing support to adopters of solar PV in Sweden, which can be qualified as established, because it has existed (in different forms) for several decades. This ecology consists mainly of public and private actors, including public energy advisors and private actors such as installers, retailers, or turnkey solution providers (Bergek, 2020). While other types of actors have also been shown to contribute to adoption support, such as the Swedish Solar Energy Association (Palm, 2015), diverse digital platforms and forums (Westelius, 2008) as well as peers and neighbors (Palm, 2017), this paper is limited to the study of public and private intermediaries.

In regard to public intermediaries, we study the total population of 186 municipal energy advisors distributed over 118 (groups of) municipalities in Sweden, covering 288 out of 290 municipalities in Sweden. They exhibit several public attributes, in accordance with Fig. 1. First, they have a public organizational form as they are employed as part of municipal organizations. Second, they receive public funding through 1–3 year-basis grants allocated by the Swedish Energy Agency. Third, they are publicly governed, as the Swedish Energy Agency defines their mission and coordinates their work. Their mission is to promote climate goals and reduce climate impact from energy use among households, associations, and small- and middle-sized enterprises, by providing (commercially) neutral and commercially independent advice adapted to the local context (Swedish Government, 2016).

As for private intermediaries, we focus on small to medium size installers and retailers of solar PV systems, as well as wholesalers, project developers, and technical consultancies (IEA PVPS, 2023). As of 2021, there were 308 companies selling and/or installing PV systems in Sweden and 51 consultancy firms offering different services related to solar PV (Lindahl et al., 2021). These companies are characterized as private intermediaries because they are organized as limited companies, their funding is based on a for-profit logic through client fees, and they are governed through an executive board. While these companies act as knowledge and network brokers, by providing their clients (adopters) with information and advice throughout their adoption processes, most of them also perform a certain extent of non-intermediation activities (e.g., sales). They can therefore not be qualified as ‘pure’ intermediaries (cf., Klerkx and Leeuwis, 2008a).

The public and private character of the studied intermediaries, based on the attributes defined in Section 2.2, is summarized in Table 1.

3.2. Survey design

The survey was designed based on categorizations and findings from previous qualitative studies (as presented in Section 2.3.). This resulted in the questions and items described in Table 2. The survey also included background questions (about their position, experience, and adopter contact) and concluding questions (e.g., other comments).

Given that the survey was based on qualitative assumptions rather than previously validated constructs, considerable attention was paid to reliability and validity. First, the items were five-point rating scales of unipolar types, ranging from “To a very low extent” to “To a very high extent”. To minimize common method bias (Jordan and Troth, 2020; Podsakoff et al., 2003), some items were reverse-scored and others had different quantified labels. Open-ended follow-up questions were included where appropriate. Moreover, the survey underwent a two-step pre-testing process (De Leeuw et al., 2012). First, face validity was assessed by a small group of experts (academics and professionals). Second, a pilot test was conducted with five knowledgeable professionals, not part of the sample frames, to refine the questions.

3.3. Data collection

The survey was distributed to the two respondent groups in June–October 2023 and January 2024. The main data collection approach was to reach respondents through endorsement from what they considered to be credible sources (Rochford and Venable, 1995). This process was more successful for public than private intermediaries. While it is well-accepted, when collecting survey data, that the response rate among companies is lower than other societal actors (e.g., Dennis Jr, 2003), further strategies were needed to reach comparable sample sizes.

For the data on public intermediaries, the municipal energy advisors received the survey via email from regional development managers of the fifteen regional energy offices in Sweden in June to July 2023 with one reminder. The regional development managers coordinate regional networks of energy advisors and keep up-to-date mailing lists of the advisors, thus suitable for endorsing participation in the survey (Rochford and Venable, 1995). The response rate was 49 % (91 out of 186).

Data collection for the private intermediaries occurred in three steps. First, from June to August 2023, the survey was disseminated via the Swedish Solar Energy Association’s newsletter, which reaches 2700 employees across 330 member companies. While this approach was chosen to reach a large number of potential respondents, it only generated a few responses despite a reminder after one month. Therefore, in a second step, from September to October 2023, the survey was posted in a social network forum for solar PV installers with 1300 members. This also yielded only few responses. The problem with these two steps is their mass-communication nature, with the risk of survey information getting lost among non-targeted content and a perceived low degree of personalization, resulting in lower participation (Sauermann and Roach, 2013). Consequently, we adopted a more targeted strategy in the third step, sending the survey to a purposefully mined segment of our target group (Dennis Jr, 2003; Fan and Yan, 2010). We collected individual email addresses for employees at a subset of installation companies, project developers, technical consultancies, and wholesalers from the Swedish Solar Energy Associations’ member list. As a result, in January 2024, 319 individuals received personal survey invitations, resulting in 56 new responses, equivalent to an 18 % response rate. The final sample of private intermediaries was 72 responses.

An overview of the sample size and demographic information about the sample is presented in Table 3.

Intermediaries’ experience of the solar industry is rather similar for public and private intermediaries. Among the public intermediaries, there is a larger share that has worked for a longer time than among the private intermediaries. As for their education, the data was collected as text responses and categorized by the authors post collection. A larger share of the public intermediaries has a higher education degree (bachelor or master), whereas more of the private intermediaries have opted for a higher vocational education on specific topics related to solar PV, energy, and buildings.

Table 1

Characterization of the intermediaries included in the study based on their public/private attributes.

Intermediary	Organization	Funding	Governance
Municipal energy advisors	Municipal organization	Public	Project-based grants from the national state budget
Solar PV companies	Limited company	Private	Profits based on client fees
		Public	Mission defined and coordinated by the Swedish Energy Agency
		Private	Executive board
			Public
			Private

Table 2
Item structure for the survey.

#	Proposition	Survey question	Item	Adapted from references
P1	Rationale for providing adoption support	In your work, how important is it for you to...?	Maximize tailored advice Maximize client satisfaction Maximize number of installations Maximize profitability Maximize own learning and development	Mignon and Broughel (2020)
P2	Value provision	To what extent do you perceive that the following make clients turn to you for support?	Price competitiveness Process rapidity Content of the service package Location Service-mindedness Relevant expertise and experience Legitimacy and recommendations Commitment Service quality	Aspeteg and Mignon (2019)
P3	Target groups	How many of your clients are...?	Households Companies Farmers Housing associations Other associations	Mignon and Winberg (2023)
P4	Stage of adoption process	To what extent do you meet clients...?	Without previous intention to adopt Considering adoption With intention to adopt That have decided to adopt That have adopted and need further support That have adopted and want to make a new investment	Glaa and Mignon (2020)
P5	Types of adoption support activities	To what extent do you provide your clients support with...?	General information and education Design and dimensioning support Investment support Technological support Administrative support Support with tenders Confirmation of clients' decisions Follow-up of ongoing client processes Network support (e.g., contacts to electricity and grid companies)	Aspeteg and Mignon (2019), Bergek (2020)
P6	Degree of specialization in their adoption support	To what extent do you also provide support about...?	Energy efficiency EV and charging Energy storage and batteries Heating systems and ventilation Buildings, insulation, and renovation Lighting Steering electricity consumption	Bergek (2020)
P7	Neutrality in their advice to adopters	How much influence do you have on your clients' choice of...?	Technical solution Solar PV product Service provider	Bankel and Mignon (2022)

3.4. Data analysis

In the first part of the analysis, descriptive statistics were used to examine patterns in each respondent group. As both Levene's test and Shapiro-Wilk's test were significant, indicating unequal variances and non-normality, respectively, Mann-Whitney's U test was used to assess significant differences between the two respondent groups for all individual items. This non-parametric test is robust for when the assumptions about homogeneity of variances and normality do not hold (Zimmerman, 1987).

Nonresponse bias was assessed by doing a comparison between early and late respondents. Such extrapolation methods are based on the assumption that late respondents are more similar to non-respondents than early respondents (Armstrong and Overton, 1977). This was done by comparing responses that were collected before and after a reminder was sent out in the middle of the data collection period. No difference was observed, leading to the assumption that nonresponse bias did not impact the results.

Table 3
Sample size, experience, and education of the two subsamples.

Descriptive statistics	Public	Private	Full sample
Sample size	91	72	163
Experience	(n=91)	(n=70)	(n=161)
Mean time (years)	6.83	5.59	6.29
<1 year	12.1 %	7.1 %	9.9 %
1–5 years	26.4 %	41.4 %	32.9 %
6–10 years	34.1 %	35.7 %	34.8 %
11–15 years	15.4 %	10.0 %	13.0 %
>16 years	12.1 %	5.7 %	9.3 %
Education	(n=91)	(n=64)	(n=155)
High school	1.1 %	23.4 %	10.3 %
Bachelor's degree	54.9 %	26.6 %	43.2 %
Master's degree	24.2 %	18.8 %	21.9 %
Doctoral degree	0.0 %	1.6 %	0.6 %
Other	19.8 %	29.7 %	23.9 %

4. Results

4.1. Descriptive statistics and Mann-Whitney U-tests

The results from the Mann-Whitney *U* tests are presented in Table 4, together with descriptive statistics in the form of mean value, 95 % confidence interval (CI), median value, and standard deviation for each item.

4.2. Similarities and differences between public and private intermediaries

As shown in Table 4, 32 of the 43 items showed significant differences between public and private intermediaries, providing support for all seven propositions. Moreover, among the non-significant items, similarities were identified based on the descriptives (mean, median, and confidence interval) as these reflect how the respondents, i.e., the intermediaries themselves, rated the importance of the different items according to their own perspectives about their work and roles.

P1 shows that there are indeed differences but also some similarities in the rationale reported by intermediaries for providing adoption support. It is significantly more important for private intermediaries to maximize client satisfaction, profitability, and their own learning and development than for public intermediaries. However, public intermediaries still prioritize client satisfaction to a very high extent and learning and development to a high extent, whereas the biggest difference is observed regarding profitability. No significant difference is observed for maximizing tailored advice or the number of installations; instead, both groups find it very important to customize their services to the adopters while maximizing the number of installations is considered neither important nor unimportant.

P2 demonstrates differences in attributes affecting the intermediaries' value provision. Public intermediaries perceive that price competitiveness significantly makes clients turn to them for support, reflecting that their services are free of charge. Moreover, private intermediaries perceive to a significantly higher extent that clients turn to them due to the content of the service package, service-mindedness, relevant expertise and experience, legitimacy and recommendations, and service quality. However, despite the significant difference in importance, the results show that also public intermediaries consider service-mindedness, expertise and experience, legitimacy and recommendations, commitment, and service quality as important for their value provision. Moreover, both public and private intermediaries rate process rapidity, location, and commitment to a similar, and high, extent.

P3 shows clear differences in the targeted adopter groups, where public intermediaries report significantly more clients from households and associations, and private intermediaries report more clients from companies. Moreover, both groups target farmers and housing societies to a low extent.

P4 indicates differences in which stage of the adoption process the clients for public and private intermediaries are in. Public intermediaries significantly report that they meet a larger share of adopters in the early, pre-decision, phases of adoption, i.e., without previous intention to adopt and considering adoption. In contrast, private intermediaries report that they meet a larger share of adopters post-decision, i.e., those who have adopted and either need further support or want to make a new investment. Additionally, public and private intermediaries report that they meet adopters in the in-decision stage of the adoption process to a similar, and high, extent.

P5 shows differences in types of adoption support activities reported by intermediaries that align with the differences in stages of the adoption process (P3). Public intermediaries report that they provide general information and education to a significantly higher extent, which matches well with their targeting adopters in the pre- and in-decision stages of the adoption process. While both intermediary types report that they provide support with tenders (an in-decision activity), private intermediaries provide significantly more support with design and dimensioning, investment, technology, and administration (in-decision) as well as confirmation of clients' decisions and follow-up of ongoing processes (post-decision).

P6 demonstrates a clear difference in the degree of specialization between public and private intermediaries. Public intermediaries are significantly less specialized than private intermediaries, reflected by the provision of significantly broader support than solar PV

Table 4
Descriptive statistics and Mann-Whitney *U* tests for public and private intermediaries.

#	Proposition	Item	Public					Private					Mann-Whitney U^a	p-value	Effect Size ^b
			95 % CI			Median	SD	95 % CI			Median	SD			
			Mean	Lower	Upper			Mean	Lower	Upper					
P1	Rationale for providing adoption support	Maximize tailored advice	4.60	4.49	4.72	5.00	0.555	4.40	4.20	4.60	5.00	0.858	2909	0.273	0.0868
		Maximize client satisfaction	4.58	4.46	4.70	5.00	0.579	4.71	4.54	4.89	5.00	0.725	2633*	0.018	0.1735
		Maximize number of installations	3.00	2.78	3.22	3.00	1.054	3.03	2.72	3.34	3.00	1.296	3141	0.876	0.0140
		Maximize profitability	1.90	1.69	2.11	2.00	1.012	3.49	3.19	3.79	4.00	1.263	1147***	< .001	0.6451
		Maximize own learning and development	4.15	3.99	4.32	4.00	0.802	4.40	4.18	4.62	5.00	0.907	2524*	0.014	0.2077
P2	Value provision	Price competitiveness	4.44	4.30	4.59	5.00	0.672	3.09	2.83	3.35	3.00	1.063	919***	< .001	0.6906
		Process rapidity	3.64	3.46	3.83	4.00	0.878	3.78	3.56	3.99	4.00	0.885	2748	0.310	0.0887
		Content of the service package	3.44	3.23	3.65	3.00	1.011	4.15	3.94	4.36	4.00	0.864	1752***	< .001	0.4035
		Location	3.87	3.67	4.06	4.00	0.939	3.56	3.27	3.86	4.00	1.180	2496	0.139	0.1333
		Service-mindedness	4.07	3.91	4.23	4.00	0.772	4.32	4.13	4.50	4.00	0.747	2435*	0.029	0.1893
		Relevant expertise and experience	4.29	4.14	4.43	4.00	0.704	4.71	4.60	4.82	5.00	0.457	2111***	< .001	0.3276
		Legitimacy and recommendations	4.03	3.84	4.22	4.00	0.905	4.62	4.49	4.76	5.00	0.571	1933***	< .001	0.3776
P3	Target groups	Commitment	3.67	3.45	3.89	4.00	1.058	3.90	3.64	4.16	4.00	1.067	2594	0.137	0.1332
		Service quality	3.75	3.54	3.95	4.00	0.935	4.58	4.43	4.73	5.00	0.628	1393***	< .001	0.5137
		Households	3.88	3.78	3.98	4.00	0.491	2.82	2.51	3.13	3.00	1.313	1827***	< .001	0.4345
		Companies	2.11	1.98	2.24	2.00	0.605	3.32	3.04	3.60	4.00	1.185	1454***	< .001	0.5562
		Farmers	1.82	1.70	1.95	2.00	0.592	2.09	1.88	2.30	2.00	0.876	2643	0.084	0.1363
		Housing society	2.28	2.13	2.44	2.00	0.738	2.09	1.87	2.30	2.00	0.913	2623	0.054	0.1579
		Other associations	1.96	1.87	2.04	2.00	0.394	1.59	1.44	1.75	2.00	0.632	1910***	< .001	0.3571
P4	Stage of adoption process	Without previous intention to adopt	2.92	2.77	3.07	3.00	0.718	2.55	2.32	2.78	3.00	0.983	2446**	0.004	0.2428
		Considering adoption	4.22	4.07	4.37	4.00	0.712	3.66	3.38	3.94	4.00	1.195	2415**	0.003	0.2524
		Have decided to adopt	3.90	3.75	4.06	4.00	0.746	3.93	3.69	4.17	4.00	1.019	2963	0.326	0.0830
		Have adopted and need further support	2.34	2.16	2.52	2.00	0.859	3.03	2.73	3.32	3.00	1.253	2149***	< .001	0.3348
		Have adopted and want to make a new investment	2.44	2.24	2.64	2.00	0.968	3.34	3.10	3.57	3.00	0.985	1664***	< .001	0.4851
P5	Types of adoption support activities	Provide general information and education	4.43	4.30	4.57	4.50	0.637	3.80	3.51	4.09	4.00	1.208	2246***	0.001	0.2768
		Provide design and dimensioning support	2.79	2.56	3.02	3.00	1.086	4.17	3.89	4.44	5.00	1.159	1189***	< .001	0.6280
		Provide investment support	2.84	2.60	3.07	3.00	1.118	4.04	3.74	4.34	4.50	1.239	1404***	< .001	0.5464
		Provide technological support	2.96	2.73	3.18	3.00	1.070	3.97	3.67	4.27	4.00	1.233	1580***	< .001	0.4837
		Provide administrative support	2.25	2.01	2.49	2.00	1.141	3.23	2.89	3.57	3.00	1.405	1853***	< .001	0.3967
		Provide support with tenders	3.62	3.39	3.85	4.00	1.107	3.67	3.32	4.02	4.00	1.452	2854	0.367	0.0808
		Provide confirmation of clients' decisions	3.09	2.84	3.34	3.00	1.161	3.88	3.54	4.22	4.00	1.398	1781***	< .001	0.3960
		Provide follow-up of ongoing client processes	2.32	2.12	2.53	2.00	0.970	3.78	3.51	4.05	4.00	1.131	1055***	< .001	0.6552
P6	Degree of specialization in their adoption support	Provide network support	2.37	2.15	2.59	2.00	1.027	3.64	3.34	3.94	4.00	1.248	1383***	< .001	0.5497
		Energy efficiency	4.15	3.97	4.33	4.00	0.868	3.54	3.24	3.83	4.00	1.229	2325***	0.001	0.2803
		EV and charging	3.71	3.55	3.88	4.00	0.807	3.23	2.93	3.52	3.00	1.233	2533*	0.013	0.2161

(continued on next page)

Table 4 (continued)

#	Proposition	Item	Public					Private					Mann-Whitney U ^a	p-value	Effect Size ^b
			95 % CI			Median	SD	95 % CI			Median	SD			
			Mean	Lower	Upper			Mean	Lower	Upper					
		Energy storage and batteries	3.86	3.68	4.03	4.00	0.838	3.86	3.58	4.14	4.00	1.175	3024	0.465	0.0639
		Heating systems, and ventilation	3.92	3.73	4.12	4.00	0.946	2.15	1.84	2.47	2.00	1.316	1022***	< .001	0.6836
		Buildings, insulation, and renovation	3.86	3.65	4.06	4.00	0.973	1.85	1.56	2.13	1.00	1.191	748***	< .001	0.7685
		Lighting	2.87	2.63	3.11	3.00	1.147	1.83	1.53	2.13	1.00	1.253	1592***	< .001	0.5072
		Steering electricity consumption	3.60	3.42	3.79	4.00	0.905	3.03	2.72	3.34	3.00	1.298	2414**	0.004	0.2527
P7	Neutrality in their advice to adopters	Influence on choice of technical solution	3.16	2.97	3.36	3.00	0.946	3.99	3.71	4.26	4.00	1.165	1759***	< .001	0.4557
		Influence on choice of solar PV product	2.33	2.14	2.53	3.00	0.924	3.73	3.41	4.04	4.00	1.318	1252***	< .001	0.6025
		Influence on choice of service provider	2.23	2.02	2.44	2.00	1.001	3.58	3.24	3.92	4.00	1.441	1549***	< .001	0.5207

^a Significant *U* test denoted as *($p < 0.05$), **($p < 0.01$), and *** ($p < 0.001$).

^b Effect size measured with rank biserial correlation.

adoption, including energy efficiency, EV and charging, heating systems, buildings, lighting, and steering of electricity consumption. A similarity is observed in that both intermediary types provide support related to energy storage and batteries.

Lastly, P7 illustrates that private intermediaries are significantly less neutral in their advice to adopters in the adoption process than public intermediaries. Private intermediaries report a significantly higher influence on adopters' choice of both technical solution, solar PV product, and service provider.

The similarities and differences between public and private intermediaries identified for each proposition are summarized in Table 5.

5. Discussion

From comparing public and private intermediaries supporting adopters of solar PV in Sweden, the results show both similarities and differences in why and how they provide intermediation support to adopters. This indicates that although there are some overlaps, they have complementary roles to play when co-existing in the ecology of intermediation.

To start with, complementarity is observed in the motivations to why the studied public and private intermediaries report that they provide intermediation support, as the results show that they have different rationales (P1) and value provision (P2). This is further emphasized by the fact that they mainly target different adopter groups (P3). Not surprisingly, private intermediaries are clearly more driven by profitability and have a stronger focus on companies, which is an investor group that usually pursues larger projects and handles investments in a more professional manner (Bankel and Mignon, 2022; Karneyeva and Wüstenhagen, 2017). In contrast, public intermediaries are less focused on profitability – which is coherent, as they are not-for-profit actors – and more focused on households and associations (i.e., the main targets of their assignment) that usually make smaller solar PV investments. For public intermediaries, price competitiveness is also reported as a very important aspect of the value that they offer, which makes sense, since they provide services free of charge (Mignon and Winberg, 2023). This indicates that public intermediaries indeed give higher priority to overall system goals, rather than short-term profits (De Silva et al., 2022; Rossi et al., 2022).

Regardless of target group, both public and private intermediaries report that they prioritize tailored advice to a very high extent. Although private intermediaries report having a significantly greater emphasis on client satisfaction, public intermediaries still rate it as very important. A similar pattern is found in the actors' value provision, where private intermediaries give significantly higher importance to expertise, experience, legitimacy, and service quality, but these aspects are still of high importance for public intermediaries. This indicates that public and private intermediaries have a similar compass guiding their adoption support, even though they provide their support to different adopters and in different ways. This is reassuring for the quality and efficiency of intermediation and goes in line with the study conducted by Mignon and Broughel (2020), where the authors showed that private intermediaries were willing to prioritize the interests of their clients (e.g., satisfaction) in front of their own interests (e.g., profitability).

Furthermore, our results indicate complementarity in the timing of the provided support activities (i.e., when in the adoption process the intermediaries provide support) as well as the type of support activities. Public intermediaries report that they focus more on the pre-decision phase, with activities such as providing general information and education, while private intermediaries report a

Table 5
Similarities and differences between public and private intermediaries (based on the perspective of intermediaries themselves).

#	Proposition	Similarities <i>Both public and private intermediaries have...</i>	Differences	
			<i>Public intermediaries have...</i>	<i>Private intermediaries have...</i>
P1	Rationale for providing adoption support	... very high emphasis on tailored advice. ... neither high nor low emphasis on the number of installations.		... greater emphasis on profitability, client satisfaction, and own learning and development.
P2	Value provision	... high emphasis on process rapidity, location, and commitment.	... greater on price competitiveness (being free of charge).	... greater emphasis on content of service package, service-mindedness, relevant expertise and experience, legitimacy and recommendations, and service quality.
P3	Target groups	... low emphasis on farmers and housing societies.	... greater emphasis on households and associations.	... greater emphasis on companies.
P4	Stage of adoption processes	... high emphasis on adopters in the in-decision stage.	... greater emphasis on adopters in the pre-decision stage.	... greater emphasis on adopters in the post-decision stage.
P5	Types of adoption support activities	... high emphasis on activities in the in-decision stage (support with tenders).	... greater emphasis on activities in the pre- and in-decision stages (general information and education).	... greater emphasis on activities in the in-decision stage (support with design and dimensioning, investment, technology, administration, and networks) and post-decision (confirm clients' decisions and follow up on ongoing processes).
P6	Degree of specialization in their adoption support	... high emphasis on providing support on energy storage and batteries.	... low degree of specialization (provide support on other energy-related issues to a high extent).	... high degree of specialization.
P7	Degree of neutrality in their advice to adopters		... low degree of influence on adopters' choices	... high degree of influence on adopters' choices

higher focus on the post-decision phase, including activities directed at designing and implementing the solar PV system (P4 and P5). Additionally, both public and private intermediaries state that they provide support to adopters in the in-decision stage of the adoption process to a high extent. This indicates a division of labor that limits competition between the intermediary types, which is positive from a sustainable system perspective, as it makes efficient use of public spending (e.g., Rossi et al., 2022). On the one hand, public intermediaries provide support at a stage when neutral information is crucial (Glaa and Mignon, 2020) as the adopters have not yet decided on their investments. At that stage, they may still decide not to adopt, thus not generating income for private intermediaries. On the other hand, private intermediaries provide support during the post-adoption stage, where it is easiest to sell customized services, and hence when it is the easiest for private intermediaries to capture economic value (Bankel and Mignon, 2022; Schoettl and Lehmann-Ortega, 2011). Consequently, it is not surprising that public and private intermediaries exhibit differences in their degree of specialization, with public intermediaries providing advice to a broader range of energy-related topics and private intermediaries being more specialized (P6). This can be done to the fact that private intermediaries strategically specialize in certain technologies and customers in order to get market shares, e.g., by strengthen resources, such as legitimacy, expertise, and network. Meanwhile, public intermediaries' mission is broader than the focus on solar PV, as their task includes the promotion of sustainable practices in a broad sense (including e.g., heating, lighting, transportation, energy efficiency), and as they are expected to be commercially independent.

A final observation is that public and private intermediaries do not report being equally neutral in their advice to adopters. While public intermediaries indicate neutrality as per their mission and provide rather general knowledge and education to adopters, private intermediaries are commercial actors providing customized support and, by doing so, they influence adopters' choices of technological solutions, products, and service providers (P7). Nevertheless, our results highlight that legitimacy and recommendations are of high importance even for private intermediaries, suggesting that their influence on the adopters' choices does not affect the adopters' trust (e.g., Karhinen et al., 2021; van Lente et al., 2003). This shows that intermediaries can indeed act as filters of information and knowledge (Sovacool et al., 2020; Zaunbrecher et al., 2021) and it stresses the importance of having actors in an ecology of intermediation that provide neutral and independent intermediation support (Kant and Kanda, 2019; Klerkx and Leeuwis, 2008b). When assessing ecologies of intermediation, it is therefore important to ensure the presence of actors providing this neutral intermediation support (e.g., in addition to other less neutral actors), for instance to assess tenders in the adoption process. Since the degree of influence is highly connected to whether intermediaries are public or private, this highlights the value of addressing the dichotomy of public and private when studying the composition of ecologies of intermediation.

In sum, the above-mentioned patterns of similarities and differences suggest that public and private intermediaries co-existing in the ecology of intermediation supporting adoption of solar PV in Sweden provide complementary services, indicating a good division of labor between the two actor types. Indeed, they have different target groups, offer support at different stages of the adoption process, and provide different, but complementary, intermediation support activities. Despite their differences, they seem to follow a similar compass in their support, by putting quality, adopter satisfaction, and knowledge on top of their priorities. This is illustrated in Fig. 2. While a spectrum of breadth may indeed be observed within each intermediary group, as shown e.g., by Bergek (2020), our results stress that in the specific ecology of intermediaries supporting solar PV adopters in Sweden, both depth and breadth in expertise and service are available, which we claim is a necessary condition for a comprehensive support of adopters, which in turn is a prerequisite for enabling sustainability transitions.

While the complementary intermediation support provided from public and private intermediaries suggests that these two actor types are rather aligned and coordinated, it is important to note that our study does not account for the complete ecology of

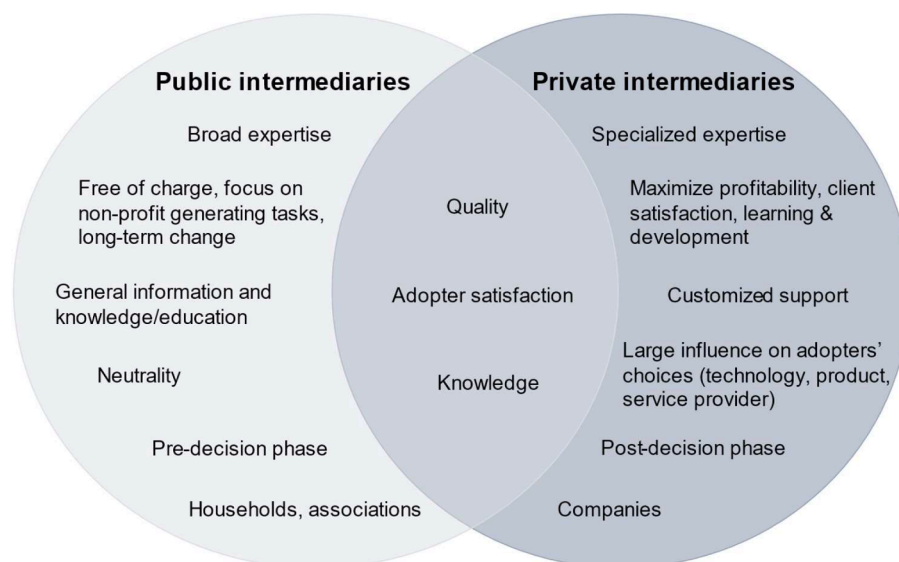


Fig. 2. Overview of the complementarity in adoption support provided by public and private intermediaries co-existing in the ecology of intermediation for solar PV adoption support in Sweden.

intermediation supporting adopters of solar PV (not including e.g., industry associations, digital platforms, and peers). Studying a complete ecology of intermediation may be difficult to accomplish, given for instance that many intermediaries are informal ones (that may not even be aware of their intermediation function (e.g., Hodson et al., 2013; Martiskainen and Kivimaa, 2018; Moss, 2009)). Nevertheless, if we had managed to include the complete ecology of intermediation to the study, we would not anticipate such complementarities or division of work. Instead, we would expect a number of overlaps in intermediation activities, target groups, decision phase and expertise. Nevertheless, since many tensions have been reported between private and public intermediaries in previous studies (e.g., Glaa and Mignon, 2020; Klerkx and Leeuwis, 2008a), our study brings clarity on potential conflictual areas.

These results contrast with the study of Glaa and Mignon (2020) who investigated a similar ecology of intermediation (i.e., support of renewable electricity technology adopters in Sweden) in 2018 and who came to the conclusion that there existed overlaps and gaps in the intermediary support – not the least among private and public intermediaries. This contrast indicates that some kind of alignment has happened over the last years, even if the design of the study, i.e., focusing on intermediation in a maturing (but not fully mature market), does not allow for an assessment of the outcomes of intermediation in terms of market competitiveness and cost reductions. From an innovation system development perspective, this process is logical; innovation system components (including knowledge and support infrastructure) become more efficient and stable as the innovation system becomes more mature (Kivimaa, Boon, et al., 2019). Yet, this provides new insights for the understanding of the temporality of ecologies of intermediation, which has until now been rather understudied (Kivimaa, Hyysalo, et al., 2019).

6. Conclusion

The aim of this paper was to provide a better understanding about ecologies of intermediation by comparing the adoption support provided by public and private intermediaries that co-exist in the context of PV adoption in Sweden. By doing so, we proposed to inform the transitions research on knowledge and support infrastructure with the potential of accelerating transitions.

Assumptions about public and private intermediaries' similarities and differences taken from previous qualitative research were tested quantitatively and the findings show that the studied public and private intermediaries provide different, but complementary, support to adopters. They base their offers on different rationales and value provision, target different adopter groups, and offer support in different stages of the adoption process, indicating a good level of alignment. While our study does not account for the complete ecology of intermediation supporting adopters of solar PV, the evolution from gaps and overlaps in the intermediation support (reported e.g., by Glaa and Mignon (2020)) to a better alignment and more complementarities suggests that this specific ecology of intermediation is processing towards maturity, along with the rest of the socio-technical system of decentralized solar PV in Sweden (e.g., Lindahl et al., 2022). Such a step is crucial for accelerating transitions, since diffusion processes and other socio-technological transformations require a strong knowledge and support infrastructure.

This paper has four main contributions. First, it provides a better understanding of the composition of ecologies of intermediation, by informing about public and private intermediaries co-existing in the same ecology of intermediation. Second, the study contributes to new insights in the temporality of ecologies of intermediation, by highlighting some characteristics of what the intermediation function can be associated with in a maturing innovation system (i.e., solar PV in Sweden). Third, the study provides a new methodological approach in the growing intermediary research, by using quantitative methods to test assumptions previously developed in qualitative results. Finally, the paper contributes with a conceptualization of attributes distinguishing public and private intermediaries, i.e., funding, organization, and governance.

Lastly, limitations of the study pinpoint areas for future research. First, this study only provides a snapshot of two actor types co-existing in one ecology of intermediation. Future research is needed to account for other actors of ecologies of intermediation and contexts to further the understanding of how ecologies of intermediation evolve over time as well as how these can be designed and coordinated. Moreover, the study addresses the perspective of intermediaries themselves, which limits nuances and may include some social desirability bias, e.g., related to rationales for the adopter support or value proposition. Hence, future studies would benefit from addressing complementarity in ecologies from other perspectives, such as from the adopters demanding and receiving intermediation support. Finally, it should be noted that, in this paper, aspects such as intermediary's impact on market competitiveness and cost reductions, have not been assessed. Further research might investigate these aspects, for instance in order to improve the understanding of the roles played by ecologies of intermediation on the efficiency and cost of PV installations.

CRedit authorship contribution statement

Lisa Bastås: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ingrid Mignon:** Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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