INTEGRATING TRANSACTION COST THEORY AND MARKET DESIGN

Reversing the discriminating alignment hypothesis to design for the Dutch electricity market and PV prosumers

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26-11-2014

Abstract

PV prosumers could have a significant contribution to the 20/20/20 goals, but the Dutch electricity system is not equipped for this. The current net metering policy has an uncertain future and net metering takes away the time dependent, system critical, component of the balance of demand and supply for prosumers. An integrated transaction cost theory and market design method is used to analyze the problems in the sector and design market design options to mitigate those problems. This is done by exploring whether the reversed discriminating alignment hypothesis could be applied to this research: instead of matching governance structures to transactions attributes, turning this around and change transaction attributes to match the already defined governance structure of the electricity market. Technical and contractual solutions were found that adapt the individual transaction attributes to let them match with the governance structure of the market. The individual solutions were then composed into three market design options. The market design options are evaluated by means of their impact on the problems that resulted from the transaction cost analysis. The results are compared to the requirements following from interviews in field research. The market design option called 'It's all in the bundle', making use of real time tariffs to steer demand, in house storage and an exclusive contract with one supplier with a bundle structure, turned out to be the preferred market design option. Future research should, first, take the direction of further developing the integrated transaction cost theory and market design method and could explore if this integration is also possible with other theories. Secondly it should be defined, in both theoretical and practical sense, what the possibilities, constraints and complexities following from the reverse discriminating alignment hypothesis are, that were not described by Williamson. Lastly the resulting market design should be fine-tuned by taking into account more system features such as consumer acceptance and production costs and complementing this research with other theoretical perspectives.

Keywords: Transaction cost theory, electricity market design, integrated approach, Prosumers, PV, renewable energy

1. Introduction

This article proposes a future market design for the Dutch electricity market in order for photovoltaic (PV) electricity generating consumers (prosumers) to contribute to a sustainable energy system. If the Dutch PV sector keeps growing with the same pace as it did the past few years, 6% of Dutch electricity consumption could be from PV electricity generation in 2020 (0,3% in 2013). This means it could be an important contribution to reach the European 20/20/20 goals which require a 14% share of energy from renewables in 2020 (4,5% in 2013) (CBS, 2014b; EC, 2009; ECN, 2012).

Using an integrated approach combining transaction cost theory and market design, this research will focus on exploring the possibilities to enlarge and accelerate the private contribution to the 20/20/20 goals. As a starting point this research takes, first, the fact that net metering mechanism (surplus energy can be released to the grid and consumed later, without paying taxes over it) has an uncertain future because the Dutch government faces big tax losses as a result from this partial tax exemption for prosumers (Energiegids.nl, 2014) (Simmons, 2013). Secondly, net metering takes away the time dependent component of the balance of demand and supply for prosumers: the fixed tariffs that consumers receive for their surplus generated electricity does not reflect the time value of electricity and does not motivate prosumers to contribute to matching demand and supply, while this is very much needed in the electricity system as a whole.

The uncertain future of net metering is thus considered as an opportunity to review the electricity system concerning PV prosumers. The integrated approach will give insight in the institutional configuration of the current electricity system concerning the feed in and settlement of privately produced PV electricity, as well as propose market design options based on this insight. These options will then be tested on their effectiveness. Together this answers the following research question:

How can the institutional configuration of the electricity market be adapted in order for PV prosumers to contribute optimally to a sustainable electricity system?

The focus of this article will be on the integrated approach used to answer the research question. The case described in this introduction will serve as an illustration to outline this approach. The general research approach for the study will be explained in section 2, followed by an explanation of the integrated transaction cost and market design method within the study in section 3. Section 4 will shortly describe the performed problem analysis and section 5 explains about the composed market design options. The option selection is described in section 6 and conclusions are provided in section 7. Section 8 contains the discussion and future research.

2. Research approach

The research framework integrating transaction cost theory and market design is depicted in Figure 1.

Transaction cost theory is first used to analyse the current configuration of the electricity market concerning prosumers. The result of this analysis is a clear overview of the problems in the market configuration of the industry. Together with Desk and Field research this overview is used to create a design space from which market design options can be constituted. These options will be evaluated on the impact they have on the problems found in the market constitution of the Dutch electricity industry. The field research will be used to validate the result.

The transaction cost method is chosen as a guiding theory because it concerns transactions and their efficient alignment with governance structures in order to economize on transaction costs. This efficient alignment is the point of focus in the current configuration of the Dutch electricity market with the transacting PV prosumers in it. The Field research consists of data collection via interviews, which is necessary because this subject concerns a variety of actors, all having a significant impact on the functioning of the system and all having various possibilities to contribute to the working of the system.

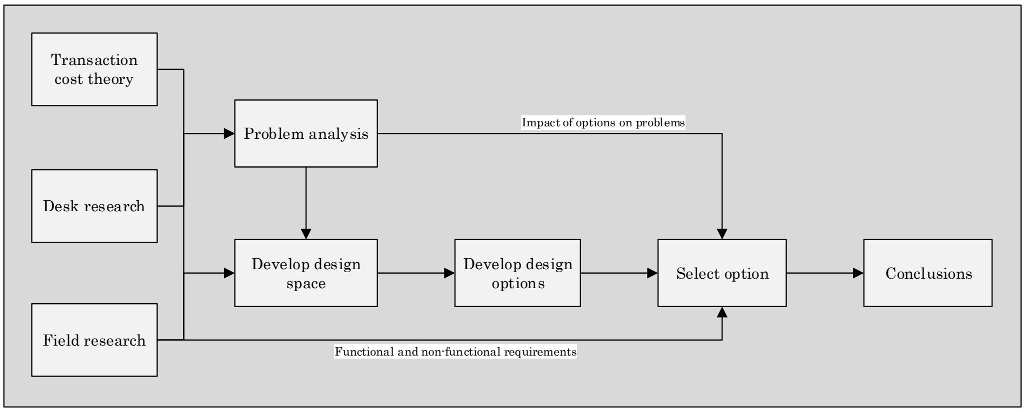

Figure 1: Research approach

3. Integrated transaction cost theory market designing

The integrated method is based on the key proposition of Williamson's Transaction cost theory: the discriminating alignment hypothesis. When governance structures (differing in costs and competences and in their attributes of incentive intensity, administrative control and contract law) are aligned with transactions (differing in their attributes: frequency, uncertainty and asset specificity), this economizes transaction costs. If governance structures are not well aligned with the transactions they are supposed to govern, incomplete contracts arise, giving economic actors room to act based upon their natural behavioural attitudes: bounded rationality (limited human capacity to receive, store, retrieve and process information) and opportunism (self-interest seeking behaviour combined with dishonesty), resulting in higher transaction costs. (Williamson, 1985, 1991, 1996, 1998). Figure 2 visualizes the discriminating alignment hypothesis.

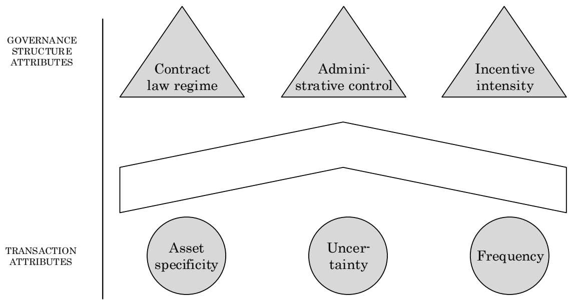

Figure 2: Discriminating alignment hypothesis

Governance structures 'rest upon' transaction attributes, in a specific configuration that is aligned with the transaction attributes. The outline of this figure will be used throughout the article to explore the possibilities of transaction cost theory, to analyse the problems in the sector and to create a design space where market design option will be composed from. It will thus provide the guiding structure for integrating transaction cost theory and market design.

The governance structure that rests upon the transaction attributes (thus governs the transaction) is dependent from the characterization of the transaction attributes. 'The market' is the most efficient governance structure to govern non-specific and low uncertainty transactions, both occasional and recurrent (depending on the situation). The other extreme, 'the hierarchy' (firms with a large degree of vertical integration. Activities are kept 'in house' instead of acquired on the market), is efficient for governing highly uncertain and very specific (idiosyncratic) transactions, also both occasional and recurrent – depending on the situation. When transactions are intermediate or highly uncertain and make use of mixed or idiosyncratic assets, then various possible forms of 'the hybrid' account for the dependence between the contracting parties (hybrids are thus in between market and hierarchy, such as joint ventures, long term contracts)(Niesten, 2009; Williamson, 1985).

However, in order to create one single European market and because "Market forces produce a better allocation of resources and greater effectiveness in the supply of services…" (EC, 1996) EU bodies and national governments prescribed the electricity sector its governance structure. Unbundled market forms of governance should be implemented and hierarchical firms with vertically integrated production, transmission, retail and/or supply are prohibited. Thus, the governance of the electricity sector is already determined, regardless of the characterization of the transaction attributes. This prohibition of vertical integration has been described by many researchers as misalignment of governance and the specific attributes of the transactions within the electricity sector. (Joskow, 1996; Williamson, 1976, 1996).

The discriminating alignment hypothesis can therefore not be used in its original configuration, since this assumes that the transaction attributes are the independent variables and that the governance structure is the dependent variable, while the governance structure is now imposed in such a way that it becomes an independent variable. The configuration depicted in figure 2 is therefore not valid anymore, the governance structure does not rest upon the transaction attributes.

This leads to exploring the one-time suggestion provided by Williamson (2003). Instead of matching governance structures to transactions and their specific attributes, it will be attempted to match transaction attributes with the already existing governance structure (in this case for a large part defined by European and Dutch laws). This is depicted in figure 3 and 4: the governance structure becomes the independent variable and the transaction attributes rests upon the governance structure, being the dependent variables, changing according to the governance structure.

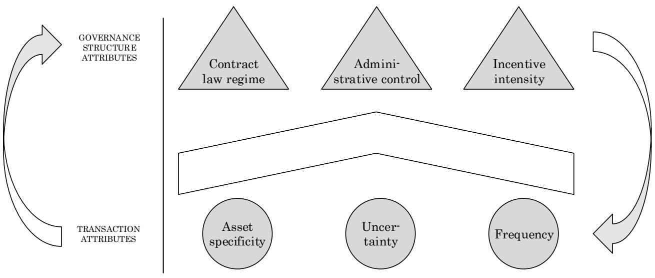

Figure 3: Reversing the discriminating alignment hypothesis

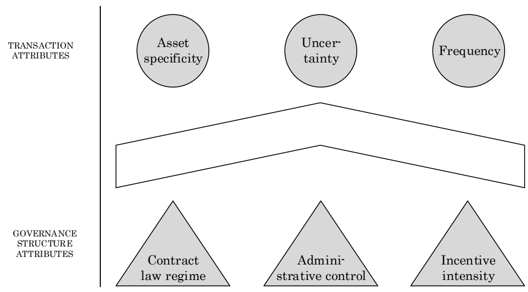

Figure 4: Reversed discriminating alignment hypothesis

Figure 4 will from now serve as the guiding structure (adapted to the reverse discriminating alignment hypothesis). This structure will first be used to analyse the problems in the current electricity sector structurally, attribute per attribute. Once the problems are known for each attribute, this structural method will again be used to find solutions for the problems found per attribute. Those attribute focused solutions will thus adapt the individual transaction attributes in order for them to align with the governance structure of the market. Those practical, attribute focused solutions will be combined into logical, effective, but mutually very different market design options. Hence the integrated transaction cost analysis and market design.

4. Problem analysis

In the problem analyses the current misalignment of transaction attributes and governance structure in the electricity sector is analysed separately for each attribute using the structure of figure 4. The basis for this analysis is the transaction unit of 1 kWh of electricity, generated by the electricity supplier and transferred through the grid and sold to the prosumer, or generated by the prosumer and 'sold' (via net metering) and transferred through the grid to the supplier. First and most important this transaction unit concerns the key change within the Dutch electricity sector: prosumers are supplying 'from the other side of the market' as well. Second, the transaction and governance structure attributes are analysed separately for the two transactions, revealing different problems. An example of the problem analysis concerning one of the transaction attributes (asset specificity) is depicted in figure 5.

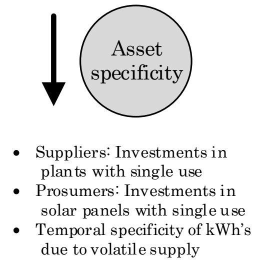

Figure 5: Part of problem analysis concerning asset specificity

Concerning asset specificity three problems are found: the investment in generation plants with a single use is very large, the relative investment for prosumers in solar panels also with a single use is very large and lastly temporal specificity due to the volatile supply of PV generated electricity and the need to balance this volatile supply with demand. Concluding, asset specificity needs to be reduced by solving these problems, in order to be aligned with the governance structure of the market.

The guiding structure is expanded with the findings from the problem analysis. The result is depicted in figure 6. Visualized by arrows and 'equal' signs in the figure, the attributes should change in the indicated direction to be aligned with the current governance structure of the market. Uncertainty and Asset specificity need to be reduced. Currently frequency is arranged in such a way that the high frequency of the transactions is 'reduced' by grouping all transactions on one yearly bill, which is very efficient and should stay this way. Incentive intensity should go up and administrative control down. The contract law regime cannot change, but within this regime risk imbalance between supplier and prosumer need to be safeguarded.

5. Market design options

Using the same guiding structure for the integrated transaction cost and market design method, the design space depicted in figure 8. To change each attribute in the intended direction, solutions on two different levels are proposed, indicated by the two colors. First, the technical governance solutions (the green blocks – demand side management and supply steering) and second the contractual governance solutions (pink blocks). To illustrate this, the attribute 'asset specificity' is used as an example again and is depicted in figure 7.

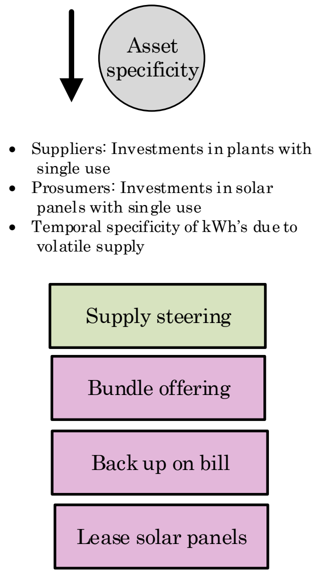

Figure 6: Part of design space concerning asset specificity

To mitigate the problems of supplier's asset specific investments, the back-up capacity that these generation plants provide, that is not paid for at this moment, could be added to the bill of the consumer. This can be mandatory for all consumers, or offered to consumers as a certain percentage of security of supply, in a bundle-structure to consumers where more custom made options can be chosen just like with cell phone contracts. The investment of prosumers in solar panels can be reduced by engaging in lease constructions with the supplier or another party. Supply steering (for example by using storage) can relieve the problems following from the volatile supply of PV generated electricity. Supply steering is categorized as a technical governance solution, and the other three solutions as contractual governance solutions.

The stand-alone solutions are combined into market design options that have an impact on all the attributes together. They have thus changed the transaction, to align it with the governance structure of the market. The contractual solutions are grouped in four arrangements, differing over two axis: Real time and fixed payments per kWh and trading with a single or multiple actors. In total three market design options are constituted from the technical and contractual arrangements. They take into account the capabilities and limitations of the concerned actors (table 1).

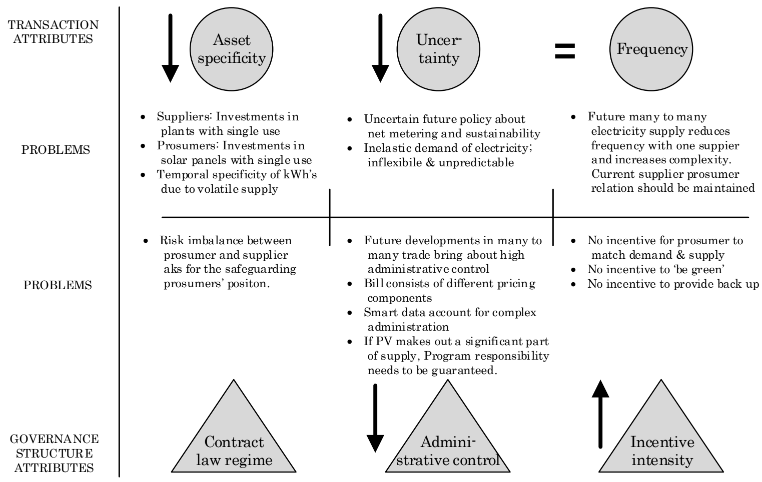

Figure 7: Conclusion from problem analysis

Table 1: Functions, capabilities, limitations of actors (MinEZ, 1998)

	Function	Capabilities	Limitations
Pro-sumer	Consume & gen-erate electricity	Adjust demand, supply, but: bounded rationality!	Program responsibility
DSO	Maintain and balance distribution grid	Data handling and analysis, physical balancing	Commercial activities, unfair pricing
Supp-lier	Deliver electricity and related services to pro-sumer, program responsibility	Generation and/or retail of electricity to prosumer, cooperate with prosumer	Vertical integration, unfair pricing
TSO	Maintain and balance high voltage transmission grid	N/A: transmission grid is outside the scope of this research	N/A: trans-mission grid out of scope
ACM	Regulator, legislative function	Determines maximum transport, connection and system use tariffs. Sets conditions for wholesale market. Legislative function. (ACM, 2014)	N/A
Min EZ/ Fin	Policy & law maker, tax office	Adapt institutional environment, create, adapt or remove stimulation policies	N/A

The market design options are:

1. *<u>It's all in the bundle</u>*: Exclusive supplier – prosumer relation using bundles
   a. Contractual: Real time tariffs/single actor;
   b. Technical: Demand side management & supply steering using real time tariffs, consumer controlled, storage located in house.

In this first market design only the prosumer and supplier take part in the transaction, using real time tariffs. These tariffs and bundle structure give the prosumer the possibility to trade economically efficient, thus both choosing a suitable bundle (containing required services and attractive conditions) and engaging in the balancing of the grid by responding to the dynamic tariffs with demand and supply adjustments. All bundle components and corresponding transactions are grouped on one monthly bill (as in the telecom industry).

2. *One for all, all for one*: Many to many trading platform with a technical layer and a competitive domain for trade between multiple actors;
   a. Contractual: real time tariffs/multiple actors;
   b. Technical: Demand side management semi-automatic, Storage on neighbourhood level.

This market design is a many to many trading framework using real time pricing and multi actor trade. The framework consists of two layers:

i. A technical layer facilitated by the DSO. To keep the balance of the grid under control in this complex framework the DSO makes use of neighbourhood storage to steer supply, and semi-automatic steering of demand.
ii. A competitive layer where electricity is traded. Prosumers, cooperatives of prosumers, suppliers, et cetera can trade electricity with whoever they want.

3. *Today and beyond:* Current supplier – prosumer trading model with technical governance additions
   a. Contractual: Fixed tariffs/single actor
   b. Technical: Automatically controlled demand side management and supply steering, Storage located in house

The third market design is an adapted version of the current model. Tariffs are not real time; they are fixed in the contract with the supplier. Thus the prosumer – supplier relation is exclusive, but in cooperation with the DSO automatic demand steering and supply steering by means of in house storage is realized to optimally balance the distribution grid. The supplier could take up the lease of storage and solar panels as a commercial activity. All transactions are between prosumer and supplier and grouped on a yearly bill.

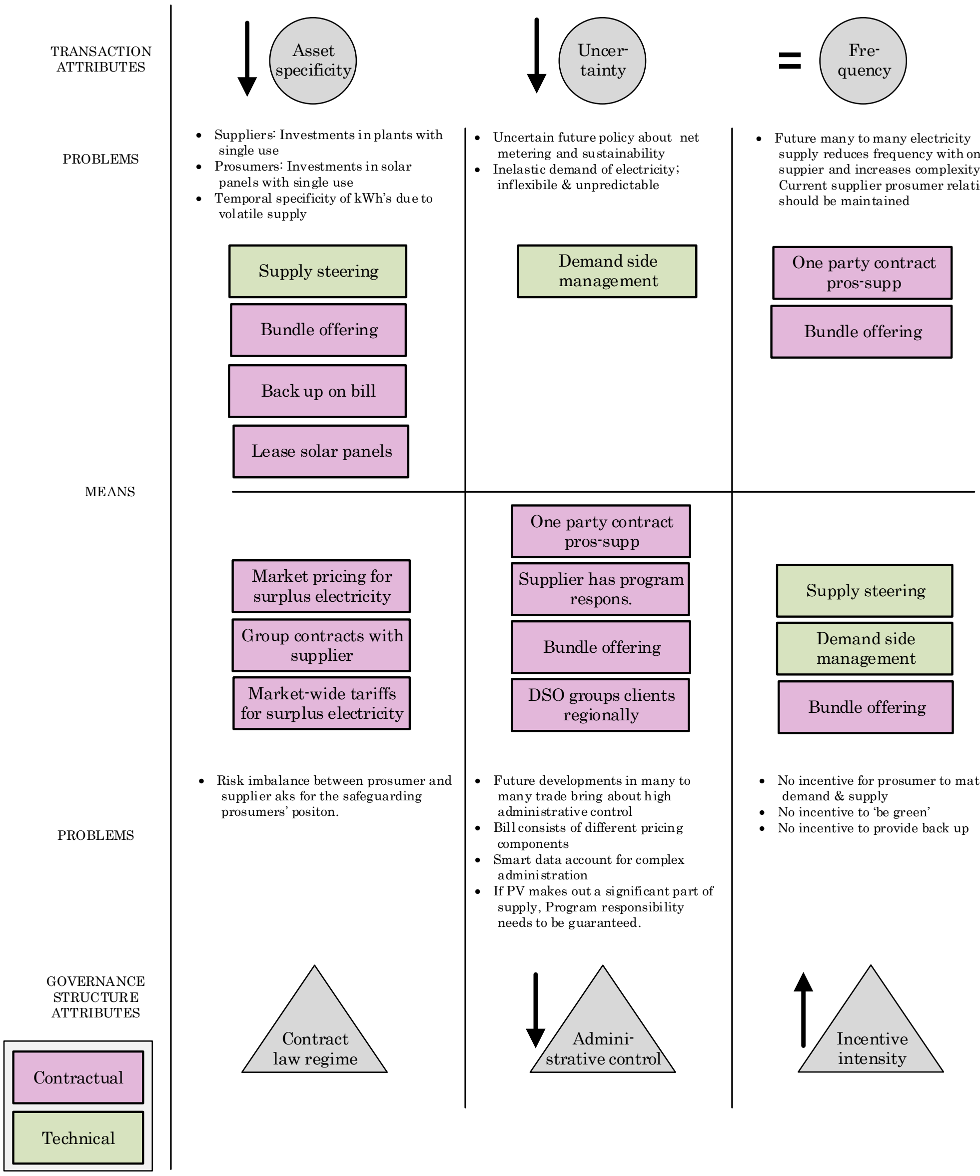

Figure 8: Design space

6. Option selection

The three market design options are first evaluated on the basis of their impact on the problems discovered using the transaction cost theory analysis (first row table 3). For each market design option it is evaluated if the attributes change in the intended direction. The first market design ('It's all in the bundle') is most suited for a future electricity system in the context of this research. One trade off that should be made by selecting this option, is that it does not significantly bring down administrative control (because of the possibly complex bundle arrangement) and the risk imbalance stays unchanged (because the exclusive supplier – prosumer relation stays intact). Compared to the other two market designs it has the most impact on incentive intensity (real time pricing influences demand and supply directly) and it maintains the current frequency of the transaction (exclusive supplier – prosumer relation retains the possibility to group transactions on a periodic bill). It also has a positive impact on asset specificity and uncertainty (price elasticity is increased and temporal specificity of the volatile supply reduced). Market design 2 ('One for all, all for one') did not turn out to be the preferred market design option because it has a negative impact on frequency (many to many trade increases the transaction frequency because grouping on a periodic bill with one supplier is not possible) and on administrative control (many to many trade brings about more and more complex administrative processes). Market design 3 ('Today and beyond') was not preferred because it has a negative impact on incentive intensity (fixed prices and automatic demand side management, with no prosumer intervention) and within the contract law regime the prosumer is still dependent from one single supplier.

This result is compared with findings from interviews conducted in field research. In this field research the actors stated their functional and non-functional requirements for a future market design (table 2). The requirements are mentioned by multiple actors are treated with relative more weight in the evaluation (second and third row in table 3). The second market option design is slightly more suited (however, the score on market design 1 is not *bad*, just a bit less *good* than market design 2). But given the impact on the problems and the high score on the non-functional requirements and its positive score on the functional requirements, market design 1 is chosen as the most suited market design for the electricity market where PV prosumers are trading PV generated electricity.

Table 2: Functional and non-functional requirements

	FUNCTIONAL REQUIREMENTS
1	Incorporate an efficiency incentive
2	Provide flexible demand and supply
3	Have connection & control within system
4	Act as a predictable system in terms of demand and supply
5	Provide room for experimentation
6	Trade back up within the market
7	Act as a smart system

	NON-FUNCTIONAL REQUIREMENTS
1	Sustainability
2	Profitability
3	Free market
4	Transparency
5	Understandable for all actors involved
6	Budget neutrality
7	Processability of data
8	Network stability
9	Fair (tariffs)
10	Affordability

7. Conclusions

An integrated transaction cost theory and market design method has been used to first analyse the problems in the Dutch electricity sector concerning PV prosumers. The method then provided the transaction cost based structure to design solutions for these problems that could be combined into market design options.

The market design 'It's all in the bundle' changes the transaction and governance attributes towards better alignment and is evaluated as acceptable by the concerned actors. This market design is defined by the preservation of the exclusive supplier – prosumer relationship, where bundles are offered consisting of choices to optimally align the contract with the personal possibilities and preferences of prosumers and where real time tariffs are used to let prosumers contribute to a better match of demand and supply, in cooperation with in house storage.

From an academic point of view, it can be concluded that reversing the discriminating alignment theory has worked: by means of the proposed technical and contractual governance arrangements the transaction attributes could be changed in the intended direct to match the already defined governance structure of the market.

Table 3: Combined evaluation of market designs

	MARKET DESIGN 1: IT'S ALL IN THE BUNDLE	MARKET DESIGN 2: ONE FOR ALL, ALL FOR ONE	MARKET DESIGN 3: TODAY AND BEYOND
	Exclusive supplier – prosumer relationship, in combination with real time pricing and bundles. In house storage.	Many to many trading in easy access framework, with semi-automatic demand side management, neighbourhood storage	Current supplier – prosumer trading model with demand automatically controlled, in house storage
IMPACT ON PROBLEMS			
FUNCTIONAL REQUIREMENTS			
NON-FUNCTIONAL REQUIREMENTS			

8. Discussion and future research

This research specifically combines transaction cost theory and market design for the case of the Dutch electricity market and PV prosumers. Future research should develop the integrated transaction cost theory and market design method further and define the integrated method in more detail, so that it can be widely used in a variety of subjects and markets. It should also be explored if this integrated method could be constructed with other (economical) theories.

Nowadays European and national laws are often defining what governance structures should look like in order to achieve an efficient (European) free market. In line with this, it might be important to endorse at academic level that not always governance structures follow transaction attributes, but that reversing this mechanism is possible as well. This research has introduced the reversal of the discriminating alignment hypothesis as quite a simple theoretical twist and did not go into detail about the constraints and complexities related to this reversal of the discriminating alignment hypothesis. It should be explored what these possibilities, constraints and complexities are, both in the theoretical and practical sense, by dedicating more research towards this idea of reverse discriminating alignment. It should be analysed what complexities arise as a consequence of the reversal, that were not described by Williamson in the original theory, and what contractual structures are needed to cope with those complexities.

The practical results of this research in terms of the resulting market design can be used as framework-to-be-fine-tuned to set-up an innovative market model for the Dutch electricity sector to handle the two-way transactions of PV prosumers, which can also be used to accommodate 'regular' consumers in the Dutch electricity sector. Thus, the actors in this market (policy makers and regulators, suppliers, DSO's, 3th parties, et cetera) could use the results to critically review the current system and consider an adaptation of the market design towards a new configuration. However, before such a market design is considered, it is important to take a look outside the scope of this research, both to design or fine tune market design options as well as to evaluate them, instead of only using the two evaluation methods from this research. This can be done by taking on different perspectives (other theories, different transaction unit) while analysing the sector, and/or by taking into account the various system features such as the importance of consumer acceptance, production costs, the emergence of cooperatives and growth of the market, smart systems, et cetera.

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