energies

MDPI

Article

Key Growth Factors and Limitations of Photovoltaic Companies in Poland and the Phenomenon of Technology Entrepreneurship under Conditions of Information Asymmetry

Bartosz Wachnik * and **Zbigniew Chyba ***

Faculty of Mechanical and Industrial Engineering, Warsaw University of Technology, 00-661 Warsaw, Poland
* Correspondence: bartosz.wachnik@pw.edu.pl (B.W.); zbigniew.chyba@pw.edu.pl (Z.C.)

Abstract: Nowadays photovoltaic trade in Poland is growing rapidly due to contemporary challenges in sustainable energy. The first Polish photovoltaic firms were established in the second decade of XXI century. It was the answer of looking for new innovative energy sources including solar energy. It was necessary to change the structure of energy sources in Poland mainly based on carbon and oil & gas. The aim of this article was the identification and assessment the key opportunities and barriers to photovoltaic industry enterprises in Poland in the context of technology entrepreneurship under conditions of information asymmetry. The paper was prepared based on the results of qualitative research using the case study method. A comparative analysis was performed based on results of a study of four purposefully selected enterprises. All of them are SMEs. The research was done in 2021. The case study method allowed for comparing the analysed enterprises in pairs, which is discussed more extensively further on in the text. The research performed will lead to conclusions and recommendations for the photovoltaic sector enterprises in Poland which will allow them to act more effectively and efficiently in conditions of competing on the global market. This paper contains the characteristics of photovoltaic trade in Poland, its macro and micro environment, the opportunities and threats of this trade and key strengths and weaknesses of characterized photovoltaic enterprises in Poland. Finally, the conclusion and recommendations of discussed Polish photovoltaic trade firms in future are evaluated.

Keywords: solar energy; solar photovoltaic; photovoltaic firms; barriers; photovoltaic trade in Poland; technology entrepreneurship; information asymmetry

check for updates

Citation: Wachnik, B.; Chyba, Z. Key Growth Factors and Limitations of Photovoltaic Companies in Poland and the Phenomenon of Technology Entrepreneurship under Conditions of Information Asymmetry. *Energies* **2021**, *14*, 8239. https://doi.org/10.3390/en14248239

Academic Editor: Jesús Manuel Riquelme-Santos

Received: 3 November 2021
Accepted: 1 December 2021
Published: 7 December 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

1.1. Theoretical Background and the Aim of Article

Demand for renewable energy sources is growing rapidly in today's world [1,2]. This is a global phenomenon pertaining to most countries, including those that belong to the European Union. It is also true in Poland, whose structure of energy sources is especially unfavorable in the context of the sustainable development concept being followed currently as well as the ever-widening use of so-called "green energy" [3]. One of responses to these challenges has been the development of the photovoltaic sector in Poland, characterized by a high rate of growth compared to other European Union countries' [4]. The establishment and growth of photovoltaics sector enterprises is the effect of the technology entrepreneurship undertaken by their founders and the entire organizations which skillfully utilize the key element of technology opportunity that appears in their surroundings to create and implement new technology solutions. The barriers to the development of photovoltaic enterprises are also due to the asymmetry of information between energy source producers and consumers, hereinafter collectively referred to as prosumers. The sector's development in Poland is largely determined by external factors, both positive (opportunities) and negative (threats, including development barriers).

Based on a BP (British Petroleum) report in 2020 [5], Poland produced 74.4% of electricity from coal in 2019, which represents a decrease of about 4% in comparison to 2018. However, the percentage of coal in the energy mix in Poland is four times more than the average in European countries (17.5%). The CO2 emission reached 309 million tonnes overall and 151 million tonnes in heat and electricity sectors [6]. Poland's environmental targets to 2030 are a 40% decrease of greenhouse gases (GHG) from the 1990 year level. Also Poland should increase the level of renewable energy sources (RES) in total Energy consumption to 32%, and ought to increase simultaneously the energy efficiency to 32.5% [7]. In 2018, the two last objectives were adjusted to 27% [8]. Nevertheless, environmental targets are demanding challenges for Poland. In the European Parliament, they are much more ambitious. According to [9], Europe intends to achieve carbon neutrality by 2050.

The Ministry of Energy of Poland presented an updated 2040 forecast for the Polish energy mix in November 2019—the EPP (Energy Policy of Poland) 2040 [10]. The document includes eight scenarios with a holistic prognosis of the energy system, including electricity, heat and transport. Those scenarios include a whole supply chain (from sources capture to the end consumer). This prognosis was constructed based on five main assumptions:

- A 56–60% coal share in electricity production in 2030;
- 23% of RES in the final gross energy consumption in 2030;
- Implementation of nuclear energy in 2033;
- A 30% CO_2 emission reduction by 2030 (in comparison to 1990);
- An increase in energy efficiency of 23% by 2030 (concerning the primary energy consumption from 2007).

The aim of this paper is to identify and evaluate key development prospects and barriers for photovoltaic sector enterprises in Poland in the context of technology entrepreneurship under conditions of information asymmetry. The paper was prepared based on the results of qualitative research using the case study method. It attempts to answer the following research question: "What are the key opportunities and limitations of photovoltaics development in Poland from the point of view of your company?".

A comparative analysis was performed based on results of a study of four purpose-selected enterprises. The case study method allowed for comparing the analysed enterprises in pairs, which is discussed more extensively further on in the text. The research performed will lead to conclusions and recommendations for the photovoltaic sector enterprises in Poland, which will allow them to act more effectively and efficiently in conditions of competing on the global market.

Generally the case study method allows the exploration and understanding of complex issues [11]. It can be considered a robust research method particularly when a holistic, in-depth investigation is required. There are a lot of applications of mentioned method in many social science studies, especially in education [12], sociology [13] and community-based problems [14]. Case study helps to explain both the process and outcome of a phenomenon [15].

Past literature explains the application of the case study method e.g. in Sociology [13], Law [16], and Medicine [17]. So the mentioned method is very universal one and useful for scientific research.

1.2. The Essence of "Photovoltaic"

In the last 20 years, the penetration of renewable energy sources (RESs) in energy systems around the world has progressively increased due to the rise of environmental concerns and governmental policies. Of the different RESs, the worldwide growth of photovoltaic (PV) technologies has been close to exponential [1,2]. The most important and challenging problem arising from the great penetration of PV in electrical systems is the high level of variability in the power supplied. In fact, this strictly depends on local weather conditions. The resulting uncertainty and variability in the PV power profile create various problems for the management of the electricity grid. First, large frequency oscillations can be induced by abrupt changes in power. Secondly, in the case of the high penetration of renewables, reverse active power flows may occur in the medium-voltage distribution power supply, or even in the high-voltage transmission line. Finally, the high penetration of PV increases the costs of the allocation of the spinning reserve, ancillary services and the energy planning of the dispatchable generators [18]. For all these reasons, highly accurate photovoltaic power prediction systems are required to optimize the management of the electricity grid from both a technical and economic point of view, without reducing energy reliability and quality.

The word "photovoltaics" consists of two elements: photo, i.e., light, and voltaics, from volt, the unit of electric potential [19]. This reflects the essence of the term, since photovoltaics concerns transforming sunlight into electrical energy. For that to happen, however, requires the photovoltaic effect (phenomenon). The photovoltaic effect signifies a process that occurs in photovoltaic cells under the influence of solar radiation. In the simplest terms, it involves the freeing of valence electrons from atomic bonds in silicon crystals (of which the cells are made). The freeing of electrons leads to a difference of potentials, which causes the formation of a direct current. An inverter then converts it to an alternating current that powers devices.

The photovoltaic effect is not the only concept related to photovoltaics, which as a field of science and technology covers a number of terms. One of them is the photovoltaic cell mentioned in the definition of the photovoltaic effect. The cell is the smallest element of a solar panel. Cells are made using polycrystalline or monocrystalline silicon. Interconnected cells make up a photovoltaic module. Photovoltaic modules are connected with each other, fastened with a special frame and covered with a protective coating, thanks to which they are properly protected against mechanical damage and UV radiation, hail, snow and other adverse weather conditions. That is a short description of the production of a solar panel, the principal element of a photovoltaic installation. A photovoltaic installation is a system of devices that makes it possible to convert sunlight into electricity. As mentioned above, its basic and at the same time most characteristic element are photovoltaic cells. However, in order to function correctly, the installation also requires other elements. One of them is an inverter, a device that converts direct current into alternating current and therefore makes it possible to power devices with electrical energy produced by the sun.

Another concept term inseparably linked with photovoltaics is the consumer. According the Renewable Energy Sources, any owner of a photovoltaic micro-installation with a capacity of up to 50 kW may become a prosumer, provided that the energy produced is not used for sale but for their own needs. Poland's RES Act is a law on renewable energy sources. It contains definitions of the principles and conditions of power generation—not only from the sun but also so-called green energy sources (wind, water, nuclear energy or biomass). The amendment of 11 August 2021 is aimed at facilitating investment processes in renewable power generation and to extend the support mechanisms available to investors applying for public guarantees of energy sales.

Photovoltaics is an area covering many concepts, which would be impossible to cover in a single article. The above text helps in understanding those that are the most important and most common in industry articles. In order to select the correct installation, it is necessary first to consider what type of interaction with the power grid will best satisfy the investor's needs. Taking this factor into consideration, the following options are available:

- On-grid photovoltaic installations, which can operate only after being connected to the power grid. They are less expensive that other PV systems since they do not require the purchase of batteries. What is more, not only do they enable generating current for own use but also for selling surplus energy to the network. These are the most frequently chosen options. Depending on the type of inverter used, on-grid photovoltaic installations can be divided into three categories: systems with a central inverter, systems with string inverters and systems with microinverters.
- Off-grid photovoltaic installations (autonomous, independent) are not connected to the power grid. The generated energy is stored in batteries, which allows it to be used

later. They work well wherever access to the grid is difficult or uneconomical, e.g., in summer houses.

– Hybrid installations (mixed, combination); in their case, PV panels are supplemented by another source of electrical energy, e.g., wind turbines or combustion generators. The produced current can be used at once or stored for later. It is also possible to connect a mixed installation to the power grid.

Photovoltaic installations can also be classified according to their location. PV systems are usually installed on roofs or on the ground, but can also be installed on balconies. Regardless of where they are located, they should not be shaded. Photovoltaic installations, whether on roofs, on the ground or on balconies, are mounted on special structures adapted to their specific location. The entire installation should be not only durable and resistant to external factors, but also visually attractive.

Photovoltaic installations can also be classified based on the destination of the energy produced. They can then be divided into:

– Small PV systems—generating current for a single road sign or streetlamp.
– Consumer systems—in the case where all of the energy produced is used by the investor.
– Prosumer systems—a portion of the generated energy is used for own needs and a portion is transferred to the power grid.
– PV farms (power plants)—which transfer all of the energy generated to the power grid.

The Energy Law Act introduced the criterium of power, classifying photovoltaic installations as micro PV installations, small PV installations and large PV installations. These installations achieve a power higher than 200 kW. They are PV farms. Photovoltaic installations can be classified based on various criteria. The type of PV system an investor chooses depends on individual needs as well as the amount of the available budget.

1.3. Characteristics of the Photovoltaic Market in Poland

The Polish PV market is experiencing a development boom stimulated by EP legislation. During the five years through the end of 2020, Poland reached first place in the EU, taking into account the growth rate of photovoltaic power. Successive ever-better forecasts confirm the Polish photovoltaic market's strength, potential, and growing position [20].

In 2020 Poland was 4th in the European Union with respect to the increase in PV capacity installed, behind only Germany, the Netherlands and Spain. The Institute for Renewable Energy (IEO) predicts that in 2021 Poland will maintain the high growth rate and its 4th place in the EU [21].

According to the IEO, the full complement of installed capacity in PV sources includes:

– Micro-installations—installations with a total installed capacity not exceeding 50 kW; their total capacity was 3022 MW at the end of 2020, and as of Q1 2021 it is 3500 MW.
– Small installations—installations with a capacity of 50 kW–500 kW; their installed capacity in Poland at the end of 2020 reached 65 MW, and currently exceeds 71 MW.
– Photovoltaic installations with a capacity above 500 kW, built under the system of certificates of origin or outside the auction support scheme; their total installed capacity was estimated at 75 MW.
– Photovoltaic installations built under the RES auction; their total installed capacity at the end of 2020 is 750 MW, and currently their capacity may be 820 MW. Most often, these are photovoltaic farms and solar power plants with a capacity of approx. 1 MW.

In Poland micro-installations possess the biggest share of the PV market. In 2020 they accounted for 77% of the installed photovoltaic capacity. This is due to several factors, including the technology's increasing popularity among prosumers, subsidies granted under Regional Operational Programs and the government program of subsidies for photovoltaics—the "My Electricity" program. The program was carried out between September 2019 and December 2020 and had its highest impact on the growth of the PV market in 2020. The program's next iteration is currently being planned. In 2020, PV installations constructed under the RES auction accounted for 19 percent of the installed capacity. The total capacity of these installations doubled compared with 2019. Further increases are expected in the coming years due to the expiring deadlines for returning the energy into the grid for the first time for projects contracted under the 2018 and 2019 RES auctions. Small PV installations account for less than 2% of the entire installed photovoltaic capacity; this small share is due to the lack of support for installations in the 50 kW–500 kW range.

The share of installed photovoltaic capacity in relation to the installed capacity in renewable energy will reach 30% at the end of 2020, being twice as high as in 2019. Thus, PV installations were ahead of biomass (11%), hydroelectric plants (8%) and bi-ogas (2%). Onshore wind power continues first to be the leading renewable energy source, accounting for 49% of installed capacity. The above data clearly indicate that for 3 years photovoltaics has been the fastest growing RES in Poland and has achieved the highest annual increases, and within 1-2 years it may have similar installed capac-ity as wind energy [20].

1.4. Global and EU-Specific Development Challenges of Photovoltaics

The photovoltaic market in the EU-28 continues to grow very rapidly. Year by year, photovoltaics continues to record high increases in installed capacity. At the end of 2020, the installed capacity in the European Union in photovoltaics amounted to approximately 153 GW, which was an increase of 18.8 GW compared to 2019. According to estimates based on IRENA data, EU countries achieved a 14% increase in the total installed PV capacity compared to 2019. The increase recorded in 2020 was 1.13 times greater than that obtained in 2019 [20].

The largest increase in photovoltaic capacity—4.74 GW—was recorded by Germany. In second place was the Netherlands, with an installed capacity of 3 GW. Spain (2.8 GW of new capacities) is in third place; it also recorded the largest increase in 2019. Poland's increase in the order of 2.4 GW puts it in fourth place, ahead of France (0.9 GW), whose share in the increase in the number of new PV installations fell. In 2020, Poland found itself in the top four in the European Union in terms of the increase in new photovoltaic capacity, after being in the top five in 2019. The growth rate of the Polish market continues to be high, keeping the country among the European leaders.

Poland leads Europe with respect to the growth rate of its photovoltaic market. Poland was followed by Sweden, Hungary, Ukraine, the Netherlands and Spain, re-spectively. Solar Power Europe predicts that by 2024 Poland will achieve an increase of installed capacity by 8.3 GW to 13 GW and will retain its fourth place in terms of in-creasing new photovoltaic capacity. The latest IEO forecasts indicate that at the end of 2024 total installed capacity will amount to 12.5 GW (an increase by 8.5 GW during 2021-2024).

1.5. Technology Entrepreneurship

The rapid growth in photovoltaic sector enterprises in Poland is made possible by the entrepreneurial behaviour of numerous managers who are able to perceive in their surroundings opportunities for technology change that can translate into market success.

Under conditions of a technology race and the shortening of product and technology lifecycles, technology entrepreneurship is gaining particular importance as one of the key manifestations of entrepreneurship. Technology entrepreneurship is interdisciplinary and multifaceted in character and can be considered both at the level of individual initiatives and innovative undertakings at the level of the whole organisation. This entrepreneurship combines the issues of academic entrepreneurship, technology management (including technology transfer) and intellectual entrepreneurship [22].

Technology entrepreneurship has been attracting significant interest in recent years, both from management theoreticians and practitioners. Even though the term has been known in the world literature for several decades, the number of publications on it did not increase markedly until the 2010s. The theoretical foundations of the concept in its modern understanding appeared in a special edition of the *Strategic Management Journal* in 2012, by scientific editor Ch. Beckman and co-editors K. Eisenhardt, S. Kotha, A.

Meyer and N. Rajagopolan, entitled "Technology Entrepreneurship" [23]. Other papers presenting an attempt to explain the concept include T. Bailetti [24]. The topic of technology entrepreneurship was undertaken by numerous authors, including S. Muegge and T. Bailetti et al. [25,26].

In recent years, many Polish-language publications on technology entrepreneurship have also appeared. Different Polish authors define the term "technology entrepreneurship" differently. According to Lachiewicz et al. [27], technological entrepreneurship can be understood "as a process that combines the elements of academic and intellectual entrepreneurship with the entrepreneurship of commercial organizations—owners, managers and employees implementing new technologies and innovative business solutions in the market environment". In the opinion of Kordel [28] "the phenomenon of technology entrepreneurship occurs when scientific or engineering development creates a key element of an opportunity, which is then transformed into a new investment. The technology project, based on the latest engineering knowledge, is a direct result of technological entrepreneurship".

Technology entrepreneurship should be considered in the broader context of an enterprise's organisational and, especially, development strategy. For that reason, the appropriate measures of the efficiency and effectiveness of technological entrepreneurship are those that relate to competitive advantage (e.g., market share, profitability ratios, etc.) [29].

The concept of technological entrepreneurship should be placed in the area of strategic management, including innovation theory and entrepreneurship theory. Technological entrepreneurship primarily concerns advanced technology sectors, although it can also be applied with respect to traditional industries. It is a process consisting of the entrepreneurial activities of an innovation leader, the team members and the members of the entire organisation. It is a special process that is primarily characterized by creative, collaborative activities or processes, innovation, a propensity toward risk and a positive focus on actions and their results, and primarily serving to the benefit of society.

Technological entrepreneurship is an innovative process that can be considered on two levels. The first of these is the stage of creating the idea for an innovation and the probability of its practical use. The second is the actual implementation and commercialisation of the innovation idea. This means that technological entrepreneurship is also a special, complex, multi-stage undertaking, requiring non-routine actions, often unique decisions, as well as specific project management competences. It must be emphasized that technological entrepreneurship should be considered in a broader context of corporate strategy and be the determinant of its formulation.

1.6. Information Asymmetry in the Conditions of Information Uncertainty in the Photovoltaic Industry

Economists have often marginalized the importance of access to complete and reliable information. Their assumption of the rationality of actions prevented many of them from pursuing further considerations. However, there were also those who, when analysing the problems of cartels, tenders, negotiations, cooperation, consumer choices, etc., noticed that potential solutions to the problem depend on access to information [30].

One of the first to do so was Adam Smith who in the 18th century described the impact of information on establishing the equilibrium in the model in which an increase in interest rates causes the best borrowers to withdraw from the market [31]. Another important researcher on access to information was A. Marshall, who lived in the 19th century, who pointed out that wages do not always correspond to the tasks that employees actually perform. The main reason is that employers do not have full information on how employees perform the tasks entrusted to them, due to imperfect procedures for controlling and verifying the effects of the work. The precursor of considering the role of information in the economy was F. von Hayek, who investigated the concept of Walrasian equilibrium, subordinating economic entities only to the market mechanism, assuming that consumers have excellent information on prices [32].

Theories that take into account the influence of information or the lack of it were developed mainly in the 1960s. They frequently concerned the idea of conflict, as was the case with the research performed by T.C. Scheling [33], leading up to the publication of *A Strategy of Conflict* in 1960. The phenomenon of incomplete access to information gained importance with the development of decision-making theory and the spread of research on conflict resolution. An interesting contribution to the development of knowledge on incomplete information was made by W. Vickrey [34], who proposed a principle of conducting an auction making use of game theory and incomplete information, known as the second-price method. The principle assumes that participants in an auction submit sealed bids. The winner is the bidder who submits the highest price but the price he has to pay is the second-highest of those proposed. This research won W. Vickrey the 1996 Nobel Prize. In the 1970s, G.A. Akerlof together with J.E. Stiglitz and M. Spence developed the foundations of the theory of markets characterised by information asymmetry. The authors concluded that entities operating in markets where there is insufficient information behave differently than those operating under the conditions of complete information. The importance of information problems in the 20th century is emphasized by the fact that the Nobel laureates in the field of economics were often economists dealing with issues directly or indirectly related to access to information. The developing research on difficulties in access to information has distinguished the types of conditions under which the market model can be considered [35]. The analyses showed that the following situations are possible:

– Imperfect information, meaning a situation in which at least one of the parties does not know the decisions made by the other parties and, as a result, is unable to precisely define its market situation.
– Uncertain information, meaning a situation in which random factors occur and the decision-maker is unable to determine the probabilities of possible solutions.
– Incomplete information, meaning a situation in which participants of the market game do not have all the information needed to make decisions, for example, they do not know about all the available resources, do not fully know the rules of the game, the set of possible solutions, the amount of pay-outs or the decisions of other market players.
– Information asymmetry, meaning a situation where one of the entities has more information than the others and can use it to gain an advantage.

Information asymmetry is defined as a situation in which one of the parties to a transaction possesses more information than the other party on the market exchange in which they are participating, which many economists perceive as a negative phenomenon [32].

According to J. Oleński [36] there are two types of asymmetry: full asymmetry, when the recipient of information buys something of which they have no knowledge and has no means of confirming the information prior to the transaction; and incomplete asymmetry, which occurs when somebody buying a product or service does not possess full information on them but can demand such information before the transaction. The existence of full and incomplete asymmetry is indispensable in some areas, for example, in the medical, pharmaceutical, legal or advisory services sectors, or in film production.

According to Y. Lichtenstein [37], the reconciliation of high-tech projects, including photovoltaic installation—i.e., reconciling the commercial terms of the transaction—can be described using agency theory. Agency theory presents the enterprise as a network of contracts referred to as agency relations, entered into by individual participants who generally consist of shareholders, managers and lenders. The theory takes into account the sharing of risk together with the so-called agency problem, occurring when the cooperating parties have different objectives and a different division of work. According to agency theory, the company's owner agency is referred to as the principal and the recipient of the photovoltaic system as the agent [38].

We can distinguish the following players on the photovoltaic market: Producer—the principal manufacturer of equipment and software for photovoltaics; Designer—the creator and architect of hardware and software technology solutions; Supplier—the provider of materials, raw materials and resources for the manufacture of photovoltaic solutions. The area of distribution has been divided into two categories: regional distribution companies (Distributors) and companies that design and install photovoltaic equipment (Resellers).

Another group of players are the Customers who decide to invest in a photovoltaic system, which constitutes an investment asset. Customers expect a return on their invested capital within specific legal, technological, ecological and economic conditions. The last category of players are local Regulators who enact Polish law and those from the EU who enact European law. The phenomenon of information asymmetry occurs between players in the photovoltaic market. The relations within which the asymmetry phenomenon occurs are presented below, together with examples of the causes of this phenomenon:

– Producer and Supplier (examples: availability of components for the production of photovoltaic devices, production requirements).
– Producer and Designer (examples: access to intellectual properties, patents, knowledge allowing for R & D).
– Producer and Distributor (examples: increase in technology advancement, mega-technological and commercial trends, limitations to the constant supply of the supplier's equipment).
– Producer and Reseller (examples: increase in technology advancement, mega-technological and commercial trends, limitations to the constant supply of the supplier's equipment).
– Reseller and Customer (examples: lack of transparency in long-term legal changes, frequent legislative changes, reduction of the profitability of installations during the investment cycle, technological conditions of devices, total cost of ownership of the installation, opportunistic behaviour).
– Reseller and Regulator (examples: lack of transparency in long-term legal changes, frequent legislative changes, reduction in the profitability of installations during the investment cycle).
– Regulator and Customer (examples: lack of transparency in long-term legal changes, frequent legislative changes, reduction in the profitability of installations during the investment cycle).

Summing up, the phenomenon of information asymmetry occurs in the relationship between each player on the market, and in addition, regulators, through the frequent and dynamic process of establishing legal standards in the field of photovoltaic installations, are a source of imperfect and uncertain, incomplete information, which may increase the asymmetry of information between the market players.

2. Materials and Methods

2.1. Research Goals/Questions. Definition of Case Study Method

The aim of this article was the identification and assessment the key opportunities and barriers to photovoltaic industry enterprises in Poland in the context of technology entrepreneurship under conditions of information asymmetry. The paper was prepared based on the results of qualitative research using the case study method.

The research questions are as follows:

Q1: What key development opportunities and barriers do enterprises involved in the sale and installation of photovoltaic devices in Poland face?

Q2: What is the impact of information asymmetry on the growth of enterprises involved in the sale and installation of photovoltaic devices in Poland face?

The explanation of case study method we can find in many literature sources [39]. Yin [40] defines the case study research method "as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used." [11].

2.2. Research Method

A comparative analysis was performed based on results of a study of four purposefully selected enterprises. The case study method allowed for comparing the analysed enterprises in pairs, which is discussed more extensively further on in the text. The research performed will lead to conclusions and recommendations for the photovoltaic sector enterprises in Poland, which will allow them to act more effectively and efficiently in conditions of competing on the global market. The case study procedure is presented in Table 1.

Table 1. Case study stages.

Stage 1	Formulating the research question
Stage 2	Selection of cases
Stage 3	Development of data-collection tools
Stage 4	Fieldwork
Stage 5	Data analysis
Stage 6	Formulating generalisations
Stage 7	Confrontation with the literature
Stage 8	Study conclusion–generalisation

Source: [22,41,42].

The selection of cases was deliberate and made on the basis of five basic criteria: data availability, vividness of the case, ensuring diversity in multiple case studies, a critical phenomenon and a metaphor that directs the researcher to a specific direction of the studied phenomenon [38]. The first is the purely pragmatic question of the availability of data, which allows for the most incisive description of the cases of those enterprises that are especially pertinent to the research question. The second criterium is the vividness of the case, which illustrates the properties being studied in an extreme form, which, however, allow for an unambiguous interpretation of the properties being studied. The third criterium is diversity. This requires that many cases be investigated in such a way as to present at least different circumstances or contradictory situations.

The number of cases studied should range from four to ten cases, which are usually compared in pairs. This gives from two to five pairs of comparisons of phenomena with a different course or taking place in different industries, enabling the formulation of generalizations largely free from the factors of circumstances or industry. The selection then consists of creating appropriate pairs of cases, e.g., high technology–low technology, mature market–emerging market, simple product–complex product and local enterprise–global enterprise.

The fourth criterium is the critical phenomenon, whose course, either extreme or running counter to the generally accepted opinion, allows for formulating generalisations. The fifth criterium concerns a metaphor that directs the researcher's attention to a specific course of the phenomenon under study or allows them to assume a specific research position. For instance, the lifecycle metaphor requires the selection of cases that will allow for observation of the emergence, development phases, maturity, decline and disappearance of a given phenomenon [22].

3. Results

3.1. Characteristics of Analysed Enterprises

Company X specialises in the construction of photovoltaic installations and provides photovoltaic services. It combines innovation, the latest technology and visionary professionals—specialists, experienced engineers and architects with extensive portfolios, as well as fitters and electricians thoroughly trained in the assembly of photovoltaic installations and thermo-modernisation. It possesses its own logistical hub and extensive structures composed of experienced professionals. It also uses the most modern technology to coordinate its operations (information based on data from the studied enterprises' web pages).

Company Y also provides photovoltaic services and specialises in the construction of installations. It provides customers with modern photovoltaics solutions. They specialize in rooftops and free-standing installations. It has designed and delivered thousands of installations in Poland. In September, it joined the Partner Programme organised by the Pomeranian Special Economic Zone. Its task is to support the business development of Kujawy and Pomorze. This cooperation is the next step toward energy transformation of the region.

Company Z is considering investing in the construction of a photovoltaic plant as a business activity. They would like to sell and install rooftops and free-standing installations. It currently specialises in refrigeration installations on semi-trailers. The company has been operating in Poland and is a leading supplier of cooling equipment. It employs ca. 70 people and its annual turnover stands at ca. EUR 25 million. Currently, it also provides services in the field of sales, installation and service of refrigeration equipment in semi-trailers.

Company Q has been operating in the energy industry uninterruptedly since 2013. It specialises in the sale and assembly of photovoltaic installations. It provides services in the area of the design, sale, installation and service of photovoltaics throughout Poland. It currently employs 50 persons and has an annual turnover of 5.4 million euros. It offers comprehensive service over all the stages of an investment project—free calculation and consulting, individualised offer, assistance in obtaining favourable funding, assembly of the installation, notification of the power plant and comprehensive assistance.

3.2. Environment and Its Factors—Threats and Opportunities

Table 2 presents the key growth factors and barriers for the most important determinants of the macroenvironment.

Table 2. Barriers and growth factors in the development of companies in the photovoltaic industry in Poland.

Barriers and Growth Factors	Company X	Company Y	Company Z	Company Q
Legal–growth factors	The need to develop renewable energy sources, also in Poland. Declarations of support for technology entrepreneurship.	Favourable legal situation, tax breaks for thermo-modernization. In general, "an embarrassment of riches".	Tax breaks.	Tax breaks and promotion of renewables.
Legal–barriers	The main barrier is the political environment. Risk caused by politicians' decisions. Changeable regulations.	Changes in regulations starting in Jan. 2022 may be a threat.	Highly changeable regulations.	New regulations starting in 2022.
Economic growth factors	Other companies aren't perceived as competitors. This is due to the niche strategy being pursued.	The increased prevalence of photovoltaics. Electricity is relatively expensive, which is an opportunity. People possess knowledge on new technologies.	Increasing customer awareness. Strong correlation between location and energy efficiency.	Fake news on solar energy farms. Rising price of electricity

Table 2. *Cont.*

Barriers and Growth Factors	Company X	Company Y	Company Z	Company Q
Economic barriers	Access to funding for large investments. A certain slowdown in the industry probably due to the pandemic.	Photovoltaic seller wants to get the balance on an annual basis.	The high demand for installations is a bottleneck. There is a price war Increased prices of photovoltaic panels due to the rise in polysilicon, the raw material from which panels are made. Increased prices of freight. Problems with post-installation servicing processes.	Increased prices of freight. Many photovoltaic components come from China. Problem with determining the total cost of possessing an installation over a period of 25 years.
Societal growth factors	Large number of unqualified workers.	No barriers in acquiring new workers.	Well-educated specialists. Very high competences of sales personnel.	Specialists' high level of professionalism.
Societal barriers	Specialists'/designers' high income expectations.		Problems with finding specialist fitters. High income expectations. Problem with finding persons able to establish contacts with customers. Problem with employee turnover.	Problem with employee turnover.
Technological barriers	Relatively small changes in the sector. Frequent technical errors in the installation	The requirement to replace meters is a small bottleneck. Imbalance as a type of barrier	The introduction of new technologies causes the competitiveness more difficult.	Low quality of the installations as a source of problems.
Technological growth factors	Development of IT tools. New technology tools.	Use of modern technology has become widespread. New hydrogen technology combined with photovoltaics.	Development in panel technology. Artificial intelligence supporting automation.	New types of solar panels increase efficiency.

Source: based on interviews.

The use of the case study method allowed to compare the organizations in pairs. The representatives of individual companies presented very divergent opinions on the issues of the political and legal environment. The president of Company X presented a particularly harsh criticism regarding the regulator's actions. He believed that the policy pursued by the regulator was, above all, a threat. The consequence of this is the instability of the law and the high unpredictability of the regulator's decisions. He stated that the declared development opportunities are in fact illusory because the dynamic changes introduced by the regulator significantly hinder the investment process both among resellers and clients.

The opinion of the representative of Company Y was diametrically opposed. He focused mainly on the good economic situation. In his opinion, the political and economic climate are very favourable for photovoltaics. He also showed an appreciation for the numerous subsidies and aid measures for the sector. Society is also showing increased interest in novel solutions in this area. This also results from consumers' growing knowledge of about modern technologies and their common use in households.

The representatives of Company Z and Company Q pointed mainly to the high qualifications of knowledge professionals and their particular technology competences. They also perceived the opportunities and threats resulting from market competition and the high social demand for modern solutions in the photovoltaic industry. Modern technology solutions, intelligent technologies and the development of artificial intelligence, combined with a high demand for those solutions, create a particularly favourable market situation and success opportunities for new entities in the photovoltaic industry. New types of solar panels are increasing the energy efficiency of photovoltaic enterprises' products, allowing them to achieve potential and an actual competitive advantage.

The main barriers mentioned by the representatives of the enterprises were the instability of regulations and the announcement of new legislative solutions for 2022. Another obstacle are problems related to employee turnover. There are problems with finding people able to effectively establish relations with customers and convince potential buyers to purchase photovoltaic enterprises' products. This is somewhat paradoxical in view of the large demand for renewable energy sources and customers' growing knowledge about new technology solutions.

3.3. Information Asymmetry in Photovoltaic Enterprise Operations in Poland

All research participants representing resellers indicated that there is a phenomenon of information asymmetry in which the risk of a failed photovoltaic installation is transferred to the end customer. Research participants indicated the following defects in the information provided within the value chain:

1. Producer–Reseller. The manufacturer does not provide information on how the photovoltaic installation will function in 10–15 years from the perspective of the technology used, so it is not possible to determine the total cost of ownership of the installation over the investment cycle horizon.

2. Regulator–Reseller. The regulator, through quick and non-determinable decisions, creates an atmosphere of uncertainty for resellers who want to sell and service devices. Resellers focus on customer service at the moment, not caring about what will happen with a given installation in a few years.

3. Regulator–Customer. Due to the changes in the principle of purchasing electricity from prosumers, it is possible to predict revenues in a limited way in the investment cycle, which lasts 10–15 years.

Research shows that between the supplier of the photovoltaic infrastructure and installation services and the end customer there exists a type of incomplete information asymmetry, when the customer buying a photovoltaic installation, including assembly, does not have full information about the configuration of devices, TCO and economic benefits. The purchase of photovoltaic installations is characterised by the following: between the supplier of the photovoltaic infrastructure and installation services and the end customer there is a type of incomplete information asymmetry, when the customer buying a photovoltaic installation, including assembly, does not have full information about the configuration of devices, TCO and economic benefits. The purchase of photovoltaic installations is characterised by the following:

- The buyers do not know what they are buying, finding out what configuration of service and equipment they decided to buy only sometime after the transaction.
- The object of the transaction is a piece of equipment and configuration service described using metainformation. What is significant, both the transaction and the

long-term utilisation are carried out in conditions of uncertainty, due mainly to the activity of the regulator.

- Due to the lack of full information on the photovoltaic installation over its entire lifecycle, the buyer is unable to make an ex-ante evaluation of its precise utility, worth, quality and, hence, its relevance and pertinence.
- Potential customers frequently have imprecisely defined information needs and consequently are unable to specify what value the information they intend to purchase has for them.

In the market game, the winner is the one who has information that is complete and certain, or perfect, and is able to use it, while the other conditions are unchanged. There are, however, two issues which need to be considered:

- Access or lack of access to information.
- The costs of acquiring, processing and internalising information.

In the case of a purchase transaction of a photovoltaic installation, access to information between the supplier and the recipient is characterized by:

- Incomplete information on information on the long-term operation of equipment throughout its life cycle, i.e., 10–15 years.
- Imperfect information due to the activity of the regulator.

In addition, the costs of acquiring, processing and internalising information may exceed the possible benefits in the long run. Respondents indicated that customers obtain information on the installations based on the knowledge of Resellers, who obtain it from the manufacturers. This information is incomplete, which is due to the early stage of the technology's development that at the same time is very rapid.

The authors' research results show that for customers investing in a photovoltaic installation, the level of information asymmetry between the supplier and customer constitutes a key factor that determines economic success over the entire lifecycle of the photovoltaic equipment. The asymmetry pertains to information on:

- Economic benefits resulting from the technological specificity of photovoltaic devices.
- Non-economic benefits resulting from the technological specificity of photovoltaic devices.
- Economic benefits resulting from the long-term (10–15 year) operation of photovoltaic devices.
- Reliability of photovoltaic devices in the long-term horizon, i.e., 10–15 years of device operation.

In the research on the phenomenon of information asymmetry carried out by the author, the suppliers admitted after completing the installation (ex post) that before the project customers did not have adequate knowledge regarding the implementation of IT systems. It was only after the implementation of the project did customers realize how little knowledge they had had about the devices and services they had acquired, and how they were exposed to abuse of trust by the supplier. The group of suppliers studied indicated the following main reasons for the information asymmetry:

- The customers' insufficient preparation in terms of defining their needs regarding the demand for electricity.
- The lack of precisely defined technological and organizational conditions for the installation of photovoltaic devices.
- The lack of sufficient knowledge on the part of the customer about the total cost of maintaining photovoltaic devices in a 10–15-year operating perspective.
- The lack of sufficiently precise knowledge on the part of the customer-prosumer of the economic benefits that can be obtained from the use of a photovoltaic installation in a 10–15-year operating perspective.

Lichtenstein [38] explains the reason of information asymmetry high level. This situation often pertains to the relationships between the supplier and the recipient of the project specified in the contract. Especially during projects carried out based on a fixed budget, the supplier-agent may be strongly motivated to bring costs down below the budgeted amount, which may impact the quality of the services provided. The authors' research shows that the supplier, when selling the photovoltaic installation project, provided mainly meta-information with a high level of generality, which was often difficult to verify. The suppliers attempted to emphasise their competences, experience and skills, pointing to:

- The employees possessing certificates relating to installation of photovoltaic devices.
- The product possessing certificates.
- References to projects performed.
- Access to information on ways of carrying out photovoltaic projects.

Summing up the above considerations, it should be stated that the information characteristics considered in the transaction between the supplier and the customer, i.e., the partial and incomplete character of the information, imperfect information and information asymmetry are an important factor determining the economic efficiency of a photovoltaic installation during its operation period, i.e., 10–15 years, which affects the stability of the development of the photovoltaic sector in Poland. A significant challenge confronting suppliers is reducing the incompleteness and imperfection of information and the asymmetry of information in their customer relations. In this case, the characteristics of the relationship in terms of information are influenced by other stakeholders of the global market, such as the regulator, device and software manufacturers, and suppliers of raw materials for the production of photovoltaic devices.

4. Conclusions

The photovoltaics sector in Poland is developing very dynamically. It is among the fastest-growing photovoltaics sectors in the entire European Union. The growing demand for renewable energy sources combined with customers' ever-increasing knowledge on new technology and its applications are creating development opportunities for new entities in the photovoltaic industry. At the same time, there is no shortage of challenges under conditions of particular uncertainty in the surroundings. Unstable law and frequently changing legislative solutions are a disincentive and weaken the optimism of the economic demand for the products of photovoltaic companies.

The qualitative research performed using the case study method allowed for analysing the key development opportunities and barriers of photovoltaic sector enterprises in Poland. The selection of four enterprises that represented differing opinions on many issues, were at different stages of the organisation lifecycle and had different market positions allowed for making certain generalisations and drawing conclusions.

The research points to the following conclusions:

- Strong demand for renewable energy sources presents a historic opportunity for photovoltaic enterprises in Poland.
- Actions resulting from the government's economic policy in the form of incentives and/or incentives to initiate business activity are a favourable.
- Declarations of support for technology entrepreneurship, seen as an effective means of using market opportunity for technological change, frequently translate into specific support initiatives for the development of new technologies and technologically advanced products.
- The worldwide trend of abandoning conventional energy sources in favour of renewable sources are one of the key development opportunities for the photovoltaic sector enterprises in Poland.
- The growing level of social awareness is encouraging potential customers to seek the latest photovoltaic product solutions.
- The frequent changes to regulations and political and legislative instability prevent photovoltaic enterprises from fully utilising growth opportunities.
- The high level of uncertainty partially nullifies the opportunity of technology change.
- One barrier from the point of view of enterprises is the high rotation of employees, especially those with special technological competences. This is the effect of rising salary expectations.

- Great opportunities to recruit unskilled workers are associated with the need to conduct additional training, which increases the costs of business activity. Salary expectations are also rising in this group.

In addition, the present research has identified the phenomenon of information asymmetry between the supplier and the recipient, which is a source of uncertainty regarding the customer's investment and uncertainty in running a business from a long-term perspective. The main source of information asymmetry is the operation of the regulator, the technological conditions related to the early stage of technology development and the customer's lack of sufficiently precise information regarding the investment. However, despite significant factors of uncertainty and risk, the development of this sector in Poland has been extremely dynamic in recent years.

Summing up, it should be emphasized that the analysed entities have differing perceptions, especially when it comes to the political, legal and economic environment. Some see official declarations of support for new technologies in the development of renewable energy sources as opportunities. Others emphasize the threats resulting from the instability of legal regulations, numerous legal loopholes and the uncertain political and economic situation.

Author Contributions: Conceptualization, B.W. and Z.C.; methodology, B.W. and Z.C.; formal analysis, B.W. and Z.C.; investigation, B.W. and Z.C.; writing—original draft preparation, B.W. and Z.C.; writing—review and editing, B.W. and Z.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by R & D grant of Warsaw University of Technology, grant number 504/04552/1103/43.140003.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Niccolai, A.; Dolara, A.; Ogliari, E. Hybrid PV Power Forecasting Methods: A Comparison of Different Approches. *Energies* **2021**, *14*, 451. [CrossRef]
2. Choudhary, P.; Srivastava, R.K. Sustainability perspectives—A review for solar trends and growth opportunities. *J. Clean. Prod.* **2019**, *227*, 589–612. [CrossRef]
3. Hasterok, D.; Castro, R.; Landrat, M.; Pikoń, K.; Doepfert, M.; Morai, H.S. Polish Energy Transition 2040: Energy Mix Optimization Using Grey Wolf Optimizer. *Energies* **2021**, *14*, 501. [CrossRef]
4. Olczak, P.; Olek, M.; Matuszewska, D.; Dyczko, A.; Mania, T. Monofacial and Bifacial Micro PV Installation as Element of Energy Transition—The Case of Poland. *Energies* **2021**, *14*, 499. [CrossRef]
5. Statistical Review of World Energy | Energy Economics | Home. Available online: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html (accessed on 13 September 2020).
6. Data & Statistics—IEA. Available online: https://www.iea.org/data-and-statistics?country=POLAND&fuel=CO2emissions&indicator=CO2emissionsbyenergysource (accessed on 13 September 2020).
7. European Union. Sustainable, secure and affordable energy for Europeans. *Sustain. Secur. Afford. Energy Eur.* **2012**, *1*, 14.
8. European Commission. *2030 Climate & Energy Framework*; European Commission: Luxembourg, 2014.
9. Lezama, F.; Soares, J.; Hernandez-Leal, P.; Kaisers, M.; Pinto, T.; Vale, Z. Local Energy Markets: Paving the Path toward Fully Transactive Energy Systems. *IEEE Trans. Power Syst.* **2019**, *34*, 4081–4088. [CrossRef]
10. Ministerstwo Energii. *Polityka Energetyczna Polski 2040*; Ministerstwo Energii: Warsaw, Poland, 2019; pp. 1–84.
11. Zainal, Z. Case study as research method. *J. Kemanus.* **2007**, *5*, 1–2.
12. Gulsecen, S.; Kubat, A. Teaching ICT to teacher candidates using PBL: A qualitative and quantitative evaluation. *Educ. Technol. Soc.* **2006**, *9*, 96–106.
13. Grassel, E.; Schirmer, B. The use of volunteers to support family careers of dementia patients: Results of a prospective longitudinal study investigating expectations towards and experience with training and professional support. *Z. Gerontol. Geriatr.* **2006**, *39*, 217–226.
14. Johnson, M.P. Decision models for the location of community corrections centers. *Environ. Plan. B-Plan. Des.* **2006**, *33*, 393–412. [CrossRef]

15. Tellis, W.M. Introduction to Case Study. *Qual. Rep.* **1997**, *3*, 1–14. Available online: http://www.nova.edu/ssss/QR/QR3-2/tellis1.html (accessed on 20 November 2021). [CrossRef]
16. Lovell, G.I. Justice Excused: The Deployment of Law in Everyday Political Encounters. *Law Soc. Rev.* **2006**, *40*, 283–324. [CrossRef]
17. Taylor, S.; Berridge, V. Medicinal plants and malaria: An historical case study of research at the London School of Hygiene and Tropical Medicine in the twentieth century. *Trans. R. Soc. Trop. Med. Hyg.* **2006**, *100*, 707–714. [CrossRef] [PubMed]
18. Dolara, A.; Grimaccia, F.; Magistrati, G.; Marchegiani, G. Optimization Models for Islanded Micro-grids: A Comparative analysis between linear programming and mixed integer programming. *Energies* **2017**, *10*, 241. [CrossRef]
19. Kluskiewicz, A.; Boruszkowski, R. Inverter Green Energy. Available online: https://inwerter.com.pl (accessed on 20 November 2021).
20. *Rynek Fotowoltaiki w Polsce Report*, 9th ed.; Institute for Renewable Energy: Warsaw, Poland, 2021; pp. 19–21.
21. Wiśniewski, G. *Rynek Fotowoltaiki w Polsce, Report 2020*; IEO: Warsaw, Poland, 2020; pp. 9–10.
22. Chyba, Z. *Przedsiębiorczość Technologiczna w Procesie Kreowania Przewagi Konkurencyjnej Przedsiębiorstwo Wysokich Technologii*; Oficyna Wydawnicza Politechniki Warszawskiej: Warszawa, Poland, 2021.
23. Beckman, C.; Eisenhardt, K.; Kotha, S.; Meyer, A.; Rajagopolan, N. (Eds.) Technology Entrepreneurship. *Strateg. Manag. J.* **2012**, *33*, 203–207.
24. Bailetti, T. Technology Entrepreneurship. Overview, Definition and Distinctive Aspects. *Technol. Innov. Manag. Rev.* **2012**, *2*, 2–25. [CrossRef]
25. Muegge, S. Business Model Discovery by Technology Entrepreneurship. *Technol. Innov. Manag. Rev.* **2012**, *2*, 5–16. [CrossRef]
26. Bailetti, T.; Bot, S.; Duxbury, T.; Hudson, D.; McPhee, C.; Muegge, S.; Weiss, M.; Wells, J.; Westerlund, M. An Overview of Four Issues on Technology Entrepreneurship in the TIM Review. *Technol. Innov. Manag. Rev.* **2012**, *2*, 28–34. [CrossRef]
27. Lachiewicz, S.; Matejun, M.; Walecka, A. *Przedsiębiorczość Technologiczna w Małych i Średnich Firmach*; Wydawnictwo WNT: Warszawa, Poland, 2013.
28. Kordel, P. *Przedsiębiorczość Technologiczna*; Wydawnictwo Politechniki Śląskiej: Gliwice, Poland, 2018.
29. Chyba, Z. Pozyskiwanie Technologii a Kreowanie Przedsiębiorczości Technologicznej. *Ekon. Organ. Przedsiębiorstwa* **2016**, *4*, 103–104.
30. Blajer-Gołębiewska, A. *Asymetria Informacji w Relacjach Inwestorskich: Perspektywa Nadzoru Korporacyjnego*; Wydawnictwo Uniwersytetu Gdańskiego: Gdańsk, Poland, 2012.
31. Smith, A. *An Inquiry into the Nature and Causes of the Wealth of Nations*, 9th ed.; Strahan & Cadell & Davies: London, UK, 1799; Volume 2, Available online: books.google.com (accessed on 20 November 2021).
32. Woszczyński, M.; Rogala-Rojek, J.; Bartoszek, S.; Gaiceanu, M.; Filipowicz, K.; Kotwica, K. In Situ Tests of the Monitoring and Diagnistic System for Individual Photovoltaic Panels. *Energies* **2021**, *14*, 1770. [CrossRef]
33. Schelling, T. *The Strategy of Conflict*; Oxford University Press: New York, NY, USA, 1960.
34. Vickrey, W. Counterspeculation and Competitive Sealed Tenders. *J. Financ.* **1961**, *16*, 8–37. [CrossRef]
35. Wachnik, B. *Wdrażanie Systemów Informatycznych Wspomagających Zarządzanie*; PWE: Warszawa, Poland, 2016.
36. Polański, B.; Pietrzak, Z.; Woźniak, B. *System Finansowy w Polsce, t. 1*; PWN: Warszawa, Poland, 2008.
37. Oleński, J. *Ekonomika Informacji. Metody*; PWE: Warszawa, Poland, 2003.
38. Lichtenstein, Y. Puzzles in Software Development Contracting. *Commun. ACM* **2004**, *47*, 61–65. [CrossRef]
39. Kataja, A.; Tuunanen, T. Information Systems Development Methods and Reducing Information Asymmetry: A Way to Decrease Project Escalation in Outsourcing? Available online: http://aisel.aisnet.org/ecis2006/126 (accessed on 21 November 2021).
40. Yin, R.K. *Case Study Research: Design and Methods*, 2nd ed.; Sage Publishing: Beverly Hills, CA, USA, 1994.
41. Czakon, W. Łabędzie Poppera—Studia przypadków w naukach o zarządzaniu. *Przegląd Organizacji* **2006**, *9*, 9–12. [CrossRef]
42. Czakon, W. Zastosowania studiów przypadku w badaniach nauk o zarządzaniu. In *Podstawy Metodologii Badań w Naukach o Zarządzaniu*; Czakon, W., Ed.; Oficyna a Wolters Kluwer Business: Warszawa, Poland, 2011; p. 102.