# Politics in frugal innovations

Assessing the relationship between political risks and the market diffusion of frugal solar-PV systems

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# Politics in frugal innovations:

## Assessing the relationship between political risks and the market diffusion of frugal solar-PV systems

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by

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# Preface

This is the thesis report 'Politics in frugal innovations'. This thesis research was conducted to obtain the master's degree in Complex Systems Engineering and Management at the Delft University of Technology, Faculty of Technology Policy and Management (TPM). From the first moment I entered the faculty TPM, I felt at home. These past six years in Delft and at TPM were more than I ever could have dreamt of. Studying and living in Delft has broadened my knowledge, provided me with various opportunities and given me everlasting memories and friendships. This has allowed me to develop myself professionally and personally.

This thesis was written in the period from February to August 2021. During this period, I received feedback and advice from my supervisors Prof. dr. C.P. van Beers, Dr. D.J. Scholten and Dr. ir. I. Bouwmans. I would like to thank my supervisors for their guidance during this process. When I ran into problems and I did not see any solutions myself, they helped me by brainstorming with me and giving advice where possible, always in a fun, relaxed and supportive way.

The past six years of studying in Delft has provided me with lifelong friendships. It means so much to me that the people I met at the start of my studies, are also the ones I can finish it with and to have experienced everything in between together. I cannot imagine having such a great time in Delft without their presence in my life. To my friends from home, we have supported each other from close by and from a distance for so many years now and have cheered each other on in every new phase of our lives. I cannot thank you enough for that. And to my rowing team who have grown from teammates to some of my best friends. We have laughed, cried, partied and rowed together too much for us to just be teammates anymore. Also, who would have thought that half of us would graduate in one summer?

Finally, I would like to thank my family. Grandma, you have always been a huge inspiration to me; your strength provides me with motivation and inspiration like no one else. Joep, thank you for your empathy, humor and support, even though so far we have always been in different phases in our lives. At last, mom and dad, thank you for your unconditional love and support, your great example when it comes to work ethic and your everlasting confidence in me. It means the world to me.

I hope you enjoy your reading,

Saskia Kooijman

Delft, August 2021

# Executive summary

Thirteen percent of the world's population currently does not have access to electricity. This lack of access to electricity limits the overall development. Having access to clean energy can provide education access, productivity and possibilities for economic growth. Frugal innovations are new or improved products, with a lower cost and fewer used resources in their production chain, while maintaining quality, achieving predefined criteria, fulfilling a specific purpose and are user-friendly. Frugal solar-photovoltaic systems, are one of the possible technologies that could be able to contribute to reducing the number of people without access to electricity. Despite the potential of frugal solar-PV systems for reducing energy poverty, market diffusion of these innovations is not a given. Political risks can pose a barrier to the market diffusion of these innovations, due to endangering a stable environment for development and investments.

However, the span of this relationship, specifically in the combination with frugal solar-PV systems, is unknown. To analyse this, the following main research question has been posed in this research: *'To what extent is there a relationship between political risks and the market diffusion of frugal solar-PV systems?'.* The answer to this research question has been researched with a mixed-methods research approach. First, a quantitative analysis is performed with a correlation analysis. The second phase includes qualitative research. Based on the results of the quantitative results, the factors which could influence the diffusion of frugal solar-PV systems in Uganda and Namibia are analysed with means of case studies and interviews.

The correlation analysis showed that there is no relationship between political risks and the diffusion of frugal solar-PV systems. There are too little significant results to convince that there is a relationship between the political risks and the diffusion of frugal solar-PV systems worldwide and per continent. Given the fact that this is a research area where little operationalising has been done so far, it is also important to find possible explanations for this result. Based on the case studies and interviews, it can be stated that that there are more factors playing a role in the diffusion of frugal solar-PV systems than the included political risks. For example, the need for frugal innovations, (renewable) energy technologies which are already invested in, the varying degree of involvement of foreign investors and non-governmental organisations, the history of relationships with other countries and current trading agreements.

To conclude, this research has contributed to the knowledge gaps and scientific debates in the frugal innovation field by looking at the market diffusion of these systems and the possible role political risks can play in this process. Valuable knowledge has been gathered, which has contributed in filling in gaps in academic research: political risks have been operationalised, a contribution has been made in the field of diffusion theories, specifically for frugal innovations, and the scope of the extent of a relationship between political risks and the diffusion of frugal solar-PV systems has been determined. The results of this research can hopefully on the long term contribute to increasing the percentage of people having access to affordable and renewable generated electricity and reducing the energy poverty worldwide.

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# List of acronyms

| | |
|---|---|
| **BOP** | Bottom of pyramid |
| **CoSEM** | Complex Systems Engineering and Management |
| **DC** | Developing country |
| **DRC** | Democratic Republic of the Congo |
| **EAC** | East African Community |
| **GDP** | Gross domestic product |
| **PR-index** | Political risk-index |
| **kWh** | Kilowatt-hour |
| **MSc** | Master of Science |
| **N/A** | Not applicable |
| **NGO** | Non-governmental organisation |
| **PAYG** | Pay-As-You-Go |
| **SADC** | Southern Africa Development Community |
| **SHS** | Solar home system |
| **Solar-PV system** | Solar-photovoltaic system |
| **SPS** | Solar pico system |
| **SRF** | Solar Revolving Fund |
| **TPM** | Technology, Policy and Management |
| **Wp** | Watt peak |

# Chapter 1 – Introduction

This chapter starts with a problem analysis in section 1.1, which is the starting position of this thesis research. Based on this, a knowledge gap is indicated, which will lead to the formulation of a research objective and the research questions in section 1.2 and 1.3 respectively. Section 1.4 indicates the scientific and societal relevance of this research and in section 1.5 the research approach will be discussed. Following this, section 1.6 discusses the suitability of this research topic with the study program of Complex Systems Engineering and Management (CoSEM). As last, section 1.7 indicates what the rest of the report will discuss.

## 1.1 – Problem analysis

In this section, the problem of energy poverty, which has been the starting point of this thesis research, is discussed in section 1.1.1. Hereafter section 1.1.2 discusses a possible solution in the form of frugal innovations. At last, the difficulties of diffusing these innovations due to potential political risks and the selected case of frugal innovations in the form of frugal solar-photovoltaic systems (frugal solar-PV systems) are discussed in section 1.1.3.

### 1.1.1 – Problem: energy poverty

940 million people, which is thirteen percent of the world's population, currently do not have access to electricity (Ritchie & Roser, 2019). This insufficient accessibility to energy in order to meet the minimum energy service standard is also known as energy poverty (Moniruzzaman & Day, 2020). Energy poverty can be defined as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development" (González-Equino, 2015, p. 379). This definition indicates important characteristics of energy poverty. First, the lack of choice indicates that people may have access to possibly dangerous primary energy sources, but lack the possibility to choose a safer, cheaper or more sustainable option (González-Equino, 2015). This lack of access to modern energy services forces citizens to use dangerous and polluting alternatives, such as burning kerosine or wood (Numminen & Lund, 2016). Having access to clean energy sources can reduce the health risks that go together with burning fuel indoors for cooking or heating purposes (Kaygusuz, 2011). Second, the term 'economic and human development' indicates that energy poverty limits the overall human development. Having access to clean energy can increase education access, productivity and possibilities for economic growth (Abbas et al., 2020; Kaygusuz, 2011; Shahsavari & Akbari, 2018). Often people who have no access to energy are also people who are in the bottom of pyramid (BOP) segment. The BOP segment consists of about four billion people who have less than two dollars per day to spend (Prahalad, 2011). The less people have to spend, the larger the part is that goes to the provision of fuels and energy services and the lower the chance is that they have the monetary resources to spend on access to (clean) energy sources (Ahonen, 2015). This keeps the inequity of energy access in place and limits the possibility for users to obtain

welfare in a broader sense. An increase in energy consumption is necessary for development and encourages autonomous initiatives, which could increase the economic sustainability (González-Equino, 2015; Kaygusuz, 2011). Pereira et al. (2010, p. 1231) identify various levels of electricity consumption in order to achieve certain development levels, as can be seen in Figure 1. Pereira et al. (2010) argue that policies should aim to increase the annual electricity consumption of each citizen to a minimum of 1000 kilowatt-hour (kWh) per person, in order to provide basic needs, such as food, shelter, improved health care provision and education.

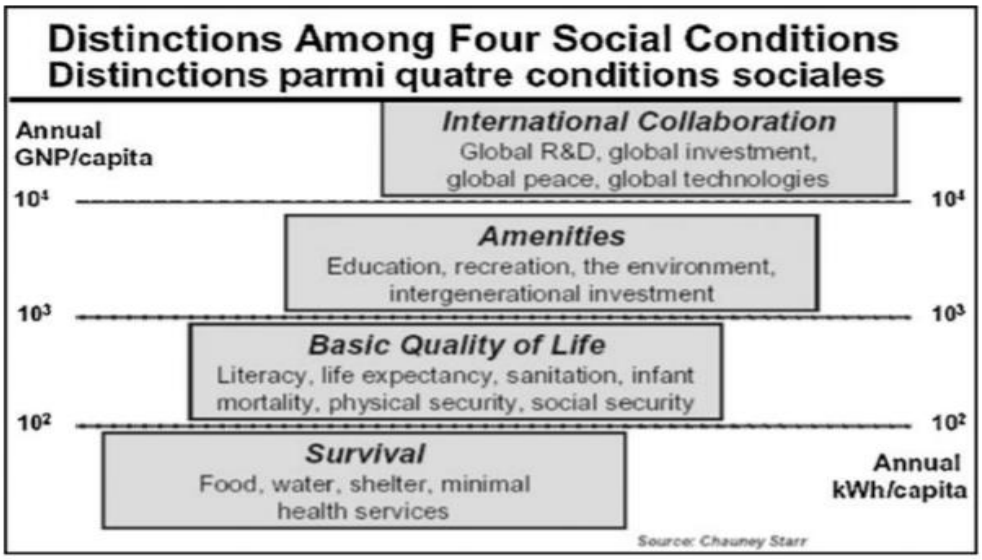


**Figure 1** – Electricity levels for development (Pereira et al., 2010, p.1231).

Energy poverty was put on the worldwide agenda by the Millennium Development Goals, which were presented in 2000 by the United Nations (Sachs, 2012). By the end of the fifteen-year period, it became clear that progress towards achieving the Millennium Development Goals was limited and unevenly distributed among countries. Specifically, the reduction of poverty in Sub-Saharan Africa and India was very limited (Fehling et al., 2013). At the end of 2015, the Millennium Development Goals were evaluated and the Sustainable Development Goals were set in place. Two of the seventeen goals are: 'Ending poverty in all its forms everywhere' and 'Ensure access to affordable, reliable, sustainable and modern energy for all' (United Nations, n.d.). However, despite these goals, Sub-Saharan Africa and India still experience energy poverty as one of their largest problems.

Figure 2 shows the worldwide distribution of the number of citizens without access to electricity in 2016 (Ritchie & Roser, 2019). This shows that Africa and India have the highest number of people without access to electricity. India has an annual electricity consumption of 94 kWh/person. In Sub-Saharan Africa 42% of the households (which are 600 million people) are not connected to the electricity grid, with an annual electricity consumption of 153 kWh/person and the lowest electrification rate worldwide (AfroBarometer, 2019; Kaygusuz, 2011; Lucas et al., 2017; Pereira et al., 2010). This shows that these regions are far from the recommended annual 1000 kWh/person electricity consumption and that energy poverty still is a large problem.

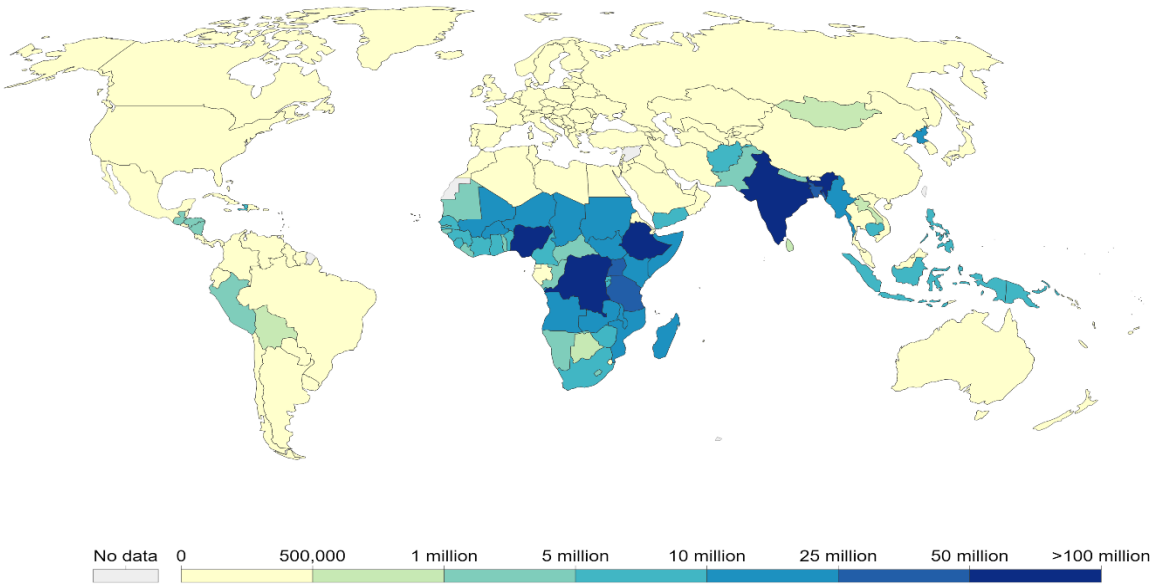


**Figure 2** – Distribution of citizens without electricity access (Ritchie & Roser, 2019).

### 1.1.2 – Possible solution: frugal innovations

Frugal innovations could provide possibilities for consumers with minimal or limited resources, which can be the case for people without electricity access. Frugal innovations are new or improved products, with a lower cost and fewer used resources in their production chain, while maintaining quality, achieving predefined criteria, fulfilling a specific purpose and are user-friendly (Agarwal & Brem, 2012; Tiwari et al., 2016). Frugal innovations are thus an option to provide products for those with limited resources, such as low capital resources, poor electricity infrastructure and poor governance structures (Knorringa et al., 2016). The main focus of frugal innovations is to provide basic needs to those in need (Khan, 2016). These innovations have an average lower price and take the lack of material resources and insufficient infrastructure into account. Therefore, they are more realistically designed for the local situation and are suitable to help the poorest people in the world (González-Equino, 2015; Tiwari et al., 2016). However, cost minimization is not the only requirement of a frugal innovation. It should not aim to have a low price, regardless of the quality of performance, but should have a low price and a suiting performance for the demand of potential users (Basu et al., 2013; Sehgal, 2010). The frugal innovation should provide these basic needs according to predetermined performance goals, so that the potential users are willing to spend their scarce (monetary) resources on purchasing this frugal innovation (Tiwari et al., 2016; Zeschky, 2011). Besides taking the local situation into account when designing a frugal innovation, the local population should also be included in this process (Agarwal & Brem, 2012; Pereira et al., 2010). This increases the chances of success, because it is more suited to their needs and the citizens understand more of the new technology, which will make them more empowered to use it (Khan, 2016; Numminen & Lund, 2016).

### 1.1.3 – Difficulties: market diffusion and the role of political risks

Despite the potential of frugal innovations, market diffusion of these innovations around the world is not a given (Mikhaylov et al., 2018). Diffusion of innovations is defined by Rogers (2003, p. 28) as "the process by which an innovation is communicated through certain channels over time among the members of a social system". However, the diffusion theory of Rogers (2003) is developed for the diffusion of high-tech innovations and not with frugal innovations in mind (Zhang, 2018). Generally, the diffusion of frugal innovations goes slower than that of high-tech innovations. A reason for this is that businesses for high-tech innovations take the business case of the innovation into account during the design process, while the design process of a frugal innovation focusses on providing the basic need, which makes it harder to diffuse the innovation to other markets (Ashfaq et al., 2018; Hossain, 2018). Furthermore, potential users of frugal innovations are often unaware that such technologies exist. Communication between different communities goes slower and there often is a lack of governmental support, thereby slowing down the diffusion between different social systems (Arshad et al., 2018). But even with this slower diffusion rate, frugal innovations still have a higher chance of being diffused than high-tech innovations in developing countries (DCs) and/or emerging markets, because the frugal innovations are more suited to the conditions in place (Khan, 2016; Tiwari & Herstatt, 2012).

As is mentioned by Mikhaylov et al. (2018), diffusion of frugal innovations is not a given. Political risks may pose a barrier to the diffusion of these systems, due to their ability to endanger a stable environment suitable for investments (O'Sullivan et al., 2017). Political risks entail a lot of different types of risks. First, political risks may limit the diffusion of a frugal innovation, due to a low political stability or high corruption, but also because of limited economic stability due to a high inflation rate or a very closed market, limiting trade with other counties (Hayakawa et al., 2013; Jadhav, 2012; Jing & Martek, 2021). As third, also social factors, such as the civil liberties that citizens have to make their own choices and the span of their political rights, can play a role in the diffusion process of frugal innovations (Busse & Hefeker, 2007; Mokhele, 2019). Thus, a political tense situation or unforeseen changes in the socio-technological environment can play a role in the diffusion of a frugal innovation (Mikhaylov et al., 2018). However, to what extent this relationship exists, specifically in the field of frugal innovations, is unknown. Agarwal et al. (2017) mention that the main focus of the frugal innovation research area has so far been on the conceptualization and design, while market diffusion of these innovations has not been researched in depth yet. One field where political risks have to be taken into account is in energy provision. Energy provision provides the base for development of countries and political risks can influence the security of this supply (Paravantis et al., 2019; Ŝprajc et al., 2019). Historically, political risks and/or conflicts have arised over access and flows of energy resources, making energy provision and the role of political risks in this a consequent topic of research (Agrell, 2009; Paravantis, et al., 2019). Therefore, to be able to assess whether a relationship exists between political risks and the market diffusion of frugal innovations, it could be helpful to analyse a frugal innovation in a field that is historically linked to political risks and to analyse a frugal

innovation that could possibly contribute to reducing the energy poverty (Agarwal et al., 2017; Hossain, 2018; Khan, 2016). So, to conduct this thesis research, frugal solar-PV systems have been chosen as case to analyse the existence of a relationship between political risks and the market diffusion of frugal innovations. Section 3.1 will elaborate further on the selection of frugal solar-PV systems as case in this research.

A frugal solar-PV system has the capacity to meet the energy poverty challenge and can have a substantial contribution to the provision of this basic need, thereby decreasing the percentage of the population without any or reliable access to electricity (Ulsrud, 2020). Solar-PV technologies can convert sunlight into electricity (Bagher et al., 2015; Husain et al., 2018). Sunlight (which consists of light photons) is absorbed in the solar-PV cell. The semiconductor material of which the solar-PV cell is made, separates this incoming light photon into electrons and holes. The electrons and holes are then directed into different parts of the solar-PV cell, after which the electrons and holes recombine, creating a current flow. The semiconductor material is designed to have a potential difference, to enable the current flow in one specific direction in order to generate electricity (Bagher et al., 2015; Smets et al., 2016). The same chemical process applies for frugal solar-PV systems. See Figure 3 for the illustration of a solar-PV cell (Ranabhat et al., 2016, p. 485).

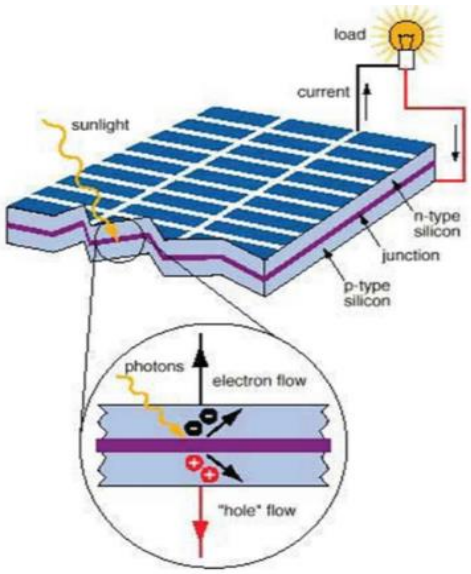


**Figure 3** – Representation of a solar-PV cell (Ranabhat et al., 2016, p. 485).

There are three main reasons for why frugal solar-PV systems can contribute to reducing the energy poverty around the world, in comparison to high-tech solar-PV systems. First, a frugal solar-PV system requires lower capital investments than providing electricity with centralized generation systems or with high-tech solar-PV systems used in mature markets (Baurzhan & Jenkins, 2016; Lay et al., 2013). High-tech solar-PV systems have disadvantages, which makes them not immediately usable for all environments. These disadvantages include too high upfront costs for energy-poor consumers or consumers in the BOP segment. Despite the recent gradual price decrease of solar-PV systems, the upfront costs can still be too high for potential consumers (Gul et al., 2016; Husain et al., 2018). Second, the high-tech solar-PV systems require skilled workers to install and maintain the system, which could pose a problem in rural areas where this service is not continuously available (Numminen & Lund, 2016). A frugal-solar PV system plays into this market niche. Third, the decentralized nature of a frugal solar-PV system makes it possible to generate electricity locally, which can provide a solution for the rural areas which are not connected to the grid and will not be connected in the foreseeable future (Kim et al., 2019). Unfortunately, little research has been done on frugal energy innovations (Numminen & Lund, 2016).

## 1.2 – Knowledge gaps

As can be derived from section 1.1, the current body of knowledge indicates various knowledge gaps regarding frugal innovations and the role of political risks in the market diffusion of these innovations.

First, little is known on frugal innovations focussing on energy provision (Ritchie & Roser, 2019). Little research has been done on frugal innovations generating electricity and if it has been done, it often is based only on case studies (Numminen & Lund, 2016). This is unfortunate, given the fact that frugal innovations can play an important role in providing electricity in countries with no or an unreliable supply of electricity (Kim et al., 2019; Rosca et al., 2017; Parwez & Shekar, 2019; Pisoni et al., 2018; Singh et al., 2012). Also, research on a whole frugal innovation providing electricity (such as a solar pico system), instead of only one component (such as a cooker) is scarce (Numminen, 2019). Given the fact that a substantial part of the world does not have access to electricity, research in this area is needed (Ritchie & Roser, 2019). Second, research on the diffusion of frugal innovations instead of high-tech innovations is scarce (Arshad, 2021; Ashfaq et al., 2018; Bianchi et al., 2017). Given the fact that current diffusion theories have mainly been aimed to analyse diffusion and scaling up high-tech innovations and are not suitable for frugal innovations, makes this a knowledge gap in the field (Hossain et al., 2016; Pisoni et al., 2018). Related to this, the frugal innovations field has focused less on market diffusion of frugal innovations than on conceptualization, while diffusion is also an important step in the supply chain of frugal innovations (Agarwal et al., 2017). Third, as Mikhaylov et al. (2018) and Vakulchuk et al. (2020) mention, the political risk implications of using solar-based technologies have not been researched in depth yet and to what extent a relationship exists between political risks and the diffusion of frugal solar-PV systems, is still unknown (Mikhaylov et al., 2018).

This research will position itself on the intersection of these three knowledge gaps.

## 1.3 – Research objective and research questions

In order to contribute in bridging the gap in the literature as is indicated in section 1.2, this research has the goal to find the extent of a relationship between the political risk and the market diffusion of a frugal solar-PV system. The result of this research can then be taken into account for decisions regarding introducing frugal solar-PV systems in countries with different political risk levels. In order to answer this research question, only countries which have specific frugal solar-PV systems in their market will be taken into account in this research. The selection of these frugal solar-PV systems will be discussed in section 3.1.

To be able to reach this research goal, the following main research question is posed:

*'To what extent is there a relationship between political risks and the market diffusion of frugal solar-PV systems?'*

In order to answer this main research question, five sub-questions will be researched:

1- *'What is known about the relationship between political risks and the market diffusion of frugal innovations?'*
2- *'How can political risks be operationalised, in order to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?'*
3- *'Which correlation analysis method should be used to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?'*
4- '*Which lessons can be learned from the correlation analysis regarding the relationship between political risks and the market diffusion of frugal solar-PV systems?'*
5- *'Which factors could explain the market diffusion of frugal solar-PV systems in Uganda and Namibia, given their respective political risks?'*

## 1.4 – Research relevance

Given the fact that so far little research has been done on frugal energy innovations in combination with political risks and market diffusion, this proposed thesis research will have the scientific relevance to research to what extent a relationship exists between the political risks and the market diffusion of frugal solar-PV systems. This will contribute on the one hand to the knowledge gap on frugal innovations providing electricity and the market diffusion of these innovations, which has been a rarely researched topic so far. On the other hand, it will include researching political risks and to what extent there is a relationship between these risks and the market diffusion of frugal energy innovations, thereby contributing to the posed scientific knowledge gaps in the literature and in section 1.2.

Research regarding frugal energy innovations is highly societally relevant, because such technologies can contribute to reducing energy poverty (Bound & Thornton, 2012; Hossain, 2018). The societal relevance of this research is to contribute to the goals of: 'Ending poverty in all its forms everywhere' and 'Ensure access to affordable, reliable, sustainable and modern energy for all' of the United Nations Sustainable Development Goals (United Nations, n.d.). This will be done by researching if there is a relationship between political risks and the market diffusion of frugal solar-PV systems. The acquired knowledge from this research can then be taken into account in future processes regarding frugal innovations, with the possible consequence that the frugal innovation is more suitable to the situation at hand. On the long term, this could contribute to increasing the percentage of people having access to affordable and renewable generated electricity and reducing the energy poverty.

## 1.5 – Research approach

To contribute to filling the knowledge gaps indicated in section 1.2 and to answer the research questions posed in section 1.3, a mixed-methods research approach will be used. First, quantitative research is performed in the form of a correlation analysis, to analyse the existence of a relationship between political risks and the market diffusion of frugal solar-PV systems. The second phase consists of qualitative research. Based on the results

of the quantitative research, the factors which could explain the diffusion of frugal solar-PV systems in Uganda and Namibia, given their respective political risks, is analysed with means of case studies and interviews.

The correlation analysis is conducted to analyse whether there is a relationship between the political risks and the market diffusion of frugal solar-PV systems (Crawford, 2006). There first is a need to develop an index for the political risk in different countries. This will be done by adding different sub-variables to one overlapping political risk index (PR-index), with means of a factor analysis. The operationalisation of political risks will be discussed further in section 3.2. Second, a correlation analysis will be conducted, because the goal is to find out whether a relationship exists between the PR-index and the market diffusion of frugal solar-PV systems. Statistical research (and specifically a correlation analysis) is used numerously in the energy field, which supports the statement that this is a suitable research approach (Narula & Reddy, 2015; Ŝprajc et al., 2019).

Second, the case study approach is used to analyse some of the interesting results of the correlation analysis, which include researching factors that might also play a role in the diffusion of frugal solar-PV systems in Uganda and Namibia. As Harrison et al. (2017) mention, case studies are appropriate for research topics that want to understand complex phenomena and specifically those in which the boundary between context and the issue is ambiguous and contains many variables. This is the case with frugal innovations and the diffusion of these (Knorringa et al., 2016). With the case study approach, different types of input, such as quantitative data, desk research and interviews are gathered from different cases, in order to learn from the selected cases to assess the role of political risks in the market diffusion of a frugal solar-PV system (Stake, 2006). A case study is a suitable research approach in this field of research. Case studies have been used in research regarding frugal innovations as well as in solar-PV research (Njoh et al., 2019; Singh et al., 2012; Tiwari et al., 2016; Wydra et al., 2019).

As last, after the case studies on Uganda and Namibia have been conducted, interviews will be held to discuss the found explanations from the case studies and provide additional explanations for the found statistical results. Experts in the field will be interviewed with semi-structured interviews. Experts can provide more information on the history, political systems and international relationships of Uganda and Namibia and can therefore help in finding plausible explanations.

This research approach shows that this research is a mixed-methods research, which means that multiple methods have been used to answer the main research question. This has as consequence that the results are not only based on quantitative results, but that also the global picture and the story behind the numbers are taken into account in this research. This provides an as complete as possible answer to the main research question.

Figure 4 shows the research flow diagram corresponding to this research approach. The research will start with reviewing literature in order to formulate the problem definition and relevance of this thesis research. Second, in phase two more literature will be reviewed to be up-to-date on the current state of research on frugal innovations, market diffusion processes in general and of frugal innovations specifically, and the potential role political risks may play in this. In phase three, more specific information

will be gathered to be able to operationalise political risks and to select a fitting correlation method for the statistical analysis. In phase four the correlation analysis will be conducted. Based on the results of this analysis, the selected countries of Uganda and Namibia will be analysed in dept with a case study approach in phase five, to indicate factors that could explain the market diffusion of frugal solar-PV systems in these countries, given their political risks. In the last phase, answers to the research questions will be given, discussion points in regard to this thesis research will be mentioned and a conclusion will be made.

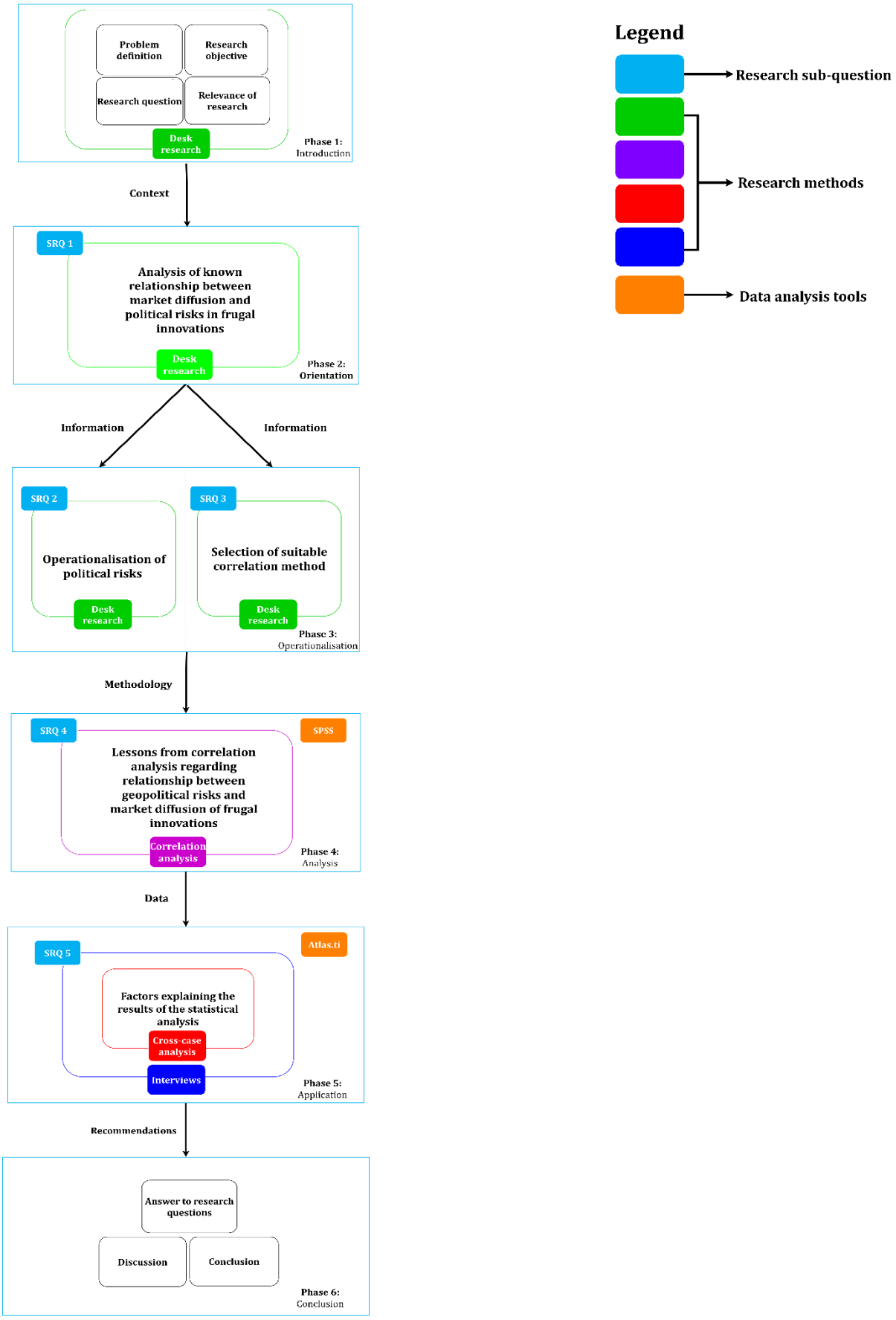


**Figure 4** – Visual representation of research approach.

## 1.6 – Suitability with CoSEM

This research has been conducted for partial fulfilment of the requirements for the degree of Master of Science (MSc) in CoSEM. This thesis research is exemplary for the program of the MSc CoSEM, because of four reasons.

First, this research has technological components embedded: composing a PR-index which can represent the political risks. Also, performing a statistical analysis in order to assess the extent to which political risks might play a role in the market diffusion of frugal solar-PV systems is explementary for a CoSEM research topic. Second, at the same time this research has a strong societal aspect: it contributes to the 'Ending poverty in all its forms everywhere' and 'Ensure access to affordable, reliable, sustainable and modern energy for all' Sustainable Development Goals of the United Nations. Third, this research covers values from the private as well as public domain. The role of private companies, local governments and non-governmental organisations (NGOs) are all taken into account. As last, this research will try to answer the main research question with multiple methods and from different perspectives. Not only will the research question be answered with means of a quantitative analysis, but also the larger societal and contextual picture will be taken into account, which is something that has been learned in this MSc program.

This shows that this is a research topic on a socio-technical system, where technical as well as institutional knowledge is needed, which makes this research suitable as a thesis research for the MSc program of CoSEM.

## 1.7 – Research outline

After this introduction, chapter 2 discusses the current available knowledge regarding frugal innovations, market diffusion of these systems and the possible influence of political risks on this diffusion process. After this, the used methodology in this research is discussed in chapter 3: the case selection of frugal solar-PV systems for this research, the operationalisation of market diffusion and political risk for the statistical analysis, the data collection and analysis steps and the credibility and validity aspects of the used methods. Chapter 4 will discuss the results of the conducted correlation analysis. Various factors that could explain the results of the correlation analysis are discussed in chapter 5, which are identified with case studies and interviews. A critical reflection on this research will be given and recommendations will be made in the discussion in chapter 6, and a conclusion will be drawn in chapter 7. The appendices show additional information gathered in this research and provide a more in-depth explanation of certain research steps.

# Chapter 2 – Theoretical framework

This chapter discusses the current available knowledge on frugal innovations, market diffusion of these innovations and the possible role of political risks in the diffusion of frugal innovations. In this chapter, the first sub-question of this research will be answered. This sub-question is: *'What is known about the relationship between political risks and the market diffusion of frugal innovations?'* Different concepts are discussed in order to answer this sub-question. Section 2.1 discusses frugal innovations. Second, section 2.2 discusses market diffusion in general and the market diffusion of frugal innovations specifically. Section 2.3 discusses the possible types of political risks that can play a role in the market diffusion of frugal innovations. At last, section 2.4 gives an answer to sub-question one.

## 2.1 – Frugal innovations

Frugal innovations aim to serve resource-constrained consumers by providing basic needs and improve their standards of living; it can reduce societal problems and provide citizens with more empowerment (Khan, 2016; Pisoni et al., 2018). Frugal innovations are products or systems that aim to minimise the use of materials and financial resources and reduce the costs of ownership for users, meanwhile meeting quality standards and fulfilling their specific purpose (Khan, 2016; Knorringa, et al., 2016).

As is stated in this definition of frugal innovations, cost reduction is an important part of frugal innovations. This can be achieved through reducing the manufacturing, material, labour or maintenance costs, or eliminating non-value adding functions for the specific situation for which the frugal innovation is designed (Simula et al., 2015). Although cost reduction is a crucial part of frugal innovations, it is not the only necessity for a successful implementation. The frugal innovation should be providing basic needs to consumers, with a high enough quality that the price-sensitive consumer is willing to spend their scarce (monetary) resources on (Knorringa, et al., 2016; Tiwari et al., 2016; Zeschky, 2011). In most cases, frugal innovations are competing against non-consumption (Tiwari & Herstatt, 2012; Tiwari et al., 2016). To convince consumers to spend their scarce resources on this unknown frugal innovation, it should fit their needs and provide value to them (Knorringa, et al., 2016; Numminen & Lund, 2016). The main aim of frugal innovations is maximizing value for consumers, while minimizing the associated costs; not low price, low performance, but low price, high performance (Basu et al., 2013; Sehgal, 2010). This asks for starting a design process from scratch (Hossain et al., 2016; Khan, 2016). Cutting existing functionalities and process costs from current high-tech technologies available in mature markets is not enough for these technologies to work in emerging markets (Sehgal, 2010; Soni & Krishnan, 2014). This is because these former non-consumers and/or BOP consumers have unique demands, which are not provided by current technologies from mature markets (Simula et al., 2015). Second, even if the current technologies from mature markets are stripped-down, their cost structure is often still too expensive for BOP consumers (Sehgal, 2010). This then asks designers to start

from scratch. Because frugal innovations are developed for the specific situation at hand, the unnecessary functionalities are reduced and as little as possible resources are used, while taking the available resources at location into account (Kim et al., 2019). This makes it possible for the poorest countries to increase the standards of living (Knorringa et al., 2016).

Frugal innovations is a relatively new scholarly domain (Pisoni et al., 2018). This provides the problem that the definition and distinction with other connected innovations can be unclear. In order to prevent confusion, the distinction between (sub-)types of (frugal) innovations will be made clear. First, jugaad innovations have emerged in India, which can be seen as the centre of frugal innovations (Rosca et al., 2017; Tiwari et al., 2016). Jugaad innovations differ from frugal innovations in the way that the former only uses locally available resources (Basu et al., 2013). This is even more a do-it-yourself type of innovation than frugal innovations; local individuals or groups themselves find solutions for their problems in their immediate environment, making them not only consumers but also producers of these innovations (Numminen & Lund, 2016; Rosca et al., 2017; Soni & Krishnan, 2014). Second, grassroot innovations are a relatively newer phenomenon than jugaad innovations. With grassroot innovations, there is a small local enterprise built around the developed innovations, which are still designed only with available resources from the immediate environment (Kumar & Bhaduri, 2014). The organizational culture around these innovations has grown in comparison to jugaad innovations. Third, reverse innovations are a specific type of frugal innovations. Reverse innovations are frugal innovations which are diffused to mature, and often higher-income, markets, commonly after some modifications to make them suitable (Agarwal & Brem, 2012; Rosca et al., 2017). This only happens for a small percentage of the frugal innovations (Simula et al., 2015).

Frugal innovations can achieve the low-price, high-performance goal, dependent on their design characteristics, which makes them more valuable to possible consumers. These characteristics are:

1- Reduced overall cost of ownership: the costs during the entire lifetime of the frugal innovation should be as low as possible (Tiwari et al., 2016). This includes not only the price of purchase, but also the costs during its lifetime (costs of usage, maintenance and reparations), in order to reach as many potential consumers as possible.
2- Robustness: in order to keep the costs of maintenance and reparations as low as possible, the product should be robust (Numminen & Lund, 2016; Tiwari et al., 2014). Next to that, frugal innovations often operate in harsh environments: extreme temperatures, humidity, and/or little sheltering (Tiwari et al., 2016). The product should be built to withstand such conditions, without requiring continuous maintenance (Pisoni et al., 2018). If a lot of maintenance is necessary and local available material, knowledge and craftsmanship is scarce, it could result in down-time of the product by having to wait for it to be repaired. This will then have the consequence that consumers have little trust in the product and often will stop using the product all together (Numminen & Lund, 2016).

3- User friendliness: many future consumers have little to no experience with likewise products and little knowledge on how to use the innovation. Therefore, in order to increase the fit to the local conditions and population, and the chance of usage, the product should be easy to use and fault-proof (Khan, 2016; Tiwari et al., 2016).
4- Economies of scale: there has to be enough access to people and markets in order to reduce the costs of development and implementation per unit of frugal innovation (Prabhu, 2017; Tiwari et al., 2014).

## 2.2 – Market diffusion of frugal innovations

Section 2.2.1 will discuss the general principle and theory of market diffusion. Section 2.2.2 focuses on market diffusion of frugal innovations and how this differs from the diffusion theory discussed in section 2.2.1.

### 2.2.1 – Process of market diffusion

Diffusion of innovations can be seen as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Ashfaq et al., 2018; Rogers, 2003, p. 28; Zhang, 2018). Given the definition of innovation diffusion, four main elements can be distinguished, which can influence this diffusion process (Arshad, 2021; Rogers, 2003):

1- The innovation:
Characteristics of the innovation can positively influence the market diffusion (Arshad, 2021; Richardson, 2009). The more the characteristics of frugal innovations match certain characteristics, the more the market diffusion could be increased. These characteristics are (Zhang, 2018):
- Relative advantage: if an innovation is considered to be better, easier to use or provides other (social) benefits to potential users, they are more likely to adopt this innovation.
- Compatibility: the more the innovation meets the demands and requirements of users, the higher the chance of diffusion is. If the innovation is not made to withstand local conditions, such as heat and humidity, users are unlikely to adopt the innovation and the chance of diffusion is low.
- Complexity: if the innovation is easy to understand and use, then the innovation diffuses quicker. In the case of frugal innovations, simplicity is one of the core values of the design, because it is known that in emerging markets little knowledge and training is available for users and a complex design can limit the usability of the frugal innovation.
- Trialability: with trialability, users can have the option to experiment and get familiar with the innovation. This can provide a base for users to decide whether or not they will use the system long-term. With frugal innovations, designers or experts should be on site to install the system and familiarise users with the system.

- Observability: if outcomes of using the innovation are observable to users, then they are more likely to keep using the system. For example, light and electricity are very observable and the experienced benefits of having this innovation can become very clear to new and potential users.

2- Communication through certain channels:
For the diffusion of an innovation, communication between at least two people is necessary. One person who has the experience and/or knowledge regarding the innovation, the other who is receiving this knowledge. Therefore, diffusion is enhanced by speaking the same language and being in close proximity of each other (Zanello et al., 2015). This makes (informal) communication easier.

3- Involvement of time:
This entails the decision process through which the potential users go to decide whether or not they will adopt the innovation. This process entails five stages (Rogers, 2003):

- Knowledge: the users hear about the innovation and receive some information.
- Persuasion: the users experiment with the innovation to see what the added benefits of using this innovation can be.
- Decision: the users decide whether or not the innovation will be adopted.
- Implementation: the users use the system, if it was decided to adopt the innovation
- Confirmation: the decision to adopt or reject the innovation is reconsidered.

4- Spread through a social system:
Diffusion of an innovation can be seen as a social process which occurs when people learn about an innovation (Dearing & Cox, 2018). Diffusion of an innovation can be speeded up or slowed down by the (informal) social structures and their communication mechanisms within this. Often, technological development and then diffusion of innovations occur in one direction: from mature markets to emerging markets (Leliveld & Knorringa, 2017).

The innovation diffusion pattern is often represented with an S-curve, as is visible in Figure 5. Innovations which diffuse very fast in the market have a steeper slope than innovations which diffuse slower (Rosenberg, 1972).

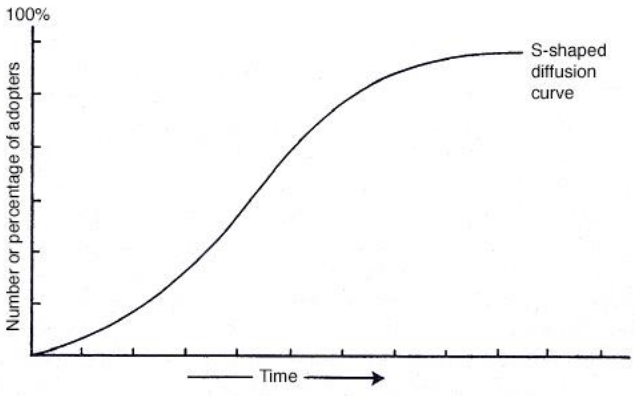


**Figure 5** – S-shaped diffusion curve (Milner, 2011).

### 2.2.2 – Process of market diffusion of frugal innovations

Frugal innovations have different characteristics compared to high-tech innovations, with the consequence that the diffusion theory discussed in the previous section is not entirely

applicable to the diffusion of frugal innovations (Zhang, 2018). The core characteristics (the innovation itself, the communication channels, the involvement of time and the social context) differ between frugal innovations and high-tech innovations, and thus frugal innovations will have different diffusion patterns (Hossain, 2018; Hossain, 2020; Hossain et al., 2016; Zhang, 2018).

Frugal and high-tech innovations have different characteristics, which can have an influence on their respective diffusion. First, the design process of a frugal innovation starts with a basic need in mind that needs to be fulfilled according to the demand of potential users and not with a business model and vision on how to scale-up and diffuse the innovation, in comparison to high-tech innovations. This slows down the diffusion to other markets (Arshad et al., 2018; Ashfaq et al., 2018; Hossain, 2018). The frugal innovation is designed for meeting a specific demand and thus for a specific situation or environment (Agarwal & Brem, 2012; Pisoni et al., 2018). This makes diffusion to other markets or regions harder (Ashfaq et al., 2018). Second, the communication channels are more difficult with frugal innovations; understandable communication between people with different geographical, socio-economical and linguistic backgrounds is harder (Arshad, 2021). Also, the difference in education and training regarding the frugal innovation at hand makes it more difficult to have understandable communication to transfer knowledge effectively (Rosca et al., 2017). Third, the process of potential users to decide whether or not they will adopt the innovation also goes slower with frugal innovations. This is because potential users often have a lack of awareness that frugal innovations exist and that these are a valid option for their demands (Arshad, 2021). Moreover, the lack of governmental and/or institutional support increases this lack of awareness of potential users. With increased support from official parties in the form of policies for example, the diffusion and use of frugal innovations could be increased due to more education and training facilities for potential users (Abrol & Gupta, 2014; Arshad, 2021; Bianchi et al., 2017; Hossain, 2018; Zanello et al., 2015). At last, the social system in which frugal innovations are introduced, are different from those in which high-tech innovations are normally introduced. Generally, the social system also influences the diffusion process; the same innovation could have a different diffusion curve in different social systems (Zhang, 2018). Innovations generally diffuse to other countries with the same socio-economic conditions, due to the overlap between the conditions and demand for which the innovation is designed (Ashfaq et al., 2018; Hossain et al., 2016).

Due to these differences between high-tech innovations and frugal innovations, they have different diffusion paths. High-tech innovations diffuse from mature markets to emerging markets, while frugal innovations are developed in emerging markets and normally stay in these markets or are diffused among other emerging markets (Schmidt & Druehl, 2008). So, a different diffusion theory is necessary for frugal innovations (Hossain, 2018). This means that the S-curve of diffusions (as has been seen in Figure 5), is different for frugal innovations. As is proven in the research of Zhang (2018), who did research on frugal innovations in the ICT-domain, frugal innovations diffuse slower in

emerging market than a high-tech innovation. This is due to the fact that frugal innovations do not have characteristics that users of high-tech innovations usually prefer. In the end, frugal innovations reach more users in DCs, as can be seen in Figure 6 (Zhang, 2018, p. 59). This is because the frugal innovations meet the demands of users in DCs better than high-tech innovations (Khan, 2016).

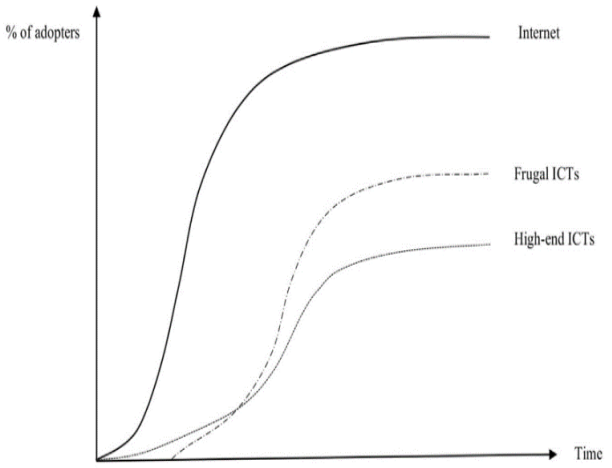


**Figure 6** – Diffusion of frugal innovations in DCs (Zhang, 2018, p. 59).

For frugal innovations to diffuse, there are different diffusion paths they can take, as can be seen in Figure 7 (Hossain et al., 2016, p. 137). The four diffusion paths are (Hossain et al., 2016; Pisoni et al., 2018):

1- Local diffusion: the diffusion of the frugal innovation is limited; the innovation can diffuse to other parts of a country or is only adopted nationally (Ashfaq et al., 2018).
2- Proximity diffusion: proximity diffusion entails diffusion to similar socio-economic environments, such as neighbouring countries.
3- Distance diffusion: the frugal innovations follow the distance diffusion path when the frugal innovation continues to diffuse to countries further than the neighbouring countries.

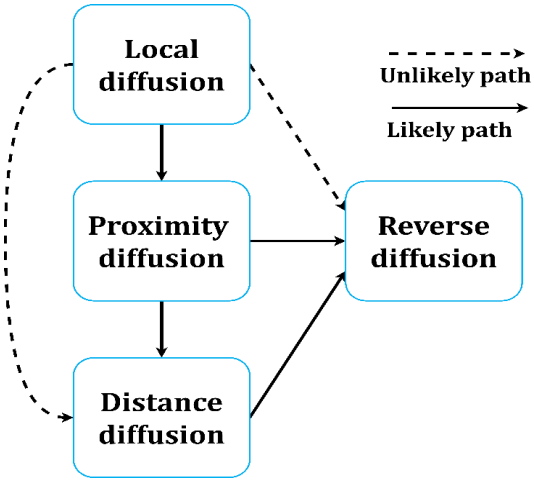


**Figure 7** – Frugal diffusion paths (Hossain et al., 2016, p. 137).

4- Reverse diffusion: in this diffusion path, the frugal innovations become a reverse innovation and innovations diffuse from emerging markets to mature markets or globally (Ashfaq et al., 2018).

A frugal innovation can follow one or more diffusion paths sequentially, although the step from local diffusion immediately to distance or reverse diffusion is unlikely, because it is improbable that earlier diffusion to neighbouring countries does not occur (Hossain et al., 2016).

Despite the knowledge gap regarding diffusion theory on frugal innovations, various possible influences on market diffusion in emerging markets are known. Diffusion of innovations is difficult in emerging markets, due to the often overall lower support of governments for innovations to develop and emerge. This makes it hard for innovations to be known to potential users and to diffuse further (Abrol & Gupta, 2014; Bianchi et al., 2017). In developing markets, the market for innovations is limited by institutional, socio-economic, legal and geographical systems and the diffusion of innovations to or within

these markets is limited due to the high cost of diffusion (Zanello et al., 2015). Having enough (monetary) resources within a developing market is one of the main difficulties for diffusion of innovations (Miller, 2009; Zanello et al., 2015). However, frugal innovations have a higher chance of diffusing in developing markets than high-tech/non-frugal innovations, due to the design process of frugal innovations (Tiwari & Herstatt, 2012). Frugal innovations are more focused on designing a possible solution to a local demand or need and therefore take the local needs, wishes, (cultural) preferences and infrastructural shortcomings into account (Zanello et al., 2015). With this, the frugal innovations achieve a higher embeddedness in the social system and therefore has a larger chance to diffuse than high-tech/non-frugal innovations.

The barriers for diffusion of innovations in emerging markets can be categorized in external and internal barriers. The external barriers will be discussed in section 2.3. Internal barriers to diffusion include factors that are internal to an organization designing and diffusing innovations (Zanello et al., 2015). These include:

- Human capital: the lack of expertise, education options and training facilities limit the diffusion of innovations. Not having enough knowledge on how to design or use innovations decreases the chance of long-term usage and therefore diffusion of the innovation (Arshad, 2021).
- Available resources: the limited (monetary) resources narrow down the affordability of the innovation for potential users, therefore limiting the potential market to which the innovation can diffuse (Zanello et al., 2015).
- Networking capabilities: with a global innovation network, the chance is higher that there are already trade agreements in place and international companies interested in new markets (Arshad, 2021).

Moreover, there are additional barriers specifically for the diffusion of frugal innovations. These barriers should be taken into account when frugal innovations are being diffused to other regions; taking these into account could make the diffusion process easier and more fitting to the situation. These are (Abrol & Gupta, 2014; Arshad, 2021; Numminen & Lund, 2016):

- Lack of awareness of potential users of the innovations.
- Lack of teamwork between public and private parties and local users.
- Non-availability of resources or only short-term availability.
- Importing costs of resources or human capital.
- Insufficient understanding of local cultures, with as consequence that the frugal innovation does not fit local demands and patterns, which will give the frugal innovation a bad reputation and will limit the diffusion.

However, despite the distinct differences with high-tech innovations, research on diffusion of frugal innovation remains scarce and more research is needed to include frugal innovations in this field (Arshad, 2021; Ashfaq et al., 2018; Bianchi et al., 2017; Hossain et al., 2016; Pisoni et al., 2018).

## 2.3 – Influence of political risks on market diffusion

As is discussed by Mikhaylov et al. (2018), diffusion of frugal innovations is not a given. Section 2.2.2 mentioned that also external barriers, which can limit the diffusion of frugal innovations. These external barriers can be combined within the general term of political risks (Zanello et al., 2015). Political risks may pose a barrier to diffusion of these systems, due to their ability to endanger a stable environment suitable for investments and creating uncertainty for innovators and investors (O'Sullivan et al., 2017). Political risks could influence the trade with other countries, which is an important aspect of the diffusion of innovations. Political risks can pose a threat for creating and/or maintaining a stable environment for development and investment, and can consist of multiple types of influencing factors (Aloui & Hamida, 2019; Alsagr & van Hemmen, 2021; Malmgren, 2015). Therefore, there is a need for combining different types of risks, in order to be able to assess to what extent these political risks play a role in the diffusion of frugal innovations. The overall political risk can be sub-categorized in three types of risk groups with corresponding risk sub-factors (Mokhele, 2019). These are:

1- Political:

Political risks can have a negative impact on the economy and innovation environment of countries (Jiang & Martek, 2021; Kruja & Dragusha, 2016). Institutional and political support is very important in emerging markets for diffusion of innovations (Zanello et al., 2015). An instable government or political environment or changing policy can discourage investments from other countries (Bianchi et al., 2017). Corruption can also limit the diffusion of innovations (Zanello et al., 2015). Third, incomplete, contradictory and/or outdated institutional agreements can limit the diffusion of innovations (Zanello et al., 2015). Fourth, the limited cooperation between private and public actors in emerging markets can have a negative influence on the development and diffusion of frugal innovations (Fischer et al., 2020). Different types of political risks can play a role in the diffusion of innovations:

- Voice and accountability: the extent to which citizens have a voice in the electoral process of their government has a significant influence on the political stability and openness of a country to innovations and external parties (Jadhav, 2012).
- Political stability: the political instability in a country has negative impacts on investments and diffusion of innovations (Jiang & Martek, 2021; Kruja & Dragusha, 2016). This also works the other way around; the introduction of an innovation can also influence the political stability of a country. The introduction of innovations could increase the production capacity of countries, thereby decreasing the dependency on other countries. This could increase the political stability (IRENA, 2019).
- Government effectiveness (Kruja & Dragusha, 2016): when (foreign) investors experience an effective operation of a government, they are more likely to invest in new innovations.

- Regulatory quality: when regulations are clear and not changing often, innovators and investors have a clear overview of the potential new market which they may enter (Jadhav, 2012). Incomplete, contradictory and/or outdated institutional agreements can limit the diffusion of innovations (Zanello et al., 2015). Also, the limited cooperation between private and public actors in emerging markets can have a negative influence on the development and diffusion of frugal innovations (Fischer et al., 2020).
- Rule of law (Kruja & Dragusha, 2016): the extent to which the political system and institutions have the power to uphold companies and citizens to their laws, provides investors with the knowledge that if legal actions have to be taken, the system will be able to process this.
- Corruption: types of corruption, such as bribes for licenses or police protection can make it harder for (foreign) investors to be attracted to a new market to introduce an innovation (Dutta et al., 2013; Hayakawa et al., 2013; Jadhav, 2012).
- Terrorism: terrorism is a type of political violence. Acts of terrorism can damage the infrastructure, thereby destroying part of the innovations and reducing the change for investors achieving a return of their investment (Alsagr & van Hemmen, 2021; Komendantova et al., 2012).

2- Economic:

The better the economic condition of a country is, the more likely it is to attract new businesses and investors (Mokhele, 2019). Economic factors include the openness of the economy for other market parties to enter the market, the economic development of the country to be able to invest in innovations, market failures and inadequate infrastructures for transport of goods, which can influence the diffusion of innovations (Hossain, 2018; Zanello et al., 2015).

- Gross domestic product (GDP): a high GDP can positively impact the entrepreneurial environment (Dutta et al., 2013; Jadhav, 2012).
- Inflation: a high inflation rate could deter foreign investment, due to lower future returns of their investment (Hayakawa et al., 2013).
- Quality of infrastructure: the quality of the infrastructure in a country influences the level of ease through which materials and people can move around in a country. The higher the quality of the infrastructure is, the easer the distribution is. For example, a lot of new technologies or innovations need materials such as lithium, cobalt and indium. With a high quality of infrastructure, this could be distributed easier from extraction to production location (Scholten et al., 2018).
- Market size (Jadhav, 2012; Kumari & Sharma, 2017): the net amount of domestic product in a country has a positive influence on the number of foreign investments made.
- Trade openness (Jadhav, 2012): the amount of import and export of products influences the way innovators and investors look at a country. When a country trades more with other countries, it can serve as indication that a country has

good relationships with other countries. Higher trade openness could increase the number of investments made (Lu et al., 2020).

- Ease of doing business (Mokhele, 2019): when a country provides a stable environment to install new businesses or make trade agreements, it attracts more investment and innovations.
- Strength of legal rights: laws to facilitate access to credit can provide potential consumers with the ability to purchase an innovation, which is important for the diffusion of innovations (Ndunguru, 2018).

3- Social:

Social dissatisfaction can increase the instability within a country and influence governmental and entrepreneurial actions (Hayakawa et al., 2013).

- Civil liberties: when citizens are free to express who they are and maintain their autonomy, then innovators have a larger segment of potential consumers to reach. If the government does not support certain innovations, the market share of that innovation diminishes rapidly, which could reduce the appeal of investing in such a country (Busse & Hefeker, 2007; Mokhele, 2019). Also, dependent on the type of innovation, the introduction of an innovation could empower citizens. The innovation could make citizens more autonomous and less dependent on the governmental provision of services, thereby democratising public services (IRENA, 2019).
- Political rights: if citizens can participate in a fair electoral process, the possibility increases that an unfitting and/or unfair government could be removed. Political rights form the base of democracy and a good democracy increases the chance of investments made in that country (Busse & Hefeker, 2007).
- Human development (Mokhele, 2019): when the human development in a country is acceptable or increasing, it shows that a country is taking care of its citizens and/or improving the living conditions for their citizens, which attracts innovations and investors.
- Inequality: as is mentioned in section 1.1.1 ('Energy poverty'), energy access is not a given for thirteen percent of the world. Access to modern technologies and innovations could reduce political instability and conflicts in energy-poor regions of the world (O'Sullivan et al., 2017). However, introduction of innovations could also increase separatism and inequality within a country and lead to instability (Scholten et al., 2020).

To conclude, political risks can play a role in the diffusion of frugal innovations. Various political risk factors have been identified which could influence the investments possibilities for frugal innovations and therefore the market diffusion of these innovations (O'Sullivan et al., 2017). The literature thus showed that there might be a relationship between political risks and the market diffusion of frugal innovations.

## 2.4 – Conclusion

This chapter aimed to answer the first sub-question of this research. This sub-question is: *'What is known about the relationship between political risks and the market diffusion of frugal innovations?'* Different concepts have been discussed in order to answer this sub-question.

The literature indicated that frugal innovations might provide a solution for potential consumers with limited resources. The frugal innovation aims to provide basic needs to consumers, with a high enough quality that the price-sensitive consumer is willing to spend their scarce (monetary) resources on, with the goal to improve citizen's standards of living and empower them (Knorringa, et al., 2016; Tiwari et al., 2016; Zeschky, 2011). Although reduction of costs is a crucial part of frugal innovations, it is not the only necessity for successful implementation and diffusion. The main aim of frugal innovations is maximizing value for consumers, while minimizing the associated costs; not low price, low performance, but low price, high performance (Basu et al., 2013; Sehgal, 2010). This asks for starting a design process from scratch, instead of cutting existing functionalities of current high-tech innovations available in mature markets (Hossain et al., 2016; Khan, 2016; Sehgal, 2010; Soni & Krishnan, 2014). This is because former non-consumers and/or BOP consumers have unique demands, which are not provided by current technologies from mature markets (Simula et al., 2015).

However, despite the possibilities that frugal innovations can provide, market diffusion of these innovations around the world is not a given (Mikhaylov et al., 2018). However, research on market diffusion of frugal innovations has been limited so far, due to unfitting diffusion theories (Zhang, 2018). Current innovation diffusion theories are mainly focused on diffusing high-tech innovations in mature markets. The different characteristics of frugal and high-tech innovations makes the usage of these current theories unsuitable to analyse the market diffusion of frugal innovations. It is known that diffusion of frugal innovations generally goes slower than that of high-tech innovations. Despite this, frugal innovations reach more users in emerging markets than high-tech innovations, due to the suitability of the frugal innovation to the local conditions and demands (Khan, 2016; Zhang, 2018). Due to these differences between high-tech innovations and frugal innovations, frugal innovations can follow different diffusion paths; high-tech innovations diffuse normally within mature markets and/or from mature markets to emerging markets, while frugal innovations are developed in emerging markets and normally stay in these markets or are diffused among other emerging markets (Schmidt & Druehl, 2008). So, due to the different characteristics of high-tech innovations and frugal innovations, a different diffusion theory is necessary for frugal innovations, but research on diffusion of frugal innovation remains scarce and more research is needed to include frugal innovations in this field (Arshad, 2021; Ashfaq et al., 2018; Bianchi et al., 2017; Hossain et al., 2016; Pisoni et al., 2018).

Section 2.2.2 indicated that political risks can limit the market diffusion of frugal innovations.; a political tense situation, or unforeseen or sudden changes in the environment can affect investment decisions and thereby influence the market diffusion of frugal innovations. Thus, political risks may pose a barrier to diffusion of these systems,

due to their ability to endanger a stable environment suitable for investments (O'Sullivan et al., 2017). Political risks can consist of multiple types of influencing factors, which have to be combined to give an overview of the overall political risk that might play a role in the market diffusion of frugal innovations. The first category are political risks. An instable government or political environment, or changing policy can discourage investments (Bianchi et al., 2017). Corruption can also limit the diffusion of innovations (Zanello et al., 2015). Second, incomplete, contradictory and/or outdated institutional agreements can limit the diffusion of innovations (Zanello et al., 2015). The second category are the economic conditions of a country. The better the economic condition of a country is, the more likely it is to attract new businesses and investors (Mokhele, 2019). As last, also the social situation plays a role. Social dissatisfaction can increase the instability within a country and influence governmental and entrepreneurial actions (Hayakawa et al., 2013). Within these categories, also more specific sub-factors have been identified, which together can give an overview of the general political risks associated with a country.

To conclude, the literature thus showed that there might be a relationship between political risks and the market diffusion of frugal innovations. Various political risk factors have been identified which could influence the investments possibilities for frugal innovations and therefore play a role in the market diffusion of these innovations (O'Sullivan et al., 2017).

# Chapter 3 – Methodology

The aim of this chapter is to discuss the used methodology in this research and to give an answer to sub-questions two and three. These respectively are: *'How can political risks be operationalised, in order to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?'* and *'Which correlation analysis method should be used to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?'*. First, section 3.1 discusses the selection of frugal solar-PV systems as the case for which the extent of a relationship between political risks and the market diffusion of frugal innovations is analysed. Second, section 3.2 discusses how the market diffusion of frugal solar-PV systems and political risks will be operationalised in this research. Section 3.3 and 3.4 discuss the data collection and analyses steps respectively. The credibility and validity aspects of the used methods in this research will be discussed in section 3.5 and the ethical considerations in section 3.6. As last, an answer will be given to sub-question two and three in the conclusion in section 3.7.

## 3.1 – Frugal solar-PV systems

In order to be able to assess whether a relationship exists between political risks and the market diffusion of frugal innovations, it could be helpful to choose a frugal innovation in a field that is historically linked to political risks and to choose a frugal innovation that could possibly contribute to reducing the energy poverty (Agarwal et al., 2017; Hossain, 2018; Khan, 2016). So, to conduct this thesis research, frugal solar-PV systems have been chosen as case to analyse the possibility of a relationship between political risks and the market diffusion of frugal innovations. This is chosen for three main reasons.

First, energy provision has always been a focus point in political research: the security of supply, the necessity of energy for economic development, and power and trade related to having access to energy resources has been at the core of the political playing field (Semkin et al., 2017).

Second, a frugal solar-PV system has the capacity to meet the energy poverty challenge and can have a substantial contribution to the provision of this basic need, thereby decreasing the percentage of the population without any or reliable access to electricity and can contribute to societal goals (Ulsrud, 2020). Solar-PV systems have been one of the fastest growing renewable energy technologies, due to the fact that solar power is abundantly available, can provide basic functions in a clean, safe and affordable way and that there is a need in the market for low-costs products based on solar power (Adwek et al., 2019). This makes solar power a suitable option for providing the functionalities for the energy demand in energy-poor countries. Frugal solar-PV systems have the potential to generate clean, reliable and affordable electricity (Gul et al., 2016). Electricity production with means of frugal solar-PV systems provides a lower-cost energy provision than with traditional energy carriers, while its production is also more environmentally friendly. Providing energy-poor consumers with frugal solar-PV systems can improve their standards of living (Feron, 2016). With renewable electricity provision, consumers can have clean electric lightning, leading to more hours of available light with a less

polluting light source and thus reducing associated health risks. In some frugal solar-PV systems, mobile phones and radios can be plugged in and charged. This all leads to more usable educational and working hours for citizens, better income opportunities and to an overall improvement of well-being in terms of health, income and education (Levänen et al., 2015). This has the possibility to reduce energy poverty and making people more self-providing (Bhide & Monroy, 2011; Numminen & Lund, 2016; Yadav et al., 2019).

Third, frugal solar-PV systems are one of the energy innovations that can be designed frugally. Frugal solar-PV systems focus on providing sustainable energy, with means of locally available renewable resources and can thus provide electricity for an affordable price for potential consumers, including the BOP segment (Ahonen, 2015; Numminen & Lund, 2016). For energy innovations to be categorized as a frugal energy innovation, the products or systems have to meet certain standards and characteristics. These are (Numminen, 2019; Numminen & Lund, 2016):

- Affordability: the energy provision innovation should be more affordable to consumers than the current options. This can be done by lowering the manufacturing costs, maintenance costs or costs of used materials.
- Environmental sustainability: the energy provision innovation should use renewable resources.
- Frugal design principles: the design of the frugal energy provision should result in a durable design, simple for consumes to use and use of minimal amounts of resources.
- Frugal energy consumption: the frugal energy provision should produce modest amounts of electricity, not more than the demand of the consumers in question is.
- Local appropriateness: in order for the frugal energy innovation to be used in the community or country for which it is designed, it should fit the (cultural and social) user preferences (Basu et al., 2013). Also, it should be made sure that the knowledge and skills for operating and maintaining the system are available (Numminen, 2019; Numminen & Lund, 2016).

These characteristics show that frugal solar-PV systems are in fact frugal innovations. The materials used for the frugal solar-PV system and output of the frugal solar-PV system can be adjusted for different goals and demands of the future consumers. Also, frugal solar-PV systems provide renewable and sustainable energy and the design of a frugal solar-PV system can be in such a way that the system has little maintenance costs, is easy to use and is robust, thereby meeting the frugal design characteristics (Basu et al., 2013).

There are different types of solar energy technologies, see Figure 8 (Feron, 2016, p. 2). The chosen frugal solar-PV systems in this research to assess the extent of a relationship between political risks and the market diffusion of these frugal energy innovations are solar pico systems (SPSs) and solar home systems (SHSs) (Bond et al., 2012; IEA, 2013; Nygaard et al., 2016). Both of these systems are included, due to the nature of the frugal innovations and the envisioned effect they have on energy poverty in countries.

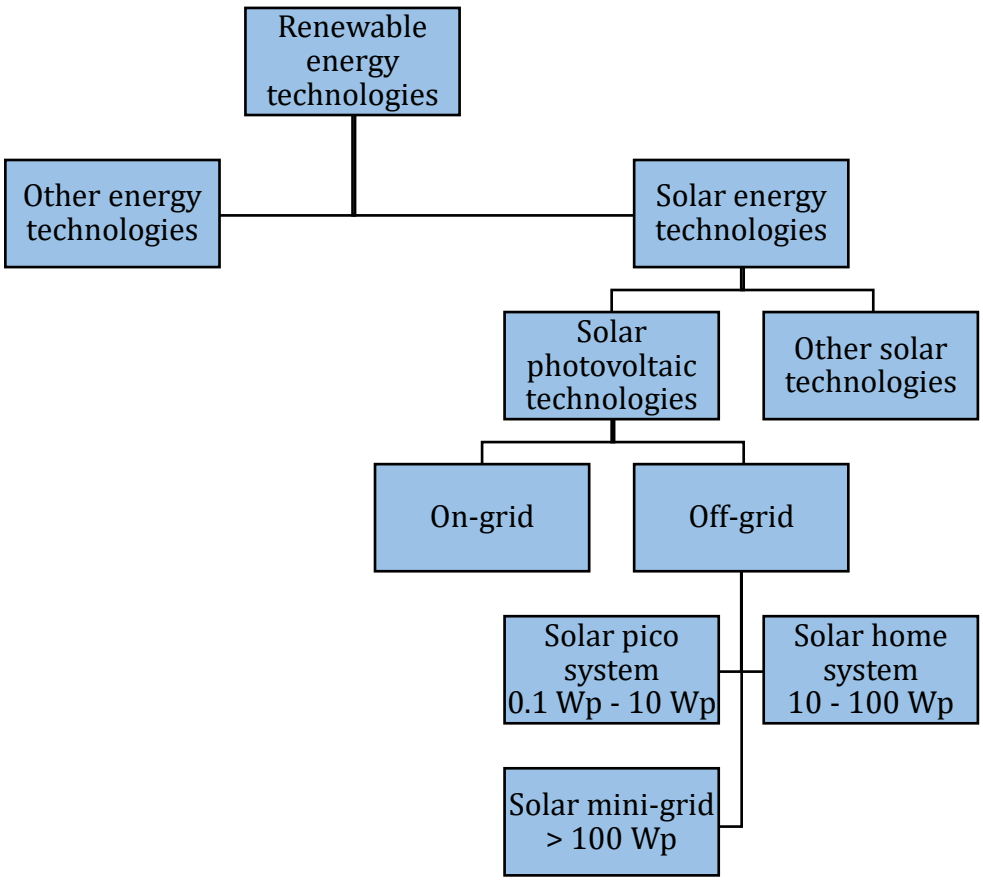


**Figure 8** – Types of renewable energy technologies (Feron, 2016, p. 2).

SPSs are frugal energy innovations (Numminen, 2019) that have a power output range between 0.1 Watt peak (Wp) and 10 Wp. SPSs are frugal energy systems, because they are designed to provide high quality services, while minimizing the costs. This comes forward in choosing the type of solar panel, battery functionalities, low maintenance requirements and high durability (Numminen, 2019; Phaesun, n.d.). These systems are mainly designed for providing the first demands of electricity: lightning and possibly charging a mobile phone or small radio (IEA, 2013). SPSs are affordable for non-consumers of electricity to make the first step on the electrification ladder. Because they are small and portable, the distribution of these systems is easier and the required knowledge and expertise for maintenance is lower, providing consumers with the possibility to provide sustainable light from renewable sources (Reiche et al., 2010). A SPS provides very little electricity, so it is only suitable for one to a couple of lights and/or one simple external appliance that can be connected. Due to the small amount of electricity generated, a SPS is seen as a pre-electrification step; consumers are still counted as non-electrified (IEA, 2013). This is because the SPS actually provides too little electricity to power larger and necessary appliances (such as a refrigerator and cooking facilities). The installation of a SPS tilts non-consumers to Tier 1 on the scale of access to electricity (Fernandez-Fuentes et al., 2021; Lucas et al., 2017) and starts the electrification process, as can be seen in Figure 9 (Hassan et al., 2020, p. 4). But at the same time, Reiche et al. (2010) showed that this starting point of having electricity between 0.1 and 10 Wp provides marginally a large improvement in living conditions for previously non-consumers.

| | Tier 0 | Tier 1 | Tier 2 | Tier 3 | Tier 3 | Tier 4 | Tier 5 |
|---|---|---|---|---|---|---|---|
| **Tier criteria** | Non-electrified | Task lightning | General lightning | Tier 2 | Tier 3 | Tier 3 | Tier 2 |
| | | Phone charging | Phone charging | Phone charging | Any medium-power appliances | Any high-power appliances | Any very high-power appliances |
| | | | | Television | | | |
| | | | | Fan (if needed) | | | |

**Figure 9** – Tier electrification ladder (Hassan et al., 2020, p. 4).

The SHS is a step up the Tier electrification ladder (Abu Saim & Khan, 2021; Reiche et al., 2010). SHSs have the biggest market share of solar-PV systems (Adwek et al., 2019). Consumers of a SHS receive then enough electricity to reach Tier 2 (Kendall & Pais, 2018), as can be seen in Figure 9. These systems have the power to provide between 10 and 100 Wp of electricity and are multipurpose; they can thus provide power for multiple light sources and more importantly, more electricity for other appliances such as mobile phones, radios and a television (Feron, 2016; Lay et al., 2013). This has a significant impact on the overall welfare of users in terms of income generation, education, health and emission reduction (Abu Saim & Khan, 2021; Adwek et al., 2019; Diallo & Moussa, 2020). SHSs are frugal energy innovations, because they cost-effectively provide a certain amount of electricity to consumers and thereby fulfilling basic needs, using a renewable energy source and are designed with the local needs and conditions in mind, so that the system is durable and maintainable in the local environment (IEA, 2013; Kendall & Pais, 2018). The simplistic design, the low maintenance and low specific required knowledge makes it possible for end-users to own the SHS, which increases the chance of success and increases the potential benefits of using the SHS (Adwek et al., 2019). Frugal solar mini-grids are excluded of this research, because these do not meet the criteria for a frugal energy innovation. Solar mini-grids require multiple electricity generators, with complex interconnections and are thus too expensive, require high maintenance and specific knowledge (Adwek et al., 2019; Feron, 2016).

SPSs and SHSs systems are both included in this research, because on the one side, a SPS can only marginally lift consumers to Tier 1, which does not generate enough electricity for consumers to be seen as electrified (IEA, 2013). But on the other side, even a frugally designed SHS can be too expensive for potential users in the lowest-income groups (Feron, 2016; Reiche et al., 2010). Therefore, to reach as many people in the BOP segment as possible, both SPSs and SHSs are included in this research.

## 3.2 – Operationalisation

To be able to conduct a correlation analysis to assess the extent of a relationship between political risks and the market diffusion of frugal solar-PV systems, both need to be operationalised in measurable variables. How this is done, is explained in this section.

First, to assess the market diffusion of a frugal solar-PV system, a proxy in the form of sales of these types of systems will be used. The sales for SPSs and SHSs together will be used to assess how these systems have diffused in different countries over a time period from the second semester of 2015 to the second semester of 2019.

Second, a way to assess the political risks has to be found. Chapter 2 identified various political risk factors influencing the market diffusion of frugal solar-PV systems. In order to be able to conduct one overall political risk score for each involved country in this research, these factors should be combined. For this, the method described in the research of Muñoz et al. (2015) has been used. In this research, the overall PR-index will be a combination of the separate sub-factors. The factors that will be included to produce one overall PR-index can be seen in Table 1, together with an explanation of what these factors measure.

**Table 1** – Included variables in the PR-index.

| Sub-variables | Sub-factors | Explanation |
|---|---|---|
| Political | Voice and accountability (V&A) | Measures to what extent citizens can participate in selecting their government. |
| | Political stability (PS) | Measures the probability that the current installed government will be overthrown in a violent way. |
| | Government effectiveness (GE) | Measures the quality of the overall governmental service. |
| | Regulatory quality (RQ) | Measures the ability of the government to design, install and maintain policies and regulations. |
| | Rule of law (RoL) | Measures the enforcement strength of laws by the government. |
| | Control of corruption (CoC) | Measures the probability for which public power is used for private gain. |
| | Terrorism (T) | Measures the risk levels of acts of terrorism occurring. |
| Economic | Quality of overall infrastructure (QoI) | Measures the quality and connectivity of the infrastructure in a country. |
| | Market size (Market) | Measures the net amount of domestic product in a country. |

| | | |
|---|---|---|
| | Trade openness (Trade) | Measures the sum of exports and imports of a country. |
| | Ease of doing business (EofB) | Measures to what extent a country is perceived as being easy to trade with or to install a new business. |
| | Strength of legal rights (Strength LR) | Measures the strength of laws to facilitate access to credit and lending of investment money. |
| Social | Civil liberties (CL) | Measures the extent to which citizens are free to express who they are and to maintain their autonomy. |
| | Political rights (PR) | Measures the extent to which citizens can participate in a fair electoral process and have enough political parties to choose from. |
| | Human Development Index (HDI) | Measures key dimensions of the average human development in a country. |
| | Inequality (Inequa) | Measures the inequality between life expectancy, education and income in a country. |

Besides the risk variables that will be used to conduct one overall PR-score per country, different control variables will also be included to have an overall view of the included countries in this research. These control variables are:

- GDP: this measures the amount of goods or services produced within a country and can be used as an economic indicator of the performance of a country.
- Inflation: inflation measures the rate of price change in the economy of a country.
- Population: measures the total amount of residents in a country, regardless of their legal status.
- Unemployment: measures what percentage of the labour force does not have employment, but is available for work and/or is seeking for work.

## 3.3 – Data collection

After it is clear what data has to be gathered to be able to answer the main research question, this required quantitative and qualitative data has to be collected. The data collection of the quantitative analysis part is discussed in section 3.3.1 and the data collection of the qualitative analysis part in section 3.3.2.

### 3.3.1 – Quantitative data collection

The data for the quantitative analysis has been collected in two steps.

First, the data for the market diffusion of frugal solar-PV systems has been gathered. As is explained in the previous section, this will be measured in sales numbers of SPSs and

SHSs worldwide. This data is gathered from the reports of Lightning Global over the years 2015 to 2019. Lightning Global is an organisation which aims to increase access to off-grid solar-PV systems for people currently living without access to electricity. Lightning Global has kept track of the amount of SPSs and SHSs that have been sold during each half year.

Second, the data for the PR-index needs to be gathered. For the different sub-factors, different types of data sources have been used. This can be seen in Table 2.

**Table 2** – Data sources for the PR-index.

| Sub-variables | Sub-factors | Data source |
|---|---|---|
| Political | Voice and accountability (V&A) | WorldBank |
| | Political stability (PS) | |
| | Government effectiveness (GE) | |
| | Regulatory quality (RQ) | |
| | Rule of law (RoL) | |
| | Control of corruption (CoC) | |
| | Terrorism (T) | Aon Political Risk Indicator |
| Economic | Quality of overall infrastructure (QoI) | Global Competitiveness Index |
| | Market size (Market) | |
| | Trade openness (Trade) | WorldBank |
| | Ease of doing business (EofB) | |
| | Strength of legal rights (Strength LR) | |
| Social | Civil liberties (CL) | Freedom in the World |
| | Political rights (PR) | |
| | Human Development Index (HDI) | Human Development Reports |

| | | |
|---|---|---|
| | Inequality (Inequa) | |
| Control variables | Gross Domestic Product (GDP) | WorldBank |
| | Inflation (Infla) | |
| | Population (Population) | |
| | Unemployment (Unemploy) | |

### 3.3.2 – Qualitative data collection

After the data for the quantitative analysis has been collected, the data for the qualitative analysis has been gathered. The qualitative research within this research consists of case studies and interviews, both with the goal to get a broader overview of the (political) situation in Uganda and Namibia and to find factors explaining the found statistical results.

First, the data for the case studies has been collected by finding fitting qualitative data on the selected cases. This included finding primary and secondary sources on the political situation, the historical development of the solar-PV sector, the necessity for frugal solar-PV systems and the cooperation within the region and with international actors. Second, the qualitative data analysis part of this research also existed of interviews. Three experts in the field of African development and governance have been interviewed, see Table 3 for an overview of each individual's professional field. In total four experts in this research field have been contacted, which were found through an internet search for professors within the African studies domain. The four experts were emailed with an explanation of the research set-up, preliminary results and the main topics of the interview. This resulted in a positive response of three experts, which were willing to cooperate in this research by participating in the interview, and one expert who indicated to be too busy to give an interview. The three interviews have been conducted with means of semi-structured interviews over Microsoft Teams. A topic list had been made before the interview, to be sure that no topics of discussion were forgotten. The topic list for the interviews can be seen in Appendix A.

**Table 3** – Overview of respondents of interviews.

| Respondent | Professional field |
|---|---|
| A | Governance and International Political Economy |
| B | African Studies – Inclusive Development in Africa |
| C | Development Economy |

## 3.4 – Data analysis

This section describes the steps taken in the data analysis. This is split between the quantitative and qualitative data analysis respectively, because different analysis methods have been used for both parts.

### 3.4.1 – Quantitative data analysis

In order to analyse the relationship between political risks and the market diffusion of frugal solar-PV systems, different analysis steps have been taken.

First, as is mentioned in section 3.3.1, the data for the market diffusion of frugal solar-PV systems has been measured in sales numbers of SPSs and SHSs worldwide through the data provided by the reports of Lightning Global over the years 2015 to 2019, per semester. Unfortunately, for some countries not all the data could be provided for every time period per semester between 2015 and 2019. This resulted in missing data points on the sales of SPSs and SHSs, which could bias the results. To minimise this, missing data points have been filled through linear interpolation, if there was data on the sales of SPSs and SHSs in the previous time period and the next time period.

Second, the gathered data on the political risks had to be analysed in order to conduct one overall PR-index. The data analysis for the political risks has been performed in the statistical analysis program SPSS. The steps of the quantitative data analysis are:

1- Standardization of scale of sub-factors:
   Because different factors from different sources are taken into account in this research, the sub-factors had to be rescaled. The original scale and the scale used in this research can be seen in Table 4. For the control variables (GDP, Inflation, Population and Employment), no rescaling had to be used, given the fact that these variables did not have to merged into the PR-index.

**Table 4** – Standardization of scale for PR-index.

| Sub-variables | Sub-factors | Original scale | New scale |
|---|---|---|---|
| Political | Voice and accountability (V&A) | -2.5 – 2.5 (bad governance performance – good governance performance) | |
| | Political stability (PS) | | |
| | Government effectiveness (GE) | | |
| | Regulatory quality (RQ) | | |
| | Rule of law (RoL) | | |

| | | | |
|---|---|---|---|
| | Control of corruption (CoC) | | 1 – 5 (good score on indicator – bad score on indicator) |
| | Terrorism (T) | 1 – 5 (low – high) | |
| Economic | Quality of overall infrastructure (QoI) | 0 – 100 (worst performance – best performance) | |
| | Market size (Market) | | |
| | Trade openness (Trade) | 0 – 100 (percentage of GDP) | |
| | Ease of doing business (EofB) | 0 – 100 (lowest performance – best performance) | |
| | Strength of legal rights (Strength LR) | 0 – 12 (weak strength – strong strength) | |
| Social | Civil liberties (CL) | 1 – 7 (all civil liberties – no civil liberties) | |
| | Political rights (PR) | 1 – 7 (all political rights – no political rights) | |
| | Human Development Index (HDI) | 0 – 1 (lowest human development – highest human development) | |
| | Inequality (Inequa) | 0 – 100 (no inequality – total inequality) | |

2- Perform factor analysis to reduce multicollinearity:
When sub-factors are correlated with each other, factor analysis can be used. Factor analysis assumes that the information of a group of variables can be revealed in a common merged variable, which contains information of the underlying correlation of these variables. This will reduce the multicollinearity between the variables. The result of this for this research is that when the data for the sub-factors are loaded into SPSS, a factor analysis will be performed to check whether these sub-factors have common information and can thus be reduced to one or multiple merged variables (Shrestha, 2021). The factor analysis will be done per sub-variables: political, economic or social. The analysis will show whether the sub-factors can be reduced to one sub-variable (political, economic or social), or

that there is no multicollinearity between the variables, and in that case the sub-factors will be taken into account on their own in the correlation analysis.

3- Conduct a PR-index:
When the sub-factors are reduced to one or multiple merged variables, the next step is to formulate an overall PR-index. The PR-index will be a combination of all the variables that come out of the factor analysis. All the variables will carry the same weight into the PR-index. For example, if the sub-factors are reduced to 6 overall sub-variables, each of these will count as one sixth in the PR-index.

4- Perform correlation analysis:
When the PR-index is complete, it is time to analyse the correlation between the PR-index and the sales of SPSs and SHSs, in order to assess to what extent there is a relationship between the political risks and the market diffusion of frugal solar-PV systems. A correlation analysis is a suiting method to assess this, because correlation is a way to assess whether a relationship between two quantitative variables exists and if this is the case, the strength and direction of this relationship (Crawford, 2006). Before the correlation analysis can be conducted, a hypothesis should be formulated. In this research a two-sided hypothesis is chosen. This means that the null-hypothesis is that there is no relationship between the variables and the alternative hypothesis is that there is a relationship between the variables, without stating the direction of this relationship. This means that there is no assumption beforehand on whether the resulting correlation coefficient will be positive or negative, which is one of the outcomes of the correlation analysis. The correlation coefficient varies between -1 and 1 (Gogtay & Thatte, 2017). A correlation coefficient of -1 indicates a negative relationship, meaning that as one variable gets larger or smaller, the other variable respectively becomes smaller or larger, a correlation coefficient of 0 indicates no relationship between the two variables and a correlation coefficient of 1 indicates a positive relationship, meaning that as one variable becomes larger or smaller, the other variable also respectively becomes larger or smaller. The second result of a correlation analysis is a p-value. This indicates how likely it is that the found correlation could have occurred when the null-hypothesis would be true. The smaller the p-value is, the smaller this likelihood is, so the more likely it is that the alternative hypothesis can be accepted (Cohen et al., 2002). The fitting correlation analysis method for this research is the Spearman rank-order correlation. As can be seen in Table 4, the PR-index has an ordinal scale. The Spearman rank-order correlation can assess the strength and direction of the relationship between the PR-index and the sales of SPSs and SHSs and is less sensitive to outliers in the dataset than other correlation analysis methods. The correlation between the sales of SPSs and SHSs and the control variables (GDP, Inflation, Population and Employment), will be assessed with a Pearson correlation. This correlation will be used, because the control variables are of ratio-scale, thereby requiring a different correlation analysis method (Schober et al., 2018).

5- Check whether the requirements for the analyses are met:

As last, there are different requirements which the used data has to meet, before the results of the correlation analysis can be perceived as credible. The requirements for the Spearman rank-order correlation and the Pearson correlation differ from each other, therefore they both will be discussed.
The requirements for a Spearman rank-order correlation are:

- The PR-index should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:

- The data is derived from a random and independent sample.
- Each data point from the variables is measured independently from each other.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed.
- There are no relevant outliers in the dataset.

### 3.4.2 – Qualitative data analysis

The analysis of the two types of qualitative research, case studies and interviews, will be discussed in this section.

First, after the data for the case studies had been gathered, the information was analysed. First, background information was analysed to form a general overview of the history and current situation of Uganda and Namibia. Second, a search for factors which could explain why Uganda has a high uptake of frugal solar-PV systems and Namibia a low uptake of frugal solar-PV systems was started. This was done by summarizing the found literature and finding common themes within these factors, such as technological reasons, socio-economic situations, political factors and international (trade) agreements and relationships, which could explain the found statistical results.

Second, after the case studies for Uganda and Namibia were performed, interviews with three experts in the field were conducted. These interviews had as goal to get an overview on the historical, political, socio-economic and international situation of Uganda and Namibia, and to discuss the found statistical results and the identified explaining factors from the case studies, to get their impression of the validity of these results, and to possibly identify additional explaining factors for the statistical results. After the interviews were conducted, they were transcribed. After this, this raw data has been structured in different fragments, to identify various general topics and structure in the interviews, such as the country that is being discussed. The third step of analysing the interviews is coding of the identified fragments of the previous step (Corbin & Strauss, 2015). These codes were first general and became more specific when more interviews

were analysed, thereby identifying different themes within the interviews, such as general types of explaining factors, including the political and socio-economic situation in Uganda and Namibia. The last step was identifying the overlap and difference between the interviews. These steps indicate that as the interviews were analysed, more selective information could be extracted, as the connections between the interviews became visible. This process can be seen in Figure 10 (Corbin & Strauss, 2015).

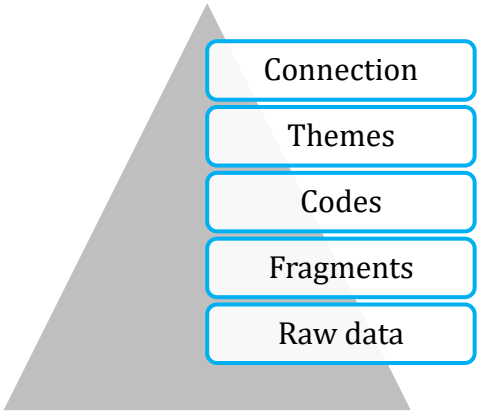


**Figure 10** – Representation of analysis of interviews (Corbin & Strauss, 2015).

## 3.5 – Credibility and validity

The credibility of this research is increased in different ways. The combination of research approaches makes this research a mixed methods research. The use of multiple methods to answer the main research question increases the credibility of this research (Ivankova & Wingo, 2018). In the first phase of the research, quantitative data has been gathered from multiple resources, after which a statistical analysis has been performed. In the second phase, a case study approach has been used to further understand the identified results from the statistical analysis and to be able to explain this to some extent. At the same time, interviews were conducted to substantiate the statistical results and the identified explaining factors from the case studies. This indicates that to find an answer to the main research question, multiple methods and data sources have been used, resulting in an increased credibility, due to method triangulation and data triangulation (Yin, 2014). This has as consequence that the results of this research are not only based on numbers, but also aims to understand the general picture behind the numbers and check where these correspond to each other. This profits the credibility of this research.

The internal validity of this research is aimed to be as high as possible through trying to minimize methodological errors and include as much factors as is possible in the timeframe of the thesis research, which could explain the relationship between political risks and the diffusion of frugal solar-PV systems. This increases the validity of this research (Patino & Ferreira, 2018). The external validity corresponds to the generalisability of the results to other groups of the population. This is aimed to achieved by taking all the countries in the world into account and not make a preliminary selection of the included countries in this research.

## 3.6 – Ethical considerations

During the statistical and case studies analyses, only open-access sources have been used to gather the necessary data and to analyse the data. There were no ethical questions to be considered when using this data. Only during the interviews was additional attention to ethics and consent necessary. The anonymity and data protection of interviewees has

to be guaranteed and consent has to be given. See Appendix B for the consent form that the interviewees have signed or have provided verbal consent to. This was done to make sure that the interviewees had a clear understanding of what was expected of them and how their data was processed after the interview.

## 3.7 – Conclusion

The aim of this chapter was to discuss the methodology used in this research and to give an answer to sub-questions two and three, which respectively are: *'How can political risks be operationalised, in order to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?'* and *'Which correlation analysis method should be used to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?'*

As is described in section 3.2, a way to assess the political risks had to be found. In chapter 2, various political risk factors had been identified, which could play a role in the market diffusion of frugal solar-PV systems. In order to be able to conduct one overall political risk score for each involved country in this research, these factors have been combined. The PR-index combines data from three different types of sub-variables: political, economic and social. The political sub-variable consists of seven sub-factors: 'voice and accountability', 'political stability', 'government effectiveness', 'regulatory quality', 'rule of law', 'control of corruption' and 'terrorism'. Second, the economic sub-variable includes five sub-factors: 'quality of overall infrastructure', 'market size', 'trade openness', 'ease of doing business' and 'strength of legal rights'. As last, the social sub-variable includes four sub-factors: 'civil liberties', 'political rights', 'human development index' and 'inequality'. These sub-factors together have been used to operationalise the political risks.

To answer the third sub-question, section 3.4.1. described the steps that have been followed in the quantitative data analysis part of this thesis research. Step four shows that the chosen correlation analysis method is a combination of the Spearman rank-order correlation method and the Pearson correlation method. The Spearman rank-order correlation will be used to assess the correlation between the PR-index and the market diffusion of frugal solar-PV systems and the Pearson correlation will be used to assess whether a relationship between the control variables and the market diffusion of frugal solar-PV systems exists.

# Chapter 4 – Results quantitative analysis

This chapter will discuss the results of the conducted correlation analysis. Section 4.1 introduces the overall characteristics of the market diffusion of frugal solar-PV systems, after which in section 4.2 the statistical results per time period will be discussed. In section 4.3 the fourth sub-question will be answered, which is: '*Which lessons can be learned from the correlation analysis regarding the relationship between political risks and the market diffusion of frugal solar-PV systems?*'.

## 4.1 – General overview of market diffusion of frugal solar-PV systems

Figure 11 shows the absolute number of sales of SPSs and SHSs on the different continents from the second semester of 2015 until the second semester of 2019. The sales data of SPSs and SHSs per country have been averaged into sales data per continent, to provide a general overview of the diffusion of these kinds of frugal innovations over the world. See Appendix C for an overview of the sales of frugal solar-PV systems per country over time.

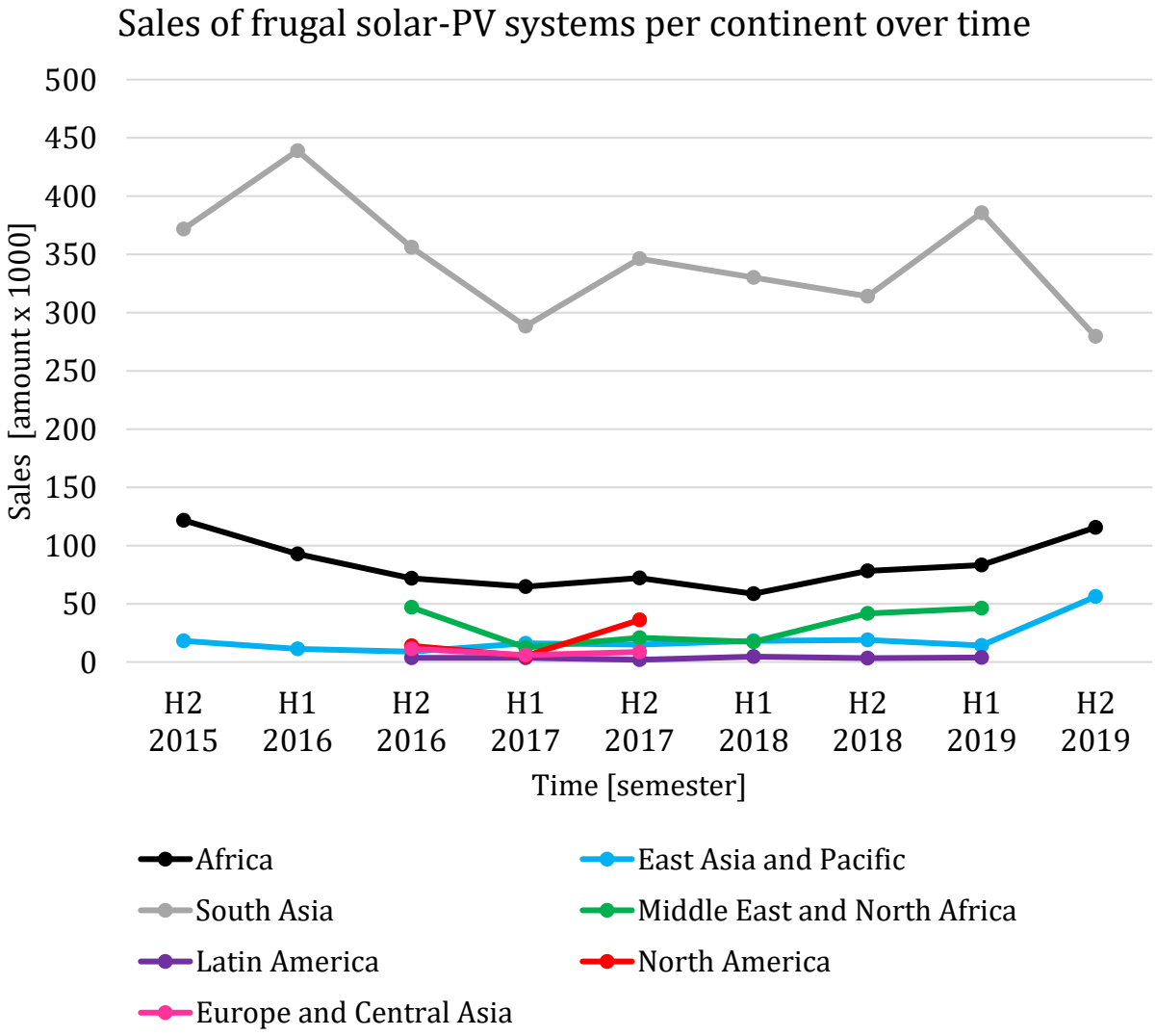


**Figure 11** – Sales of frugal solar-PV systems per continent.

The graph in Figure 11 shows that the continent of South Asia, including countries as Bangladesh, India, Nepal and Pakistan, have on average a much higher sales of frugal innovations than the other countries. This can be explained due to the sales of frugal solar-PV systems in India. This is a country with worldwide the highest sales: in 2016 an average of 1.5 million SPSs and SHSs were sold. The sales on the other continents were lower, but all around the same order of magnitude. The continent with the second highest sales over time is Africa. Frugal innovations are focused generally upon areas with a high non-electrification percentage, which could explain why both the continents Africa and South Asia have the highest sales of SPSs and SHSs. Continents such as Europe and Central Asia and North America have on average a lower diffusion of frugal solar-PV systems. This can be explained with the fact that, as was discussed in chapter 2, that frugal innovations are aiming at different market segments than high-tech innovations. Providing electricity to citizens is less of a problem in Europe and Central Asia and North America than in continents such as Africa and South Asia. However, it should be noted that Latin America also has a low diffusion of frugal solar-PV systems, as it can be seen that Latin America is at the bottom of Figure 11. This is unexpected, given the fact that frugal solar-PV systems could contribute to increasing the low electrification rate of this continent.

It is interesting to see whether the result of Figure 11 can be explained further. The population size of a country can have an influence on the number of products diffused. If the population size is larger, there are more people to reach for diffusing an innovation, which means that the government could be set upon investing more. For example, India is one of the countries with the most citizens worldwide. Therefore, it can be interesting to see whether this large difference in sales between South Asia and the rest of the world is still visible when the sales per capita are used, instead of the absolute sales of frugal innovations. Figure 12 shows the sales per capita of SPSs and SHSs overtime per continent. First, as Figure 12 shows, the large difference with the continent of South Asia and the rest of the world has diminished when looking at the sales per capita instead of absolute sales, which reduces the bias implicated in Figure 10. In comparison, East Asia and Pacific had little absolute sales of SPSs and SHSs, as was seen in Figure 10, but per capita there are actually a lot of SPSs and SHSs sold in this continent. Furthermore, Figure 12 shows that the sales per capita vary over time for the three continents with the most sales per capita of SPSs and SHSs (Africa, East Asia and Pacific and Middle East and North America). These continents include countries are very suitable for frugal solar-PV systems for electrification and are therefore increasingly installing frugal solar-PV systems. Third, Latin America is still at the bottom of the range regarding the sales of frugal solar-PV systems. The usage of sales per capita instead of absolute sales of SPSs and SHSs did not change this. This is unexpected. It can be explained by the fact that there are less (foreign) investments, international programs or NGOs active on this continent, or that other (renewable) energy technologies are more suitable for the conditions on the Latin American continent.

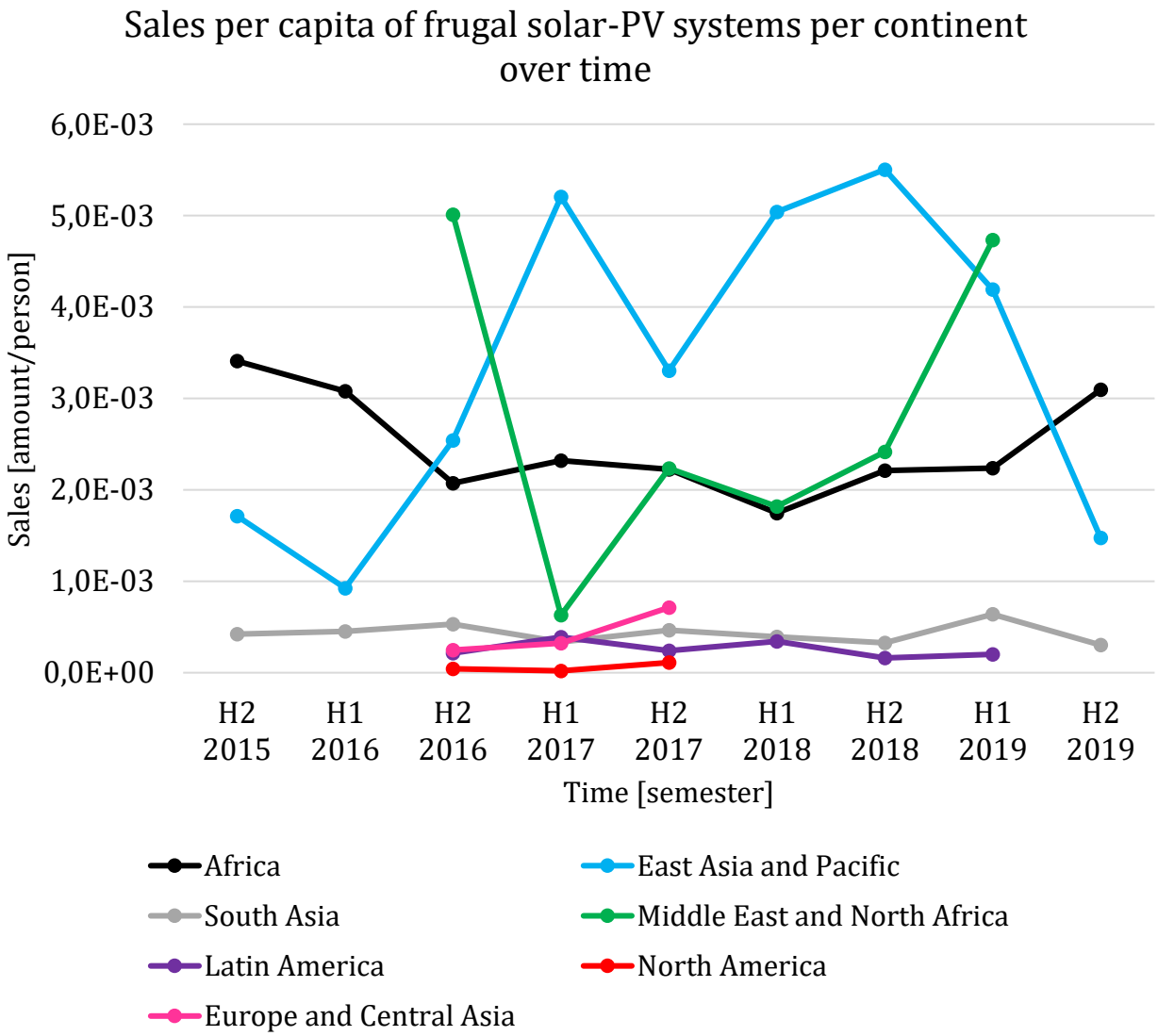


**Figure 12** – Sales per capita of frugal solar-PV systems per continent.

As last, the effect of GDP on the investments made in frugal solar-PV systems and the diffusion of these systems is also interesting to see. Figure 13 shows the results of this. Africa has a large diffusion of frugal solar-PV systems, despite the average low GDP of the included countries on this continent. This could be explained with the possible contribution of foreign investments and international programs or NGOs, in order to decrease the energy poverty on this continent (such as Lightning Africa). The Middle East and North Africa continent, which had a relatively high diffusion of frugal solar-PV systems per capita, has now a low diffusion of SPSs and SHSs when this is measured per GDP. Besides that, it can be seen that a continent as Europe and Central Asia has a low number of sales per GDP, but this continent includes countries that on average have a much larger electrification rate than countries in Africa, so their need to invest into these kinds of systems might be much lower, thereby lowering the sales per GDP of these continents.

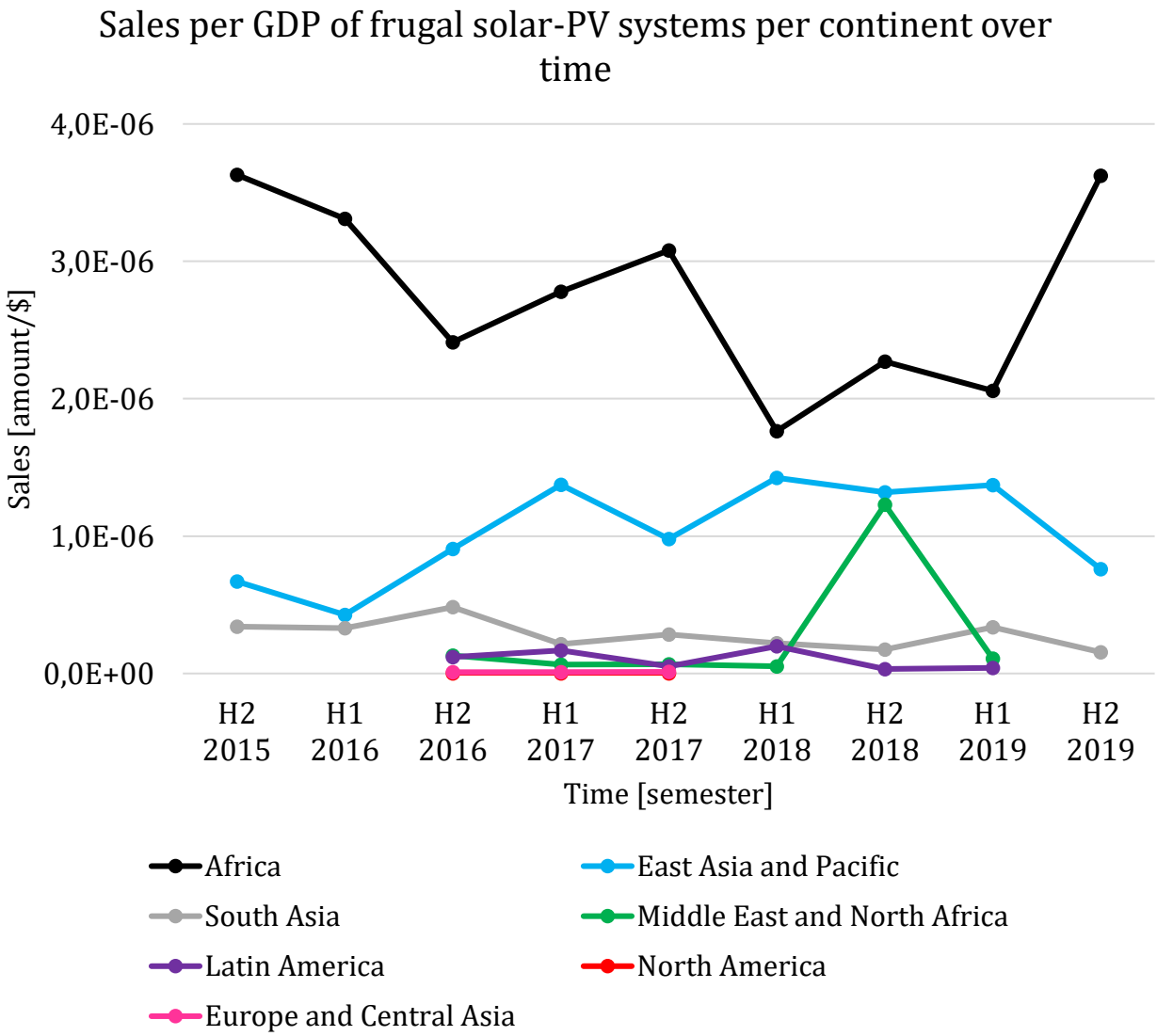


**Figure 13** – Sales per GDP of frugal solar-PV systems per continent.

## 4.2 – Results of the correlation analyses

Following the analysis of the worldwide sales of frugal solar-PV systems, the relationship between political risks and the diffusion of these frugal solar-PV systems has been assessed, following the methodology described in chapter 3. Table 5 shows the results of this, in which the far-right column describes whether this correlation is significant or not, with means of a p-value. The following two-sided hypothesis is made:

H0 = there is no relationship between the political risks and the market diffusion of frugal solar-PV systems.

H1 = there is a relationship between the political risks and the market diffusion of frugal solar-PV systems.

When the resultant p-value of the correlation analysis is smaller than 0.050, the null-hypothesis can be rejected, which then means that there is a relationship between the political risks and the market diffusion of frugal solar-PV systems. For example, the p-value of the second semester of 2016 (period H2 2016) is smaller than 0.050 (p = 0.015), indicating that there is a significant relationship between the PR-index and the sales of

frugal solar-PV systems in that time period. The significant time periods are coloured blue for clarity for the reader. The reader is referred to Appendix D for a detailed description of the steps taken in the correlation analysis.

**Table 5** – Results of correlation analysis worldwide over time.

| Period | Countries included | Correlation coefficient PR-index and sales | Two-sided p-value PR-index and sales |
|---|---|---|---|
| H2 2015 | 23 | -0.126 | 0.567 |
| H1 2016 | 27 | 0.101 | 0.615 |
| H2 2016 | 53 | 0.333 | 0.015 |
| H1 2017 | 59 | 0.352 | 0.006 |
| H2 2017 | 60 | 0.207 | 0.112 |
| H1 2018 | 47 | 0.262 | 0.075 |
| H2 2018 | 45 | 0.225 | 0.137 |
| H1 2019 | 42 | 0.353 | 0.022 |
| H2 2019 | 29 | -0.138 | 0.476 |

Table 5 indicates that of the nine time periods included, the correlation was only statistically significant in three of these periods: the second semester of 2016 and the first semesters of 2017 and 2019. The results of the correlation analysis in the other time periods implicate that there is no relationship between the PR-index and the sales of frugal solar-PV systems. The result that three out of nine time periods show a significant result can indicate that there is no clear relationship between the political risks worldwide and the diffusion of frugal solar-PV systems.

It could be interesting to visually represent the relationship between the PR-index and the sales of frugal solar-PV systems. This is done with a scatterplot, which can be seen in Figure 14. Figure 14 shows the PR-index on the X-axis and the absolute number of sales of frugal solar-PV systems with a logarithmic scale on the Y-axis for the time period H2 2016. This graph shows some interesting results. First, India has the highest number of sales, which can be expected given its large population. Second, the graph seems to indicate that countries as Ethiopia, Kenya, Nigera, Tanzania and Uganda have a relatively high PR-index, while still relatively a lot of frugal solar-PV systems have been implemented. On the same note, countries such as Namibia and South Africa have quite low sales of frugal innovations for a relatively stable environment with a low PR-index, while these are countries that could be interested in frugal innovations. It is also interesting to see that there is a division in areas in Africa, which clusters is visible in this graph. Ethiopia, Kenya, Tanzania and Uganda are all countries in East Africa and Namibia and South Africa are neighbours in Southern Africa, indicating that there might be a local trade or cooperation within these areas. This could influence the local diffusion of the SPSs and SHSs. Countries such as the Democratic Republic of the Congo (DRC) and Somalia show expected results; these countries have a high PR-index and low sales of frugal innovations.

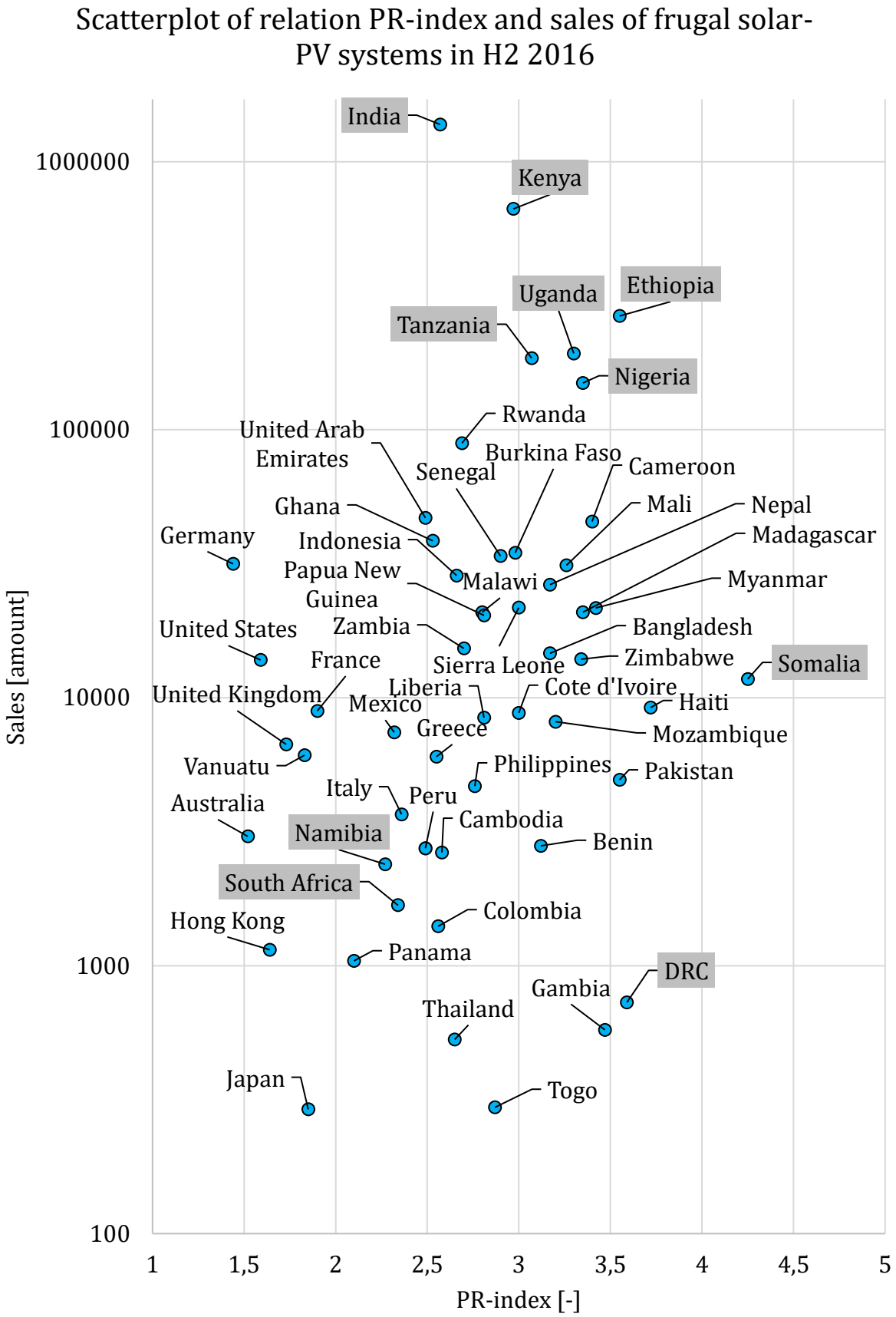


**Figure 14** – Scatterplot of sales of frugal solar-PV systems and PR-index.

Third, as can be seen in Figure 14, countries on the European and Central Asia and North American continents have a low PR-index and low sales in comparison to other continents. The low sales can be due to the disinterest in the frugal innovation market. As is discussed in chapter 2, these countries could be more interested in high-tech innovations, thereby explaining the low sales of frugal innovations. The inclusion of these continents and markets which are generally not the market for frugal innovations, could potentially bias the results of the correlation analysis. Therefore, the correlation analysis is also performed per continent to see whether the results of the correlation analysis differ per continent. When the correlation analysis between the sales of SPSs and SHSs and the PR-index is performed per continent, the results show that there is no significant correlation between the two variables in any time period for the continents of Africa, East Asia and Pacific, and Europe and Central Asia. This is striking, because the African and East Asian and Pacific continents are one of the largest markets for frugal innovations. It could be that there actually is no relationship between the political risks and the diffusion of frugal solar-PV systems on these continents, or that the PR-index does not grasp the entire political playing field on these continents, thereby not showing any significant results. South Asia and Middle East and North America both had time periods with a significant correlation coefficient. The Latin American continent shows the most significant results: the second semesters of 2016 and 2018, and the first semester or 2019, all with a positive correlation analysis, indicating that on this continent there is a positive relationship between the PR-index and the sales of SPSs and SHSs. For the numerical results of this, the reader is referred to Appendix E.

However, as is seen in section 4.1, taking the population size and the GDP of countries into account in the sales data could provide a more unbiased overview of the relationship between political risks and the sales of frugal solar-PV systems. For this part of the analysis, the following hypothesis was made per time period:

H0 = there is no relationship between the political risks and the market diffusion of frugal solar-PV systems per capita or per GDP.

H1 = there is a relationship between the political risks and the market diffusion of frugal solar-PV systems per capita or per GDP.

Table 6 shows the results of the correlation analysis between on the one hand the PR-index and the sales per capita, and on the other hand the PR-index and the sales per GDP. The significant time periods are coloured blue for clarity for the reader. The results indicate that when the sales per capita are taken into account instead of the absolute sales, one of the nine time periods shows a significant relationship between the sales per capita and the PR-index. This diminishes the proven significant results shown in Table 5. However, when the GDP of the countries are taken into account, then the same time periods as in Table 5 were significant, and even one more: the second semesters of 2016 and 2017 and the first semesters of 2017 and 2019 show a significant relationship between the PR-index and the sales per GDP. The significant results also have a relatively large positive correlation coefficient, which shows that there is a positive relationship between PR-index and the sales per GDP.

**Table 6** – Results of correlation analysis worldwide including population and GDP.

| Period | Countries included | Correlation coefficient PR-index and sales/capita | Two-sided p-value PR-index and sales/capita | Countries included | Correlation coefficient PR-index and sales/GDP | Two-sided p-value PR-index and sales/GDP |
|---|---|---|---|---|---|---|
| H2 2015 | 23 | -0.064 | 0.773 | 23 | -0.006 | 0.979 |
| H1 2016 | 27 | -0.034 | 0.864 | 27 | 0.053 | 0.794 |
| H2 2016 | 53 | 0.285 | 0.038 | 52 | 0.562 | 0.000 |
| H1 2017 | 59 | 0.083 | 0.534 | 58 | 0.288 | 0.028 |
| H2 2017 | 60 | 0.012 | 0.930 | 59 | 0.405 | 0.001 |
| H1 2018 | 47 | -0.013 | 0.933 | 46 | 0.236 | 0.114 |
| H2 2018 | 45 | -0.045 | 0.767 | 44 | 0.184 | 0.232 |
| H1 2019 | 42 | 0.122 | 0.441 | 41 | 0.341 | 0.029 |
| H2 2019 | 29 | 0.030 | 0.876 | 29 | 0.100 | 0.607 |

As was the case with the correlation between the sales and the PR-index, it could be interesting to see the distribution of the correlation within these significant time periods. This is again done with a scatterplot, which can be seen in Figure 15. Figure 15 shows the PR-index on the X-axis and with a logarithmic scale the sales per GDP of frugal solar-PV systems on the Y-axis for the time period H2 2016. A number of observations can be made from Figure 15. First, Figure 15 shows a slight increase in sales per GDP with an increasing PR-index, which is in line with the positive correlation coefficient visible in Table 6 for the time period H2 2016. Second, India has shifted from the top of the segment to the middle of the segment, which shows that inclusion of the GDP can provide a more reliable picture of countries and their sales. Third, Vanuatu is a country that has moved to the top of the segment. Vanuatu has relatively high sales per GDP with a low PR-index. Vanuatu is an island that is quite small, with a relatively low GDP, while still has been able to invest in frugal solar-PV systems. Fourth, as was the case in Figure 14, Ethiopia and Uganda remain at the top of the segment; they have one of the highest sales per GDP, while having a high PR-index. At the same time, within the African continent, Namibia, Ghana and South Africa have lower sales, while having a relatively low PR-index. DRC still has a low sales per GDP with a high PR-index, which is in line with expectations. As last, the Europe and Central Asia and North America continents still have low sales per GDP, while having a relatively high GDP worldwide. These continents have low sales of frugal innovations, which could be due to the suitability of high-tech innovations on these continents.

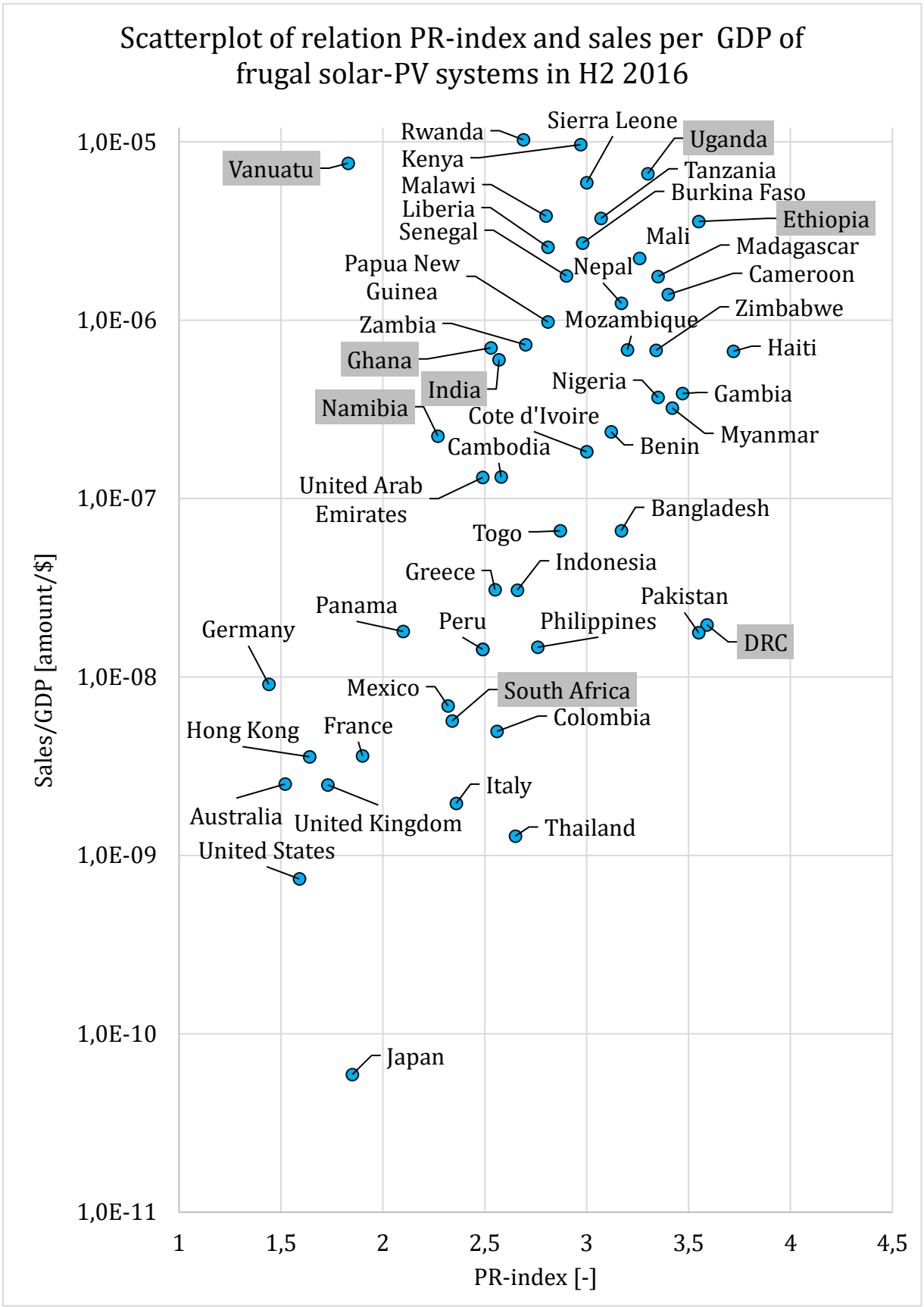


**Figure 15** – Scatterplot of sales per GDP of frugal solar-PV systems and PR-index.

As was the case when the correlation between the sales of SPSs and SHSs were analysed, the inclusion of the Europe and Central Asia and North America continents could possibly bias the results of the correlation analysis. Therefore, the correlation analysis between the PR-index and the sales per capita, and the PR-index and the sales per GDP is also performed per continent to see whether the results from the correlation analyses change when conducted per continent. Both of these correlation analyses showed no significant results for the continents Africa, East Asia and Pacific, and Europe and Central Asia, indicating that there is no relationship between the PR-index and the sales per capita, and the PR-index and the sales per GDP on these continents. Also, only for one time period was the relationship between the PR-index and the sales per capita or per GDP on the South Asian continent significant. This result was not expected for the continents Africa, East Asia and Pacific and South Asia, given the fact that this is a main market for frugal innovations and has been on the radar for foreign investments, international programs and NGOs. This could mean that there is no relationship between political risks and market diffusion on these continents, or other factors could play a role that have not been included in this research. Third, the Middle East and North Africa continent showed the most significant results: two time periods of the total nine time periods showed a significant result for the correlation analysis for the relationship between the PR-index and the sales per capita and three significant time periods for the correlation analysis for the relationship between the PR-index and the sales per GDP. As last, Latin America showed two significant relationships between both the PR-index and the sales per capita as per GDP, both with a positive correlation coefficient. This indicated that if either the PR-index or the sales per capita or sales per GDP increases or decreases, the other variable changes in the respective same direction. For further information on this specific part of the correlation analysis, the reader is referred to Appendix E.

## 4.3 – Conclusion

This chapter discussed the results from the conducted correlation analysis, in order to be able to answer sub-question four: '*Which lessons can be learned from the correlation analysis regarding the relationship between political risks and the market diffusion of frugal solar-PV systems?'.*

When looking at the distribution of sales of frugal innovations per continent, some conclusions can be made. First, the population size could bias the results. For example, India has a large population, which also showed a large number of diffused frugal innovations. When the population size was taken into account, this result diminished. Also, the GDP of a country can have an influence on the diffusion of frugal solar-PV systems: a country with a low GDP, can show surprising results in the sales per capita or GDP, as was the case in Vanuatu. Also, surprising was that countries such as Ethiopia, Kenya, Nigera, Tanzania and Uganda, which have a relatively high PR-index, still managed to implement relatively a lot of frugal solar-PV systems. On the other hand, countries such as Namibia and South Africa have quite low sales of frugal innovations for a relatively stable environment with a low PR-index, while these are countries that also could be interested in frugal innovations.

Based on the conducted correlation analyses, it can be concluded that there is no clear correlation between the PR-index and the sales of frugal solar-PV systems. As can be seen in Table 5, of the nine time periods included in this research, the relationship between the PR-index and the sales of frugal solar-PV systems was only statistically significant in three of these periods. To further analyse this result, a scatterplot between the PR-index and the sales of frugal solar-PV systems was shown for one of the significant time periods. This showed some interesting results. Figure 14 showed that some countries within the same geographical area cluster together in the scatterplot. For example, East African countries clustered together; all having a relatively high PR-index, while relatively a lot of SPSs and SHSs have been diffused in this region. On the same note, countries such as Namibia and South Africa in Southern Africa have quite low sales of SPSs and SHSs, while having a relatively low PR-index. This could indicate that neighbouring countries might cooperate in the diffusion of frugal solar-PV systems. When not the sales, but the sales per capita were taken into account this correlation analysis, only one of the time periods included showed a significant relationship between the PR-index and the sales per capita. However, when the GDP of the countries was taken into account, performing a correlation analysis between the PR-index and the sales per GDP, four of the nine time periods showed significant results, which is around half of the included time periods. A scatterplot was made to visualise the relationship between the PR-index and the sales of SPSs and SHSs per GDP. This again showed a potential regional cooperation in East and Southern Africa.

Due to the possible bias of measuring the diffusion of frugal innovations in market for which they are not originally intended, all the correlation analyses were repeated per continent. The continents Africa, East Asia and Pacific and Europe and Central Asia showed no significant results for all the correlation analyses and South Asia only indicated two significant time periods for the relationship between the political risks and the diffusion of frugal solar-PV systems. This was unexpected for these continents, given the fact that these continents are a main focus point of frugal innovations.

To conclude, based on the three types of conducted correlation analyses, there is no correlation between political risks and the sales of SPSs and SHSs. The correlation analysis analysing the relationship between the political risks and the diffusion of frugal solar-PV systems showed limited significant results. Also, the correlation between the political risks and the sales of SPSs and SHSs per capita showed one significant result worldwide and very little per continent. When the correlation analyses between the political risks and the sales of frugal solar-PV systems per GDP were performed worldwide, four of the nine time periods showed significant results. However, when this was analysed per continent, Africa, East Asia and Pacific and Europe and Central Asia showed no significant results, decreasing the likelihood that there actually is a relationship between political risks and the sales of frugal solar-PV systems per GDP. Based on the results of the correlation analyses, it can be stated that there is no relationship between political risks and market diffusion worldwide or on specific continents, or that other factors could play a role, which have not been included in this research. The case studies and interviews have been conducted to find possible explanations for these results and to find additional factors that could play a role. These results are discussed in chapter 5.

# Chapter 5 – Results qualitative analyses

The results of the case studies and interviews will be discussed in this chapter. After the selection process of the case studies is explained, various factors that could explain the results of the correlation analysis will be discussed. Section 5.1 will provide the general reasons of the selection of Uganda and Namibia for the case studies. Then section 5.2 will outline the general situation in Uganda and provide possible reasons to explain the results of the statistical analysis. Section 5.3 will do the same for Namibia. Section 5.4 will end this chapter with an answer on sub-question five: *'Which factors could explain the market diffusion of frugal solar-PV systems in Uganda and Namibia, given their respective political risks?'*.

## 5.1 – Overview of Uganda and Namibia

Based on the results of the correlation analysis, as is described in chapter 4, different interesting results were seen. First, three of the nine time periods were statistically significant and those who were significant had a positive correlation coefficient between the PR-index and the sales of frugal innovations. Second, when the sales per GDP was used instead of the absolute sales, more time periods showed statistically significant results. The aim of this chapter is to compare somewhat similar cases with different PR-indices and sales of SPSs and SHSs, in order to find factors that could explain results of the correlation analyses of these countries. Some countries provided results that were expected, for example, countries such as DRC and Somalia. These countries had relative fewer sales of frugal solar-PV systems, while having a relatively high PR-index. Other interesting results where India and Vanuatu. India had the most sales of frugal solar-PV systems and a medium PR-index. This effect diminished when instead of the sales, the sales per capita were used in the correlation analysis. Because of this, and the fact that there already is a lot of research conducted in India regarding frugal innovations, this country is excluded for further analysis in this research. Second, Vanuatu had a lot of sales per GDP, with a low PR-index. Vanuatu is a small island, which could not be compared to a relatively larger country on another continent. Specifically in the continent of Africa, interesting and unexpected results came up. For example, countries such as Ethiopia, Kenya, Nigeria, Tanzania and Uganda had a lot of sales of SPSs and SHSs, while having a high PR-index. On the other side, countries such as Namibia and South Africa had little sales of frugal solar-PV systems, with a relative low PR-index.

These unexpected results are interesting to research further: how can frugal innovations diffuse better in countries with apparently more political risks and tensions, while this diffusion goes less well in relatively stable environments? To research this, two countries on both sides of the spectrum (one with a relative high PR-index and relative high sales of SPSs and SHSs, and one with a relative low PR-index and relative low sales of SPSs and SHSs) are chosen, in order to research whether factors can be found that can explain the results from the correlation analyses in chapter 4. Figure 16 shows the

absolute sales of frugal solar-PV systems of Uganda and Namibia on a logarithmic scale, in comparison to their respective PR-indices, with each dot showing one semester in time.

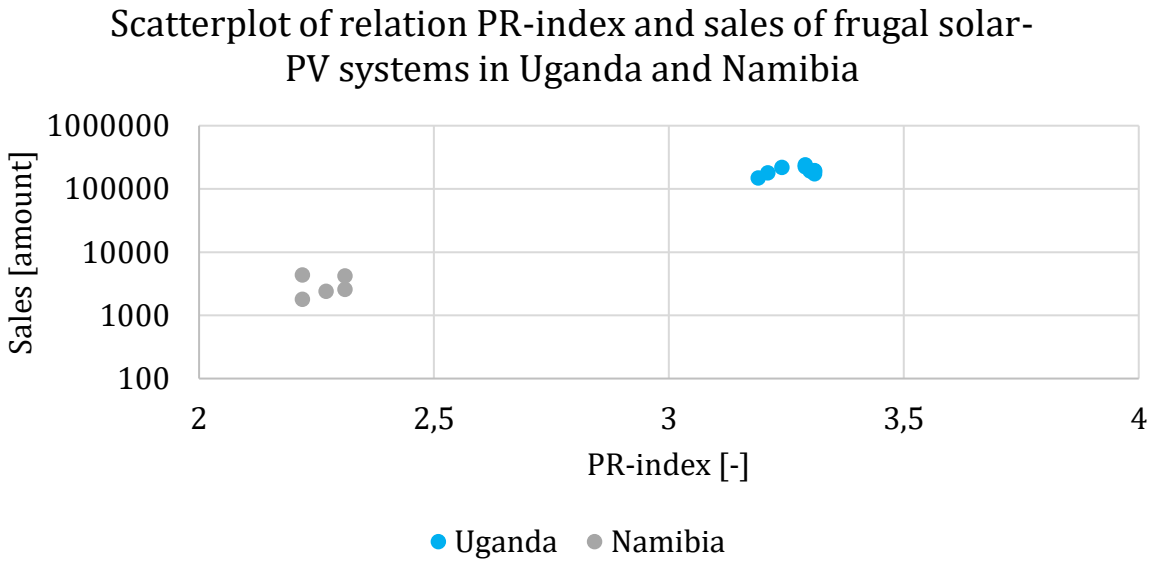


**Figure 16** – Comparison Uganda and Namibia in sales of frugal solar-PV systems.

As can be seen in Figure 16, for both countries, the sales of frugal solar-PV systems remain around the same between the different semesters and the PR-index also does not change that much over time. Uganda is chosen as case, because it has one of the highest PR-indices of the included countries (on average a PR-index of 3.3), while having relatively high sales of SPSs and SHSs, even when the population size and GDP of the country is taken into account. Namibia is chosen as this country has relatively fewer sales of SPSs and SHSs and a low PR-index (on average a PR-index of 2.2). Both countries are part of Sub-Saharan Africa, so it could be interesting to see whether these differences could be (partly) explained or understood.

## 5.2 – Factors explaining the diffusion in Uganda

With a high solar radiation, Uganda is very suitable for using solar-PV systems for generating electricity. Besides this, the electrification rate in Uganda is very low, specifically in the rural areas. Only six percent of the households are connected to the grid, with wood fuel being the main source of energy for households and some large hydropower installations providing electricity for the main grid in Uganda (Akena, 2020; WWF Uganda, 2012). The solar-PV market in Uganda is divided in usage for households and institutions. Households can on average only afford SPSs systems or small SHSs, in order to provide electric light and charge a mobile phone, while larger SHSs are used to provide electricity to schools or tourist locations (Kato et al., 2020).

As is seen in Figure 16, Uganda has a large amount of frugal solar-PV systems. There are different factors found in literature explaining the relatively high diffusion of frugal solar-PV systems, while having a relatively high PR-index, but also input from conducted interviews is used to find explanations for this result.

First, Uganda has been largely dependent on their hydropower installations, due to their location next to Lake Victoria and the White Nile. However, prolonged droughts and effects of climate change has lowered the water levels in Lake Victoria, limiting the power output from Ugandan hydropower installations (Energypedia, 2014a; WWF Uganda, 2012). Due to the uncertain output of their hydropower generators, the Ugandan government aims to diversify their sources of electricity generation (Akena, 2020; Mugagga & Chamdimba, 2019).

Second, the Ugandan government is increasingly focussing on reducing its energy poverty and is trying to provide an enabling policy environment for the renewable energy sector. The government has started the Uganda Photovoltaic Pilot Project for Rural Electrification, in order to increase the electrification rates, specifically in rural areas, which are unlikely to be connected to the main grid in the foreseeable future (Energypedia, 2020). To help this program, the Rural Electrification Agency has been installed to keep the targets in check and provide incentives for increasing the viability of the roll-out of off-grid small-scale solar-PV systems (Energypedia, 2020; WWF Uganda, 2012). The Ugandan government is also trying to achieve better rural electrification rates by targeting the supply side, as well as the demand side of off-grid solar-PV systems. According to Mugagga & Chamdimba (2019), the growth of frugal solar-PV systems in Uganda is due to the increase in organisation of local supply chains of frugal solar-PV systems or sub-parts of these. Also, one of the most mature off-grid solar-PV markets is Kenya, which produces over 120.000 SHSs (Reiche et al., 2010). Kenya has grown in producing these solar-PV systems themselves, which can benefit Uganda, given their proximity and trading agreements due to the inclusion of both countries in the East Africa Community (EAC). Respondent A also agreed with this:

> *'Due to the maturity of the [frugal solar-PV] market in Kenya, there could be a lot of investors in Kenya who have a connection to Uganda and are therefore more likely to invest there.'*

On the other side, the Ugandan government and solar-PV companies are also trying to reach more citizens, to make them aware on the existence of frugal solar-PV systems and educate them on the added benefits in comparison to their usual means of generating light or warmth (Da Silva et al., 2015). The awareness of potential consumers to the existence of frugal solar-PV systems is increased through marketing campaigns on dry cell batteries-run radios, which a large part of the Ugandan citizens owns (ACE TAF, 2021; Aarakit et al., 2021).

Third, the Ugandan government is providing financial support systems to increase the viability of (foreign) investments in frugal solar-PV systems (Aarakit et al., 2021). This includes tax incentives and subsidies (WWF Uganda, 2012). The Renewable Energy Feed-in-Tariff was installed in 2007 to promote the development and diffusion of off-grid solar-PV systems. The diffusion of SHSs have been helped by measures as this; it provided suppliers of these systems with more security and provided potential consumers with more favourable loan and credit options (Hansen et al., 2015). The Pay-As-You-GO (PAYG) system is an example of one of these financial support systems, which can make frugal solar-PV systems more affordable for potential consumers and thereby providing a

cheaper and more consistent electricity source. The PAYG-systems provides consumers with a standard amount of electricity and if they want more, then they can pay for this with a flexible payment schedule (Kato et al., 2020; Koigi, 2020). Payment is organised through mobile money platforms. The use of these mobile money platforms within Uganda was already quite widespread, so it was a small step for consumers to use these for their electricity bills, thereby lowering the barrier to use these for frugal solar-PV systems (Mugagga & Chamdimba, 2019; Snel, 2019).

Fourth, not only the large efforts of the government to provide institutional and financial support can explain the higher diffusion of frugal solar-PV systems in Uganda than in Namibia. There are also socio-economic reasons explaining this. Uganda has a larger percentage of citizens without access to electricity (58.7%) and a larger part of its population living in rural areas (76% of the population), where the access to electricity is even lower: 31.8% of the population has access to electricity. (Worldbank, 2019a; Worldbank, 2019b). This means that a large portion of the population is at the bottom of the energy ladder and is still in Tier 0 (Aarakit et al., 2021). Moreover, the absence of a quality electricity supply and available infrastructure plays a role in the implementation of these systems and the acceptance of frugal innovations by citizens (Aarakit et al., 2021). This indicates that there is a larger consumer segment for frugal innovations in Uganda. As respondent B indicated:

> *'I think that the electricity infrastructure is less developed in regions such as Uganda, Ethiopia and Tanzania, which could explain why there are more of these kinds of projects here.'*

At last, there are also geopolitical reasons identified which could explain why Uganda has a higher diffusion of frugal innovations than Namibia. First, Uganda has a history gaining independence through violence and has had conflicts with neighbouring countries, but over the years it has become more stable than its neighbours, such as Burundi, DRC, Rwanda and South-Sudan (McKnight, 2015). Due to its relative stability given its surrounding countries, and an increase in incoming refugees from neighbouring countries, Uganda has been one of the favourites for international support and foreign investments (Energypedia, 2020). As respondent A said:

> *'Uganda has always been an important receiver of development aid. It is seen as a kind of beacon of stability in an unstable region.'*

Respondent B agreed with this as well. This respondent said that Uganda is almost a 'donor darling', meaning that it is very popular for NGOs and other international companies to invest in Uganda:

> *'Uganda is stable enough to try new things, specifically in comparison to Burundi, DRC and South-Sudan, but it is not as far developed as Kenya and Ethiopia economically.'*

These NGOs and international companies can help in providing financial support, organizing the supply chain and helping the government with institutional guidelines for the production, distribution and use of (frugal) solar-PV systems (European Commission, 2021). For example, NGOs help in providing subsidies, thereby partly relieving the government from financial barriers for electrification of rural areas, but also help mapping the supply chain and potential bottlenecks in this (Hansen et al., 2015; Lighting

Africa, 2018). Second, the cooperation between the countries in East Africa has been increasing. The EAC aims to increase the political and economic integration between Burundi, Kenya, Rwanda, South-Sudan, Tanzania and Uganda (Ngwenya & Lema, 2020). The EAC aims to increase the political and economic cooperation between the individual countries, with means of removing import duties between the countries, increasing the interconnected infrastructure and installing overarching political institutions (Economic Consulting Associates Limited, 2018; European Commission, 2021; Ngwenya & Lema, 2020). This regional trading network can improve the diffusion of innovations, goods and knowledge.

## 5.3 – Factors explaining the diffusion in Namibia

Namibia is a sparsely populated country in South-West Africa. After gaining independence from South Africa in 1990, Namibia is still very dependent on South Africa for its electricity provision, given the fact that Namibia has not built large-scale electricity generation capacity since its independence (Amesho & Edoun, 2019; Energypedia, 2020; RVO, 2015). Due to the growth of electricity demand and scarcity of import options, Namibia has been investing in fossil-fuel based generation facilities, due to its abundance in natural resources (International Trade Administration, 2020). However, national progress in the renewable energy sector is being made. Namibia has a high solar radiation, which makes it suitable for solar-PV technologies (Amesho & Edoun, 2019). In 2015, the first large-scale solar-PV system was installed, but off-grid solar-PV technologies have dealt with various economic, political and technical barriers, despite various programs trying to reduce these (United Nations Environment Programme, 2017).

This is a starting point for trying to find an explanation of the relatively low diffusion of frugal solar-PV systems in Namibia, while this country has a low PR-index which could indicate a relatively stable investment environment.

First, the Namibian government does not provide clear targets for its energy sector and no reliable and consistent policies or regulatory frameworks regarding off-grid solar-PV systems (Amesho & Edoun, 2019; De Almeida et al., 2020). This discourages investors and decreases the effectivity of electrification programs for rural areas in Namibia (Jadhav et al., 2017). One of these programs is the Off-grid Energization Master Plan, which has the aim to increase the electrification rate of the rural area in Namibia (International Trade Administration, 2020). However, there is no dedicated agency for rural electrification in Namibia, which for example was the case in Uganda (RECP, 2014). This has as consequence that many parties work together on different programs and targets, without one agency having the overview of the progress being made. This, together with the unclarity regarding targets and regulations, provides a large grey area for developers and investors active in rural electrification (RECP, 2014).

The lack of clear targets and regulations from the government is one of the reasons frugal solar-PV systems are not diffused highly in Namibia. The lack of financial systems is a second barrier to the diffusion of frugal solar-PV systems in Namibia; there is currently no business model for frugal solar-PV systems (Amesho & Edoun, 2019; De Almeida et al., 2020). There are no clear tariffs for off-grid renewable energy technologies.

This shows this grey area and the consequence of not having a dedicated agency for rural electrification (RECP, 2014). This lack of financial support systems discourages (foreign) investments in renewable energy technologies (International Trade Administration, 2020). One attempt of the Namibian government to implement supporting financial system for off-grid solar-PV systems is the Solar Revolving Fund (SRF). However, this cannot be compared to the credit systems in Uganda for example. The SRF is a loan system for all kinds of small-scale renewable energy technologies. Users agree to a loan of five years, with an interest rate, and have to provide proof of having to be employed for over two years with a steady income (Energypedia, 2014b). This does not noticeably lower the barrier for people in the BOP segment to have access to electricity.

Third, there are also socio-economic reasons explaining why Namibia has a lower diffusion of frugal solar-PV systems. Namibia has a smaller percentage of citizens without access to electricity in comparison to Uganda (44.8% instead of 58.7%), a smaller part of its population lives in rural areas (49% instead of 76%), has a higher quality of electricity supply and citizens have on average a higher income per year (Average Salary Survey, 2021; Worldbank, 2019a; Worldbank, 2019b). Also, the respondents in the interviews argued that difference in overall welfare between Uganda and Namibia could play a large role in the difference in sales of frugal solar-PV systems. Frugal innovations can be less necessary for Namibian citizens, because they have suitable alternatives:

> *'I believe that Namibia already has a relatively good energy infrastructure. Namibia and the Southern African region have been relatively highly developed in comparison to the rest of the African continent, which could explain why there is a lower need for frugal projects.'*
>
> [Respondent B].

Fourth, foreign investors, NGO and other donor programs are not very active in Namibia (Amesho & Edoun, 2019). The overall foreign investment and donor support in Namibia's energy sector is low (International Trade Administration, 2020). This can be explained due to the rigid financial system, the lack of clear policies and the higher welfare in comparison to the rest of Africa, but also because of the relatively high development in comparison to the rest of Africa:

> *'Namibia has a relatively high GDP, it is a middle-income country, despite the inequality. But because of that, Namibia is not a traditional donor country.'* [Respondent B].

Moreover, Namibia is a sparsely populated country, which should not be underestimated according to respondent A. The large distances between settlements discourages the investments and viability of on- and off-grid investments in electrification. Not only is the implementation of these frugal solar-PV systems more expensive, the supply chain is also harder to set up. This discourages investors even more, besides the fact that there is no business model or governmental programs to electrify the rural and/or energy-poor citizens of Namibia (Amesho & Edoun, 2019).

The geopolitical situation of Namibia plays a fifth role in explaining why Namibia has relatively lower sales of frugal solar-PV systems. Historically, Namibia has been very dependent on South Africa, due to the unofficial incorporation of Namibia into South Africa. This can have as consequence that Namibia has less of their own international

relationships, besides South Africa. According to respondent C, the geopolitical history of South Africa has played a large role in the current international position of Namibia:

*'South Africa still focuses on import substitution, which can very well be the case with solar-PV systems. South Africa has learned that lesson during the apartheid.'*

Due to the boycott during the apartheid in South Africa, South Africa has aimed to reduce its dependence on other countries. South Africa has a relatively large solar-PV market, through which frugal solar-PV systems can be exported to Namibia due to their proximity and shared history. This could explain the low number of sales of frugal solar-PV systems sold by other companies or NGOs (Prasad, 2007). Besides the cooperation between Namibia and South Africa, there is less cooperation in Southern Africa. In comparison to the EAC in East Africa, the Southern Africa Development Community (SADC) consists of sixteen countries, aiming to increase the political and economic cooperation. However, the SADC is less successful in achieving this than the EAC. South-West Africa has been built around the relatively high developed and dominant South Africa: the mutual relationships in the SADC are very different than in the EAC, according to respondent A:

*'The relationship is very bilateral: it is South Africa relative to Namibia, South Africa relative to Botswana, but not Namibia relative to Botswana. The SADC is a hub-and-spoke type of cooperation, while East [Africa] is more an equal network.'*

## 5.4 – Conclusion

This chapter aims to find an answer to the following sub-question: *'Which factors could explain the market diffusion of frugal solar-PV systems in Uganda and Namibia, given their respective political risks?'.* This sub-question is answered with means of case studies of Uganda and Namibia and interviews with experts in historical and social studies of Africa. Interesting to see is that Uganda historically has been more involved in conflict situations, but still has more sales of frugal solar-PV systems. Some key differences between Uganda and Namibia have been found that can explain the differences found in the correlation analyses, as has been described in chapter 4.

First, the need for frugal solar-PV systems is lower in Namibia than in Uganda. Namibia is generally more developed than Uganda, with a higher electrification rate than Uganda, a better electricity infrastructure and citizens have more to spend on average.

Second, the Ugandan government seems to be more invested in reducing its energy poverty problem than the Namibian government. Uganda has more policies, targets, financial schemes and separate governmental institutes focussing solemnly on reducing the (rural) energy poverty with the means of frugal solar-PV systems. The Ugandan government is focussing on lowering the barriers for implementing frugal solar-PV systems on the supply side, as well as the demand side, in which the Namibian government is less successful. Uganda tries to provide more security for investors and lower the financial barriers for potential consumers by offering flexible payment schemes and making potential consumers more aware of the existence of these innovations.

Third, historically Uganda has always been more on the radar of NGOs and foreign investors, despite, or even because, it is located in a geopolitically instable region of Africa. Uganda is seen as a donor darling in East Africa, meaning that it has traditionally been a

favourite of foreign investors and NGOs to invest in. Uganda has been seen as a safe haven in a geopolitical tense region; Uganda still needs foreign investments and international support of NGOs, because it is still a developing country and is stable enough in comparison to their neighbouring countries regarding to be able to use the provided support and diffused innovations.

Fourth, the regional cooperation in East Africa is more equal and intense than in Southern Africa. The EAC has a network type of trade system, in which the supply chain and trade between various countries is encouraged by lowering the import taxes at the border, while the SADC is built around the dominant position of South Africa.

# Chapter 6 – Discussion

Section 6.1 starts with an overview and reflection on the results of the quantitative and qualitative analyses, as they have been discussed in chapter 4 and 5. In section 6.2 a critical reflection will be given on the results of this research in perspective to previously conducted research and current theories. Third, in section 6.3 the contribution of this research will be discussed, practical recommendations will be given and possible future research topics will be mentioned. The strengths and limitations of this research will be discussed in section 6.4.

## 6.1 – Reflection on research results

First, it is helpful to reflect on the combined results of the correlation analyses, the case studies and the interviews. In this research, both quantitative and qualitative research has been conducted. This has provided a lot of insights in the relationship between political risks and the market diffusion of frugal solar-PV systems. Despite the fact that the results of the correlation analyses showed no significant relationship between political risks and the market diffusion of frugal solar-PV systems, there are still interesting conclusions which can be drawn, specifically in combination with the results from the case studies and the interviews.

First, as was stated in section 1.2 'Knowledge gaps', not a lot of research has been done so far on the frugal innovations generating electricity and if it is conducted, it is often solemnly based on case studies. This research has aimed to incorporate statistical analyses in this research field, in order to contribute in operationalising the political risks, the market diffusion of frugal innovations generating electricity and the relationship between these concepts.

Second, the continents Africa, East Asia and Pacific and South Asia were the continents with the highest amount of diffused frugal solar-PV systems. This was expected, given the fact that the literature indicated that these were the main markets for diffusion of frugal solar-PV systems, due to the energy poverty, limited reliable electricity infrastructure and relatively instable political systems on these continents. However, the continents Africa and East Asia and Pacific showed no significant results for all the correlation analyses. This was unexpected. The conducted case studies and interviews showed that there might be more factors influencing the diffusion of frugal solar-PV systems than just the included political factors. For example, the need for frugal innovations, the (renewable) energy technologies which are already invested in, the varying degree of involvement of foreign investors and NGOs in specific areas in the world, the history of the relationships with other countries and the current trading agreements. This shows that there is a path dependency in the choice whether there will be invested in frugal solar-PV systems, which has not been included in this research, but could explain the fact that no correlation has been found. The literature also indicated that culture and user preferences are very important in the success of frugal innovations. Cultural aspects, user preferences and country specific user demands have not been included in this research, while this could

play a role in whether or not frugal innovations diffuse successfully in countries with different political risks. If the frugal innovation seamlessly meets users demands, this could diminish the barrier that political risks might pose to the diffusion of frugal solar-PV systems. This indicates that for future research, it could be helpful to try to also operationalise and include these kinds of factors, or make the scope of the research smaller, so that more specific political risks are included in this research.

Third, the correlation analyses showed that it is beneficial to not only take the absolute sales data of SPSs and SHSs into account, but also scale this with the population size and the GDP. The incorporation of population size diminished the effect that some countries showed a large diffusion of frugal solar-PV systems. Also, some continents showed surprising results, such as Africa. Despite the fact that African countries have on average a relatively low GDP, it was shown that this continent had a relatively large diffusion of SPSs and SHSs. This indicates that Africa is a main market for frugal solar-PV systems, possibly due to the energy poverty on this continent and abundance of solar radiation. This could also indicate the involvement of foreign investors, international companies and/or NGOs on this continent. The results of the case studies and the conducted interviews showed that certain areas in Africa are very focused on producing and diffusing frugal solar-PV systems. Kenya has been identified as a central actor in diffusing frugal solar-PV systems. Other countries interested in frugal innovations can benefit from this if they are in close proximity to Kenya. This was also shown in the scatterplots in chapter 4. These scatterplots showed possible cooperating regions on certain continents. For example, East African countries (such as Kenya, Ethiopia and Uganda) clustered together; all having a relatively high PR-index, while relatively a lot of SPSs and SHSs have been diffused to this region. On the same note, countries such as Namibia and South Africa in Southern Africa have quite low sales of SPSs and SHSs, while having a relatively low PR-index. This could indicate that neighbouring countries might cooperate in diffusing frugal solar-PV systems. This is something that the interviewees also mentioned. The regional cooperation in East Africa, were Kenya and Uganda are located, is more equal and intense than in Southern Africa. The EAC has a network type of trade system, in which the cross-border supply chain and trade between various countries is encouraged by lowering the import taxes at the border, while the SADC is built around the dominant position of South Africa. This could explain why East African countries still have a relatively high SPSs and SHSs, while having a relatively high PR-index. Also, Uganda has historically been more on the radar of NGOs, as it has been seen as a safe haven in a region with relatively a lot of tensions. The relationships with other countries, trading agreements and involvement of NGOs have not been incorporated in this research, while this does play a role in the diffusion of frugal innovations. This could explain why there was no significant relationship between political risks and the market diffusion of frugal solar-PV systems.

## 6.2 – Reflection on research results in light of previous research

This paragraph will also reflect on the results of this research in comparison to previously conducted research and theories.

First, as the research of Khan (2016) and Tiwari & Herstatt (2012) mentioned, there is a concentration of frugal innovations visible in certain areas in the world. This is because frugal innovations are designed cost-effectively and with the demands of potential energy-poor or BOP consumers in mind, in contrast to high-tech innovations. This was also visible in the collected data for this research. Continents with the most sold frugal solar-PV systems were Africa, East Asia and Pacific and South Asia, which are also the most energy-poor continents. However, a comparison of the diffusion of high-tech solar-PV systems and frugal solar-PV systems has not been conducted, so the consequent statement of Khan (2016) that frugal innovations reach more users in total than high-tech innovations, cannot be supported nor rejected.

Second, Hossain (2018) mentioned the necessity for a different diffusion theory for frugal innovations, due to the different characteristics of frugal and high-tech innovations. Pisoni et al. (2018) mentioned four possible diffusion paths for frugal innovations: local diffusion, proximity diffusion, distance diffusion and reverse diffusion. This research showed different types of diffusion paths of frugal innovations. Local diffusion of frugal innovations was visible within countries. Second, there also was a proximity diffusion: the frugal solar-PV systems were diffused in the period between 2015 to 2019 to neighbouring countries with similar socio-economic environments. This was for example the case in Southern Africa with Namibia and South Africa, which is also in line with the statements of Ashfaq et al. (2018). Third, the distance diffusion path was also visible in this research. The SPSs and SHSs have diffused to countries further than the neighbouring countries. This was for example visible in East Africa. Multiple countries in that region were mentioned to have a high level of sales of frugal solar-PV systems. Moreover, the role of the EAC can play a role here. As Arshad (2021) mention, the existence of networking capabilities can increase and quicken the diffusion process, because there are close connections within an innovation network. Only the reverse diffusion path has not been identified in this research. This could be possible the case with the existence of frugal solar-PV systems on the European and Central Asia and North American continent, but there is no direction of the diffusion examined, so an agreement nor rejection to this part of the theory of Pisoni et al. (2018) cannot be stated.

Third, research has been conducted by Abrol & Gupta (2014), Arshad (2021) and Numminen & Lunch (2016) on barriers limiting the diffusion of frugal innovations. These were lack of awareness of potential users of the innovations, lack of teamwork between public and private parties and local users, non-availability of resources or only short-term availability and importing costs of resources or human capital. In the case studies and interviews the influence of lack of awareness of potential users, the lack of cooperation between public and private parties, and importing costs of resources or human capital were identified as factors explaining the difference between the diffusion of frugal innovations in Uganda and Namibia. Uganda has installed governmental programs to increase awareness of potential users of the existence of these systems, works together with NGOs to increase the electrification rate and is very active in the EAC, which has lowered the tax on goods trading between the countries included in the EAC (Da Silva et al., 2015). This shows that these barriers in fact can play a role in the diffusion of frugal

solar-PV systems, so the results of this research are in line with the research of Abrol & Gupta (2014), Arshad (2021) and Numminen & Lunch (2016).

## 6.3 – Contribution of this research and recommendations

As was indicated in section 1.2 'Knowledge gaps', little research has been done on diffusion of frugal innovations and the political role in this is unknown. There were multiple research gaps that this research aimed to contribute to. First, little research has been conducted on frugal innovations providing electricity and specifically on whole frugal energy systems, such as a SPS or SHS. Second, research on diffusion of frugal innovations instead of high-tech innovations is scarce. Third, various researchers indicate that research regarding the extent of the relationship between political risks and the diffusion of frugal solar-PV systems is still unknown.

This research has made different scientific contributions, aiming at filling parts of these knowledge gaps. First, this system has looked at the diffusion of SPSs and SHSs worldwide and has aimed to make a contribution to operationalising the political risks, by providing a method for assessing different factors and composing a political risk-index. Following this, correlation analyses has been performed to assess the possible relationship between political risks and the diffusion of frugal solar-PV systems. This showed that there is no relationship between the political risks and the diffusion of frugal solar-PV systems, but the case studies and interviews provided a lot of additional information and factors that has expanded the understanding of the diffusion of frugal innovations. Factors such as the need for frugal innovations, (renewable) energy technologies which are already invested in, the varying degree of involvement of foreign investors and NGOs in specific areas in the world, the history of the relationships with other countries, current trading agreements and cultural aspects and user demands, play a large role in the diffusion of frugal innovations. This is valuable knowledge in a relative new field as frugal innovations and specifically frugal solar-PV systems. Based on this, it can be concluded that the diffusion process of frugal innovations is a complex process with a lot of actors and factors possibly influencing it, which can be hard to grasp in a numerical analysis.

These results leave room for further research in the field of frugal energy innovations and the diffusion of these. One possibility is analysing the difference in diffusion processes between frugal innovations and high-tech innovations. As was mentioned in section 6.2, a concentration of frugal innovations visible in certain areas in the world in this research, but it is unknown to what extent the diffusion process between frugal innovations and high-tech innovations in emerging markets differ. This research topic could provide a good comparison between the diffusion process of high-tech innovations and of frugal innovations, thereby possibly contributing to composing a diffusion theory for frugal innovations specifically. Another possibility is increasing the scope of the PR-index, as is composed in this research. This research showed that there is no relationship between the political risks and the diffusion of SPSs and SHSs, but based on the case studies and interviews, it can be stated that more contextual factors should be taken into account, in order to provide a larger picture of the diffusion process. On the other hand, the included

political risks in the PR-index could also be reduced, thereby reducing the scope of the research. Zooming in on specific political risks, thereby analysing these more in dept, could also provide valuable insights.

This research aimed to contribute societally by providing more research on frugal solar-PV systems, which can contribute to reducing energy poverty worldwide. The acquired knowledge on the role that political risks can play in the diffusion of SPSs and SHSs and which other contextual and path-dependent factors should also be considered, can be taken into account in future projects regarding frugal innovations. This can provide governments, foreign investors and NGOs with an overview of the possible political factors, which are included in the PR-index, which could play a role in the diffusion of fugal solar-PV systems. Also, the lessons from the case studies and interviews provide additional information on which factors might influence the diffusion process. This could provide interested actors with starting points when looking at the diffusion of frugal innovations and making the process run more secure and smoothly on the supply-side, and provide frugal innovations in a way that potential consumers respond to. On the long term, this acquired knowledge could contribute to increasing the percentage of people having access to affordable and renewable generated electricity and reducing the energy poverty.

Based on the results from this research, also recommendations for the industry can be made. First, this research has showed that a perceived political tense situation might not have an influence on the diffusion of frugal innovations, aimed at providing basic electricity services for BOP consumers. This could decrease the barrier for (foreign) investors in this market segment. Also, this research shows that each potential investment in a certain country should require a detailed analysis of the specific country, the demands of the certain types of consumer segments and the relationships and (trade) agreements with other countries. As the case studies showed, this could all influence the degree to which frugal innovations suit the receiving market segments and how well the frugal innovations are diffused and used. This could increase the suitability of offered types of innovations to different types of consumer segments and socio-economic business environments.

## 6.4 – Reflection on used research methods

Besides a reflection of the achieved results of this research, it is also important to review the used methods to have acquired these, in order to keep the strengths of these in mind and draw lessons from this for future research.

The first strength of this research is the use of multiple research methods. In the first phase of the research, quantitative data has been gathered from multiple resources, after which a correlation analysis has been performed. In the second phase, case studies and interviews have been used to further understand the identified results from the correlation analysis and to be able to explain this to some extent. With the use of these different methods and multiple data sources as input for these methods, the sub-results have been substantiated. This has as consequence that the results of this research are not only based on numbers from the statistical analysis, but case studies and interviews also

have been used to try to grasp the bigger picture. The second strength of this research is the use of consistent and as much the same data sources as inputs for the sub-factors in the statistical analysis and conduction of the PR-index. This provides more credibility, as the same kinds of methods are used for the original collection of this data, which reduces the potential bias due to using different databases. When choosing these databases, it has been looked at whether these databases could provide data for other sub-factors. Besides this, also the general credibility of databases in the scientific community and the mention of used databases in conducted research in the field of politics were taken into account for the selection of the databases used in this research. Where it has been possible, the Aon Political Risk Indicator and the WorldBank databases have been the primary choice for collection of data for the sub-factors.

However, this research also has some limitations, which could influence the credibility of this conducted research. First, despite the fact that the method discussed in the research of Muñoz et al. (2015) has been very helpful in providing a framework for the set-up of a PR-index, it can be questioned to what extent this actually measures the political risks certain countries experience. With the combination of political, economic and social factors, it is possible that it measures a type of welfare-index, or multi-factor country risk index. When there would have been more time to conduct the correlation analysis and to gather data, it could be helpful in the future to expand the used PR-index in this research with more sub-factors representing in more detail the political risks in countries. Second, the sub-factors included in the PR-index were originally not all in the same units. To be able to compose these sub-factors into one overall PR-index, these factors had to be transformed into other sub-factors with the same unit. This poses the risk that detailed information has been lost, because of the categorical measurement unit of the PR-index (a risk index between zero and five), instead of the previous detail of a continuous number or a category ranging between zero and twelve. A possible consequence is that potential small differences between countries have disappeared in the PR-index and have therefore influenced the results of the correlation analysis. As last, data for the diffusion of frugal solar-PV systems, operationalised with data on the sales of SPSs and SHSs, was only available for four and a half years, or nine semesters. This was not surprising, as frugal innovations and specifically frugal-solar PV systems are a relatively new field of research. When more data is available in the future, the general trends regarding the diffusion of frugal innovations can be analysed more in depth. Also, there will probably be more research done by that time, thereby providing more knowledge on possible factors that could play a role in the diffusion of frugal innovations and a way to operationalise this. This could provide a more inclusive answer and maybe result in more convincing results of correlation analyses.

# Chapter 7 – Conclusion

Currently, thirteen percent of the world's population does not have access to electricity. Frugal energy innovations, such as SPSs and SHSs, could contribute to reducing the energy poverty around the world. However, diffusion of these systems around the world is not a given; political risks can impact the diffusion. This research has aimed to find the extent of the relationship between the political risk and the market diffusion of frugal solar-PV systems. This is done with a mixed-method research approach: a correlation analysis to operationalise the extent of the relationship between the political risk and the diffusion of frugal solar-PV systems and case studies and interviews to gather a larger overview of the possible factors playing a role in the market diffusion of frugal solar-PV systems.

Five sub-questions are answered in this research, in order to be able to answer the main research question.

Literature has been reviewed to answer the first sub-question: '*What is known about the relationship between political risks and the market diffusion of frugal innovations?*'. The literature indicated that frugal innovations might provide a solution for potential consumers with limited resources. The main aim of frugal innovations is maximizing value for consumers, while minimizing the associated costs; not low price, low performance, but low price, high performance (Basu et al., 2013; Sehgal, 2010). However, despite the possibilities that frugal innovations can provide, market diffusion of these innovations around the world is not a given (Mikhaylov et al., 2018). The reviewed literature indicated that diffusion of frugal innovations tends to go slower than diffusion of high-tech innovations, but still reaches in total more consumers in energy-poor countries than high-tech innovations would, due to the fact that frugal innovations have more potential to meet potential consumer demands. Political risks can limit the market diffusion of frugal innovations; a political tense situation, or unforeseen or sudden changes in the environment can play a role in the market diffusion of frugal innovations. The extent of this relationship had not yet been analysed, but the literature expressed potential political risk factors which were taken into account to design a PR-index to analyse this relationship.

As is described in section 3.2, a way to assess the political risks had to be found. In chapter 2, various political risk factors had been identified, which could play a role in the market diffusion of frugal solar-PV systems. With this, sub-question two could be answered. This was: *'How can political risks be operationalised, in order to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?'*. The PR-index combines data from three different types of sub-variables: political, economic and social, which include different sub-factors. The political sub-variable consists of seven sub-factors: 'voice and accountability', 'political stability', 'government effectiveness', 'regulatory quality', 'rule of law', 'control of corruption' and 'terrorism'. Second, the economic sub-variable includes five sub-factors: 'quality of overall infrastructure', 'market size', 'trade openness', 'ease of doing business' and 'strength of

legal rights'. As last, the social sub-variable includes four sub-factors: 'civil liberties', 'political rights', 'human development index' and 'inequality'.

The third sub-question was: '*Which correlation analysis method should be used to assess the relationship between political risks and the market diffusion of frugal solar-PV systems?*'. The used correlation method in this research is a combination of the Spearman rank-order correlation method and the Pearson correlation method. The Spearman rank-order correlation is used to assess the correlation between the PR-index and the market diffusion of frugal solar-PV systems, and the Pearson correlation is used to assess whether there is a relation between the control variables and the market diffusion of frugal solar-PV systems.

The fourth sub-question aimed to draw conclusions from the conducted correlation analyses. The fourth sub-question was: '*Which lessons can be learned from the correlation analysis regarding the relationship between political risks and the market diffusion of frugal solar-PV systems?*'. The analysis of diffusion of frugal solar-PV systems over the world indicated that South-Asia and Africa were the continents with the most SPSs and SHSs implemented between the second semester of 2015 until 2019. This shows that these frugal energy innovations diffuse highly in parts of the world with the lowest electricity rate. However, based on the conducted correlation analyses, it can be concluded that there is no clear correlation between the PR-index and the sales of frugal solar-PV systems. As can be seen in Table 5, of the nine time periods included in this research, the relationship between the PR-index and the sales of frugal solar-PV systems was only statistically significant in three of these periods. To further analyse this result, a scatterplot between the PR-index and the sales of frugal solar-PV systems was shown for one of the significant time periods. Figure 14 showed that some countries within the same geographical area cluster together in the scatterplot. For example, East African countries clustered together; all having a relatively high PR-index, while relatively a lot of SPSs and SHSs have been diffused to this region. On the same note, countries such as Namibia and South Africa in Southern Africa have quite low sales of SPSs and SHSs, while having a relatively low PR-index. This could indicate that neighbouring countries might cooperate in the diffusion of frugal solar-PV systems. When country specifics are taken into account, such as population size and GDP, the correlation between the political risks and the sales of SPSs and SHSs per capita worldwide showed only one significant time period. When the correlation analysis between political risks and the sales of frugal solar-PV systems per GDP was performed worldwide, four of the nine time periods showed significant results, but this was not the case when this was analysed per continent. When this was analysed per continent, Africa, East Asia and Pacific and Europe and Central Asia showed no significant results, decreasing the likelihood that there actually is a relationship between political risks and the sales of SPSs and SHSs per GDP. Thus, it can be concluded that there is no relationship between political risks and the diffusion of frugal solar-PV systems.

The last sub-question tried to find an explanation behind the found results from the correlation analyses. This fifth sub-question was: *'Which factors could explain the market diffusion of frugal solar-PV systems in Uganda and Namibia, given their respective political risks?*'. This sub-question is answered with means of case studies of Uganda and Namibia

and through interviews with experts in historical and social studies of Africa, which both provided a lot of information on possible factors also playing a role in the diffusion of frugal solar-PV systems. It was interesting to see that Uganda historically has been more involved in conflict situations, but still has more sales of frugal solar-PV systems. This was explained due to the fact that there is a higher need for frugal energy innovations in Uganda than in Namibia. Second, Uganda has always been more on the radar of NGOs and foreign investors, possibly because it is located in an instable region of Africa. Despite this, the regional cooperation in East Africa is more active than in the Southern region of Africa, thereby promoting the exchange of innovations, goods and knowledge throughout this region.

The answers on the posed sub-questions have led to an answer to the main research question of this research, which was: *'To what extent is there a relationship between political risks and the market diffusion of frugal solar-PV systems?'*.
The correlation analysis showed that there is no relationship between the political risks and the diffusion of frugal solar-PV systems. There are too little significant results to convince that there is a relationship between the political risks and the diffusion of frugal solar-PV systems worldwide and per continent. Despite the fact that the results of the correlation analyses showed no significant relationship between political risks and the market diffusion of frugal solar-PV systems, there are very interesting and valuable conclusions that have been drawn, specifically in combination with the results from the case studies and the interviews. The conducted case studies and interviews showed that there might be more factors playing a role the diffusion of frugal solar-PV systems than the included political factors. For example, the need for frugal innovations, (renewable) energy technologies which are already invested in, the varying degree of involvement of foreign investors and NGOs, the history of the relationships with other countries and current trading agreements. This shows that there can be a path dependency in the choice whether there will be invested in frugal solar-PV systems, Also, the literature indicated that culture and user preferences are very important in the successful diffusion of frugal innovations. This is valuable knowledge in a relative new field as frugal innovations and specifically frugal solar-PV systems. Based on this, it can be concluded that the diffusion process of frugal innovations is a complex process, with a lot of a lot of factors and path dependencies that could play a role.

To conclude, this research has contributed to the knowledge gaps and scientific debates in the frugal energy innovation field by looking at the market diffusion of these systems and the possible role political risks can play in this process. Valuable knowledge has been gathered, which has contributed in filling the posed knowledge gaps. Political risks have been operationalised, a contribution has been made in the field of diffusion theories, specifically for frugal innovations, and the scope of the extent of a relationship between political risks and the diffusion of frugal solar-PV systems has been determined. The results of this research can hopefully contribute on the long term to increasing the percentage of people having access to affordable and renewable generated electricity, thereby reducing the energy poverty worldwide.

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# Appendices

The appendices show additional information gathered in this research and provide a more in-depth explanation of certain research steps.

## Appendix A – Topic list for interviews

This appendix shows the topic list which is used during the interviews. Given the fact that the interviews are semi-structured, it is important to have a list of subjects that have a priority for being discussed, so no topics are forgotten during the interviews. The topic list is stated below.

### Topic 1 – Interview logistics

**Starting question:** "Should we discuss the general course of this interview and discuss informed consent regarding using your provided data from this interview?"

- Consent for recording this interview.
- Personal information is anonymised.
- Possibility to stop this interview at all times, without providing a reason.
- Provide verbal or written consent.
- If wished, the transcribed interview and/or thesis report could be sent to you.

### Topic 2 – Explanation thesis research

**Starting question:** "Would you like me to discuss the outline of my thesis project and some general background information on aspects of this?"

- Previous knowledge on frugal innovations and diffusion theory is not necessary.
- Main research question: 'To what extent is there a relationship between political risks and the market diffusion of frugal solar-PV systems?'.
- Frugal solar-PV systems aim to provide sustainable energy, with means of locally available low-costs renewable resources, inclusive for the low-income consumer segment, in order to reduce the energy poverty.
- Influence of politics on diffusion of frugal energy innovations:
  - Frugal energy innovations are often implemented through NGOs and international cooperation. This thesis projects aims to research to what extent political risks can play a role in the environment suitable for investments in frugal energy innovations.
- Results from statistical analysis:
  - Some countries show unexpected results: some countries are politically unstable and despite that still have a lot of frugal energy innovations (Uganda), while other countries that are politically stable have little frugal energy innovations implemented (Namibia).
- Aim of this interview is to learn more about the general history and (geo)political situation in Uganda and Namibia, in order to be able to better interpret and maybe explain the statistical results.

### Topic 3 – Situation in Uganda

**Starting question**: "Given the history of Uganda, do you think that the (geo)political situation in Uganda is favourable for foreign and domestic investments and diffusion of innovations?"

- More political tensions than in Namibia.
- History of Uganda seems more volatile with varying alliances with Rwanda.
- Uganda seems to have trouble with property rights regarding the White Nile and Lake Victoria.
- East African Cooperation seems to be more active than the South-West region of Africa. Is this correct?
- Does the history of conflicts within Uganda and neighbouring countries (Rwanda and South Sudan) influence Uganda's governmental investment decisions to this day?

### Topic 4 – Situation in Namibia

**Starting question**: "Given the history of Namibia, do you think that the (geo)political situation in Uganda is unfavourable for foreign and domestic investments and diffusion of innovations?"

- Influence of late dependence of Namibia from South Africa.
- Close trading relation with South Africa.
- Long-sitting government (SWAPO).
- Influence of being a sparsely populated country.
- Does the history of conflicts with neighbouring countries (Angola, Botswana and South Africa, Botswana) influence Namibia's governmental investment decisions to this day?

### Topic 5 – Comparison situations Uganda and Namibia

**Starting question**: "Do you think that overall Uganda has a more favourable business climate than Namibia? Can a possible difference between the two be explained?"

- Uganda seems to have more NGOs involved and international attention than Namibia. Is this correct and can this be explained?
- The Ugandan government seems to be more invested in reducing the energy poverty in the rural area. Can this be explained?

## Appendix B – Informed consent form for interviews

In this appendix the informed consent form is visible, which is shown and signed by the interview participants.

| **Please tick the appropriate boxes** | **Yes** | **No** |
|---|---|---|
| 1- I have read and understood the study information or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction. | ☐ | ☐ |
| 2- I consent voluntarily to be a participant in this study, I understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. | ☐ | ☐ |
| 3- I understand that taking part in the study involves giving a recorded interview, which will be transcribed as text. | ☐ | ☐ |
| 4- I understand that information I provide will be used for this thesis research, but not for secondary uses or for other purposes. | ☐ | ☐ |
| 5- I understand that personal information collected about me that can identify me, such as my name and function, will not be shared beyond the study team and this will be anonymised in the results and thesis report. | ☐ | ☐ |
| 6- I agree that my anonymised information can be quoted in research outputs. | ☐ | ☐ |

_____ _____ _____

Name of participant Signature Date

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| | | |
|---|---|---|
| 1- I declare that the information sheet has been read out to the potential participant and, to the best of my ability, ensured that the participant understands to what he/she is consenting. | ☐ | ☐ |

_____ _____ _____

Name of researcher Signature Date

# Appendix C – Overall market diffusion overview

Table 7 shows the sales of SPSs and SHSs together for different countries, spanning over a time frame from the second semester of 2015 (July 2015 – December 2015), until the second semester of 2019 (January 2020 – December 2019).

**Table 7** – Overview of sales of frugal solar-PV systems worldwide.

| Countries | Sales H2 2015 | Sales H1 2016 | Sales H2 2016 | Sales H1 2017 | Sales H2 2017 | Sales H1 2018 | Sales H2 2018 | Sales H1 2019 | Sales H2 2019 |
|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | |
| Angola | | | | 272 | | | | | 2950 |
| Benin | 28076 | 172634 | 2800 | 15949 | 10841 | 5733 | 8755 | 24244 | 29021 |
| Burkina Faso | | 19273 | 34733 | 123945 | 46581 | 22809 | 23725 | 38188 | 13289 |
| Burundi | | | | | | | | | |
| Cameroon | | | 45444 | 30886 | 1967 | 49715 | 54649 | 79134 | 71864 |
| Central Africa Republic | | | | | | | | | 48027 |
| Chad | | | | | | | 9235 | | |
| Cote d'Ivoire | 24388 | 20762 | 8776 | 9533 | 15360 | 17446 | 22921 | 27682 | 35522 |
| DRC | | 73191 | 729 | 46090 | 242271 | 11197 | 54316 | 38147 | |
| Ethiopia | 363950 | 231097 | 265723 | 210913 | 158634 | 147647 | 338177 | 293778 | 717759 |
| Gambia | | | 576 | | | | | 734 | |
| Ghana | 15667 | 12510 | 38496 | 25789 | 37863 | 26160 | 13096 | 13702 | 17337 |
| Guinea | | | | | | | | 4367 | |
| Kenya | 472612 | 561604 | 666881 | 413544 | 502099 | 519154 | 749909 | 974972 | 994511 |
| Liberia | | 5668 | 8421 | 15251 | 13384 | 11517 | 9650 | 1225 | |
| Madagascar | | | 20845 | 41700 | 43950 | 27355 | 23998 | 11013 | 30686 |
| Malawi | 26365 | 16987 | 20844 | 17598 | 125640 | 22772 | 33783 | 8903 | 51703 |
| Mali | 22162 | 10417 | 31184 | 30591 | 42620 | 16448 | 20802 | 35423 | 10140 |
| Mozambique | | 6048 | 8137 | 2655 | 10523 | 9536 | 8548 | 7561 | 6573 |
| Namibia | | | 2390 | 1798 | 4372 | 4218 | 2567 | | |
| Niger | | | | 2480 | 1160 | 3955 | 3595 | 3234 | 13811 |
| Nigeria | 74437 | 128837 | 149414 | 107999 | 107576 | 153112 | 133801 | 135410 | 166284 |
| Rwanda | 84724 | 129779 | 89161 | 190781 | 80529 | 47741 | 98723 | 65030 | 47984 |
| Senegal | 19780 | 13806 | 33776 | 67503 | 17883 | 31335 | 18104 | 29572 | 25681 |
| Sierra Leone | 16277 | 2551 | 21689 | 14397 | 19074 | 17990 | 16905 | 15821 | 22635 |
| Somalia | | | 11740 | 12856 | 13972 | 22049 | 30127 | 38204 | 11616 |
| South Africa | 50339 | 8108 | 1681 | 34866 | 18589 | 13848 | 30039 | 20672 | 12201 |
| Tanzania | 473009 | 187694 | 185073 | 69143 | 103299 | 103695 | 102038 | 87552 | 176375 |
| Togo | | | 296 | 2668 | 1920 | 4505 | 7727 | 26809 | 23904 |
| Uganda | 148686 | 190725 | 192695 | 240151 | 224074 | 173556 | 193600 | 179530 | 219755 |
| Zambia | 77836 | 40510 | 15268 | 16483 | 21268 | 37978 | 88000 | 70260 | 118458 |
| Zimbabwe | 49199 | 24087 | 13918 | 3749 | 8398 | 21583 | 14168 | 15189 | 16210 |
| **East Asia and Pacific** | | | | | | | | | |
| Australia | | | 3037 | 5031 | 7024 | | | 1188 | |
| Cambodia | | 8903 | 2645 | | | | 438 | | |
| China | | | | 19177 | 9829 | 7552 | 4143 | 733 | 11207 |
| Fiji | | | | 13054 | 5100 | 13621 | 22142 | | |
| Hong Kong | | | 1146 | 1585 | 2024 | 5024 | 6346 | 7668 | |
| Indonesia | 2296 | 8798 | 28576 | 64613 | 100650 | 26289 | | | |
| Japan | | | 291 | 1350 | 2409 | 1667 | | | |
| Malaysia | | | | | | | | 500 | |
| Myanmar | 12474 | 2432 | 21623 | 12983 | 4343 | 71746 | 27196 | 59474 | 148235 |
| Papua New Guinea | 39652 | 25277 | 20287 | 18349 | 16410 | 36908 | 30249 | 37298 | 24399 |
| Philippines | | | 4679 | 55197 | 6163 | 24855 | 38891 | 11087 | 40657 |
| Samoa | | | | 3118 | | | | | |
| Singapore | | | | | | 645 | | | |
| Thailand | | | 530 | 1244 | 1959 | 2673 | 2709 | 506 | |
| Vanuatu | | | 6104 | 7983 | 7840 | 9729 | 38962 | 9350 | |
| **South Asia** | | | | | | | | | |
| Bangladesh | 3345 | 7576 | 14642 | 21707 | 119050 | 85426 | 51802 | 185405 | 46575 |
| India | 1455269 | 1717774 | 1378130 | 1087282 | 1255174 | 1219589 | 1184003 | 953466 | 781165 |
| Nepal | 12822 | 9749 | 26413 | 5890 | 4067 | 2243 | 420 | | |
| Pakistan | 15588 | 20740 | 4937 | 38433 | 6733 | 13044 | 19355 | 17742 | 10756 |
| **Middle East and North Africa** | | | | | | | | | |
| Iraq | | | | 27016 | | | | | |
| Lebanon | | | | 1710 | 1590 | 1470 | 1350 | | |
| United Arab Emirates | | | 46897 | 8686 | 40162 | 32941 | 39593 | 46245 | |
| Yemen | | | | | | | 83846 | | |
| **Latin America** | | | | | | | | | |
| Bolivia | | | | 5300 | 2357 | | | | |
| Colombia | | | 1403 | 841 | 279 | | | | |
| Guatemala | | | | | 644 | 2304 | 3965 | 5625 | |
| Haiti | | | 9189 | 9200 | 2740 | 8760 | | | |
| Mexico | | | 7423 | | | | | | |
| Panama | | | 1042 | 2250 | | | | | |
| Peru | | | 2742 | 2221 | 2661 | 3100 | 2571 | 2042 | |
| Puerto Rico | | | 0 | 1421 | 2841 | 4262 | | | |
| **North America** | | | | | | | | | |
| Canada | | | | 375 | | | | | |
| United States | | | 13827 | 9898 | 36033 | | | | |
| **Europe and Central Asia** | | | | | | | | | |
| Belgium | | | | | 7666 | | | | |
| Denmark | | | | 4665 | 4792 | | | | |
| France | | | 8928 | 1076 | 11046 | | | | |
| Germany | | | 31577 | 11224 | 36098 | | | | |
| Greece | | | 6023 | 8767 | 11510 | | | | |
| Ireland | | | | | 437 | | | | |
| Italy | | | 3670 | 7141 | 1612 | | | | |
| Norway | | | | | 4699 | | | | |
| Sweden | | | | | 62 | | | | |
| United Kingdom | | | 6692 | 2952 | 9091 | | | | |

# Appendix D – Sub-steps of quantitative analysis

Appendix D shows the sub-steps performed in the statistical correlation analysis to answer sub-question four. The following hypothesis was made for the statistical correlation analyses per time period:

H0 = there is no relationship between the political risks and the market diffusion of frugal solar-PV systems.

H1 = there is a relationship between the political risks and the market diffusion of frugal solar-PV systems.

## Appendix D.1 – Quantitative results of H2 2015

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 8 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 8** – Overview of political sub-factors in H2 2015.

| Countries | Sales H2 2015 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | |
| Benin | 28076 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 1,14E+10 | 0,85 | 4 | 4 | 3 | 3 | 3 | 1,06E+07 | 2 | 2 | 3 | 2 | 2,57 |
| Cote d'Ivoire | 24388 | 3 | 4 | 4 | 4 | 4 | 3 | 4 | 4,58E+10 | 42,52 | 2 | 3 | 3 | 3 | 3 | 2,32E+07 | 3 | 3 | 3 | 2 | 3,10 |
| Ethiopia | 363950 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 6,46E+10 | 10,84 | 3 | 3 | 4 | 3 | 4 | 1,01E+08 | 4 | 3 | 3 | 2 | 2,20 |
| Ghana | 15667 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 4,86E+10 | 13,59 | 3 | 3 | 2 | 3 | 3 | 2,78E+07 | 2 | 1 | 3 | 2 | 6,81 |
| Kenya | 472612 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 6,40E+10 | 10,02 | 2 | 3 | 3 | 3 | 3 | 4,79E+07 | 3 | 3 | 3 | 2 | 2,80 |
| Malawi | 26365 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 6,37E+09 | 20,53 | 3 | 4 | 2 | 3 | 3 | 1,67E+07 | 3 | 2 | 3 | 2 | 5,85 |
| Mali | 22162 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,31E+10 | 2,88 | 3 | 4 | 2 | 3 | 3 | 1,74E+07 | 3 | 3 | 3 | 2 | 7,73 |
| Nigeria | 74437 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 4,87E+11 | 2,86 | 4 | 2 | 4 | 3 | 3 | 1,81E+08 | 3 | 3 | 3 | 2 | 4,31 |
| Rwanda | 84724 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 8,55E+09 | 0,50 | 2 | 4 | 3 | 2 | 1 | 1,14E+07 | 4 | 4 | 3 | 2 | 1,14 |
| Senegal | 19780 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1,78E+10 | 1,07 | 3 | 3 | 3 | 3 | 3 | 1,46E+07 | 2 | 2 | 3 | 2 | 6,76 |
| Sierra Leone | 16277 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 4,22E+09 | 18,86 | 4 | 4 | 2 | 3 | 3 | 7,17E+06 | 2 | 2 | 3 | 2 | 4,64 |
| South Africa | 50339 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3,18E+11 | 5,17 | 2 | 2 | 2 | 2 | 3 | 5,54E+07 | 2 | 2 | 2 | 2 | 25,15 |
| Tanzania | 473009 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 4,74E+10 | 7,59 | 3 | 3 | 3 | 3 | 3 | 5,15E+07 | 2 | 2 | 3 | 2 | 2,10 |
| Uganda | 148686 | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 3,22E+10 | 5,19 | 3 | 3 | 4 | 3 | 3 | 3,82E+07 | 3 | 3 | 3 | 2 | 1,86 |
| Zambia | 77836 | 3 | 3 | 4 | 3 | 3 | 3 | 2 | 2,12E+10 | 6,66 | 3 | 3 | 2 | 2 | 3 | 1,59E+07 | 3 | 2 | 3 | 2 | 10,10 |
| Zimbabwe | 49199 | 4 | 4 | 4 | 5 | 4 | 4 | 3 | 2,00E+10 | 0,61 | 3 | 4 | 3 | 3 | 3 | 1,38E+07 | 4 | 3 | 3 | 2 | 5,29 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | |
| Indonesia | 2296 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 8,61E+11 | 3,98 | 3 | 1 | 3 | 2 | 3 | 2,58E+08 | 3 | 2 | 2 | 1 | 4,51 |
| Myanmar | 12474 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6,78E+10 | 6,29 | 4 | 3 | 3 | 3 | 5 | 5,27E+07 | 4 | 4 | 3 | | 0,77 |
| Papua New Guinea | 39652 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 2,17E+10 | -1,23 | | | | 3 | 4 | 8,11E+06 | 2 | 3 | 3 | | 2,56 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 3345 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1,95E+11 | 5,87 | 3 | 2 | 3 | 3 | 3 | 1,56E+08 | 3 | 3 | 3 | 2 | 4,38 |
| India | 1455269 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,10E+12 | 4,94 | 3 | 1 | 3 | 3 | 3 | 1,31E+09 | 2 | 2 | 2 | 2 | 5,56 |
| Nepal | 12822 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,14E+10 | 4,94 | 4 | 3 | 3 | 3 | 3 | 2,70E+07 | 3 | 2 | 3 | 2 | 3,10 |
| Pakistan | 15588 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 2,71E+11 | 4,11 | 3 | 2 | 4 | 3 | 5 | 1,99E+08 | 3 | 4 | 3 | 1 | 3,57 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 9.

**Table 9** – Results of factor analysis of H2 2015.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 73.867 | 'Internal politics' |
| | Political stability (PS) | | | 'External politics' |
| | Government effectiveness (GE) | | | 'Internal politics' |
| | Regulatory quality (RQ) | | | 'Internal politics' |
| | Rule of law (RoL) | | | 'Internal politics' |
| | Control of corruption (CoC) | | | 'External politics' |
| | Terrorism (T) | | | 'External politics' |
| Economic | Quality of overall infrastructure (QoI) | 0.089 | Not applicable (N/A) | N/A |
| | Market size (Market) | | | |
| | Trade openness (Trade) | | | |
| | Ease of doing business (EofB) | | | |
| | Strength of legal rights (Strength LR) | | | |
| Social | Civil liberties (CL) | 0.006 | 80.016 | 'Human rights' |
| | Political rights (PR) | | | 'Human rights' |

| | | | | |
|---|---|---|---|---|
| | Human Development Index (HDI) | | | 'Societal development' |
| | Inequality (Inequa) | | | 'Societal development' |

This means that the political sub-factors will be merged in two different new political sub-variables ('Internal politics' and 'External politics'). The economic sub-factors were not correlated enough to have to be merged into one or multiple new variables, so these will stay the same sub-factors. The four social sub-factors will be merged in two different new social sub-variables ('Human rights' and 'Societal development').

3- Conduct a PR-index:

After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H2 2015 is:

PR = $(\frac{1}{9})$ * Internal politics + $(\frac{1}{9})$ * External politics + $(\frac{1}{9})$ * QoI + $(\frac{1}{9})$ * Market + $(\frac{1}{9})$ * Trade + $(\frac{1}{9})$ * EofB + $(\frac{1}{9})$ * Strength LR + $(\frac{1}{9})$ * Human rights + $(\frac{1}{9})$ * Societal development

The resultant PR-index per country in the period H2 2015 can be seen in Table 10. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 10** – PR-index overview of H2 2015.

| Countries | Sales H2 2015 | PR-index |
|---|---|---|
| **Africa** | | |
| Benin | 28076 | 3.18 |
| Cote d'Ivoire | 24388 | 2.99 |
| Ethiopia | 363950 | 3.41 |
| Ghana | 15667 | 2.63 |
| Kenya | 472612 | 2.94 |
| Malawi | 26365 | 2.94 |
| Mali | 22162 | 3.21 |
| Nigeria | 74437 | 3.32 |
| Rwanda | 84724 | 2.68 |
| Senegal | 19780 | 2.83 |
| Sierra Leone | 16277 | 3.06 |
| South Africa | 50339 | 2.27 |
| Tanzania | 473009 | 2.90 |
| Uganda | 148686 | 3.19 |
| Zambia | 77836 | 2.66 |
| Zimbabwe | 49199 | 3.32 |
| **East Asia and Pacific** | | |

| | | |
|---|---|---|
| Indonesia | 2296 | 2.52 |
| Myanmar | 12474 | 3.67 |
| Papua New Guinea | 39652 | 3.26 |
| **South Asia** | | |
| Bangladesh | 3345 | 3.06 |
| India | 1455269 | 2.63 |
| Nepal | 12822 | 3.16 |
| Pakistan | 15588 | 3.46 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.567. This means that there is no correlation between the sales of these systems and the PR-index. There was also no correlation between the logarithmic function of the sales of SPSs and SHSs and the control variables.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:
- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:
- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.
- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.2 – Quantitative results of H1 2016

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 11 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 11** – Overview of political sub-factors in H1 2016.

| Countries | Sales H1 2016 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market | Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Benin | 172634 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 1,18E+10 | 0,68 | 4 | 4 | 3 | 3 | 3 | 1,09E+07 | 2 | 2 | 3 | 2 | 2,52 |
| Burkina Faso | 19273 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 1,28E+10 | 2,60 | | | 3 | 3 | 3 | 1,86E+07 | 2 | 3 | 3 | 2 | 5,60 |
| Cote d'Ivoire | 20762 | 3 | 4 | 4 | 3 | 4 | 4 | 3 | 4,80E+10 | -2,09 | 2 | 3 | 3 | 3 | 3 | 2,38E+07 | 3 | 3 | 3 | 2 | 2,60 |
| DRC | 73191 | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 3,71E+10 | 4,35 | 4 | 3 | 3 | 4 | 3 | 7,88E+07 | 4 | 4 | 3 | 2 | 4,35 |
| Ethiopia | 231097 | 4 | 5 | 4 | 3 | 3 | 3 | 4 | 7,43E+10 | 10,40 | 3 | 3 | 4 | 3 | 4 | 1,04E+08 | 4 | 5 | 3 | 2 | 2,17 |
| Ghana | 12510 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 5,50E+10 | 15,25 | 3 | 3 | 2 | 3 | 3 | 2,85E+07 | 2 | 1 | 2 | 2 | 5,45 |
| Kenya | 561604 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 6,92E+10 | 5,55 | 2 | 3 | 4 | 2 | 3 | 4,91E+07 | 3 | 3 | 3 | 2 | 2,76 |
| Liberia | 5668 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,28E+09 | 4,85 | 3 | 4 | 1 | 4 | 2 | 4,59E+06 | 3 | 2 | 3 | 2 | 3,08 |
| Malawi | 16987 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 5,43E+09 | 19,54 | 4 | 4 | 1 | 3 | 2 | 1,72E+07 | 2 | 2 | 3 | 2 | 5,79 |
| Mali | 10417 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,40E+10 | 1,35 | 4 | 4 | 2 | 3 | 3 | 1,80E+07 | 3 | 3 | 3 | 2 | 7,60 |
| Mozambique | 6048 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,19E+10 | 13,68 | 4 | 3 | 1 | 3 | 5 | 2,78E+07 | 3 | 3 | 3 | 2 | 3,38 |
| Nigeria | 128837 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 4,05E+11 | 9,54 | 4 | 2 | 4 | 3 | 3 | 1,86E+08 | 3 | 3 | 3 | 2 | 7,06 |
| Rwanda | 129779 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 8,70E+09 | 5,03 | 2 | 4 | 3 | 2 | 1 | 1,17E+07 | 4 | 4 | 3 | 2 | 1,11 |
| Senegal | 13806 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1,90E+10 | 0,96 | 3 | 4 | 3 | 3 | 3 | 1,50E+07 | 2 | 2 | 3 | 2 | 6,70 |
| Sierra Leone | 2551 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,67E+09 | 1,78 | 4 | 4 | 2 | 3 | 3 | 7,33E+06 | 2 | 2 | 3 | 2 | 4,59 |
| South Africa | 8108 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2,96E+11 | 7,21 | 2 | 2 | 2 | 2 | 3 | 5,62E+07 | 2 | 2 | 2 | 2 | 26,54 |
| Tanzania | 187694 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 4,98E+10 | 7,47 | 3 | 3 | 4 | 3 | 3 | 5,31E+07 | 3 | 2 | 3 | 2 | 2,08 |
| Uganda | 190725 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 2,91E+10 | 4,78 | 3 | 3 | 4 | 3 | 3 | 3,96E+07 | 3 | 4 | 3 | 2 | 1,83 |
| Zambia | 40510 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 2,10E+10 | 13,55 | 3 | 3 | 2 | 2 | 3 | 1,64E+07 | 3 | 2 | 3 | 2 | 10,88 |
| Zimbabwe | 24087 | 4 | 4 | 4 | 5 | 4 | 4 | 5 | 2,05E+10 | 2,16 | 3 | 4 | 3 | 3 | 3 | 1,40E+07 | 3 | 3 | 3 | 2 | 5,24 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| Cambodia | 8903 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 2,00E+10 | 3,38 | 3 | 3 | 1 | 3 | 1 | 1,58E+07 | 3 | 4 | 3 | 1 | 0,72 |
| Indonesia | 8798 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 9,32E+11 | 2,44 | 3 | 1 | 4 | 2 | 3 | 2,62E+08 | 3 | 2 | 2 | 1 | 4,30 |
| Myanmar | 2432 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 6,72E+10 | 5,37 | | | 2 | 3 | 5 | 5,30E+07 | 3 | 4 | 3 | | 1,14 |
| Papua New Guinea | 25277 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 2,08E+10 | 2,52 | | | | 3 | 2 | 8,27E+06 | 2 | 3 | 3 | | 2,53 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 7576 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,21E+11 | 6,73 | 3 | 2 | 4 | 3 | 3 | 1,58E+08 | 3 | 3 | 2 | 2 | 4,35 |
| India | 1717774 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,29E+12 | 3,24 | 2 | 1 | 3 | 3 | 3 | 1,32E+09 | 2 | 2 | 2 | 2 | 5,51 |
| Nepal | 9749 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 2,12E+10 | 5,16 | 4 | 3 | 3 | 3 | 3 | 2,73E+07 | 3 | 2 | 3 | 2 | 3,05 |
| Pakistan | 20740 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 2,79E+11 | 0,40 | 3 | 2 | 4 | 3 | 5 | 2,04E+08 | 3 | 3 | 3 | 2 | 3,78 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 12.

**Table 12** – Results of factor analysis of H1 2016.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 71.782 | 'External politics' |
| | Political stability (PS) | | | 'External politics' |
| | Government effectiveness (GE) | | | 'Internal politics' |
| | Regulatory quality (RQ) | | | 'Internal politics' |
| | Rule of law (RoL) | | | 'Internal politics' |
| | Control of corruption (CoC) | | | 'Internal politics' |
| | Terrorism (T) | | | 'External politics' |
| Economic | Quality of overall infrastructure (QoI) | 0.044 | 67.683 | 'Internal market' |
| | Market size (Market) | | | 'Internal market' |
| | Trade openness (Trade) | | | 'Internal market' |
| | Ease of doing business (EofB) | | | 'International business' |
| | Strength of legal rights (Strength LR) | | | 'International business' |
| Social | Civil liberties (CL) | 0.001 | 78.754 | 'Human rights' |
| | Political rights (PR) | | | 'Human rights' |

| | | | | |
|---|---|---|---|---|
| | Human Development Index (HDI) | | | 'Societal development' |
| | Inequality (Inequa) | | | 'Societal development' |

This means that the political sub-factors can be merged into two political sub-variables, the economic sub-factors merged into two sub-variables and the social sub-factors can also be merged into two sub-variables, thereby resulting in six sub-variables which will form the overall PR-index.

3- Conduct a PR-index:

After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H1 2016 is:

PR = $(\frac{1}{6})$ * Internal politics + $(\frac{1}{6})$ * External politics + $(\frac{1}{6})$ * Internal market + $(\frac{1}{6})$ * International business + $(\frac{1}{6})$ * Human rights + $(\frac{1}{6})$ * Societal development

The resultant PR-index per country in the period H1 2016 can be seen in Table 13. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 13** – PR-index overview of H1 2016.

| Countries | Sales H1 2016 | PR-index |
|---|---|---|
| **Africa** | | |
| Benin | 172634 | 3.03 |
| Burkina Faso | 19273 | 2.99 |
| Cote d'Ivoire | 20762 | 3.04 |
| DRC | 73191 | 3.71 |
| Ethiopia | 231097 | 3.57 |
| Ghana | 12510 | 2.47 |
| Kenya | 561604 | 2.93 |
| Liberia | 5668 | 2.94 |
| Malawi | 16987 | 2.74 |
| Mali | 10417 | 3.36 |
| Mozambique | 6048 | 3.25 |
| Nigeria | 128837 | 3.36 |
| Rwanda | 129779 | 2.79 |
| Senegal | 13806 | 2.81 |
| Sierra Leone | 2551 | 2.97 |
| South Africa | 8108 | 2.36 |
| Tanzania | 187694 | 2.97 |
| Uganda | 190725 | 3.31 |
| Zambia | 40510 | 2.74 |
| Zimbabwe | 24087 | 3.40 |

| East Asia and Pacific | | |
|---|---|---|
| Cambodia | 8903 | 2.82 |
| Indonesia | 8798 | 2.58 |
| Myanmar | 2432 | 3.36 |
| Papua New Guinea | 25277 | |
| **South Asia** | | |
| Bangladesh | 7576 | 3.17 |
| India | 1717774 | 2.61 |
| Nepal | 9749 | 3.17 |
| Pakistan | 20740 | 3.53 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.615. This means that there is no correlation between the sales of these systems and the PR-index. There is a correlation between the sales of SPSs and SHSs with the GDP of a country and the population. These p-values respectively are 0.031 and 0.009.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:
- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:
- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.
- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.3 – Quantitative results of H2 2016

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 14 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 14** – Overview of political sub-factors in H2 2016.

| Countries | Sales H2 2016 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market | Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Benin | 2800 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 1,18E+10 | 0,68 | 4 | 4 | 3 | 3 | 3 | 1,09E+07 | 2 | 2 | 3 | 2 | 2,52 |
| Burkina Faso | 34733 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 1,28E+10 | 2,60 | | | 3 | 3 | 3 | 1,86E+07 | 2 | 3 | 3 | 2 | 5,60 |
| Cameroon | 45444 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3,26E+10 | 1,09 | 4 | 3 | 3 | 3 | 3 | 2,39E+07 | 4 | 4 | 3 | 2 | 3,47 |
| Cote d'Ivoire | 8776 | 3 | 4 | 4 | 3 | 4 | 4 | 3 | 4,80E+10 | -2,09 | 2 | 3 | 3 | 3 | 3 | 2,38E+07 | 3 | 3 | 3 | 2 | 2,60 |
| DRC | 729 | 4 | 5 | 5 | 4 | 4 | 4 | 5 | 3,71E+10 | 4,35 | 4 | 3 | 3 | 4 | 3 | 7,88E+07 | 4 | 4 | 3 | 2 | 4,35 |
| Ethiopia | 265723 | 4 | 5 | 4 | 3 | 3 | 3 | 4 | 7,43E+10 | 10,40 | 3 | 3 | 4 | 3 | 4 | 1,04E+08 | 4 | 5 | 3 | 2 | 2,17 |
| Gambia | 576 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 1,48E+09 | 7,82 | 3 | 5 | 3 | 3 | 3 | 2,15E+06 | 4 | 5 | 3 | 2 | 9,24 |
| Ghana | 38496 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 5,50E+10 | 15,25 | 3 | 3 | 2 | 3 | 3 | 2,85E+07 | 2 | 1 | 2 | 2 | 5,45 |
| Kenya | 666881 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 6,92E+10 | 5,55 | 2 | 3 | 4 | 2 | 3 | 4,91E+07 | 3 | 3 | 3 | 2 | 2,76 |
| Liberia | 8421 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,28E+09 | 4,85 | 3 | 4 | 1 | 4 | 2 | 4,59E+06 | 3 | 2 | 3 | 2 | 3,08 |
| Madagascar | 20845 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 1,18E+10 | 8,96 | 4 | 4 | 2 | 3 | 5 | 2,49E+07 | 3 | 2 | 3 | 2 | 1,76 |
| Malawi | 20844 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 5,43E+09 | 19,54 | 4 | 4 | 2 | 3 | 2 | 1,72E+07 | 2 | 2 | 3 | 2 | 5,79 |
| Mali | 31184 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,40E+10 | 1,35 | 4 | 4 | 2 | 3 | 3 | 1,80E+07 | 3 | 3 | 3 | 2 | 7,60 |
| Mozambique | 8137 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,19E+10 | 13,68 | 4 | 3 | 1 | 3 | 5 | 2,78E+07 | 3 | 3 | 3 | 2 | 3,38 |
| Namibia | 2390 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 1,07E+10 | 8,34 | 2 | 4 | 1 | 2 | 3 | 2,36E+06 | 2 | 2 | 2 | 2 | 23,35 |
| Nigeria | 149414 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 4,05E+11 | 9,54 | 4 | 2 | 4 | 3 | 3 | 1,86E+08 | 3 | 3 | 3 | 2 | 7,06 |
| Rwanda | 89161 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 8,70E+09 | 5,03 | 2 | 4 | 3 | 2 | 1 | 1,17E+07 | 4 | 4 | 3 | 2 | 1,11 |
| Senegal | 33776 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1,90E+10 | 0,96 | 3 | 4 | 3 | 3 | 3 | 1,50E+07 | 2 | 2 | 3 | 2 | 6,70 |
| Sierra Leone | 21689 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,67E+09 | 1,78 | 4 | 4 | 2 | 3 | 3 | 7,33E+06 | 2 | 2 | 3 | 2 | 4,59 |
| Somalia | 11740 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 1 | 4 | 5 | 1,42E+07 | 5 | 5 | | | 13,17 |
| South Africa | 1681 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2,96E+11 | 7,21 | 2 | 2 | 2 | 2 | 3 | 5,62E+07 | 2 | 2 | 2 | 2 | 26,54 |
| Tanzania | 185073 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 4,98E+10 | 7,47 | 3 | 3 | 4 | 3 | 3 | 5,31E+07 | 3 | 2 | 3 | 2 | 2,08 |
| Togo | 296 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 4,49E+09 | 1,91 | | | 1 | 3 | 3 | 7,51E+06 | 3 | 3 | 3 | 2 | 2,95 |
| Uganda | 192695 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 2,91E+10 | 4,78 | 3 | 3 | 4 | 3 | 3 | 3,96E+07 | 3 | 4 | 3 | 2 | 1,83 |
| Zambia | 15268 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 2,10E+10 | 13,55 | 3 | 3 | 2 | 2 | 3 | 1,64E+07 | 3 | 2 | 3 | 2 | 10,88 |
| Zimbabwe | 13918 | 4 | 4 | 4 | 5 | 4 | 4 | 5 | 2,05E+10 | 2,16 | 3 | 4 | 3 | 3 | 3 | 1,40E+07 | 3 | 3 | 3 | 2 | 5,24 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| Australia | 3037 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1,21E+12 | -0,53 | 2 | 2 | 3 | 1 | 1 | 2,42E+07 | 1 | 1 | 1 | 1 | 5,71 |
| Cambodia | 2645 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 2,00E+10 | 3,38 | 3 | 3 | 1 | 3 | 1 | 1,58E+07 | 3 | 4 | 3 | 1 | 0,72 |
| Hong Kong | 1146 | 3 | 2 | 1 | 1 | 1 | 1 | 3 | 3,21E+11 | 1,64 | 1 | 2 | 1 | 1 | 2 | 7,34E+06 | 2 | 3 | 1 | | 3,39 |
| Indonesia | 28576 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 9,32E+11 | 2,44 | 3 | 1 | 4 | 2 | 3 | 2,62E+08 | 3 | 2 | 2 | 1 | 4,30 |
| Japan | 291 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 4,92E+12 | 0,27 | 1 | 1 | 4 | 2 | 3 | 1,27E+08 | 1 | 1 | 1 | 1 | 3,10 |
| Myanmar | 21623 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 6,72E+10 | 5,37 | | | 2 | 3 | 5 | 5,30E+07 | 3 | 4 | 3 | | 1,14 |
| Papua New Guinea | 20287 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 2,08E+10 | 2,52 | | | | 3 | 2 | 8,27E+06 | 2 | 3 | 3 | | 2,53 |
| Philippines | 4679 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3,19E+11 | 1,28 | 3 | 2 | 2 | 3 | 5 | 1,04E+08 | 2 | 2 | 2 | 1 | 2,69 |
| Thailand | 530 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 4,13E+11 | 2,66 | 3 | 2 | 1 | 2 | 4 | 6,90E+07 | 3 | 4 | 2 | 1 | 0,69 |
| Vanuatu | 6104 | 2 | 2 | 4 | 3 | 3 | 3 | 1 | 8,04E+08 | 1,85 | | | | 2 | 1 | 2,78E+05 | 2 | 2 | 2 | 1 | 1,79 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 14642 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,21E+11 | 6,73 | 3 | 2 | 4 | 3 | 3 | 1,58E+08 | 3 | 3 | 2 | 2 | 4,35 |
| India | 1378130 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,29E+12 | 3,24 | 2 | 1 | 3 | 3 | 3 | 1,32E+09 | 2 | 2 | 2 | 2 | 5,51 |
| Nepal | 26413 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 2,12E+10 | 5,16 | 4 | 3 | 3 | 3 | 3 | 2,73E+07 | 3 | 2 | 3 | 2 | 3,05 |
| Pakistan | 4937 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 2,79E+11 | 0,40 | 3 | 2 | 4 | 3 | 5 | 2,04E+08 | 3 | 3 | 3 | 2 | 3,78 |
| **Middle East and North Africa** | | | | | | | | | | | | | | | | | | | | | |
| United Arab Emirates | 46897 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 3,57E+11 | -3,27 | 1 | 2 | 1 | 2 | 5 | 9,36E+06 | 4 | 4 | 1 | | 1,64 |
| **Latin Ameria** | | | | | | | | | | | | | | | | | | | | | |
| Colombia | 1403 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 2,83E+11 | 5,15 | 3 | 2 | 4 | 2 | 1 | 4,82E+07 | 3 | 2 | 2 | 2 | 8,69 |
| Haiti | 9189 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 1,37E+10 | 12,90 | | | 3 | 4 | 5 | 1,08E+07 | 3 | 3 | 3 | 2 | 13,86 |
| Mexico | 7423 | 3 | 4 | 3 | 3 | 4 | 4 | 3 | 1,08E+12 | 5,61 | 3 | 2 | 2 | 2 | 1 | 1,23E+08 | 2 | 2 | 2 | 2 | 3,86 |
| Panama | 1042 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 5,79E+10 | 2,00 | 2 | 3 | 1 | 2 | 3 | 4,04E+06 | 2 | 2 | 1 | 1 | 3,32 |
| Peru | 2742 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1,92E+11 | 3,08 | 3 | 2 | 3 | 2 | 3 | 3,09E+07 | 2 | 2 | 2 | 1 | 3,38 |
| Puerto Rico | 0 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 1,04E+11 | 2,22 | | | 1 | 2 | 1 | 3406672 | 1 | 1 | | | 11,80 |
| **North America** | | | | | | | | | | | | | | | | | | | | | |
| United States | 13827 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 1,87E+13 | 1,04 | 1 | 1 | 4 | 1 | 1 | 3,23E+08 | 1 | 1 | 1 | 1 | 4,87 |
| **Europe and Central Asia** | | | | | | | | | | | | | | | | | | | | | |
| France | 8928 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2,47E+12 | 0,52 | 1 | 1 | 2 | 2 | 4 | 6,67E+07 | 1 | 1 | 1 | 1 | 10,04 |
| Germany | 31577 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 3,47E+12 | 1,33 | 1 | 1 | 1 | 2 | 3 | 8,23E+07 | 1 | 1 | 1 | 1 | 4,12 |
| Greece | 6023 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 1,95E+11 | -0,24 | 2 | 3 | 2 | 2 | 5 | 1,08E+07 | 2 | 2 | 1 | 1 | 23,54 |
| Italy | 3670 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 1,88E+12 | 1,13 | 2 | 2 | 3 | 2 | 5 | 6,06E+07 | 1 | 1 | 1 | 1 | 11,69 |
| United Kingdom | 6692 | 2 | 3 | 1 | 1 | 1 | 1 | 2 | 2,69E+12 | 2,14 | 2 | 1 | 3 | 1 | 3 | 6,56E+07 | 1 | 1 | 1 | 1 | 4,81 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 15.

**Table 15** – Results of factor analysis of H2 2016.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 73.528 | 'Political' |
| | Political stability (PS) | | | |
| | Government effectiveness (GE) | | | |
| | Regulatory quality (RQ) | | | |
| | Rule of law (RoL) | | | |
| | Control of corruption (CoC) | | | |
| | Terrorism (T) | | | |
| Economic | Quality of overall infrastructure (QoI) | 0.000 | 66.576 | 'Quality of trade' |
| | Market size (Market) | | | 'Quality of trade' |
| | Trade openness (Trade) | | | 'Trade rights' |
| | Ease of doing business (EofB) | | | 'Quality of trade' |

| | | | | |
|---|---|---|---|---|
| | Strength of legal rights (Strength LR) | | | 'Trade rights' |
| Social | Civil liberties (CL) | 0.000 | 76.286 | 'Social' |
| | Political rights (PR) | | | |
| | Human Development Index (HDI) | | | |
| | Inequality (Inequa) | | | |

3- Conduct a PR-index:
After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H2 2016 is:
PR = $(\frac{1}{4})$ * Political + $(\frac{1}{4})$ * Quality of trade + $(\frac{1}{4})$ * Trade rights + $(\frac{1}{4})$ * Social
The resultant PR-index per country in the period H2 2016 can be seen in Table 16. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 16** – Results of factor analysis of H2 2016.

| Countries | Sales H2 2016 | PR-index |
|---|---|---|
| **Africa** | | |
| Benin | 2800 | 3.12 |
| Burkina Faso | 34733 | 2.98 |
| Cameroon | 45444 | 3.40 |
| Cote d'Ivoire | 8776 | 3.00 |
| DRC | 729 | 3.59 |
| Ethiopia | 265723 | 3.55 |
| Gambia | 576 | 3.47 |
| Ghana | 38496 | 2.53 |
| Kenya | 666881 | 2.97 |
| Liberia | 8421 | 2.81 |
| Madagascar | 20845 | 3.35 |
| Malawi | 20844 | 2.80 |
| Mali | 31184 | 3.26 |
| Mozambique | 8137 | 3.20 |
| Namibia | 2390 | 2.27 |
| Nigeria | 149414 | 3.35 |
| Rwanda | 89161 | 2.69 |
| Senegal | 33776 | 2.90 |

| | | |
|---|---|---|
| Sierra Leone | 21689 | 3.00 |
| Somalia | 11740 | 4.25 |
| South Africa | 1681 | 2.34 |
| Tanzania | 185073 | 3.07 |
| Togo | 296 | 2.87 |
| Uganda | 192695 | 3.30 |
| Zambia | 15268 | 2.70 |
| Zimbabwe | 13918 | 3.34 |
| **East Asia and Pacific** | | |
| Australia | 3037 | 1.52 |
| Cambodia | 2645 | 2.58 |
| Hong Kong | 1146 | 1.64 |
| Indonesia | 28576 | 2.66 |
| Japan | 291 | 1.85 |
| Myanmar | 21623 | 3.42 |
| Papua New Guinea | 20287 | 2.81 |
| Philippines | 4679 | 2.76 |
| Thailand | 530 | 2.65 |
| Vanuatu | 6104 | 1.83 |
| **South Asia** | | |
| Bangladesh | 14642 | 3.17 |
| India | 1378130 | 2.57 |
| Nepal | 26413 | 3.17 |
| Pakistan | 4937 | 3.55 |
| **Middle East and North Africa** | | |
| United Arab Emirates | 46897 | 2.49 |
| **Latin Ameria** | | |
| Colombia | 1403 | 2.56 |
| Haiti | 9189 | 3.72 |
| Mexico | 7423 | 2.32 |
| Panama | 1042 | 2.10 |
| Peru | 2742 | 2.49 |
| Puerto Rico | 0 | 1.61 |
| **North America** | | |
| United States | 13827 | 1.59 |
| **Europe and Central Asia** | | |
| France | 8928 | 1.90 |
| Germany | 31577 | 1.44 |
| Greece | 6023 | 2.55 |
| Italy | 3670 | 2.36 |
| United Kingdom | 6692 | 1.73 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.015. This means that there is a correlation between the sales of these systems

and the PR-index. There was also a correlation between the sales of SPSs and SHSs and the population of the countries included in the analysis of H2 2016.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:
- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:
- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.
- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.4 – Quantitative results of H1 2017

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 17 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 17** – Overview of political sub-factors in H1 2017.

| Countries | Sales H1 2017 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market | Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Angola | 272 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 1,22E+11 | 22,61 | | | 3 | 4 | 5 | 2,98E+07 | 4 | 4 | 3 | 2 | 7,10 |
| Benin | 15949 | 3 | 3 | 4 | 3 | 4 | 4 | 3 | 1,27E+10 | -0,37 | 4 | 4 | 2 | 3 | 3 | 1,12E+07 | 2 | 2 | 3 | 2 | 2,44 |
| Burkina Faso | 123945 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 1,41E+10 | 1,42 | | | 3 | 3 | 3 | 1,92E+07 | 3 | 2 | 3 | 2 | 5,13 |
| Cameroon | 30886 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3,50E+10 | 1,48 | 4 | 3 | 3 | 3 | 3 | 2,46E+07 | 4 | 4 | 3 | 2 | 3,41 |
| Cote d'Ivoire | 9533 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 5,16E+10 | -1,84 | | | 3 | 3 | 3 | 2,44E+07 | 3 | 3 | 3 | 2 | 3,27 |
| DRC | 46090 | 4 | 5 | 5 | 4 | 5 | 4 | 5 | 3,80E+10 | 43,07 | 4 | 3 | 2 | 4 | 3 | 8,14E+07 | 4 | 5 | 3 | 2 | 4,26 |
| Ethiopia | 210913 | 4 | 5 | 4 | 4 | 3 | 4 | 4 | 8,18E+10 | 6,68 | 3 | 3 | 4 | 3 | 4 | 1,06E+08 | 4 | 5 | 3 | 2 | 2,12 |
| Ghana | 25789 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 5,90E+10 | 10,35 | 3 | 3 | 2 | 3 | 3 | 2,91E+07 | 2 | 1 | 2 | 2 | 4,22 |
| Kenya | 413544 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 7,90E+10 | 10,94 | 2 | 3 | 4 | 2 | 3 | 5,02E+07 | 3 | 3 | 2 | 2 | 2,69 |
| Liberia | 15251 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,29E+09 | -2,18 | 4 | 4 | 1 | 3 | 1 | 4,70E+06 | 3 | 2 | 3 | 2 | 3,00 |
| Madagascar | 41700 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 1,32E+10 | 4,96 | 4 | 3 | 2 | 3 | 5 | 2,56E+07 | 3 | 2 | 3 | 2 | 1,73 |
| Malawi | 17598 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 6,30E+09 | 13,46 | 4 | 4 | 2 | 3 | 1 | 1,77E+07 | 2 | 2 | 3 | 2 | 5,70 |
| Mali | 30591 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,54E+10 | 1,93 | 4 | 3 | 3 | 3 | 3 | 1,85E+07 | 3 | 3 | 3 | 2 | 7,41 |
| Mozambique | 2655 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,32E+10 | 7,64 | 4 | 3 | 1 | 3 | 5 | 2,86E+07 | 3 | 3 | 3 | 2 | 3,31 |
| Namibia | 1798 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 1,27E+10 | 8,34 | 2 | 4 | 1 | 2 | 3 | 2,40E+06 | 2 | 2 | 2 | 2 | 21,57 |
| Niger | 2480 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 1,12E+10 | 0,84 | | | 4 | 3 | 3 | 2,16E+07 | 3 | 3 | 4 | 2 | 0,49 |
| Nigeria | 107999 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 3,76E+11 | 11,12 | 4 | 2 | 4 | 3 | 2 | 1,91E+08 | 3 | 2 | 3 | 2 | 8,39 |
| Rwanda | 190781 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 9,25E+09 | 8,08 | 2 | 4 | 3 | 2 | 1 | 1,20E+07 | 4 | 4 | 3 | 2 | 1,06 |
| Senegal | 67503 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,10E+10 | 0,60 | 3 | 3 | 3 | 3 | 3 | 1,54E+07 | 2 | 2 | 3 | 2 | 6,61 |
| Sierra Leone | 14397 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,74E+09 | 14,64 | 4 | 4 | 2 | 3 | 3 | 7,49E+06 | 2 | 2 | 3 | 2 | 4,50 |
| Somalia | 12856 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 1 | 5 | 5 | 1,46E+07 | 5 | 5 | | | 13,02 |
| South Africa | 34866 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3,50E+11 | 5,27 | 3 | 2 | 3 | 2 | 3 | 5,70E+07 | 2 | 2 | 2 | 2 | 27,04 |
| Tanzania | 69143 | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 5,33E+10 | 2,70 | 3 | 3 | 4 | 3 | 3 | 5,47E+07 | 3 | 2 | 3 | 2 | 2,03 |
| Togo | 2668 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4,82E+09 | 0,86 | | | 2 | 3 | 3 | 7,70E+06 | 3 | 3 | 3 | 2 | 3,74 |
| Uganda | 240151 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3,08E+10 | 4,41 | 3 | 3 | 4 | 3 | 3 | 4,12E+07 | 3 | 4 | 3 | 1 | 1,79 |
| Zambia | 16483 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 2,59E+10 | 10,10 | 3 | 3 | 2 | 2 | 1 | 1,69E+07 | 3 | 3 | 3 | 2 | 11,63 |
| Zimbabwe | 3749 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 2,20E+10 | 2,44 | 3 | 4 | 3 | 3 | 3 | 1,42E+07 | 3 | 3 | 3 | 2 | 5,15 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| Australia | 5031 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1,33E+12 | 3,73 | 2 | 2 | 3 | 1 | 1 | 2,46E+07 | 1 | 1 | 1 | 1 | 5,59 |
| China | 19177 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 1,23E+13 | 4,23 | 2 | 1 | 4 | 2 | 4 | 1,39E+09 | 4 | 5 | 2 | 1 | 4,40 |
| Fiji | 13054 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 5,35E+09 | 1,70 | | | 1 | 2 | 3 | 8,77E+05 | 3 | 2 | 2 | 1 | 4,24 |
| Hong Kong | 1585 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 3,41E+11 | 2,88 | 1 | 2 | 1 | 1 | 2 | 7,39E+06 | 2 | 3 | 1 | 1 | 3,09 |
| Indonesia | 64613 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 1,02E+12 | 4,29 | 3 | 1 | 4 | 2 | 3 | 2,65E+08 | 3 | 2 | 2 | 1 | 3,88 |
| Japan | 1350 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 4,87E+12 | -0,23 | 1 | 1 | 4 | 2 | 3 | 1,27E+08 | 1 | 1 | 1 | | 2,80 |
| Myanmar | 12983 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 6,89E+10 | 5,45 | | | 2 | 3 | 5 | 5,34E+07 | 3 | 3 | 3 | 1 | 1,56 |
| Papua New Guinea | 18349 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,27E+10 | 7,70 | | | | 3 | 2 | 8,44E+06 | 2 | 2 | 3 | | 2,47 |
| Philippines | 55197 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 3,28E+11 | 2,32 | 3 | 2 | 2 | 3 | 5 | 1,05E+08 | 2 | 2 | 2 | 1 | 2,55 |
| Samoa | 3118 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 8,32E+08 | -0,05 | | | 2 | 2 | 2 | 1,95E+05 | 2 | 2 | 2 | | 8,44 |
| Thailand | 1244 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 4,56E+11 | 1,98 | 3 | 2 | 1 | 2 | 3 | 6,92E+07 | 3 | 4 | 2 | 1 | 0,83 |
| Vanuatu | 7983 | 2 | 2 | 4 | 3 | 3 | 3 | 1 | 8,80E+08 | 4,15 | | | | 2 | 1 | 2,86E+05 | 2 | 2 | 2 | 1 | 1,75 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 21707 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,50E+11 | 6,28 | 3 | 2 | 4 | 3 | 3 | 1,60E+08 | 3 | 3 | 2 | 2 | 4,37 |
| India | 1087282 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,65E+12 | 3,78 | 2 | 1 | 3 | 2 | 2 | 1,34E+09 | 2 | 2 | 2 | 2 | 5,41 |
| Nepal | 5890 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,52E+10 | 9,68 | 3 | 3 | 3 | 3 | 1 | 2,76E+07 | 3 | 2 | 3 | 2 | 2,97 |
| Pakistan | 38433 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 3,05E+11 | 4,01 | 3 | 2 | 4 | 3 | 5 | 2,08E+08 | 3 | 3 | 3 | 2 | 3,94 |
| **Middle East and North Africa** | | | | | | | | | | | | | | | | | | | | | |
| Iraq | 27016 | 4 | 5 | 4 | 4 | 5 | 4 | 5 | 1,95E+11 | 14,62 | | | 2 | 3 | 5 | 3,76E+07 | 4 | 3 | 2 | 2 | 13,02 |
| Lebanon | 1710 | 4 | 1 | 4 | 3 | 4 | 4 | 5 | 5,31E+10 | 2,90 | 4 | 3 | 2 | 3 | 5 | 6,81E+06 | 3 | 3 | 2 | | 6,18 |
| United Arab Emirates | 8686 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 3,86E+11 | 5,50 | 1 | 2 | 1 | 2 | 5 | 9,49E+06 | 4 | 4 | 1 | | 2,46 |
| **Latin Ameria** | | | | | | | | | | | | | | | | | | | | | |
| Bolivia | 5300 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 3,75E+10 | 6,06 | | | 3 | 3 | 5 | 1,12E+07 | 2 | 2 | 2 | 2 | 3,66 |
| Colombia | 841 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 3,12E+11 | 5,13 | 3 | 2 | 4 | 2 | 1 | 4,89E+07 | 2 | 2 | 2 | 2 | 8,87 |
| Haiti | 9200 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 1,42E+10 | 10,09 | 4 | 4 | 3 | 4 | 5 | 1,10E+07 | 3 | 3 | 3 | 2 | 13,72 |
| Panama | 2250 | 2 | 3 | 3 | 3 | 3 | 4 | 2 | 6,22E+10 | 1,75 | 2 | 3 | 1 | 2 | 2 | 4,11E+06 | 2 | 2 | 1 | 2 | 3,90 |
| Peru | 2221 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,11E+11 | 3,62 | 3 | 2 | 3 | 2 | 3 | 3,14E+07 | 2 | 2 | 2 | 1 | 3,35 |
| **North America** | | | | | | | | | | | | | | | | | | | | | |
| Canada | 375 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1,65E+12 | 2,46 | 2 | 2 | 2 | 2 | 2 | 3,65E+07 | 1 | 1 | 1 | 1 | 6,34 |
| United States | 9898 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 1,95E+13 | 1,88 | 1 | 1 | 4 | 1 | 1 | 3,25E+08 | 1 | 1 | 1 | 1 | 4,36 |
| **Europe and Central Asia** | | | | | | | | | | | | | | | | | | | | | |
| Denmark | 4665 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 3,32E+11 | 1,18 | 1 | 3 | 1 | 1 | 2 | 5,76E+06 | 1 | 1 | 1 | 1 | 5,83 |
| France | 1076 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2,60E+12 | 0,52 | 1 | 1 | 2 | 2 | 4 | 6,69E+07 | 2 | 1 | 1 | 1 | 9,41 |
| Germany | 11224 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 3,68E+12 | 1,35 | 1 | 1 | 1 | 2 | 3 | 8,27E+07 | 1 | 1 | 1 | 1 | 3,75 |
| Greece | 8767 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2,04E+11 | 0,60 | 2 | 3 | 2 | 2 | 5 | 1,08E+07 | 2 | 2 | 1 | 1 | 21,49 |
| Italy | 7141 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 1,96E+12 | 0,73 | 2 | 2 | 3 | 2 | 5 | 6,05E+07 | 1 | 1 | 1 | 1 | 11,21 |
| United Kingdom | 2952 | 2 | 3 | 2 | 1 | 1 | 1 | 3 | 2,67E+12 | 1,89 | 2 | 1 | 2 | 1 | 3 | 6,61E+07 | 1 | 1 | 1 | 1 | 4,33 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 18.

**Table 18** – Results of factor analysis of H1 2017.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 74.611 | 'Political' |
| | Political stability (PS) | | | |
| | Government effectiveness (GE) | | | |
| | Regulatory quality (RQ) | | | |
| | Rule of law (RoL) | | | |
| | Control of corruption (CoC) | | | |
| | Terrorism (T) | | | |
| Economic | Quality of overall infrastructure (QoI) | 0.000 | 89.946 | 'Internal market' |
| | Market size (Market) | | | 'Internal market' |
| | Trade openness (Trade) | | | 'Trade openness' |
| | Ease of doing business (EofB) | | | 'Internal market' |

| | | | | |
|---|---|---|---|---|
| | Strength of legal rights (Strength LR) | | | 'Strength of legal rights' |
| Social | Civil liberties (CL) | 0.000 | 69.214 | 'Social' |
| | Political rights (PR) | | | |
| | Human Development Index (HDI) | | | |
| | Inequality (Inequa) | | | |

3- Conduct a PR-index:
After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H1 2017 is:
PR = $(\frac{1}{5})$ * Political + $(\frac{1}{5})$ * Internal Market + $(\frac{1}{5})$ * Trade openness + $(\frac{1}{5})$ * Strength of legal rights + $(\frac{1}{5})$ * Social
The resultant PR-index per country in the period H1 2017 can be seen in Table 19. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 19** – PR-index overview of H1 2017.

| Countries | Sales H1 2017 | PR-index |
|---|---|---|
| **Africa** | | |
| Angola | 272 | 3.82 |
| Benin | 15949 | 2.87 |
| Burkina Faso | 123945 | 2.99 |
| Cameroon | 30886 | 3.32 |
| Cote d'Ivoire | 9533 | 3.09 |
| DRC | 46090 | 3.35 |
| Ethiopia | 210913 | 3.70 |
| Ghana | 25789 | 2.49 |
| Kenya | 413544 | 3.05 |
| Liberia | 15251 | 2.35 |
| Madagascar | 41700 | 3.31 |
| Malawi | 17598 | 2.44 |
| Mali | 30591 | 3.25 |
| Mozambique | 2655 | 3.16 |
| Namibia | 1798 | 2.22 |
| Niger | 2480 | 3.37 |
| Nigeria | 107999 | 3.13 |
| Rwanda | 190781 | 2.55 |

| | | |
|---|---|---|
| Senegal | 67503 | 2.85 |
| Sierra Leone | 14397 | 2.90 |
| Somalia | 12856 | 4.20 |
| South Africa | 34866 | 2.64 |
| Tanzania | 69143 | 3.19 |
| Togo | 2668 | 2.92 |
| Uganda | 240151 | 3.29 |
| Zambia | 16483 | 2.34 |
| Zimbabwe | 3749 | 3.25 |
| **East Asia and Pacific** | | |
| Australia | 5031 | 1.62 |
| China | 19177 | 3.16 |
| Fiji | 13054 | 2.14 |
| Hong Kong | 1585 | 1.53 |
| Indonesia | 64613 | 2.83 |
| Japan | 1350 | 2.18 |
| Myanmar | 12983 | 3.27 |
| Papua New Guinea | 18349 | 2.76 |
| Philippines | 55197 | 2.94 |
| Samoa | 3118 | 2.03 |
| Thailand | 1244 | 2.40 |
| Vanuatu | 7983 | 1.83 |
| **South Asia** | | |
| Bangladesh | 21707 | 3.23 |
| India | 1087282 | 2.39 |
| Nepal | 5890 | 2.64 |
| Pakistan | 38433 | 3.74 |
| **Middle East and North Africa** | | |
| Iraq | 27016 | 3.44 |
| Lebanon | 1710 | 3.31 |
| United Arab Emirates | 8686 | 2.59 |
| **Latin America** | | |
| Bolivia | 5300 | 3.29 |
| Colombia | 841 | 2.52 |
| Haiti | 9200 | 3.78 |
| Panama | 2250 | 1.99 |
| Peru | 2221 | 2.62 |
| **North America** | | |
| Canada | 375 | 1.69 |
| United States | 9898 | 1.77 |
| **Europe and Central Asia** | | |
| Denmark | 4665 | 1.39 |
| France | 1076 | 2.17 |
| Germany | 11224 | 1.58 |
| Greece | 8767 | 2.74 |
| Italy | 7141 | 2.69 |
| United Kingdom | 2952 | 1.84 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.006, with a correlation coefficient of 0.352. This means that there is a positive correlation between the sales of these systems and the PR-index. There also is a correlation between the sales of SPSs and SHSs and the population of the countries included in the analysis of H1 2017.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:
- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:
- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.
- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.5 – Quantitative results of H2 2017

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:

Table 20 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 20** – Overview of political sub-factors in H2 2017.

| Countries | Sales H2 2017 | V&A | PS | GE | RQ | ROL | CoC | I | GDP | Infla | QoI | Market | Trade | EoIB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Benin | 10841 | 3 | 3 | 4 | 3 | 4 | 4 | 3 | 1,27E+10 | -0,37 | 4 | 4 | 2 | 3 | 3 | 1,12E+07 | 2 | 2 | 3 | 2 | 2,44 |
| Burkina Faso | 46581 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 1,41E+10 | 1,42 | | | 3 | 3 | 3 | 1,92E+07 | 3 | 2 | 3 | 2 | 5,13 |
| Cameroon | 1967 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3,50E+10 | 1,48 | 4 | 3 | 3 | 3 | 3 | 2,46E+07 | 4 | 4 | 3 | 2 | 3,41 |
| Cote d'Ivoire | 15360 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 5,16E+10 | -1,84 | | | 3 | 3 | 3 | 2,44E+07 | 3 | 3 | 3 | 2 | 3,27 |
| DRC | 242271 | 4 | 5 | 5 | 4 | 5 | 4 | 5 | 3,80E+10 | 43,07 | 4 | 3 | 2 | 4 | 3 | 8,14E+07 | 4 | 5 | 3 | 2 | 4,26 |
| Ethiopia | 158634 | 4 | 5 | 4 | 4 | 3 | 4 | 4 | 8,18E+10 | 6,68 | 3 | 3 | 4 | 3 | 4 | 1,06E+08 | 4 | 5 | 3 | 2 | 2,12 |
| Ghana | 37863 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 5,90E+10 | 10,35 | 3 | 3 | 2 | 3 | 3 | 2,91E+07 | 2 | 1 | 2 | 2 | 4,22 |
| Kenya | 502099 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 7,90E+10 | 10,94 | 2 | 3 | 4 | 2 | 3 | 5,02E+07 | 3 | 3 | 3 | 2 | 2,69 |
| Liberia | 13384 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,29E+09 | -2,18 | 4 | 4 | 1 | 3 | 1 | 4,70E+06 | 3 | 2 | 3 | 2 | 3,00 |
| Madagascar | 43950 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 1,32E+10 | 4,96 | 4 | 3 | 2 | 3 | 5 | 2,56E+07 | 3 | 2 | 3 | 2 | 1,73 |
| Malawi | 125640 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 6,30E+09 | 13,46 | 4 | 4 | 2 | 3 | 1 | 1,77E+07 | 2 | 2 | 3 | 2 | 5,70 |
| Mali | 42620 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,54E+10 | 1,93 | 4 | 3 | 3 | 3 | 3 | 1,85E+07 | 3 | 3 | 3 | 2 | 7,41 |
| Mozambique | 10523 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,32E+10 | 7,64 | 4 | 3 | 1 | 3 | 5 | 2,86E+07 | 3 | 3 | 3 | 2 | 3,31 |
| Namibia | 4372 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 1,27E+10 | 8,34 | 2 | 4 | 1 | 2 | 3 | 2,40E+06 | 2 | 2 | 2 | 2 | 21,57 |
| Niger | 1160 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 1,12E+10 | 0,84 | | | 4 | 3 | 3 | 2,16E+07 | 3 | 3 | 4 | 2 | 0,49 |
| Nigeria | 107576 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 3,76E+11 | 11,12 | 4 | 2 | 4 | 3 | 2 | 1,91E+08 | 3 | 2 | 3 | 2 | 8,39 |
| Rwanda | 80529 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 9,25E+09 | 8,08 | 2 | 4 | 3 | 2 | 1 | 1,20E+07 | 4 | 4 | 3 | 2 | 1,06 |
| Senegal | 17883 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,10E+10 | 0,60 | 3 | 3 | 3 | 3 | 3 | 1,54E+07 | 2 | 2 | 3 | 2 | 6,61 |
| Sierra Leone | 19074 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,74E+09 | 14,64 | 4 | 4 | 2 | 3 | 3 | 7,49E+06 | 2 | 2 | 3 | 2 | 4,50 |
| Somalia | 13972 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 1 | 5 | 5 | 1,46E+07 | 5 | 5 | | | 13,02 |
| South Africa | 18589 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3,50E+11 | 5,27 | 3 | 2 | 3 | 2 | 3 | 5,70E+07 | 2 | 2 | 2 | 2 | 27,04 |
| Tanzania | 103299 | 3 | 4 | 4 | 4 | 3 | 3 | 3 | 5,33E+10 | 2,70 | 3 | 3 | 4 | 3 | 3 | 5,47E+07 | 3 | 2 | 3 | 2 | 2,03 |
| Togo | 1920 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4,82E+09 | 0,86 | | | 2 | 3 | 3 | 7,70E+06 | 3 | 3 | 3 | 2 | 3,74 |
| Uganda | 224074 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3,08E+10 | 4,41 | 3 | 3 | 4 | 3 | 3 | 4,12E+07 | 3 | 4 | 3 | 1 | 1,79 |
| Zambia | 21268 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 2,59E+10 | 10,10 | 3 | 3 | 2 | 2 | 1 | 1,69E+07 | 3 | 3 | 3 | 2 | 11,63 |
| Zimbabwe | 8398 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 2,20E+10 | 2,44 | 3 | 4 | 3 | 3 | 3 | 1,42E+07 | 3 | 3 | 3 | 2 | 5,15 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| Australia | 7024 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1,33E+12 | 3,73 | 2 | 2 | 3 | 1 | 1 | 2,46E+07 | 1 | 1 | 1 | 1 | 5,59 |
| China | 9829 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 1,23E+13 | 4,23 | 2 | 1 | 4 | 2 | 4 | 1,39E+09 | 4 | 5 | 2 | 1 | 4,40 |
| Fiji | 5100 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 5,35E+09 | 1,70 | | | 1 | 2 | 3 | 8,77E+05 | 3 | 2 | 2 | | 4,24 |
| Hong Kong | 2024 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 3,41E+11 | 2,88 | 1 | 2 | 1 | 1 | 2 | 7,39E+06 | 2 | 3 | 1 | 1 | 3,09 |
| Indonesia | 100650 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 1,02E+12 | 4,29 | 3 | 1 | 4 | 2 | 3 | 2,65E+08 | 3 | 2 | 2 | 1 | 3,88 |
| Japan | 2409 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 4,87E+12 | -0,23 | 1 | 1 | 4 | 2 | 3 | 1,27E+08 | 1 | 1 | 1 | | 2,80 |
| Myanmar | 4343 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 6,89E+10 | 5,45 | | | 2 | 3 | 5 | 5,34E+07 | 3 | 3 | 3 | 1 | 1,56 |
| Papua New Guinea | 16410 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,27E+10 | 7,70 | | | | 3 | 2 | 8,44E+06 | 2 | 2 | 3 | | 2,47 |
| Philippines | 6163 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 3,28E+11 | 2,32 | 3 | 2 | 2 | 3 | 5 | 1,05E+08 | 2 | 2 | 2 | 1 | 2,55 |
| Thailand | 1959 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 4,56E+11 | 1,98 | 3 | 2 | 1 | 2 | 3 | 6,92E+07 | 3 | 4 | 2 | 1 | 0,83 |
| Vanuatu | 7840 | 2 | 2 | 4 | 3 | 3 | 3 | 1 | 8,80E+08 | 4,15 | | | | 2 | 1 | 2,86E+05 | 2 | 2 | 2 | 1 | 1,75 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 119050 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,50E+11 | 6,28 | 3 | 2 | 4 | 3 | 3 | 1,60E+08 | 3 | 3 | 2 | 2 | 4,37 |
| India | 1255174 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,65E+12 | 3,78 | 2 | 1 | 3 | 2 | 2 | 1,34E+09 | 2 | 2 | 2 | 2 | 5,41 |
| Nepal | 4067 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,52E+10 | 9,68 | 3 | 3 | 3 | 3 | 1 | 2,76E+07 | 3 | 2 | 3 | 2 | 2,97 |
| Pakistan | 6733 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 3,05E+11 | 4,01 | 3 | 2 | 4 | 3 | 5 | 2,08E+08 | 3 | 3 | 3 | 2 | 3,94 |
| **Middle East and North Africa** | | | | | | | | | | | | | | | | | | | | | |
| Lebanon | 1590 | 4 | 1 | 4 | 3 | 4 | 4 | 5 | 5,31E+10 | 2,9 | 4 | 3 | 2 | 3 | 5 | 6,81E+06 | 3 | 3 | 2 | | 6,18 |
| United Arab Emirates | 40162 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 3,86E+11 | 5,50 | 1 | 2 | 1 | 2 | 5 | 9,49E+06 | 4 | 4 | 1 | | 2,46 |
| **Latin Ameria** | | | | | | | | | | | | | | | | | | | | | |
| Bolivia | 2357 | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 3,75E+10 | 6,06 | | | 3 | 3 | 5 | 1,12E+07 | 2 | 2 | 2 | 2 | 3,66 |
| Colombia | 279 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 3,12E+11 | 5,13 | 3 | 2 | 4 | 2 | 1 | 4,89E+07 | 2 | 2 | 2 | 2 | 8,87 |
| Guatemala | 644 | 3 | 4 | 4 | 3 | 4 | 4 | 3 | 7,16E+10 | 1,74 | 3 | 3 | 3 | 2 | 2 | 1,61E+07 | 3 | 3 | 2 | 2 | 2,46 |
| Haiti | 2740 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 1,42E+10 | 10,09 | 4 | 4 | 3 | 4 | 5 | 1,10E+07 | 3 | 3 | 3 | 2 | 13,72 |
| Peru | 2661 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,11E+11 | 3,62 | 3 | 2 | 3 | 2 | 3 | 3,14E+07 | 2 | 2 | 2 | 1 | 3,35 |
| Puerto Rico | 2841 | 3 | 3 | 3 | 2 | 2 | 3 | | 1,03E+11 | 2,09 | | | 1 | 2 | 1 | 3,33E+06 | | | | | 10,80 |
| **North America** | | | | | | | | | | | | | | | | | | | | | |
| United States | 36033 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 1,95E+13 | 1,88 | 1 | 1 | 4 | 1 | 1 | 3,25E+08 | 1 | 1 | 1 | 1 | 4,36 |
| **Europe and Central Asia** | | | | | | | | | | | | | | | | | | | | | |
| Belgium | 7666 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 5,03E+11 | 1,83 | 2 | 2 | 1 | 2 | 4 | 2,21E+06 | 1 | 1 | 1 | 1 | 7,09 |
| Denmark | 4792 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 3,32E+11 | 1,18 | 1 | 3 | 1 | 1 | 2 | 5,76E+06 | 1 | 1 | 1 | 1 | 5,83 |
| France | 11046 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2,60E+12 | 0,52 | 1 | 1 | 2 | 2 | 4 | 6,69E+07 | 2 | 1 | 1 | 1 | 9,41 |
| Germany | 36098 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 3,68E+12 | 1,35 | 1 | 1 | 1 | 2 | 3 | 8,27E+07 | 1 | 1 | 1 | 1 | 3,75 |
| Greece | 11510 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2,04E+11 | 0,60 | 2 | 3 | 2 | 2 | 5 | 1,08E+07 | 2 | 2 | 1 | 1 | 21,49 |
| Ireland | 437 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 3,36E+11 | 1,13 | 2 | 2 | 1 | 1 | 3 | 4,81E+06 | 1 | 1 | 1 | 1 | 6,71 |
| Italy | 1612 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 1,96E+12 | 0,73 | 2 | 2 | 3 | 2 | 5 | 6,05E+07 | 1 | 1 | 1 | 1 | 11,21 |
| Norway | 4699 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3,98E+11 | 3,95 | 2 | 2 | 2 | 1 | 3 | 5,28E+06 | 1 | 1 | 1 | 1 | 4,16 |
| Sweden | 62 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 5,41E+11 | 2,14 | 1 | 2 | 1 | 1 | 3 | 1,01E+07 | 1 | 1 | 1 | 1 | 6,72 |
| United Kingdom | 9091 | 2 | 3 | 2 | 1 | 1 | 1 | 3 | 2,67E+12 | 1,89 | 2 | 1 | 2 | 1 | 3 | 6,61E+07 | 1 | 1 | 1 | 1 | 4,33 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 21.

**Table 21** – Results of factor analysis of H2 2017.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 76.617 | 'Political' |
| | Political stability (PS) | | | |
| | Government effectiveness (GE) | | | |
| | Regulatory quality (RQ) | | | |
| | Rule of law (RoL) | | | |
| | Control of corruption (CoC) | | | |
| | Terrorism (T) | | | |
| Economic | Quality of overall infrastructure (QoI) | 0.000 | 90.176 | 'Internal market' |
| | Market size (Market) | | | 'Internal market' |
| | Trade openness (Trade) | | | 'Trade openness' |
| | Ease of doing business (EofB) | | | 'Internal market' |

| | | | | |
|---|---|---|---|---|
| | Strength of legal rights (Strength LR) | | | 'Strength of legal rights' |
| Social | Civil liberties (CL) | 0.000 | 73.883 | 'Social' |
| | Political rights (PR) | | | |
| | Human Development Index (HDI) | | | |
| | Inequality (Inequa) | | | |

3- Conduct a PR-index:

After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H2 2017 is:

PR = $(\frac{1}{5})$ * Political + $(\frac{1}{5})$ * Internal Market + $(\frac{1}{5})$ * Trade openness + $(\frac{1}{5})$ * Strength of legal rights + $(\frac{1}{5})$ * Social

The resultant PR-index per country in the period H2 2017 can be seen in Table 22. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 22** – PR-index overview of H2 2017.

| Countries | Sales H2 2017 | PR-index |
|---|---|---|
| **Africa** | | |
| Benin | 10841 | 2.87 |
| Burkina Faso | 46581 | 2.99 |
| Cameroon | 1967 | 3.32 |
| Cote d'Ivoire | 15360 | 3.09 |
| DRC | 242271 | 3.35 |
| Ethiopia | 158634 | 3.70 |
| Ghana | 37863 | 2.49 |
| Kenya | 502099 | 3.10 |
| Liberia | 13384 | 2.35 |
| Madagascar | 43950 | 3.31 |
| Malawi | 125640 | 2.44 |
| Mali | 42620 | 3.25 |
| Mozambique | 10523 | 3.16 |
| Namibia | 4372 | 2.22 |
| Niger | 1160 | 3.37 |
| Nigeria | 107576 | 3.13 |
| Rwanda | 80529 | 2.55 |

| | | |
|---|---|---|
| Senegal | 17883 | 2.85 |
| Sierra Leone | 19074 | 2.90 |
| Somalia | 13972 | 4.20 |
| South Africa | 18589 | 2.64 |
| Tanzania | 103299 | 3.19 |
| Togo | 1920 | 2.92 |
| Uganda | 224074 | 3.29 |
| Zambia | 21268 | 2.34 |
| Zimbabwe | 8398 | 3.25 |
| **East Asia and Pacific** | | |
| Australia | 7024 | 1.62 |
| China | 9829 | 3.16 |
| Fiji | 5100 | 2.21 |
| Hong Kong | 2024 | 1.53 |
| Indonesia | 100650 | 2.83 |
| Japan | 2409 | 2.18 |
| Myanmar | 4343 | 3.27 |
| Papua New Guinea | 16410 | 2.76 |
| Philippines | 6163 | 2.94 |
| Thailand | 1959 | 2.40 |
| Vanuatu | 7840 | 1.83 |
| **South Asia** | | |
| Bangladesh | 119050 | 3.23 |
| India | 1255174 | 2.39 |
| Nepal | 4067 | 2.64 |
| Pakistan | 6733 | 3.74 |
| **Middle East and North Africa** | | |
| Lebanon | 1590 | 3.31 |
| United Arab Emirates | 40162 | 2.59 |
| **Latin America** | | |
| Bolivia | 2357 | 3.29 |
| Colombia | 279 | 2.52 |
| Guatemala | 644 | 2.75 |
| Haiti | 2740 | 3.78 |
| Peru | 2661 | 2.62 |
| Puerto Rico | 2841 | 1.67 |
| **North America** | | |
| United States | 36033 | 1.77 |
| **Europe and Central Asia** | | |
| Belgium | 7666 | 2.06 |
| Denmark | 4792 | 1.39 |
| France | 11046 | 2.17 |
| Germany | 36098 | 1.58 |
| Greece | 11510 | 2.74 |
| Ireland | 437 | 1.68 |
| Italy | 1612 | 2.69 |

| | | |
|---|---|---|
| Norway | 4699 | 1.76 |
| Sweden | 62 | 1.52 |
| United Kingdom | 9091 | 1.84 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.112. This means that there is no correlation between the sales of these systems and the PR-index. There was a correlation between the sales of SPSs and SHSs and the inflation rate and population within the countries included in the analysis of H2 2017.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:
- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:
- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.
- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.6 – Quantitative results of H1 2018

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 23 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 23** – Overview of political sub-factors in H1 2018.

| Countries | Sales H1 2018 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market | Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Benin | 5733 | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 1,43E+10 | 0,59 | 4 | 4 | 2 | 3 | 3 | 1,15E+07 | 2 | 2 | 3 | 2 | 2,37 |
| Burkina Faso | 22809 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 1,61E+10 | 2,03 | 4 | 4 | 2 | 3 | 3 | 1,98E+07 | 2 | 3 | 3 | 2 | 4,70 |
| Cameroon | 49715 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3,87E+10 | 1,60 | 4 | 3 | 3 | 3 | 3 | 2,52E+07 | 4 | 4 | 3 | 2 | 3,36 |
| Cote d'Ivoire | 17446 | 3 | 4 | 4 | 3 | 4 | 3 | 4 | 5,80E+10 | 0,63 | 4 | 3 | 3 | 3 | 3 | 2,51E+07 | 3 | 3 | 3 | 2 | 3,21 |
| DRC | 11197 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4,68E+10 | 28,97 | 4 | 3 | 2 | 4 | 3 | 8,41E+07 | 4 | 5 | 3 | 2 | 4,18 |
| Ethiopia | 147647 | 4 | 4 | 4 | 4 | 3 | 3 | 5 | 8,43E+10 | 12,38 | 4 | 3 | 4 | 3 | 4 | 1,09E+08 | 4 | 5 | 3 | 2 | 2,07 |
| Ghana | 26160 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 6,56E+10 | 10,21 | 4 | 3 | 2 | 2 | 3 | 2,98E+07 | 2 | 1 | 2 | 2 | 4,16 |
| Kenya | 519154 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 8,78E+10 | 2,42 | 3 | 3 | 4 | 2 | 1 | 5,14E+07 | 3 | 3 | 2 | 2 | 2,64 |
| Libera | 11517 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,26E+09 | -1,85 | 4 | 4 | 1 | 3 | 1 | 4,82E+06 | 2 | 2 | 3 | 2 | 2,94 |
| Madagascar | 27355 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,39E+10 | 7,58 | | | 2 | 3 | 5 | 2,63E+07 | 3 | 2 | 3 | 2 | 1,69 |
| Malawi | 22772 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 6,92E+09 | 6,67 | 4 | 4 | 2 | 2 | 1 | 1,81E+07 | 2 | 2 | 3 | 2 | 5,62 |
| Mali | 16448 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,71E+10 | 1,46 | 4 | 4 | 2 | 3 | 3 | 1,91E+07 | 3 | 3 | 3 | 2 | 7,31 |
| Mozambique | 9536 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,48E+10 | 3,00 | 4 | 3 | 1 | 3 | 5 | 2,95E+07 | 3 | 3 | 3 | 2 | 3,24 |
| Namibia | 4218 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1,35E+10 | 4,30 | 3 | 4 | 1 | 2 | 3 | 2,45E+06 | 2 | 2 | 2 | 2 | 19,88 |
| Niger | 3955 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1,28E+10 | 2,43 | | | 4 | 3 | 3 | 2,24E+07 | 3 | 3 | 4 | 2 | 0,47 |
| Nigeria | 153112 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 3,97E+11 | 10,23 | 4 | 2 | 4 | 3 | 2 | 1,96E+08 | 3 | 2 | 3 | 2 | 8,45 |
| Rwanda | 47741 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 9,64E+09 | -0,67 | 3 | 4 | 3 | 2 | 1 | 1,23E+07 | 4 | 4 | 3 | 2 | 1,02 |
| Senegal | 31335 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,32E+10 | -0,49 | 4 | 3 | 2 | 3 | 3 | 1,59E+07 | 2 | 2 | 3 | 2 | 6,53 |
| Sierra Leone | 17990 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 4,09E+09 | 13,43 | 4 | 4 | 3 | 3 | 3 | 7,65E+06 | 2 | 2 | 3 | 2 | 4,42 |
| Somalia | 22049 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 1 | 4 | 5 | 1,50E+07 | 5 | 5 | | | 12,89 |
| South Africa | 13848 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3,68E+11 | 3,92 | 3 | 2 | 3 | 2 | 3 | 5,78E+07 | 2 | 2 | 2 | 2 | 26,91 |
| Tanzania | 103695 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 5,80E+10 | 4,78 | 4 | 3 | | 3 | 3 | 5,63E+07 | 3 | 3 | 3 | 2 | 1,99 |
| Togo | 4505 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5,36E+09 | 1,46 | | | 2 | 3 | 3 | 7,89E+06 | 3 | 3 | 3 | 2 | 3,66 |
| Uganda | 173556 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3,29E+10 | 4,54 | 4 | 3 | 4 | 3 | 3 | 4,27E+07 | 3 | 4 | 3 | 2 | 1,75 |
| Zambia | 37978 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 2,63E+10 | 7,41 | 3 | 3 | 2 | 2 | 1 | 1,74E+07 | 3 | 3 | 3 | 2 | 12,01 |
| Zimbabwe | 21583 | 4 | 4 | 4 | 5 | 4 | 4 | 3 | 2,43E+10 | 5,22 | 4 | 4 | 3 | 3 | 3 | 1,44E+07 | 3 | 4 | 3 | 2 | 5,07 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| China | 7552 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 1,39E+13 | 3,50 | 2 | 1 | 4 | 2 | 4 | 1,39E+09 | 4 | 5 | 2 | 1 | 4,30 |
| Fiji | 13621 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 5,58E+09 | 1,43 | | | 1 | 2 | 3 | 8,83E+05 | 2 | 2 | 2 | | 4,16 |
| Hong Kong | 5024 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 3,62E+11 | 3,66 | 1 | 2 | 1 | 1 | 2 | 7,45E+06 | 2 | 3 | 1 | 1 | 3,04 |
| Indonesia | 26289 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 1,04E+12 | 3,82 | 3 | 1 | 3 | 2 | 3 | 2,68E+08 | 3 | 2 | 2 | 1 | 4,40 |
| Japan | 1667 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 4,95E+12 | -0,10 | 1 | 1 | 4 | 2 | 3 | 1,27E+08 | 1 | 1 | 1 | 1 | 2,40 |
| Myanmar | 71746 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 7,62E+10 | 6,27 | | | 2 | 3 | 5 | 5,37E+07 | 3 | 3 | 3 | 2 | 0,87 |
| Papua New Guinea | 36908 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,41E+10 | 9,80 | | | | 3 | 2 | 8,61E+06 | 2 | 2 | 3 | | 2,41 |
| Philippines | 24855 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 3,47E+11 | 3,74 | 4 | 2 | 2 | 2 | 5 | 1,07E+08 | 2 | 2 | 2 | 1 | 2,34 |
| Singapore | 645 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 3,73E+11 | 3,09 | 1 | 2 | 1 | 1 | 2 | 5,64E+06 | 3 | 3 | 1 | 1 | 3,65 |
| Thailand | 2673 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 5,07E+11 | 1,46 | 3 | 2 | 1 | 2 | 3 | 6,94E+07 | 3 | 4 | 2 | 1 | 0,77 |
| Vanuatu | 9729 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 9,15E+08 | 3,21 | | | | 2 | 1 | 2,93E+05 | 2 | 2 | 2 | | 1,72 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 85426 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,74E+11 | 5,60 | 4 | 2 | 4 | 3 | 3 | 1,61E+08 | 3 | 3 | 2 | 2 | 4,29 |
| India | 1219589 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,71E+12 | 4,56 | 2 | 1 | 3 | 2 | 2 | 1,35E+09 | 2 | 2 | 2 | 2 | 5,33 |
| Nepal | 2243 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 2,92E+10 | 6,70 | 4 | 3 | 3 | 3 | 1 | 2,81E+07 | 3 | 2 | 2 | 2 | 2,90 |
| Pakistan | 13044 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 3,15E+11 | 2,46 | 3 | 2 | 4 | 3 | 5 | 2,12E+08 | 3 | 3 | 3 | 2 | 4,08 |
| **Middle East and North Africa** | | | | | | | | | | | | | | | | | | | | | |
| Lebanon | 1470 | 3 | 5 | 4 | 3 | 4 | 4 | 5 | 5,50E+10 | 5,46 | 3 | 3 | 2 | 3 | 5 | 6,85E+06 | 3 | 4 | 2 | | 6,10 |
| United Arab Emirates | 32941 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 4,22E+11 | 8,21 | 2 | 2 | 1 | 1 | 3 | 9,63E+06 | 4 | 5 | 1 | | 2,23 |
| **Latin Ameria** | | | | | | | | | | | | | | | | | | | | | |
| Guatemala | 2304 | 3 | 4 | 4 | 3 | 4 | 4 | 3 | 7,31E+10 | 1,23 | 3 | 3 | 3 | 2 | 2 | 1,63E+07 | 3 | 3 | 2 | 2 | 2,41 |
| Haiti | 8760 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 1,60E+10 | 10,11 | 1 | 4 | 3 | 4 | 5 | 1,11E+07 | 3 | 3 | 3 | 2 | 13,58 |
| Peru | 3100 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 2,22E+11 | 2,02 | 1 | 2 | 3 | 2 | 3 | 3,20E+07 | 2 | 2 | 2 | 1 | 3,18 |
| Puerto Rico | 4262 | 3 | 3 | 3 | 2 | 2 | 3 | | 1,01E+11 | 2,39 | | | 1 | 2 | 1 | 3,19E+06 | | | | | 9,20 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 24.

**Table 24** – Results of factor analysis of H1 2018.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 70.445 | 'Political' |
| | Political stability (PS) | | | |
| | Government effectiveness (GE) | | | |
| | Regulatory quality (RQ) | | | |
| | Rule of law (RoL) | | | |
| | Control of corruption (CoC) | | | |
| | Terrorism (T) | | | |
| Economic | Quality of overall infrastructure (QoI) | 0.000 | 67.445 | 'Quality of trade' |
| | Market size (Market) | | | 'Quality of trade' |
| | Trade openness (Trade) | | | 'Trade rights' |
| | Ease of doing business (EofB) | | | 'Quality of trade' |
| | Strength of legal rights (Strength LR) | | | 'Trade rights' |
| Social | Civil liberties (CL) | 0.000 | 88.694 | 'Human rights' |
| | Political rights (PR) | | | 'Human rights' |

| | | | | |
|---|---|---|---|---|
| | Human Development Index (HDI) | | | 'Societal development' |
| | Inequality (Inequa) | | | 'Societal development' |

3- Conduct a PR-index:
After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H1 2018 is:
PR = $(\frac{1}{5})$ * Political + $(\frac{1}{5})$ * Quality of trade + $(\frac{1}{5})$ * Trade rights + $(\frac{1}{5})$ * Human rights + $(\frac{1}{5})$ * Societal development
The resultant PR-index per country in the period H1 2018 can be seen in Table 25. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 25** – PR-index overview of H1 2018.

| Countries | Sales H1 2018 | PR-index |
|---|---|---|
| **Africa** | | |
| Benin | 5733 | 2.79 |
| Burkina Faso | 22809 | 2.92 |
| Cameroon | 49715 | 3.37 |
| Cote d'Ivoire | 17446 | 3.08 |
| DRC | 11197 | 3.58 |
| Ethiopia | 147647 | 3.64 |
| Ghana | 26160 | 2.34 |
| Kenya | 519154 | 2.69 |
| Libera | 11517 | 2.55 |
| Madagascar | 27355 | 3.04 |
| Malawi | 22772 | 2.52 |
| Mali | 16448 | 3.16 |
| Mozambique | 9536 | 3.11 |
| Namibia | 4218 | 2.31 |
| Niger | 3955 | 3.30 |
| Nigeria | 153112 | 3.03 |
| Rwanda | 47741 | 2.87 |
| Senegal | 31335 | 2.67 |
| Sierra Leone | 17990 | 2.92 |
| Somalia | 22049 | 4.25 |
| South Africa | 13848 | 2.44 |
| Tanzania | 103695 | 3.08 |
| Togo | 4505 | 3.00 |
| Uganda | 173556 | 3.31 |
| Zambia | 37978 | 2.59 |

| | | |
|---|---|---|
| Zimbabwe | 21583 | 3.33 |
| **East Asia and Pacific** | | |
| China | 7552 | 2.96 |
| Fiji | 13621 | 2.14 |
| Hong Kong | 5024 | 1.58 |
| Indonesia | 26289 | 2.46 |
| Japan | 1667 | 1.71 |
| Myanmar | 71746 | 3.20 |
| Papua New Guinea | 36908 | 2.74 |
| Philippines | 24855 | 2.62 |
| Singapore | 645 | 1.68 |
| Thailand | 2673 | 2.52 |
| Vanuatu | 9729 | 1.89 |
| **South Asia** | | |
| Bangladesh | 85426 | 3.10 |
| India | 1219589 | 2.29 |
| Nepal | 2243 | 2.68 |
| Pakistan | 13044 | 3.39 |
| **Middle East and North Africa** | | |
| Lebanon | 1470 | 3.20 |
| United Arab Emirates | 32941 | 2.29 |
| **Latin America** | | |
| Guatemala | 2304 | 2.75 |
| Haiti | 8760 | 3.33 |
| Peru | 3100 | 2.29 |
| Puerto Rico | 4262 | 1.89 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.075. This means that there is no correlation between the sales of these systems and the PR-index. There was no a correlation between the sales of SPSs and SHSs and the control variables included in the analysis of H1 2018.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:

- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:

- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution.

The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.

- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.7 – Quantitative results of H2 2018

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 26 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 26** – Overview of political sub-factors in H2 2018.

| Countries | Sales H2 2018 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market | Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Benin | 8755 | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 1,43E+10 | 0,59 | 4 | 4 | 2 | 3 | 3 | 1,15E+07 | 2 | 2 | 3 | 2 | 2,37 |
| Burkina Faso | 23725 | 3 | 4 | 4 | 3 | 3 | 3 | 4 | 1,61E+10 | 2,03 | 4 | 4 | 2 | 3 | 3 | 1,98E+07 | 2 | 3 | 3 | 2 | 4,70 |
| Cameroon | 54649 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3,87E+10 | 1,60 | 4 | 3 | 3 | 3 | 3 | 2,52E+07 | 4 | 4 | 3 | 2 | 3,36 |
| Chad | 9235 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 1,12E+10 | 5,01 | 4 | 4 | 2 | 4 | 3 | 1,55E+07 | 4 | 5 | 3 | 2 | 1,89 |
| Cote d'Ivoire | 22921 | 3 | 4 | 4 | 3 | 4 | 3 | 4 | 5,80E+10 | 0,63 | 4 | 3 | 3 | 3 | 3 | 2,51E+07 | 3 | 3 | 3 | 2 | 3,21 |
| DRC | 54316 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4,68E+10 | 28,97 | 4 | 3 | 2 | 4 | 3 | 8,41E+07 | 4 | 5 | 3 | 2 | 4,18 |
| Ethiopia | 338177 | 4 | 4 | 4 | 4 | 3 | 3 | 5 | 8,43E+10 | 12,38 | 4 | 3 | 4 | 3 | 4 | 1,09E+08 | 4 | 5 | 3 | 2 | 2,07 |
| Ghana | 13096 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 6,56E+10 | 10,21 | 4 | 3 | 2 | 2 | 3 | 2,98E+07 | 2 | 1 | 2 | 2 | 4,16 |
| Kenya | 749909 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 8,78E+10 | 2,42 | 3 | 3 | 4 | 2 | 1 | 5,14E+07 | 3 | 3 | 2 | 2 | 2,64 |
| Liberia | 9650 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 3,26E+09 | -1,85 | 4 | 4 | 1 | 3 | 1 | 4,82E+06 | 2 | 2 | 3 | 2 | 2,94 |
| Madagascar | 23998 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,39E+10 | 7,58 | | | 2 | 3 | 5 | 2,63E+07 | 3 | 2 | 3 | 2 | 1,69 |
| Malawi | 33783 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 6,92E+09 | 6,67 | 4 | 4 | 2 | 2 | 1 | 1,81E+07 | 2 | 2 | 3 | 2 | 5,62 |
| Mali | 20802 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,71E+10 | 1,46 | 4 | 4 | 2 | 3 | 3 | 1,91E+07 | 3 | 3 | 3 | 2 | 7,31 |
| Mozambique | 8548 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 1,48E+10 | 3,00 | 4 | 3 | 1 | 3 | 5 | 2,95E+07 | 3 | 3 | 3 | 2 | 3,24 |
| Namibia | 2567 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 1,35E+10 | 4,30 | 3 | 4 | 1 | 2 | 3 | 2,45E+06 | 2 | 2 | 2 | 2 | 19,88 |
| Niger | 3595 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1,28E+10 | 2,43 | | | 4 | 3 | 3 | 2,24E+07 | 3 | 3 | 4 | 2 | 0,47 |
| Nigeria | 133801 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 3,97E+11 | 10,23 | 4 | 2 | 4 | 3 | 2 | 1,96E+08 | 3 | 2 | 3 | 2 | 8,45 |
| Rwanda | 98723 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 9,64E+09 | -0,67 | 3 | 4 | 3 | 2 | 1 | 1,23E+07 | 4 | 4 | 3 | 2 | 1,02 |
| Senegal | 18104 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,32E+10 | -0,49 | 4 | 3 | 2 | 3 | 3 | 1,59E+07 | 2 | 2 | 3 | 2 | 6,53 |
| Sierra Leone | 16905 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 4,09E+09 | 13,43 | 4 | 4 | 3 | 3 | 3 | 7,65E+06 | 2 | 2 | 3 | 2 | 4,42 |
| Somalia | 30127 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 1 | 4 | 5 | 1,50E+07 | 5 | 5 | | | 12,89 |
| South Africa | 30039 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3,68E+11 | 3,92 | 3 | 2 | 3 | 2 | 3 | 5,78E+07 | 2 | 2 | 2 | 2 | 26,91 |
| Tanzania | 102038 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 5,80E+10 | 4,78 | 4 | 3 | | 3 | 3 | 5,63E+07 | 3 | 3 | 3 | 2 | 1,99 |
| Togo | 7727 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5,36E+09 | 1,46 | | | 2 | 3 | 3 | 7,89E+06 | 3 | 3 | 3 | 2 | 3,66 |
| Uganda | 193600 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3,29E+10 | 4,54 | 4 | 3 | 4 | 3 | 3 | 4,27E+07 | 3 | 4 | 3 | 2 | 1,75 |
| Zambia | 88000 | 3 | 3 | 4 | 3 | 3 | 4 | 3 | 2,63E+10 | 7,41 | 3 | 3 | 2 | 2 | 1 | 1,74E+07 | 3 | 3 | 3 | 2 | 12,01 |
| Zimbabwe | 14168 | 4 | 4 | 4 | 5 | 4 | 4 | 3 | 2,43E+10 | 5,22 | 4 | 4 | 3 | 3 | 3 | 1,44E+07 | 3 | 4 | 3 | 2 | 5,07 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| Cambodia | 438 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 2,46E+10 | 3,11 | 4 | 3 | 1 | 3 | 1 | 1,62E+07 | 3 | 4 | 3 | 1 | 0,13 |
| China | 4143 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 1,39E+13 | 3,50 | 2 | 1 | 4 | 2 | 4 | 1,39E+09 | 4 | 5 | 2 | 1 | 4,30 |
| Fiji | 22142 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 5,58E+09 | 1,43 | | | 1 | 2 | 3 | 8,83E+05 | 2 | 2 | 2 | | 4,16 |
| Hong Kong | 6346 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 3,62E+11 | 3,66 | 1 | 2 | 1 | 1 | 2 | 7,45E+06 | 2 | 3 | 1 | 1 | 3,04 |
| Myanmar | 27196 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 7,62E+10 | 6,27 | | | 2 | 3 | 5 | 5,37E+07 | 3 | 3 | 3 | 2 | 0,87 |
| Papua New Guinea | 30249 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,41E+10 | 9,80 | | | | 3 | 2 | 8,61E+06 | 2 | 2 | 3 | | 2,41 |
| Philippines | 38891 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 3,47E+11 | 3,74 | 4 | 2 | 2 | 2 | 1 | 1,07E+08 | 2 | 2 | 2 | 1 | 2,34 |
| Thailand | 2709 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 5,07E+11 | 1,46 | 3 | 2 | 1 | 2 | 3 | 6,94E+07 | 3 | 4 | 2 | 1 | 0,77 |
| Vanuatu | 5610 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 9,15E+08 | 3,21 | | | | 2 | 1 | 2,93E+05 | 2 | 2 | 2 | | 1,72 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 51802 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,74E+11 | 5,60 | 4 | 2 | 4 | 3 | 3 | 1,61E+08 | 3 | 3 | 2 | 2 | 4,29 |
| India | 1184003 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,71E+12 | 4,56 | 2 | 1 | 3 | 2 | 2 | 1,35E+09 | 2 | 2 | 2 | 2 | 5,33 |
| Nepal | 420 | 3 | 4 | 4 | 4 | 3 | 4 | 3 | 2,92E+10 | 6,70 | 4 | 3 | 3 | 3 | 1 | 2,81E+07 | 3 | 2 | 2 | 2 | 2,90 |
| Pakistan | 19355 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 3,15E+11 | 2,46 | 3 | 2 | 4 | 3 | 5 | 2,12E+08 | 3 | 3 | 3 | 2 | 4,08 |
| **Middle East and North Africa** | | | | | | | | | | | | | | | | | | | | | |
| Lebanon | 1350 | 3 | 5 | 4 | 3 | 4 | 4 | 5 | 5,50E+10 | 5,46 | 3 | 3 | 2 | 3 | 5 | 6,85E+06 | 3 | 4 | 2 | | 6,10 |
| United Arab Emirates | 39593 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 4,22E+11 | 8,21 | 2 | 2 | 1 | 1 | 3 | 9,63E+06 | 4 | 5 | 1 | | 2,23 |
| Yemen | 83846 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 2,35E+10 | 14,85 | 5 | 4 | | 4 | 5 | 2,85E+07 | 4 | 5 | 3 | 2 | 13,01 |
| **Latin America** | | | | | | | | | | | | | | | | | | | | | |
| Guatemala | 3965 | 3 | 4 | 4 | 3 | 4 | 4 | 3 | 7,31E+10 | 1,23 | 3 | 3 | 3 | 2 | 2 | 1,63E+07 | 3 | 3 | 2 | 2 | 2,41 |
| Peru | 2571 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 2,22E+11 | 2,02 | 1 | 2 | 3 | 2 | 3 | 3,20E+07 | 2 | 2 | 2 | 1 | 3,18 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 27.

**Table 27** – Results of factor analysis of H2 2018.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 68.595 | 'Political' |
| | Political stability (PS) | | | |
| | Government effectiveness (GE) | | | |
| | Regulatory quality (RQ) | | | |
| | Rule of law (RoL) | | | |
| | Control of corruption (CoC) | | | |
| | Terrorism (T) | | | |
| Economic | Quality of overall infrastructure (QoI) | 0.003 | 70.212 | 'Quality of trade' |
| | Market size (Market) | | | 'Quality of trade' |
| | Trade openness (Trade) | | | 'Trade rights' |
| | Ease of doing business (EofB) | | | 'Quality of trade' |
| | Strength of legal rights (Strength LR) | | | 'Trade rights' |
| Social | Civil liberties (CL) | 0.000 | 85.603 | 'Human rights' |
| | Political rights (PR) | | | 'Human rights' |

| | | | | |
|---|---|---|---|---|
| | Human Development Index (HDI) | | | 'Societal development' |
| | Inequality (Inequa) | | | 'Societal development' |

3- Conduct a PR-index:
After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H2 2018 is:
PR = $(\frac{1}{5})$ * Political + $(\frac{1}{5})$ * Quality of trade + $(\frac{1}{5})$ * Trade rights + $(\frac{1}{5})$ * Human rights + $(\frac{1}{5})$ * Societal development
The resultant PR-index per country in the period H2 2018 can be seen in Table 28. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 28** – PR-index overview of H2 2018.

| Countries | Sales H2 2018 | PR-index |
|---|---|---|
| **Africa** | | |
| Benin | 8755 | 2.79 |
| Burkina Faso | 23725 | 2.92 |
| Cameroon | 54649 | 3.37 |
| Chad | 9235 | 3.53 |
| Cote d'Ivoire | 22921 | 3.08 |
| DRC | 54316 | 3.58 |
| Ethiopia | 338177 | 3.64 |
| Ghana | 13096 | 2.34 |
| Kenya | 749909 | 2.69 |
| Liberia | 9650 | 2.55 |
| Madagascar | 23998 | 3.04 |
| Malawi | 33783 | 2.52 |
| Mali | 20802 | 3.16 |
| Mozambique | 8548 | 3.11 |
| Namibia | 2567 | 2.31 |
| Niger | 3595 | 3.30 |
| Nigeria | 133801 | 3.03 |
| Rwanda | 98723 | 2.87 |
| Senegal | 18104 | 2.67 |
| Sierra Leone | 16905 | 2.92 |
| Somalia | 30127 | 4.25 |
| South Africa | 30039 | 2.44 |
| Tanzania | 102038 | 3.08 |
| Togo | 7727 | 3.00 |
| Uganda | 193600 | 3.31 |

| | | |
|---|---|---|
| Zambia | 88000 | 2.59 |
| Zimbabwe | 14168 | 3.33 |
| **East Asia and Pacific** | | |
| Cambodia | 438 | 2.68 |
| China | 4143 | 2.96 |
| Fiji | 22142 | 2.14 |
| Hong Kong | 6346 | 1.58 |
| Myanmar | 27196 | 3.20 |
| Papua New Guinea | 30249 | 2.74 |
| Philippines | 38891 | 2.22 |
| Thailand | 2709 | 2.52 |
| Vanuatu | 5610 | 1.89 |
| **South Asia** | | |
| Bangladesh | 51802 | 3.10 |
| India | 1184003 | 2.29 |
| Nepal | 420 | 2.68 |
| Pakistan | 19355 | 3.39 |
| **Middle East and North Africa** | | |
| Lebanon | 1350 | 3.20 |
| United Arab Emirates | 39593 | 2.29 |
| Yemen | 83846 | 4.27 |
| **Latin America** | | |
| Guatemala | 3965 | 2.75 |
| Peru | 2571 | 2.29 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.137. This means that there is no correlation between the sales of these systems and the PR-index. There was also no correlation between the sales of SPSs and SHSs and any of the included control variables in the analysis of H2 2018.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:

- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:

- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then

made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.

- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.8 – Quantitative results of H1 2019

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 29 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 29** – Overview of political sub-factors in H1 2019.

| Countries | Sales H1 2019 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market | Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Benin | 24244 | 3 | 3 | 3 | 3 | 4 | 3 | 2 | 1,44E+10 | -0,32 | 4 | 4 | 2 | 3 | 3 | 1,18E+07 | 2 | 2 | 3 | 2 | 2,32 |
| Burkina Faso | 38188 | 3 | 4 | 4 | 3 | 3 | 3 | 5 | 1,60E+10 | -0,63 | 4 | 4 | 3 | 3 | 3 | 2,03E+07 | 2 | 3 | 3 | 2 | 4,62 |
| Cameroon | 79134 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 3,90E+10 | 2,52 | 4 | 3 | 3 | 3 | 3 | 2,59E+07 | 4 | 4 | 3 | 2 | 3,32 |
| Cote d'Ivoire | 27682 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 5,85E+10 | 0,20 | 4 | 3 | 3 | 2 | 3 | 2,57E+07 | 3 | 3 | 3 | 2 | 3,17 |
| DRC | 38147 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5,04E+10 | 4,70 | 4 | 3 | 2 | 4 | 3 | 8,68E+07 | 4 | 5 | 3 | 2 | 4,13 |
| Ethiopia | 293778 | 4 | 4 | 4 | 4 | 3 | 3 | 5 | 9,59E+10 | 12,86 | 4 | 3 | 4 | 3 | 4 | 1,12E+08 | 4 | 4 | 3 | 2 | 2,04 |
| Gambia | 734 | 3 | 3 | 4 | 4 | 3 | 3 | 2 | 1,83E+09 | 7,15 | 3 | 4 | 3 | 3 | 3 | 2,35E+06 | 3 | 3 | 3 | 2 | 8,94 |
| Ghana | 13702 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 6,70E+10 | 9,19 | 4 | 3 | 2 | 3 | 3 | 3,04E+07 | 2 | 1 | 2 | 2 | 4,12 |
| Guinea | 4367 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1,23E+10 | 8,81 | 3 | 4 | 2 | 3 | 3 | 1,28E+07 | 3 | 3 | 3 | 2 | 4,14 |
| Kenya | 974972 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 9,55E+10 | 3,96 | 3 | 3 | 4 | 2 | 1 | 5,26E+07 | 3 | 3 | 2 | 2 | 2,60 |
| Liberia | 1225 | 3 | 3 | 4 | 4 | 4 | 4 | 5 | 3,07E+09 | -3,73 | | | 1 | 3 | 1 | 4,94E+06 | 2 | 2 | 3 | 2 | 2,89 |
| Madagascar | 11013 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 1,41E+10 | 5,46 | 4 | 3 | 3 | 3 | 5 | 2,70E+07 | 3 | 2 | 3 | 2 | 1,67 |
| Malawi | 8903 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 7,67E+09 | 8,17 | 4 | 4 | 2 | 2 | 1 | 1,86E+07 | 2 | 2 | 3 | 2 | 5,56 |
| Mali | 35423 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,73E+10 | 1,93 | 3 | 4 | 3 | 3 | 3 | 1,97E+07 | 3 | 3 | 3 | 2 | 7,24 |
| Mozambique | 7561 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 1,53E+10 | 4,45 | 4 | 3 | 1 | 3 | 5 | 3,04E+07 | 3 | 3 | 3 | 2 | 3,19 |
| Niger | 3234 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1,29E+10 | 0,11 | | | 4 | 3 | 3 | 2,33E+07 | 3 | 3 | 4 | 2 | 0,46 |
| Nigeria | 135410 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 4,48E+11 | 10,38 | 4 | 2 | 4 | 3 | 2 | 2,01E+08 | 3 | 2 | 3 | 2 | 8,53 |
| Rwanda | 65030 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 1,04E+10 | 2,56 | 3 | 4 | 3 | 2 | 1 | 1,26E+07 | 4 | 4 | 3 | 2 | 0,99 |
| Senegal | 29572 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,36E+10 | 1,68 | 4 | 3 | 2 | 3 | 3 | 1,63E+07 | 2 | 2 | 3 | 2 | 6,47 |
| Sierra Leone | 15821 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 4,12E+09 | 8,63 | | | 3 | 3 | 3 | 7,81E+06 | 2 | 2 | 3 | 2 | 4,36 |
| Somalia | 38204 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 1 | 4 | 5 | 1,54E+07 | 5 | 5 | | | 12,79 |
| South Africa | 20672 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3,51E+11 | 4,02 | 3 | 2 | 3 | 2 | 3 | 5,86E+07 | 2 | 2 | 2 | 2 | 28,47 |
| Tanzania | 87552 | 4 | 3 | 4 | 4 | 4 | 3 | 3 | 6,32E+10 | 4,63 | 4 | 3 | | 3 | 3 | 5,80E+07 | 3 | 3 | 3 | 2 | 1,96 |
| Togo | 26809 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5,49E+09 | 2,49 | | | 2 | 2 | 3 | 8,08E+06 | 3 | 3 | 3 | 2 | 3,60 |
| Uganda | 179530 | 4 | 4 | 4 | 3 | 3 | 4 | 3 | 3,52E+10 | 2,16 | 3 | 3 | 4 | 3 | 3 | 4,43E+07 | 3 | 4 | 3 | 2 | 1,72 |
| Zambia | 70260 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 2,33E+10 | 7,63 | 4 | 3 | 2 | 2 | 1 | 1,79E+07 | 3 | 3 | 3 | 2 | 11,91 |
| Zimbabwe | 15189 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,14E+10 | -4,04 | 4 | 4 | | 3 | 3 | 1,46E+07 | 3 | 3 | 3 | 2 | 5,02 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| Australia | 1188 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1,40E+12 | 3,40 | 2 | 2 | 3 | 1 | 1 | 2,54E+07 | 1 | 1 | 1 | 1 | 5,16 |
| China | 733 | 5 | 3 | 2 | 3 | 3 | 3 | 3 | 1,43E+13 | 1,29 | 2 | 1 | 4 | 2 | 4 | 1,40E+09 | 4 | 5 | 2 | 1 | 4,60 |
| Hong Kong | 7668 | 3 | 3 | 1 | 1 | 1 | 1 | 2 | 3,66E+11 | 2,36 | 1 | 2 | 1 | 1 | 2 | 7,51E+06 | 2 | 3 | 1 | 1 | 2,96 |
| Malaysia | 500 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3,65E+11 | 0,06 | 2 | 2 | 1 | 1 | 3 | 3,19E+07 | 3 | 3 | 1 | | 3,31 |
| Myanmar | 59474 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 7,61E+10 | 7,65 | | | | 3 | 5 | 5,40E+07 | 3 | 3 | 3 | | 0,50 |
| Papua New Guinea | 37298 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,48E+10 | 0,02 | | | | 3 | 2 | 8,78E+06 | 2 | 3 | 3 | 2 | 2,37 |
| Philippines | 11087 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 3,77E+11 | 0,76 | 3 | 2 | 2 | 2 | 5 | 1,08E+08 | 2 | 2 | 2 | 1 | 2,24 |
| Thailand | 506 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 5,44E+11 | 0,75 | 3 | 2 | 1 | 1 | 3 | 6,96E+07 | 3 | 5 | 2 | 1 | 0,72 |
| Vanuatu | 9350 | 2 | 2 | 4 | 3 | 3 | 3 | 1 | 9,34E+08 | 2,57 | | | | 2 | 1 | 3,00E+05 | 2 | 2 | 2 | | 1,69 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 185405 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3,03E+11 | 4,46 | 3 | 2 | 4 | 3 | 3 | 1,63E+08 | 3 | 3 | 2 | 2 | 4,22 |
| India | 953466 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,87E+12 | 2,91 | 2 | 1 | 4 | 2 | 2 | 1,37E+09 | 2 | 2 | 2 | 2 | 5,27 |
| Pakistan | 17742 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 2,78E+11 | 8,62 | 3 | 2 | 4 | 2 | 5 | 2,17E+08 | 3 | 3 | 3 | 2 | 3,98 |
| **Middle East and North Africa** | | | | | | | | | | | | | | | | | | | | | |
| United Arab Emirates | 46245 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 4,21E+11 | -1,90 | 1 | 2 | 1 | 1 | 3 | 9,77E+06 | 4 | 5 | 1 | | 2,28 |
| **Latin Ameria** | | | | | | | | | | | | | | | | | | | | | |
| Guatemala | 5625 | 3 | 4 | 4 | 3 | 4 | 4 | 3 | 7,67E+10 | 3,41 | 4 | 3 | 3 | 2 | 2 | 1,66E+07 | 3 | 3 | 2 | 2 | 2,36 |
| Peru | 2042 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2,27E+11 | 1,56 | 3 | 2 | 3 | 2 | 3 | 3,25E+07 | 2 | 2 | 2 | 1 | 3,03 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 30.

**Table 30** – Results of factor analysis of H1 2019.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 68.242 | 'Political' |
| | Political stability (PS) | | | |
| | Government effectiveness (GE) | | | |
| | Regulatory quality (RQ) | | | |
| | Rule of law (RoL) | | | |
| | Control of corruption (CoC) | | | |
| | Terrorism (T) | | | |
| Economic | Quality of overall infrastructure (QoI) | 0.000 | 66.014 | 'Quality of trade' |
| | Market size (Market) | | | 'Quality of trade' |
| | Trade openness (Trade) | | | 'Trade rights' |
| | Ease of doing business (EofB) | | | 'Quality of trade' |
| | Strength of legal rights (Strength LR) | | | 'Trade rights' |
| Social | Civil liberties (CL) | 0.000 | 89.163 | 'Human rights' |
| | Political rights (PR) | | | 'Human rights' |

| | | | | |
|---|---|---|---|---|
| | Human Development Index (HDI) | | | 'Societal development' |
| | Inequality (Inequa) | | | 'Societal development' |

3- Conduct a PR-index:
After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H1 2019 is:
PR = $(\frac{1}{5})$ * Political + $(\frac{1}{5})$ * Quality of trade + $(\frac{1}{5})$ * Trade rights + $(\frac{1}{5})$ * Human rights + $(\frac{1}{5})$ * Societal development
The resultant PR-index per country in the period H1 2019 can be seen in Table 31. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 31** – PR-index overview of H1 2019.

| Countries | Sales H1 2019 | PR-index |
|---|---|---|
| **Africa** | | |
| Benin | 24244 | 2.73 |
| Burkina Faso | 38188 | 3.05 |
| Cameroon | 79134 | 3.40 |
| Cote d'Ivoire | 27682 | 3.01 |
| DRC | 38147 | 3.60 |
| Ethiopia | 293778 | 3.54 |
| Gambia | 734 | 3.00 |
| Ghana | 13702 | 2.41 |
| Guinea | 4367 | 3.07 |
| Kenya | 974972 | 2.69 |
| Liberia | 1225 | 2.47 |
| Madagascar | 11013 | 3.18 |
| Malawi | 8903 | 2.52 |
| Mali | 35423 | 3.20 |
| Mozambique | 7561 | 3.14 |
| Niger | 3234 | 3.30 |
| Nigeria | 135410 | 3.03 |
| Rwanda | 65030 | 2.87 |
| Senegal | 29572 | 2.67 |
| Sierra Leone | 15821 | 2.79 |
| Somalia | 38204 | |
| South Africa | 20672 | 2.44 |
| Tanzania | 87552 | 3.08 |
| Togo | 26809 | 2.80 |
| Uganda | 179530 | 3.21 |

| | | |
|---|---|---|
| Zambia | 70260 | 2.69 |
| Zimbabwe | 15189 | 3.23 |
| **East Asia and Pacific** | | |
| Australia | 1188 | 1.42 |
| China | 733 | 2.96 |
| Hong Kong | 7668 | 1.61 |
| Malaysia | 500 | 2.05 |
| Myanmar | 59474 | 3.60 |
| Papua New Guinea | 37298 | 2.74 |
| Philippines | 11087 | 2.55 |
| Thailand | 506 | 2.59 |
| Vanuatu | 9350 | 1.91 |
| **South Asia** | | |
| Bangladesh | 185405 | 3.03 |
| India | 953466 | 2.39 |
| Pakistan | 17742 | 3.32 |
| **Middle East and North Africa** | | |
| United Arab Emirates | 46245 | 2.22 |
| **Latin America** | | |
| Guatemala | 5625 | 2.81 |
| Peru | 2042 | 2.34 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.022. This means that there is a correlation between the sales of these systems and the PR-index. There was no correlation between the sales of SPSs and SHSs and control variables included in the analysis of H1 2019.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:

- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:

- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is

used, because for the Spearman rank-order correlation this is not a requirement.

- There are no relevant outliers in the dataset. This requirement is met.

## Appendix D.9 – Quantitative results of H2 2019

As is described in chapter 3, the statistical analysis consists of five steps. These will be discussed here.

1- Standardization of scale of sub-factors:
Table 32 shows the overall scores of the countries on the different sub-factors of the political risk.

**Table 32** – Overview of political sub-factors in H2 2019.

| Countries | Sales H2 2019 | V&A | PS | GE | RQ | RoL | CoC | T | GDP | Infla | QoI | Market | Trade | EofB | Strenght LR | Population | CL | PR | HDI | Inequa | Unemploy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Africa** | | | | | | | | | | | | | | | | | | | | | |
| Angola | 2950 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 8,88E+10 | 27,23 | 4 | 3 | 2 | 3 | 5 | 3,18E+07 | 3 | 4 | 3 | 2 | 6,93 |
| Benin | 29021 | 3 | 3 | 3 | 3 | 4 | 3 | 2 | 1,44E+10 | -0,32 | 4 | 4 | 2 | 3 | 3 | 1,18E+07 | 2 | 2 | 3 | 2 | 2,32 |
| Burkina Faso | 13289 | 3 | 4 | 4 | 3 | 3 | 3 | 5 | 1,60E+10 | -0,63 | 4 | 4 | 3 | 3 | 3 | 2,03E+07 | 2 | 3 | 3 | 2 | 4,62 |
| Cameroon | 71864 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 3,90E+10 | 2,52 | 4 | 3 | 3 | 3 | 3 | 2,59E+07 | 4 | 4 | 3 | 2 | 3,32 |
| Central Africa Republic | 48027 | 4 | 5 | 5 | 4 | 5 | 4 | 5 | 2,22E+09 | 2,41 | | | 2 | 4 | 3 | 4,75E+06 | 5 | 5 | 4 | 3 | 4,04 |
| Cote d'Ivoire | 35522 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 5,85E+10 | 0,20 | 4 | 3 | 3 | 2 | 3 | 2,57E+07 | 3 | 3 | 3 | 2 | 3,17 |
| Ethiopia | 717759 | 4 | 4 | 4 | 4 | 3 | 3 | 5 | 9,59E+10 | 12,86 | 4 | 3 | 4 | 3 | 4 | 1,12E+08 | 4 | 4 | 3 | 2 | 2,04 |
| Ghana | 17337 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 6,70E+10 | 9,19 | 4 | 3 | 2 | 3 | 3 | 3,04E+07 | 2 | 1 | 2 | 2 | 4,12 |
| Kenya | 994511 | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 9,55E+10 | 3,96 | 3 | 3 | 4 | 2 | 1 | 5,26E+07 | 3 | 3 | 2 | 2 | 2,60 |
| Madagascar | 30686 | 3 | 3 | 4 | 4 | 4 | 4 | 3 | 1,41E+10 | 5,46 | 4 | 3 | 3 | 3 | 5 | 2,70E+07 | 3 | 2 | 3 | 2 | 1,67 |
| Malawi | 51703 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 7,67E+09 | 8,17 | 4 | 4 | 2 | 2 | 1 | 1,86E+07 | 2 | 2 | 3 | 2 | 5,56 |
| Mali | 10140 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 1,73E+10 | 1,93 | 3 | 4 | 3 | 3 | 3 | 1,97E+07 | 3 | 3 | 3 | 2 | 7,24 |
| Mozambique | 6573 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 1,53E+10 | 4,45 | 4 | 3 | 1 | 3 | 5 | 3,04E+07 | 3 | 3 | 3 | 2 | 3,19 |
| Niger | 13811 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 1,29E+10 | 0,11 | | | 4 | 3 | 3 | 2,33E+07 | 3 | 3 | 4 | 2 | 0,46 |
| Nigeria | 166284 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 4,48E+11 | 10,38 | 4 | 2 | 4 | 3 | 2 | 2,01E+08 | 3 | 2 | 3 | 2 | 8,53 |
| Rwanda | 47984 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 1,04E+10 | 2,56 | 3 | 4 | 3 | 2 | 1 | 1,26E+07 | 4 | 4 | 3 | 2 | 0,99 |
| Senegal | 25681 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2,36E+10 | 1,68 | 4 | 3 | 2 | 3 | 3 | 1,63E+07 | 2 | 2 | 3 | 2 | 6,47 |
| Sierra Leone | 22635 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 4,12E+09 | 8,63 | | | 3 | 3 | 3 | 7,81E+06 | 2 | 2 | 3 | 2 | 4,36 |
| Somalia | 11616 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | | | | 1 | 4 | 5 | 1,54E+07 | 5 | 5 | | | 12,79 |
| South Africa | 12201 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3,51E+11 | 4,02 | 3 | 2 | 3 | 2 | 3 | 5,86E+07 | 2 | 2 | 2 | 2 | 28,47 |
| Tanzania | 176375 | 4 | 3 | 4 | 4 | 4 | 3 | 3 | 6,32E+10 | 4,63 | 4 | 3 | | 3 | 3 | 5,80E+07 | 3 | 3 | 3 | 2 | 1,96 |
| Togo | 23904 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5,49E+09 | 2,49 | | | 2 | 2 | 3 | 8,08E+06 | 3 | 3 | 3 | 2 | 3,60 |
| Uganda | 219755 | 4 | 4 | 4 | 3 | 3 | 4 | 3 | 3,52E+10 | 2,16 | 3 | 3 | 4 | 3 | 3 | 4,43E+07 | 3 | 4 | 3 | 2 | 1,72 |
| Zambia | 118458 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 2,33E+10 | 7,63 | 4 | 3 | 2 | 2 | 1 | 1,79E+07 | 3 | 3 | 3 | 2 | 11,91 |
| Zimbabwe | 16210 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2,14E+10 | -4,04 | 4 | 4 | | 3 | 3 | 1,46E+07 | 3 | 3 | 3 | 2 | 5,02 |
| **East Asia and Pacific** | | | | | | | | | | | | | | | | | | | | | |
| China | 11207 | 5 | 3 | 2 | 3 | 3 | 3 | 3 | 1,43E+13 | 1,29 | 2 | 1 | 4 | 2 | 4 | 1,40E+09 | 4 | 5 | 2 | 1 | 4,60 |
| Myanmar | 148235 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 7,61E+10 | 7,65 | | | | 3 | 5 | 5,40E+07 | 3 | 3 | 3 | | 0,50 |
| Papua New Guinea | 24399 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 2,48E+10 | 0,02 | | | | 3 | 2 | 8,78E+06 | 2 | 3 | 3 | 2 | 2,37 |
| Philippines | 40657 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 3,77E+11 | 0,76 | 3 | 2 | 2 | 2 | 5 | 1,08E+08 | 2 | 2 | 2 | 1 | 2,24 |
| **South Asia** | | | | | | | | | | | | | | | | | | | | | |
| Bangladesh | 46575 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3,03E+11 | 4,46 | 3 | 2 | 4 | 3 | 3 | 1,63E+08 | 3 | 3 | 2 | 2 | 4,22 |
| India | 781165 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 2,87E+12 | 2,91 | 2 | 1 | 4 | 2 | 2 | 1,37E+09 | 2 | 2 | 2 | 2 | 5,27 |
| Pakistan | 10756 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 2,78E+11 | 8,62 | 3 | 2 | 4 | 2 | 5 | 2,17E+08 | 3 | 3 | 3 | 2 | 3,98 |

2- Perform factor analysis to reduce multicollinearity:
Second, the factor analysis is performed in SPSS. To test whether the sub-factors should be merged into one or multiple sub-variables, the Bartlett's Test of Sphericity is used. When the sub-factors should be merged together in one or more sub-variables, then the p-value of the Bartlett's Test of Sphericity should be smaller than 0.050. The sub-factors per sub-variable are tested for this, to see whether they should be merged together or not. The result is visible in Table 33.

**Table 33** – Results of factor analysis of H2 2019.

| Sub-variable | Sub-factors | P-value of Bartlett's Test of Sphericity | Variance explained (%) | Merged into which new sub-variable |
|---|---|---|---|---|
| Political | Voice and accountability (V&A) | 0.000 | 72.862 | 'Internal politics' |
| | Political stability (PS) | | | 'External politics' |
| | Government effectiveness (GE) | | | 'Internal politics' |
| | Regulatory quality (RQ) | | | 'Internal politics' |
| | Rule of law (RoL) | | | 'Internal politics' |
| | Control of corruption (CoC) | | | 'Internal politics' |
| | Terrorism (T) | | | 'External politics' |
| Economic | Quality of overall infrastructure (QoI) | 0.000 | 72.336 | 'Internal market' |
| | Market size (Market) | | | 'Internal market' |
| | Trade openness (Trade) | | | 'Internal market' |
| | Ease of doing business (EofB) | | | 'International business' |
| | Strength of legal rights (Strength LR) | | | 'International business' |
| Social | Civil liberties (CL) | 0.000 | 85.986 | 'Human rights' |
| | Political rights (PR) | | | 'Human rights' |

| | | | | |
|---|---|---|---|---|
| | Human Development Index (HDI) | | | 'Societal development' |
| | Inequality (Inequa) | | | 'Societal development' |

3- Conduct a PR-index:
After the new variables are made, the next step is to formulate a general PR-index. The formula for this in the case of H2 2019 is:
PR = $(\frac{1}{6})$ * Internal politics + $(\frac{1}{6})$ * External politics + $(\frac{1}{6})$ * Internal market + $(\frac{1}{6})$ * International business + $(\frac{1}{6})$ * Human rights + $(\frac{1}{6})$ * Societal development
The resultant PR-index per country in the period H2 2019 can be seen in Table 34. The PR-index has a value between 1 and 5, with a score of 1 meaning that the country has the lowest possible political risk and a value of 5 meaning that the country has the highest possible political risk.

**Table 34** – PR-index overview of H2 2019.

| Countries | Sales H2 2019 | PR-index |
|---|---|---|
| **Africa** | | |
| Angola | 2950 | 3.33 |
| Benin | 29021 | 2.76 |
| Burkina Faso | 13289 | 3.23 |
| Cameroon | 71864 | 3.56 |
| Central Africa Republic | 48027 | 3.90 |
| Cote d'Ivoire | 35522 | 3.12 |
| Ethiopia | 717759 | 3.63 |
| Ghana | 17337 | 2.47 |
| Kenya | 994511 | 2.76 |
| Madagascar | 30686 | 3.19 |
| Malawi | 51703 | 2.57 |
| Mali | 10140 | 3.44 |
| Mozambique | 6573 | 3.28 |
| Niger | 13811 | 3.50 |
| Nigeria | 166284 | 3.27 |
| Rwanda | 47984 | 2.81 |
| Senegal | 25681 | 2.75 |
| Sierra Leone | 22635 | 2.85 |
| Somalia | 11616 | |
| South Africa | 12201 | 2.49 |
| Tanzania | 176375 | 3.13 |
| Togo | 23904 | 3.00 |
| Uganda | 219755 | 324 |
| Zambia | 118458 | 2.77 |
| Zimbabwe | 16210 | 3.42 |

| East Asia and Pacific | | |
|---|---|---|
| China | 11207 | 2.92 |
| Myanmar | 148235 | |
| Papua New Guinea | 24399 | |
| Philippines | 40657 | 2.76 |
| **South Asia** | | |
| Bangladesh | 46575 | 3.17 |
| India | 781165 | 2.56 |
| Pakistan | 10756 | 3.50 |

4- Perform correlation analysis:
The correlation between sales of SPSs and SHSs and the PR-index gave a p-value of 0.476. This means that there is no correlation between the sales of these systems and the PR-index. There was also no correlation between the sales of SPSs and SHSs and the included control variables in the analysis of H2 2019.

5- Check whether the requirements for the analyses are met:
The requirements for a Spearman rank-order correlation are both met. These were:
- The PR-index variable should at least be of ordinal scale.
- The relationship between the variables should be monotonic.

The requirements for a Pearson correlation analysis are:
- The data is derived from a random and independent sample. This requirement is met.
- Each data point from the variables is measured independently from each other. This requirement is met.
- The data on the sales of SPSs and SHSs should be continuous and normally distributed. This requirement is not met. In order to be able to analyse this, the variable should be transformed in order for it to have a normal distribution. The sales data is transformed with a natural logarithmic function, which then made the data normally distributed. The Shapiro-Wilk test is used to analyse whether the data on the sales of SPSs and SHSs is normally distributed. So only for the Pearson correlation analysis the logarithmic function of this variable is used, because for the Spearman rank-order correlation this is not a requirement.
- There are no relevant outliers in the dataset. This requirement is met.

## Appendix E – Results quantitative analysis per continent

This appendix shows the results of the statistical analysis per continent. This analysis is conducted to find out whether inclusion of various continents which are not the main market of frugal innovations might influence the results of the correlation analysis.

Table 35 shows the results of the correlation analysis between the sales of SPSs and SHSs and the PR-index. The significant time periods are coloured blue for clarity for the reader. The following hypothesis was made per time period and per continent:

H0 = there is no relationship between the political risks and the market diffusion of frugal solar-PV systems.

H1 = there is a relationship between the political risks and the market diffusion of frugal solar-PV systems.

Interesting to see is that the African continent shows no significant results, while this is one of the main markets of frugal innovations. The Latin America continent shows the most significant results: the second semesters of 2016 and 2018 and the first semester of 2019, all with a positive correlation coefficient, indicating that in Latin America there is a positive relationship between the PR-index and the sales of SPSs and SHSs.

**Table 35** – Results of continental correlation analysis over time.

| Period | Countries included | Correlation coefficient PR-index and sales | Two-sided p-value PR-index and sales |
|---|---|---|---|
| **Africa** | | | |
| H2 2015 | 16 | 0.280 | 0.294 |
| H1 2016 | 20 | 0.372 | 0.107 |
| H2 2016 | 26 | 0.091 | 0.659 |
| H1 2017 | 27 | -0.005 | 0.982 |
| H2 2017 | 26 | 0.044 | 0.831 |
| H1 2018 | 26 | 0.147 | 0.473 |
| H2 2018 | 27 | 0.253 | 0.202 |
| H1 2019 | 27 | 0.209 | 0.142 |
| H2 2019 | 25 | -0.085 | 0.686 |
| **East Asia and Pacific** | | | |
| H2 2015 | 3 | 0.500 | 0.667 |
| H1 2016 | 4 | -0.200 | 0.800 |
| H2 2016 | 10 | 0.430 | 0.214 |
| H1 2017 | 12 | 0.483 | 0.112 |
| H2 2017 | 11 | 0.282 | 0.400 |
| H1 2018 | 11 | 0.582 | 0.060 |
| H2 2018 | 9 | -0.133 | 0.732 |
| H1 2019 | 9 | 0.317 | 0.406 |
| H2 2019 | 4 | 0.400 | 0.600 |

| South Asia | | | |
|---|---|---|---|
| H2 2015 | 4 | -0.200 | 0.800 |
| H1 2016 | 4 | -0.200 | 0.800 |
| H2 2016 | 4 | -0.800 | 0.200 |
| H1 2017 | 4 | -0.200 | 0.800 |
| H2 2017 | 4 | -0.400 | 0.600 |
| H1 2018 | 4 | -0.400 | 0.600 |
| H2 2018 | 4 | -0.400 | 0.600 |
| H1 2019 | 3 | -1.000 | 0.000 |
| H2 2019 | 3 | -1.000 | 0.000 |
| **Middle East and North Africa** | | | |
| H2 2015 | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A |
| H2 2016 | 1 | N/A | N/A |
| H1 2017 | 3 | 0.500 | 0.667 |
| H2 2017 | 2 | -1.000 | 0.000 |
| H1 2018 | 2 | -1.000 | 0.000 |
| H2 2018 | 3 | 0.500 | 0.667 |
| H1 2019 | 1 | N/A | N/A |
| H2 2019 | 0 | N/A | N/A |
| **Latin America** | | | |
| H2 2015 | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A |
| H2 2016 | 6 | 0.812 | 0.050 |
| H1 2017 | 5 | 0.600 | 0.285 |
| H2 2017 | 6 | -0.200 | 0.704 |
| H1 2018 | 4 | 0.200 | 0.800 |
| H2 2018 | 2 | 1.000 | 0.000 |
| H1 2019 | 2 | 1.000 | 0.000 |
| H2 2019 | 0 | N/A | N/A |
| **North America** | | | |
| H2 2015 | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A |
| H2 2016 | 1 | N/A | N/A |
| H1 2017 | 2 | 1.000 | 0.000 |
| H2 2017 | 1 | N/A | N/A |
| H1 2018 | 0 | N/A | N/A |
| H2 2018 | 0 | N/A | N/A |
| H1 2019 | 0 | N/A | N/A |
| H2 2019 | 0 | N/A | N/A |

| Europe and Central Asia | | | |
|---|---|---|---|
| H2 2015 | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A |
| H2 2016 | 5 | -0.800 | 0.104 |
| H1 2017 | 6 | 0.086 | 0.872 |
| H2 2017 | 10 | 0.323 | 0.362 |
| H1 2018 | 0 | N/A | N/A |
| H2 2018 | 0 | N/A | N/A |
| H1 2019 | 0 | N/A | N/A |
| H2 2019 | 0 | N/A | N/A |

Table 36 shows the results of the correlation analysis between the PR-index and the sales of SPSs and SHSs per capita, and between the PR-index and the sales of SPSs and SHSs per GDP. The significant time periods are coloured blue for clarity for the reader. The following hypothesis was made per time period and per continent:

H0 = there is no relationship between the political risks and the market diffusion of frugal solar-PV systems per capita or per GDP.

H1 = there is a relationship between the political risks and the market diffusion of frugal solar-PV systems per capita or per GDP.

Interesting to see is that the African continent again shows no significant results, as well as the East Asia and Pacific and Europe and Central Asia continents.

**Table 36** – Results of continental correlation analysis including population and GDP.

| Period | Countries included | Correlation coefficient PR-index and sales/capita | Two-sided p-value PR-index and sales/capita | Countries included | Correlation coefficient PR-index and sales/GDP | Two-sided p-value PR-index and sales/GDP |
|---|---|---|---|---|---|---|
| **Africa** | | | | | | |
| H2 2015 | 16 | 0.122 | 0.652 | 16 | 0.144 | 0.594 |
| H1 2016 | 20 | 0.130 | 0.584 | 20 | 0.162 | 0.496 |
| H2 2016 | 26 | -0.094 | 0.649 | 25 | -0.006 | 0.978 |
| H1 2017 | 27 | -0.245 | 0.219 | 26 | -0.088 | 0.668 |
| H2 2017 | 26 | -0.226 | 0.266 | 25 | -0.044 | 0.834 |
| H1 2018 | 26 | -0.091 | 0.660 | 25 | -0.011 | 0.959 |

| | | | | | | |
|---|---|---|---|---|---|---|
| H2 2018 | 27 | 0.067 | 0.738 | 26 | 0.145 | 0.480 |
| H1 2019 | 27 | 0.122 | 0.546 | 26 | 0.172 | 0.401 |
| H2 2019 | 25 | -0.031 | 0.884 | 24 | 0.076 | 0.725 |
| **East Asia and Pacific** | | | | | | |
| H2 2015 | 3 | 0.500 | 0.667 | 3 | 0.500 | 0.667 |
| H1 2016 | 4 | 0.400 | 0.600 | 4 | 0.400 | 0.600 |
| H2 2016 | 10 | 0.382 | 0.276 | 10 | 0.552 | 0.098 |
| H1 2017 | 12 | 0.000 | 1.000 | 12 | 0.063 | 0.846 |
| H2 2017 | 11 | -0.251 | 0.457 | 11 | 0.114 | 0.739 |
| H1 2018 | 11 | -0.082 | 0.811 | 11 | 0.173 | 0.612 |
| H2 2018 | 9 | -0.583 | 0.099 | 9 | -0.250 | 0.516 |
| H1 2019 | 9 | -0.100 | 0.798 | 9 | 0.083 | 0.831 |
| H2 2019 | 4 | 0.600 | 0.400 | 4 | 0.800 | 0.200 |
| **South Asia** | | | | | | |
| H2 2015 | 4 | -0.400 | 0.600 | 4 | -0.400 | 0.600 |
| H1 2016 | 4 | -0.400 | 0.600 | 4 | -0.400 | 0.600 |
| H2 2016 | 4 | -0.800 | 0.200 | 4 | -0.400 | 0.600 |
| H1 2017 | 4 | -0.800 | 0.200 | 4 | -0.800 | 0.200 |
| H2 2017 | 4 | -0.800 | 0.200 | 4 | -0.400 | 0.600 |
| H1 2018 | 4 | -0.800 | 0.200 | 4 | -0.800 | 0.200 |
| H2 2018 | 4 | -0.400 | 0.600 | 4 | -0.400 | 0.600 |
| H1 2019 | 3 | -0.500 | 0.667 | 3 | -0.500 | 0.667 |

| | | | | | | |
|---|---|---|---|---|---|---|
| H2 2019 | 3 | -1.000 | 0.000 | 3 | -1.000 | 0.000 |
| **Middle East and North Africa** | | | | | | |
| H2 2015 | 0 | N/A | N/A | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2016 | 1 | N/A | N/A | 1 | N/A | N/A |
| H1 2017 | 3 | -0.500 | 0.667 | 3 | 1.000 | 0.000 |
| H2 2017 | 2 | -1.000 | 0.000 | 2 | -1.000 | 0.000 |
| H1 2018 | 2 | -1.000 | 0.000 | 2 | -1.000 | 0.000 |
| H2 2018 | 3 | -0.500 | 0.667 | 3 | 0.500 | 0.667 |
| H1 2019 | 1 | N/A | N/A | 1 | N/A | N/A |
| H2 2019 | 0 | N/A | N/A | 0 | N/A | N/A |
| **Latin America** | | | | | | |
| H2 2015 | 0 | N/A | N/A | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2016 | 6 | 0.551 | 0.257 | 6 | 0.551 | 0.257 |
| H1 2017 | 5 | 0.300 | 0.624 | 5 | 0.600 | 0.285 |
| H2 2017 | 6 | -0.029 | 0.957 | 6 | 0.486 | 0.329 |
| H1 2018 | 4 | -0.200 | 0.800 | 4 | 0.400 | 0.600 |
| H2 2018 | 2 | 1.000 | 0.000 | 2 | 1.000 | 0.000 |
| H1 2019 | 2 | 1.000 | 0.000 | 2 | 1.000 | 0.000 |
| H2 2019 | 0 | N/A | N/A | 0 | N/A | N/A |
| **North America** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| H2 2015 | 0 | N/A | N/A | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2016 | 1 | N/A | N/A | 1 | N/A | N/A |
| H1 2017 | 2 | 1.000 | 0.000 | 2 | 1.000 | 0.000 |
| H2 2017 | 1 | N/A | N/A | 1 | N/A | N/A |
| H1 2018 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2018 | 0 | N/A | N/A | 0 | N/A | N/A |
| H1 2019 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2019 | 0 | N/A | N/A | 0 | N/A | N/A |
| **Europe and Central Asia** | | | | | | |
| H2 2015 | 0 | N/A | N/A | 0 | N/A | N/A |
| H1 2016 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2016 | 5 | 0.100 | 0.873 | 5 | 0.100 | 0.873 |
| H1 2017 | 6 | 0.029 | 0.957 | 6 | 0.200 | 0.704 |
| H2 2017 | 10 | 0.232 | 0.519 | 10 | 0.232 | 0.519 |
| H1 2018 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2018 | 0 | N/A | N/A | 0 | N/A | N/A |
| H1 2019 | 0 | N/A | N/A | 0 | N/A | N/A |
| H2 2019 | 0 | N/A | N/A | 0 | N/A | N/A |