The Feasibility of Meeting the Demand for Fresh Food from Horticulture in Iceland

Azusa Yamada

Supervisor:
Sveinn Agnarsson
Ragnheidur Inga Thorarinsdottir
The Feasibility of Meeting the Demand for Fresh Food from Horticulture in Iceland

Azusa Yamada

Final Thesis for MS Degree in Environment and Natural Resources

Supervisors:
Sveinn Agnarsson
Ragnheidur Inga Thorarinsdottir

Faculty of Business Administration
School of Social Sciences, University of Iceland
Graduating February 2020
The feasibility of meeting the demand for fresh food from horticulture in Iceland.

This is a 30-credit thesis submitted in fulfilment of the requirements for an MS degree in Environment and Natural Resources linked with the Faculty of Business Administration, School of Social Sciences, University of Iceland.

© 2020 Azusa Yamada
This thesis can be copied only with the author’s permission.

Printed by: Háskólaprent
Reykjavík 2020
Acknowledgements

First and foremost, I would like to express my deepest gratitude to my supervisors, Ragnheidur Inga Thorarinsdottir and Sveinn Agnarsson. Thank you, Ragnheidur, for seeing the potential in this topic at an early stage and encouraging me with constructive advice. Sveinn, thank you for your profound belief in my work and unparalleled support. I couldn’t have come this far without your support and guidance. I would also like to acknowledge and thank all of the interviewees and experts, whose names cannot be disclosed, who were involved in this project. Their passionate participation and input were indispensable to this work. I am also grateful to the Watanabe Trust Fund of the University of Iceland scholarship programme for allowing me to explore my passions and cultivate my intellectual curiosity in this beautiful country. I am grateful also to Daniel Charles Kavanagh for his help with contacting local growers and his continual words of encouragement. I am also indebted to Claudiu Eduard Nedelciu, Jackson Rose, and Súsanna Rós Westlund for the time they devoted to reading this thesis and their valuable comments. Their willingness to provide their help so generously has been very much appreciated. Finally and most importantly, none of this could have happened without my friends and family. This dissertation stands as a testament to your unconditional love and support. For that, I am forever grateful.
Abstract

Iceland has successfully produced a variety of vegetables all year round using greenhouses. Despite the ability to produce fresh food products in the country using natural resources, imported products have accounted for a considerable portion of Iceland’s market. However, the threats generated by growing global food demand and changing food production systems due to climate change will become a concern for Iceland, as food safety and security are necessary for national security. Given Iceland’s abundant natural resources, is it possible to increase domestically produced food in the market? This study examines the competitiveness of the Icelandic horticultural industry in order to evaluate the feasibility of increasing food production. This study analysed the current market for the main horticultural crops cultivated in the country – tomatoes, bell peppers, salads, mushrooms, and cucumbers – and evaluated the competitiveness of the industry using Porter’s five forces. Prior to the evaluation, interviews were conducted with Icelandic growers to reflect local inputs, and the results were applied to each competitive force. The overall assessment of each force applied to the industry reveals that Iceland’s horticultural industry has moderately high competitiveness, indicating that the industry should be able to increase domestic production using Iceland’s current resources. However, the industry’s products face a strong threat of substitutes, making it difficult to increase food production under the current circumstances. Hence, effective measures should be implemented where needed by taking advantage of two industry strengths: the low power of suppliers and new entrants.

Keywords:
Horticulture; competitiveness; Iceland; climate change; local product

Lykilorð: 
Garðyrkja; samkeppnishæfni; Íslendingar loftslagsbreytingar; staðbundin vara
# Table of contents

Acknowledgements .............................................................................................................. 3
Abstract ................................................................................................................................. 4
Útfrættur ................................................................................................................................ 5
List of Figures .......................................................................................................................... 9
List of Tables ..........................................................................................................................11
Abbreviations .........................................................................................................................12

1. Introduction ....................................................................................................................... 13
   1.1. Objective ..................................................................................................................... 14
   1.2. Thesis framework ...................................................................................................... 14

2. Background ....................................................................................................................... 15
   2.1. Growing food demand ............................................................................................. 15
   2.2. Agriculture and land use ........................................................................................ 17
   2.3. Climate change ......................................................................................................... 18
      2.3.1. Rising global temperature .................................................................................. 18
      2.3.2. Impacts of climate change in Arctic regions ....................................................... 19
      2.3.3. Impacts on agriculture ....................................................................................... 21
   2.4 Technological development in agriculture ................................................................ 22
   2.5. Agriculture in Iceland .............................................................................................. 23
      2.5.1. Food demand in Iceland ..................................................................................... 24
         2.5.1.1. Population growth ....................................................................................... 25
         2.5.1.2. Tourism ....................................................................................................... 25
         2.5.1.3. Fruit and vegetable consumption ............................................................... 26
      2.5.2. Local food production ....................................................................................... 30
         2.5.2.1. Historical overview ..................................................................................... 31
         2.5.2.2. Agricultural industry ................................................................................... 31
         2.5.2.3. Utilisation of natural resources ..................................................................... 34
         2.5.2.4. Greenhouses ............................................................................................... 36
         2.5.2.5. Pesticide use ............................................................................................... 39
      2.5.3. Reliance on imports ......................................................................................... 41
         2.5.3.1. Products Iceland imports ............................................................................. 42
         2.5.3.2. Countries Iceland imports from ................................................................. 44
      2.5.4. Impact of climate change on food supply in Iceland ......................................... 44
   2.6. Research question ....................................................................................................... 45

3. Methodology and theoretical framework ........................................................................... 46
   3.1. Scope .......................................................................................................................... 46
   3.2. Interviews .................................................................................................................. 46
   3.3. Competitiveness ........................................................................................................ 47
   3.4. Porter’s five forces ..................................................................................................... 49
      3.4.1. Rivalry among existing competitors ................................................................. 50
      3.4.2. Bargaining power of suppliers ........................................................................... 51
      3.4.3. Bargaining power of buyers .............................................................................. 52
List of Figures

Figure 1. World population growth from 1950 to 2100. Data from United Nations, Department of Economic and Social Affairs, Population (2019).


Figure 3. Observed global temperature change and modelled responses to stylized anthropogenic emission and forcing pathways. Reprinted from ‘Summary for policymakers In Global warming of 1.5°C,’ by IPCC. 2018. Copyright 2018 by IPCC.

Figure 4. Change in average surface temperature (1986–2005 to 2081–2100). Reprinted from ‘Summary for policymakers in Global warming of 1.5°C’, by Hoegh-Guldberg et al., 2018. Copyright 2018 by IPCC.

Figure 5. Change in average precipitation (1986–2005 to 2081–2100). Reprinted from ‘Summary for policymakers’, by Hoegh-Guldberg et al., 2018. Global warming of 1.5°C, p. 32. Copyright 2018 by IPCC.


Figure 8. Foreign visitors to Iceland 1949–2017 (Icelandic Tourist Board, 2019).

Figure 9. Percentage of the population that meets the recommended daily intake of vegetables and fruits in 2014 (Statistics Iceland, 2017).

Figure 10. Percentage of the population aged 15 years old and older with daily fruit consumption.

Figure 11. Percentage of the population aged 15 years old and older with daily vegetable consumption (Inchley et al., 2016).


Figure 13. Composition of agricultural food trade in 2017. Reprinted from Agricultural Policy Monitoring and Evaluation 2019, by OECD, July 1, 2019, retrieved from https://www.oecd-
Figure 14. Geothermal fields in Iceland. Reprinted from The Resources by the National Energy Authority, n.d., retrieved from https://nea.is/geothermal/the-resource/.


Figure 16. Share of horticultural producers by production type (National Energy Authority, 2017a).

Figure 17. Share of horticultural producers by region (National Energy Authority, 2017a).


Figure 20. Reliance on imported products by food category. Reprinted from Local Food in Iceland: Identifying Behavioural Barriers to Increased Production and Consumption by Halldorsdottir and Nicholas, 2016. doi:10.1088/1748-9326/11/11/115004.

Figure 21. Comparison of the amount of imported and domestic food in the market in 2017 (Appendix 1).

Figure 22. Five forces model proposed by Porter (1985).

Figure 23. Transition of amount of imported and domestic tomato from 2007 to 2017.

Figure 24. Market share of companies in tomato sector.

Figure 25. Transition in amount of imported and domestic bell peppers from 2007 to 2017.

Figure 26. Market share of companies in bell pepper sector.

Figure 27. Transition of amount of imported and domestic salad from 2007 to 2017.

Figure 28. Market share of companies in salad sector.

Figure 29. Transition of amount of imported and domestic mushrooms from 2007 to 2017.

Figure 30. Market share of companies in mushroom sector.

Figure 31. Transition of amount of imported and domestic cucumbers from 2007 to 2017.

Figure 32. Market share of companies in cucumber sector.
Figure 33. Structure of Iceland’s electricity industry. Reprinted from Our Energy 2030 by Lars Christensen, 2016, retrieved from https://www.si.is/media/orku-og-umhverfismal/Iceland-Energy-2030.pdf.

Figure 34. Size of indoor horticultural farming in Iceland (National Energy Authority, 2017b).

List of Tables

Table 1. Breakdown of major crop production
Table 2. Overall evaluation for market concentration.
Table 3. Overall evaluation for rivalry
Table 4. Overall evaluation for suppliers’ power
Table 5. Overall evaluation for buyers’ power
Table 6. Overall evaluation for substitutes
Table 7. Overall evaluation for new entrants
Table 8. Comprehensive evaluation for horticultural industry in Iceland
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Artificial intelligence</td>
</tr>
<tr>
<td>CSA</td>
<td>Climate-smart agriculture</td>
</tr>
<tr>
<td>FV</td>
<td>Fruits and vegetables</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>PA</td>
<td>Precision agriculture</td>
</tr>
<tr>
<td>PSE</td>
<td>Producer support estimate</td>
</tr>
</tbody>
</table>
1. Introduction

Iceland’s fresh food market is filled with vast quantities of imported agricultural products. It is no wonder Iceland relies heavily on imports for food supplies, given the country’s unfavourable environmental crop growth conditions. The global population has been increasing, and food demand is expected to expand on a global scale. Agriculture has already caused enormous environmental impacts and expended vast natural resources, and the growing food demand will exert additional pressure on the finite resources required for food production. In addition to the environmental pressure generated by agriculture, climate change may exert extra pressure and affect the dynamics of agricultural food systems. Relying heavily on imports could jeopardize Iceland’s food security considering the increased global food demand along with population growth and the potential environmental impacts associated with climate change. Iceland cultivates a variety of vegetable crops using greenhouses, which provide favourable environmental conditions for crop growth. The country is also rich in natural resources, which could be utilized to encourage food production within the country. Despite the country’s capacity to produce fresh food, a limited number of products are commercially cultivated, and imported products represent a considerable share of the fresh food market. This study attempts to help Iceland expand its domestically produced fresh food in both quantity and in variety by analysing its horticultural industry and identifying the obstacles Icelandic growers are facing as well as their advantages over foreign producers. A variety of vegetables are being commercially produced in Iceland. This study examines Iceland’s horticultural industry – focusing on the tomato, bell pepper, salad, mushroom, and cucumber sectors – by applying Michael Porter’s five forces: rivalry among existing competitors, the bargaining power of suppliers, the bargaining power of buyers, threats of product substitutes, and the threat of new entrants to the industry. As the available industry data are insufficient, interviews with local growers are also conducted. In addition to the inputs obtained from the interviews, data collected from Statistics Iceland (Hagstofa Íslands) and the National Energy Authority (Orkustofnun) are used for the analysis.
1.1. Objective
The objective of this study is to examine the feasibility of meeting Iceland's demand for fresh food produced by horticulture. This study analyses the five main horticultural crops produced in Iceland using Porter’s five competitive forces. It attempts to reveal the weaknesses and strengths of each sector and provides a big picture of the industry. Any similarities between the five vegetable sectors can be perceived as either industry weaknesses or strengths, which can be used for future reference. This study thus provides insights into the industry useful for both growers and the government – for example, concerning how to ensure food security.

1.2. Thesis framework
This thesis is divided into seven chapters. In chapter two, the thesis’s background is described, starting with global issues and then narrowing the focus down to the Icelandic case. The discussion of global issues covers four topics associated with agriculture: the global demand for food, finite natural resources, climate change, and technological development in agriculture. The following sections about Iceland discuss the nation’s food demand and supply, its reliance on imported products, and the potential impact of climate change on its food supplies. Chapter three presents the theoretical framework of the thesis and then introduces and explains Porter’s five forces. In chapter four, the results obtained from the interviews with the farmers are examined. Chapter five demonstrates each of the five forces applied to the horticultural industry with data collected through a literature review and interview inputs. Chapter six discusses the results and outlines the limitations of the study. Finally, conclusions are drawn in chapter seven.
2. Background

This chapter provides background information on the dynamics of global food systems, focusing on the growing food demand, finite natural resources, the effects of climate change, and technological developments in agriculture. The focus then shifts from global issues to the Icelandic case in order to address the country’s food systems.

2.1. Growing food demand

Global food demand is expected to grow by at least 50% over the next four decades (FAO, 2017). The world population was less than one billion until 1800 but has changed dramatically since then (Roser et al., 2019). The population has reached 7.7 billion through remarkably rapid growth due to enormous improvements in healthcare and a decline in mortality rates over the last 100 years. The population is expected to continue growing and reach 9.7 billion by 2050 and 10.9 billion by 2100 (United Nations, Department of Economic and Social Affairs, Population Division, 2019).

Figure 1. World population growth from 1950 to 2100. Data from United Nations, Department of Economic and Social Affairs, Population (2019).
Though considered temporary, growth in the global population is exponential: 141 million people are born and 57 million die every year, representing an 84.21 million per-year increase in the world population (Roser et al., 2019).

In addition to accelerating the food demand, global population growth is also likely to increase urbanization and subsequently cause a shift in dietary habits. Nearly two-thirds of the global population lived in rural areas until four decades ago; now, more than half of the world’s population is living in urban areas (FAO, 2017). In three or four decades from now, the percentage of the population residing in urban areas is expected to be somewhat similar to the number of rural residents four decades ago. Aside from the increase in the global population, a net addition of 2.4 billion people is expected to be residing in urban areas in 2050. This urbanization is shifting food consumption patterns, as urban and higher-income societies tend to increase demand for energy-intensive food (McMichael et al., 2007; Popkin, 1999; FAO, 2017). Although this can differ considerably across nations, urbanized countries consume much greater amounts of animal protein sources, such as pork, poultry, and beef, and dairy products. While average annual global meat consumption is 36.9 kg per capita, it is 17.2 kg in lower-income countries and 81.8 kg in high-income countries (McMichael et al., 2007). Energy-intensive food includes not only meat, but also processed foods that require costly expenditures of labour as well as the natural resources needed to produce raw materials for the products. Cohen and Garrett (2010) confirm that, as the opportunity costs of preparing food are likely to increase in urban areas, products such as fast food, frozen ready food, and store-bought meals will be purchased more often, especially among urban residents with higher incomes.

Income growth is also expected in low- and middle- income countries due to the rising global population, and raising the basic wage table would accelerate the dietary transition (FAO, 2017). Cereal oriented diets are now changing towards a higher consumption of meat, fruits, and vegetables. Though changing diets apply additional pressure on natural resources, commensurate outputs must be produced to feed the population. Thus, it is critical to address the anticipated challenges confronting the global food situation immediately utilizing the available land area and resources.
2.2. Agriculture and land use

The world’s food production systems depend solely on natural resources, which are finite and unevenly distributed. Water is an essential resource for agriculture and is used intensively in the agricultural industry. While water plays an irreplaceable role in food production, freshwater availability is limited. Of the global freshwater withdrawals for anthropogenic activities, more than 70% is taken up for agricultural purposes (UN water, 2019). Despite water’s significant role in food production, water scarcity has been observed in every continent. Arid regions are facing particularly severe water stress. In addition to water scarcity, limited land area is also a critical issue for agriculture. The Earth’s surface consists of 71% ocean and 29% land (see Figure 2; Roser & Ritchie, 2013). About 70% of the Earth’s total land surface (149 million km$^2$) is considered fit for habitation, with the rest occupied by glaciers and barren land, including vegetated area, deserts, and beaches. While almost half of the global habitable area is taken up by agricultural production, the land area used for food production totals 51 million km$^2$: 77% for livestock and 23% for crops. Crop production requires about 7% of the total land surface and is responsible for 35% of global greenhouse gas emissions (Roser & Ritchie, 2013; Halldorsdottir & Nicholas, 2016). Livestock dominates the limited amount of agricultural land, including land areas for grazing and production of animal feed, but the global caloric and protein supplies from meat and dairy consumption total only 17% and 33% respectively. Crop production does not require the large land area raising livestock requires. However, given the increasing demand for food along with the global population growth, it will be crucial to increase crop production efficiency, by making the best possible use of the land area or considering the reallocation of land for food production.
2.3. Climate change

In addition to the environmental limitations of agricultural activities, climate change has an enormous impact on agriculture, as agriculture is very sensitive to external conditions. Scientists’ predictions regarding climate change are variable and uncertain; however, given the increases in global temperature, underestimating the effects of climate change could result in irrecoverable outputs. This section explains the relationship between the greenhouse effect and global warming and discusses the potential effects on the Arctic region. It then sums up climate change’s impacts on agriculture in general.

2.3.1. Rising global temperature

According to a special report by the Intergovernmental Panel on Climate Change (IPCC) (2018), the global mean temperature has increased by one degree compared to that of the years 1850-1900 and is likely to continue increasing by two degrees. Figure 3 illustrates the change in global mean surface temperature from 1960 to 2017 and a projection of the
temperature reflected from stylized anthropogenic emissions for the next eight decades. The grey line reflects observed monthly global mean surface temperatures from 1960 to 2017, while the orange line indicates the estimated rate of anthropogenic global warming with the likely range shown in orange shading. Although there is a significant fluctuation in temperature, the orange line shows a tendency toward an increase to date.

Figure 3. Observed global temperature change and modelled responses to stylized anthropogenic emission and forcing pathways. Reprinted from ‘Summary for policymakers In Global warming of 1.5°C,’ by IPCC. 2018. Copyright 2018 by IPCC.

2.3.2. Impacts of climate change in Arctic regions

Both the North and South Poles are exceptionally vulnerable and are more sensitive to climate change than the rest of the world. The scope of this study covers only the Arctic regions. The Arctic is severely affected by climate change, which is considered a possible cause of warming, increased precipitation, and the melting of glaciers and sea ice (ACIA, 2004). Changes in arctic climate are projected to accelerate global climate change even further and exert more significant effects on the rest of the world.

Cold regions are more likely to experience a rise in the mean temperature (Callendar, 1938). Surface temperatures in the Arctic have been increasing twice as fast as the mean global temperature over recent decades (ACIA, 2005). The average temperature of 60 degrees
north latitude has been warming by 1 to 2°C compared with the temperature minimum in the 1960s and 1970s (Polyakov et al., 2002), and the mean temperature in the Arctic is expected to increase the warming by approximately 4 to 7°C over the next century (ACIA, 2004). The most substantial warming is seen in winter and spring and the smallest in summer, with variations between regions (ACIA, 2005).

Figure 4. Change in average surface temperature (1986–2005 to 2081–2100). Reprinted from ‘Summary for policymakers in Global warming of 1.5°C’, by Hoegh-Guldberg et al., 2018. Copyright 2018 by IPCC.

In addition to the temperature increase, precipitation in the Arctic has increased at a rate of 1% per decade over the last hundred years (ACIA, 2005).

Figure 5. Change in average precipitation (1986–2005 to 2081–2100). Reprinted from ‘Summary for policymakers’, by Hoegh-Guldberg et al., 2018. Global warming of 1.5°C, p. 32. Copyright 2018 by IPCC.

Climate change has reduced Arctic sea ice and glaciers and increased river runoff. Not only is the degradation of permafrost visually apparent (Lemke et al., 2007), but longitudinal measurements reveal that a thick active layer is widely deficient (Sturm et al., 2001). Moreover, glacial melt and river runoff are increasing the freshwater going into the ocean,
increasing global sea levels and decelerating ocean circulation. As the massive scale of ocean movements carry warm waters from the tropics to the poleward sides, the deceleration of ocean circulation will eventually affect the Arctic regions as well (ACIA, 2004).

2.3.3. Impacts on agriculture

Climate change is expected to alter agricultural conditions on a global scale. Since agriculture is directly exposed to the natural environment and is sensitive to changes in environmental conditions, it is critical to facilitate adaptation to the adverse effects of climate change. A report published by IPCC on the impacts of global warming of 1.5°C (2018) demonstrates how climate change will affect the agricultural sector in the next decades. If the global temperature proceeds at the speed it has since the post-industrial era began, it is expected to increase up to 1.5°C between 2030 and 2050. A rise of 0.5 degrees can provoke an increase in mean temperature in both land and ocean regions, extreme precipitation events, and potential drought and precipitation deficits. A rise in temperature by 1 degree can worsen the prospects even further.

Climatic change associated with global warming is likely to induce extreme temperatures on a regional level. Land regions are more susceptible than ocean ones; indeed, temperature extremes on land are apt to increase even more than the global mean surface temperature. In the case of global warming by 1.5°C and 2°C, the temperature on hot days in mid-latitudes will increase by up to 3°C and 4°C respectively. On the other side of the spectrum – in high latitudes – extreme cold nights will warm by approximately 4.5°C and 6°C (IPCC, 2018). Considering that agricultural practices are generally based on land areas, an increase in temperature may require farmers to provide additional care for crops or change to crops that are resistant to changing climatic environments, as different crops have different optimal temperatures.

Climate change affects not only global surface temperatures but also precipitation events. As global warming increases, it is more likely to heighten the risk of heavy precipitation and drought. The risk of heavy precipitation is higher at global warming of 2°C than at 1.5°C,
particularly in regions located at high northern latitudes or high elevation, or both, such as eastern Asia and eastern North America (IPCC, 2018).

Climate change can adversely impact agriculture, especially when it uses cultivation methods reliant on the power of nature. The potential effects of climate change can threaten the size of agricultural yields and thus affect food prices. Hence, climate change affects agriculture not only in one country but also in neighbouring countries as well.

2.4 Technological development in agriculture

Given the potential impacts of climate change and the increasing demand for food, it is critical to increase crop yields and production efficiency on national and global scales. Precision agriculture (PA) emerged in the 1980s in a fundamental overhaul of agricultural production systems (Gebbers & Adamchuk, 2010). PA is designed to apply the right treatment at the right time in the right place, adopting information-based management with the help of technology, which makes food production more efficient and improves outcomes. With a broad range of application, PA has been applied in many different cases to increase profitability. First, PA was developed for accurate fertilizer application across agricultural fields, and not only for field crop production; it also yields good results in horticulture and viticulture. Although it is considered almost impossible to evaluate the effect of PA, a review of 234 studies published from 1988 to 2005 demonstrates that it was found to be practical in around 68% of the cases. Agricultural production systems have significantly improved since then through the enhancement of information management. Apart from PA, smart farming, the Internet of Things (IoT), the Internet of Everything (IoE), cloud and fog computing, big data, data analytics, and machine learning have also been adopted to promote effective agricultural practices (Prabhu, n.d.). Moreover, agricultural practices associated with data-based management have been developed, such as the automatic guidance of agricultural vehicles and implements, autonomous machinery and processes, product traceability, on-farm research, and software for the overall management of production systems.
The emphasis in agricultural production has been on efficiency, but sustainability was also cited in 2010 as an essential matter for sustainable agriculture. The FAO introduced climate-smart agriculture (CSA) at the Hague Conference on Agriculture, Food Security and Climate Change that year. Its principal aim is to pursue the development of sustainable agriculture for food security under the circumstances affected by climate change. It has three objectives: 1) food security, 2) adaptation to climate change, and 3) mitigation to climate change. In concrete terms, the first objective is to increase production yield sustainably while increasing incomes; the second is to merely adapt and enhance resilience to climate change; and the third is to reduce GHG emissions associated with agricultural activities. By providing not only technology but also educational assistance to farmers, CSA aims to achieve a fundamental revision of food production systems. The emergence of the term sustainability indicates that 2050 food demand must be met by making the best use of finite resources and adapting to changes caused by climate change while also minimizing detrimental impacts on the environment.

2.5. Agriculture in Iceland

Iceland is situated between 63.3° and 66.7° north in the North Atlantic Ocean and is separated by oceans from other countries. It is located 287 km away from the nearest land area, Greenland, and about 970 km away from the closest part of the mainland of Europe, Norway (Malmstrom, 1958). The total land area of the nation is approximately 103,000 km². Almost 37% of the landmass is taken up by geographical features such as lakes (2.6%), glaciers (11.6%), and vegetation (23%), and the rest is simply wasteland (Statistics Iceland, 2018a). Due to its geographical location, Iceland abounds with unique features such as a subarctic climate, dark winters, and volcanic activity, which have a profound effect on social and economic activities in the country (Arnalds, 2005). The surrounding ocean is the dominant influence on the climate of the island. As warm Gulf Stream and cold arctic currents meet where Iceland is situated, cyclones that rotate a system of winds passing close to Iceland cause frequent changes in weather in their path (Einarsson, n.a.). Although temperatures vary depending on the region, Iceland’s average temperature is around 10°C in the summer and -1°C in the winter. The lengths of days differ dramatically between summer
and winter: While the sun stays up almost all day after the summer solstice, it stays up for only a few hours in the winter. Due to these natural conditions, the growing season in Iceland is only about four months (Government of Iceland, n.a.). Given all these features, Iceland’s environmental conditions are unfavourable for agriculture.


2.5.1. Food demand in Iceland

Due to the limited environmental conditions for crop growth, Iceland must be aware of its food demand in order to be able to provide essential nutrients to Icelanders. *Horticultural Marketing*, published by the FAO, indicates that the most influential of the factors influencing changes in food demand are food prices, food availability, dietary preferences, number of consumers, consumers’ financial capability, and cost of food production (Dixie, 2005). This section examines the number of consumers and dietary preferences in Iceland to determine its food demand.
2.5.1.1. Population growth

The population of Iceland is the smallest among European countries (Promote Iceland, 2019). Though the population is small, it has grown dramatically over the last century. Figure 7 shows Iceland’s population development from 1703 to 2066. It was 50,358 in 1703 and remained virtually unchanged until the 1830s (Statistics Iceland, 2019a, 2019c). Since then, it has increased rapidly and reached 356,991 on January 1, 2019. It is projected to continue growing.

![Graph of Iceland's population development from 1703 to 2066.](image)


2.5.1.2. Tourism

Not only has the population grown, but the number of foreign visitors to Iceland has increased as well. Iceland had approximately 5,000 tourists until several years after World War II, but Iceland has increased in popularity as a travel destination since then (see Figure 8). Tourism in Iceland has accelerated at a nearly exponential rate since 2010 when a powerful volcanic eruption occurred and the development of inbound tourism began. The number of tourists who visited in 2010, 488,622, had grown nearly fourfold to 2,224,074 by 2017. The mean yearly growth rate since 2010 is estimated to be 24.3%; the most notable
increase from 2010 to 2017 was 39.0% between 2015 and 2016 (Icelandic Tourist Board, 2018).

The combination of a growing population and increased tourism is increasing food demand in the country. Predicting future food demand is difficult, as several factors affect its growth; however, Iceland must ensure a sufficient food supply by taking into account the external influences on food demand. Understanding food consumption is critical, but no data are available on overall food consumption or on estimated potential future food consumption in Iceland. The next section examines the demand for fruits and vegetables in Iceland by analysing the daily consumption of fruits and vegetables compared with that of other EU countries.

2.5.1.3. Fruit and vegetable consumption

Despite the increasing number of potential food consumers, fruits and vegetables (FV) are not consumed as much as recommended in dietary guidelines. Consuming at least 400 g of fruits and vegetables daily is recommended to build and sustain health (Joint WHO/FAO
Iceland’s Directorate of Health (2018) suggests that consuming no less than 500 g of vegetables (excluding starchy foods such as potatoes and tubers) and fruits is ideal. The main reason for the exception of potatoes is to encourage the public to eat a variety of vegetables and break from traditional eating habits. Vegetables are defined as the edible part of a plant, while potatoes tend to be put in a separate food group in many dietary guidelines, such as being subsumed under starchy foods rather than being acknowledged as vegetables (Agudo, 2005). By explicitly excluding potatoes from the vegetable group, proponents of the recommendations aim to increase vegetable intake.

The consumption of FV is lower in Northern Europe than in the rest of the world and is particularly low in Iceland. Figure 9 shows FV consumption in Europe. Blue bars show the percentage of the population that eats five or more portions of FV per day, considered ideal according to WHO/FAO Expert Consultation guidelines. The red bars show the percentage of the population that eats one to four portions per day. The rest of the percentage indicates no daily FV consumption. A FV consumption of five or more portions is shown in descending order. More than two-thirds of Iceland’s population eat FV every day, as they do in Denmark, another Nordic country. However, only 10.1% of people follow the ideal diet suggested in the guideline in Iceland, which is less than half the number who follows it in Denmark.
Figure 9. Percentage of the population that meets the recommended daily intake of vegetables and fruits in 2014 (Statistics Iceland, 2017).

Figure 9 shows the percentage of the population with a daily FV consumption, while Figures 10 and 11 show the daily consumption of vegetables and fruits, respectively, of people aged 15 years old and older in EU countries, including Iceland, Turkey, Norway, and Switzerland. Figure 10 indicates that Iceland’s average fruit consumption (46%) is lower than the EU average of 54%.
Figure 10. Percentage of the population aged 15 years old and older with daily fruit consumption (Inchley et al., 2016).

Figure 11 shows that 47% of the population in Iceland eats vegetables every day or more than five portions a day. This proportion is one percent higher than that of daily fruit consumption for Iceland. Nevertheless, the daily consumption of both is low, lower than the EU average (54% for fruit consumption and 51% for vegetables).
The number of people with daily FV consumption is less than half of Iceland’s population. Vegetable and fruit intake is low among Iceland’s small population. Merely one-tenth of Icelanders has a proper intake of vegetables and fruits as advised by official guidelines. Given that the ideal amount of food is supplied to the nation based on the guidelines, Iceland must generate a significant amount of food waste, as most of the population is not following the suggested diet.

Considering the relatively low consumption of FV in Iceland, the country generates weak demand for FV. However, tourism can exert a considerable impact on the market for dietary items, as there are more FV consumers abroad than in Iceland. Being on an upward trend, tourism has tremendous FV consumption potential in Iceland.

2.5.2. Local food production

It is considered ideal to include a certain amount of FV in a meal, yet these food items are new aspects of Icelandic eating habits. Historically, the Icelandic diet consisted of animal-source foods with a minimal amount of FV. Due to the necessity of importing food
commodities, domestically produced animal foods were vital components of Iceland’s diet until the 19th century. With the utilization of natural resources and technology, however, Icelandic food production systems have dramatically changed and likewise Icelanders’ dietary habits. This section explains food supplies in Iceland by, first, providing an historical overview of the agriculture industry and offering basic information about the industry, including Iceland’s fisheries and livestock. Then, the application of natural resources to food production is discussed. Third, indoor farming using greenhouses is explained in order to describe the common way of producing a variety of vegetables in Iceland. Finally, pesticide use in the country is addressed.

2.5.2.1. Historical overview
In the second half of the 9th century, Nordic people and their accompanying Celtic slaves migrated to Iceland to settle land (Steingrimsdottir et al., 2018). Bringing their farm animals with them, the newcomers earned their livelihoods from animal husbandry and coastal fishing. During settlement, animal-source foods produced in the country provided the basis for the essential nutrients required in the daily diets. Iceland has continued to develop over the centuries, with both increases and decreases in population since settlement. The island was dependent on imports from Denmark for its cereal supply, as there was practically no grain production in Iceland. By the early 19th century, after imports began, grain availability increased rapidly and altered Iceland’s dietary patterns, replacing animal products with rye bread and porridge. In addition to the emergence of domestically produced grain, the production of starchy, tuberous crops such as potatoes began in 1758 (Jonsson, 1998). Iceland then had great success in producing potatoes as demand increased, and they came to be consumed as a staple. This generated diversity in Icelandic eating dietary habits.

2.5.2.2. Agricultural industry
Of Iceland’s 2018 GDP of 2797 billion ISK (International Monetary Fund, 2018), 4.5% was generated from the food industry, comprising 1.1% from agriculture and 3.4% from fishing (Statistics Iceland, 2019a). During the 20th century, the fishing industry made a significant contribution to the Icelandic economy via its fish exports and processing. Iceland’s fisheries
developed drastically during World War II, when British forces seized control of Iceland and consolidated its infrastructure (Steingrimsdottir et al., 2018). At the time, fish products were exported as a valuable commodity, and the fishing industry created prosperity in the country. Although the share of total Icelandic exports has been in decline since the early 1990s, fisheries have remained an essential pillar of export activities, accounting for 42% of Iceland’s goods exports and approximately 22% of its total export earnings from goods and services in 2015.

Agricultural activities account for approximately 1% of Iceland’s total GDP (IMF, 2018). While the nation’s vegetated area covers nearly a fifth of its landmass, arable land accounts for less than five per cent of the vegetated area, with the rest either undeveloped or used as pasture. Livestock accounts for 85% of Iceland’s total agricultural production; it is raised mainly for domestic consumption, supplying meat and dairy products (OECD, 2019a). Hay and cereals for livestock feed and root vegetables and green vegetables for human consumption make up the rest of the total agricultural production (15%). Most vegetables are cultivated in greenhouses harnessing geothermal power.

According to the Icelandic Labour Force Survey of Statistics Iceland (2018b), 212,900 people aged 16 to 74 worked in the labour force as of July 2018. The activity rate is 82.2%, the employment rate is 81.5%, one of the highest in the world (OECD, 2019c), and the unemployment rate is 2.5%. Of Iceland’s employed, 1.9% are engaged in crop and animal production and related activities, including hunting, as a primary or secondary job (Statistics Iceland, 2018b).

Iceland is a net importer of agricultural products without fishery goods, yielding about 0.6 billion USD in 2017, and has had a steady increase in imports over the previous decade (see Figure 12; OECD, 2019a). Iceland’s main agricultural product exports are sheep meat, fur skins, and horses for breeding, Iceland’s imports are more diversified: 77% of Iceland’s imports of agricultural products are used primarily for final consumption (see Figure 13).


Tariffs, import quotas, and non-tariff import restrictions are imposed on meat, dairy products, and vegetables that are likely to compete with local produce since imported products are often competitive against domestic ones. Iceland provides one of the highest levels of government support to agriculture, and the highest among OECD countries (OECD, 2019a). Of Iceland’s total support estimate (TSE), equivalent to 1.2% of Iceland’s GDP in 2016,
95% comprises a producer support estimate (PSE); 59% of gross farm receipts is comprised of PSE, which makes Iceland the second-highest in gross farm receipts (the OECD average was 18.77% in 2016; OECD, 2019b).

2.5.2.3. Utilisation of natural resources
The management of sustainable water use is a major global issue due to the limited availability of freshwater. In Iceland, however, water is abundant due to the high precipitation of about 2,000 mm a year and runoff from glaciers, which cover 10% of the country’s landmass. Aside from the geographical factors in the nation’s rich water resources, its small population of 356,991 gives Iceland the second highest per capita freshwater availability in the world (Davidsdottir, 2018; Shiklomanov & Rodda, 2003).

Not only does Iceland have plentiful water resources, but it also provides high-quality water; 95% of the groundwater distributed in Iceland requires almost no treatment because water collected from rainfall and glacial runoff is percolated through porous bedrock made from basaltic rock, which contains lower chemical concentrations than other types of rock (Reimann et al., 1996; Alessa et al., 2008). Gunnarsdottir et al. (2016) find that Icelandic drinking water must meet compliance standards and demonstrates the best performance among EU member states.

Additionally, Iceland is a leading country in the utilisation of renewable energy resources, as its geographical location allows for considerable renewable energy potential. Glaciers, one of the most significant resources, cover one-tenth of Iceland’s land area; they store water and power and generate electricity (Statistics Iceland, 2018a). Plentiful geothermal resources are typically found around the continental boundary, as the country sits on two tectonic plates, the North American plate on the west side and the Eurasian plate on the east side (see Figure 14). Given these abundant natural resources, approximately 81% of the nation’s primary energy supply comes from renewable energy: about 20% from hydropower and 60% from geothermal power (National Energy Authority, 2019a). The share of renewable energy in gross final energy consumption in Iceland is 72.6%, by far the highest amongst European countries, as the EU average is 17.04% (EEA, 2018).
Most of Iceland’s electricity is generated from renewable sources. Of the nation’s total electricity production (19.828 GWh in 2018), 69.7% is generated by hydropower from 57 power plants and 30.3% is generated by geothermal power from eight power plants (National Energy Authority, 2019a).

In addition to generating electricity, geothermal power plants also provide geothermal heat. This supports human activities in several ways. According to the National Energy Authority, geothermal heat produced by Main Activity Producers is used for space heating, fish farming, industry, snow melting, swimming pools, and greenhouses. Nearly 80% of the geothermal heat produced (24.449 TJ) is used for space heating (National Energy Authority, 2018a).

One way of utilising hot water is soil heating, which prevents ice formation in the soil during the winter (Gunnlaugsson et al., 2003). Once an ice core begins to form, it extends 10 to 30 cm down into the soil, causing waterlogging, and keeps the soil temperature cold as it melts.
away at a slow pace. To prepare for planting and sowing at the end of April, soil heating is applied to prevent ice formation. Soil heating is also used during the summer to maintain the soil temperature at over 20°C because, normally, the temperature rarely exceeds the average summer temperature of 11°C. Soil heating was first used in the 1850s, when potatoes were cultivated in geothermically heated soil. Since the introduction of plastics in the 1970s, soil heating techniques for the modern cultivation of field vegetables has advanced exponentially and has enabled the commercial growing of crops even in Iceland’s open fields.

2.5.2.4. Greenhouses

![Image](https://orkustofnun.is/media/radstefnur/orkunoktun-heimila-og-ldnadar-2005/13_40-Bjorn-Gunnlaugsson,-Landbunadarhaskolinn,-Orkuhagkvaemni-i-grodurhusum--.pdf)


The accessibility to abundant natural resources allows Iceland to produce fresh food in a country with a sub-optimum environment for crop growth. Although the cold climate and dark winters shorten the growing season, indoor farming enables people to grow more food
in terms of quantity and variety, even in the off-season, by controlling the conditions inside the greenhouse, such as light, temperature, humidity, and ventilation. Indoor farming using geothermal energy in Iceland dates back to 1924 (Gunnlaugsson et al., 2003). Its main use in the horticultural industry is for greenhouse heating and soil disinfection.

In 2017, 101 greenhouses were in operation, and the total greenhouse area under glass was 191,728 m² and 688,365 m³ (National Energy Authority, 2017a). The horticultural industry has been declining over the years, so the total area with greenhouses in use is decreasing. There were 121 greenhouses in operation, with a total greenhouse area of 199,000 m², in 2001. In 2008, the number of greenhouses declined to 96, with an area of 194,000 m². Of the total area used for horticulture, 44.6% is presumably used for vegetable and fruit production and the rest is used for cut flowers, pot plants, and forest plants (see Figure 16; Butrico, 2013; National Energy Authority, 2017a).

![Figure 16. Share of horticultural producers by production type (National Energy Authority, 2017a).](image)

As Figure 17 shows, horticultural producers show different tendencies across regions. The most actively farmed region is the southern region of Iceland, accounting for approximately 60% in terms of both horticultural producers and greenhouse size. Both of the bars show a similar trend (with a slight difference), indicating that Icelandic producers tend to have a
similar size of greenhouses regardless of regions (National Energy Authority, 2017a). The southern, northeastern, and capital regions have slightly larger greenhouse sizes than numbers of producers, indicating that these regions have larger greenhouses. However, the other regions have less floor space than producers, meaning that there are more producers than production space.

With a combination of technologies and effective use of resources, Iceland produces a large variety of fresh food products using greenhouses: cucumbers, strawberries, small and large whole tomatoes, cherry tomatoes, campari tomatoes, beefsteak tomatoes, plum tomatoes, bell peppers, parsley, mushrooms, spinach, lettuce, and iceberg lettuce (Thorkelsson et al., 2012). There is even more variety among the local produce, but information regarding those crops is currently unavailable on any official websites, perhaps due to the difficulty of updating changing data. Crop production and quantity can vary greatly depending on the season and the production capacity of farms. However, production data are available on five types of vegetables domestically produced at stable rates: tomatoes, bell peppers, salad, mushrooms, and cucumbers. Of the five crops, tomatoes, bell peppers and cucumbers are
subsidised by the government. Taking into account the preferential selection of the five crops, they undoubtedly play a pivotal role in Iceland’s horticultural industry.

2.5.2.5. Pesticide use
Due to Iceland’s cold climate and comparatively low livestock densities, a modest amount of pesticides and fertilisers are used. Pesticides are chemical products commonly used in the agricultural sector to prevent damage from weeds, fungi, and insects. The three main types of pesticides are herbicides (against weeds), fungicides (against fungi), and insecticides (against unwanted insects) (Nordic Council of Ministers, 2014). Fertilisers are chemical or organic substances applied to the soil to increase its fertility. The primary nutrients contained in commercial fertilisers are nitrogen (N), phosphorus (P), and potassium (K). Despite their beneficial effects, they can also cause environmental deterioration, particularly to marine habitats, as nutrients are partially washed out with runoff water rather than absorbed thoroughly by plants, encouraging unwanted algae growth. Icelandic rivers and lakes remain unpolluted by nitrogen or phosphorus. Iceland has the lowest usage of nitrogen and phosphorus among OECD countries (OECD, 2019d). Iceland applied 7.21 kg of nitrogen and 1.54 kg of phosphorus per hectare of arable land in 2017, while the OECD average was 64.15 kg and 5.16 kg respectively, but the usage of fertilisers has decreased over the last two decades. Pesticide use in Nordic countries has been almost halved over the last three decades. As seen in Figure 18, Iceland has by far the lowest rate (Nordic Council of Ministers, 2014).
Organic farming is an alternative agricultural method of livestock or crop production based on ecological management without the addition of artificial substances. By 2000, all Nordic countries had experienced an increase in the percentage of fields practising organic farming (see Figure 19). In Iceland, the practice has grown significantly over the last two decades. Iceland’s organic farming rate is the world’s highest; there are 36 certified organic producers in Iceland, most in the horticultural sector.

2.5.3. Reliance on imports

Despite the ability to produce fresh foods in the country, Iceland’s reliance on imports for food supplies is still high, as Icelandic horticulture is falling far behind amid inexpensive horticultural products from abroad. Given the small variety of vegetables commercially grown in Iceland, Iceland’s food dependency rate on imports is high. There are no official data regarding food dependency, but several studies on local food production in Iceland suggest a reliance on imports for food supplies.

Of a total food and beverage consumption worth 135 billion ISK, 87.6 billion ISK (64.9%) was produced in Iceland in 2010. However, this includes items produced in Iceland with imported ingredients (Johannsson, 2011). Williams (2017) claims that Iceland remains dependent on imports, even for food products locally manufactured with high production frequency, to satisfy domestic demand. Additionally, Halldorsdottir and Nicholas (2016) demonstrate that
Iceland’s food supplies for cereals, oils, and fruits are entirely dependent on imports. Remarkably, marine products, accounting for a large share of domestic total food produce, also rely on imports for 84% of the domestic consumption. While meat and dairy products are locally produced and mostly self-reliant, 61% of vegetables consumed in Iceland come from abroad. Thus, imported foods supply approximately 50% of the current Icelandic diet (see Figure 20).

![Figure 20. Reliance on imported products by food category. Reprinted from Local Food in Iceland: Identifying Behavioural Barriers to Increased Production and Consumption by Halldorsdottir and Nicholas, 2016. doi:10.1088/1748-9326/11/11/115004.](image)

### 2.5.3.1. Products Iceland imports

Williams (2017) shows that the total amount of imported food products for two years, besides meat and marine products, is 87,716 tonnes (43,563 tonnes in 2014 and 44,153 tonnes in 2015). The top five highest imported food items are fresh apples at 7,924 tonnes, bananas at 7,260 tonnes, plantains at 5,928, other new potatoes at 3,889 tonnes, and oranges at 3,781 tonnes. In terms of fruit production, as strawberries are the only fruit commercially grown in the country, it is little wonder that Iceland is heavily reliant on imports for fruit. However, potatoes, among the most extensively produced crops in Iceland, are also imported in order to meet demand. The local production rate (Production / (production + import - export) *100) of potatoes was 82.65% in 2017 and 66.26% in 2018 (Statistics Iceland, 2018b, 2019b). Potatoes ordinarily traded in Iceland are divided into two
types – baking potatoes larger than 65 mm and other new potatoes. As baking potatoes are hard to grow in the Icelandic climate, most are imported. Interestingly, other new potatoes commercially grown in Iceland were the fourth-highest imported food items for two years (2014 to 2015).

The vegetables commercially grown in Iceland are potatoes, turnips, carrots, tomatoes, cucumbers, cauliflower, cabbage, peppers, Chinese cabbage, broccoli, salad, and mushrooms. Though Iceland's vegetable production is more varied than this (as mentioned), those are the only food items with data available in Statistics Iceland, the government database. This study covers only vegetables cultivated using greenhouses: tomatoes, peppers, salad, mushroom, and cucumbers. Figure 21 provides an overview of the horticultural industry of Iceland in 2017, presenting the percentage of domestic produce in blue and that of imports in red for each of the five vegetables. As shown in the figure, imported products are the biggest competitors in some sectors.

![Figure 21. Comparison of the amount of imported and domestic food in the market in 2017 (Appendix 1).](image)

Apart from the difference in volume between the species, this figure shows a considerable disparity in market share between domestic and foreign products. While most of the cucumbers consumed in Iceland are produced domestically, less than 50% of Iceland’s tomatoes, bell peppers, and salad are locally produced, despite the subsidies tomato, bell
pepper, and cucumber producers receive. This leads to a question: Why is Iceland still heavily dependent on imported food items despite its ability to produce fresh vegetables? Before we consider this question, the next section discusses the countries Iceland relies on for its food supplies.

2.5.3.2. Countries Iceland imports from
According to the study of Williams (2017) on food imports to Iceland except for dairy, meat, and cereal grains, Iceland’s food comes from 114 countries. The top five highest importing countries are the Netherlands (mainly onions, pears, apples, peppers, and iceberg lettuce), Spain (oranges, mandarins, watermelons, lemons, and peppers), Ecuador (bananas, plantains, pineapples, watermelons, and mangoes), the United States (sweet potatoes, apples, grapes, raisins, and dried beans), and France (apples, new baking potatoes, other new potatoes, onions, and carrots) in descending order of import amounts. Best Food Importers (2016), a database of the food industry, claims that most of Iceland’s fruits and nuts are delivered from South America and that most of its vegetables come from the Netherlands. Ecuador, Spain, and the Netherlands are the three highest importing countries but account for only 10% of total imports, implying that Iceland has a diversified range of suppliers (Williams, 2017).

2.5.4. Impact of climate change on food supply in Iceland
Though the diversity among food sources from abroad should enhance Iceland’s food security, the effects of climate change could easily jeopardize this. One of the expected impacts of climate change on the geography of food production is a shift of crop cultivation land from low latitude areas to high latitude areas (FAO, 2015; 2017). While near-equatorial regions such as sub-Saharan Africa, India, and northern Australia are expected to see declining volumes of total crop production, Canada, Europe, and North America are predicted to see increased production. Research also demonstrates that 23 of 43 individual species should benefit from climate change, gaining increased land suitable for cropping, while the rest will lose (Lane and Jarvis, 2007). In addition to regional alterations in farming behaviour, climate change might also restrict the wild species of cultivated crops. Not all
species can adapt and survive outside their current optimal environments, so it is inevitable that some will become extinct rather than evolve. Approximately 20% of the wild variants of cultivated crop species may become extinct over the next 50 years (FAO, 2015). Moreover, extreme weather events will cause a variety of changes in food production. The increase in the frequency and intensity of unusual climatic events could put the resources and infrastructures underpinning agricultural practices in jeopardy. This could increase food prices, which has already been observed globally: When extreme weather has hit major food-producing countries, international food prices escalated. Given the expected impacts on food production from climate change, its decentralized food supply will not help enhance Iceland’s food security.

2.6. Research question

Given the effects of the increased food demand, technological developments, and climate change, it is going to be critical for Iceland to enhance its own food security by increasing domestic food production. Despite Iceland’s ability to grow fresh food items within the country, the market is currently filled with imports. To determine the reasons for this situation, this study examines the competitiveness of Iceland’s horticulture industry by analysing the five vegetable sectors: tomatoes, cucumbers, salad, mushrooms, and bell peppers. This study attempts to determine whether Iceland can increase locally produced horticultural crops in a market dominated by imported products.

As crop production in Iceland requires intensive energy inputs, the expenses required for cultivation could hinder entrance to the horticultural business. Assuming there are few producers of fresh food items in Iceland, increasing the number of producers seems to be a way to make local products more competitive, against both domestic rivals and imports. However, competitiveness has several factors and can be measured in many ways. The following chapter outlines one way to measure the competitiveness of the current Icelandic horticultural industry.
3. Methodology and theoretical framework

This study examines the competitiveness of the industry to determine the country’s capacity to meet the demand for fresh foods grown in greenhouses. This study adopts a hybrid research methodology, employing theoretical analysis combined with interviews. Due to the limited availability of data on the horticulture industry, interviews were conducted with 11 Icelandic greenhouse farmers to gain insights into their industry. The inputs derived from the interviews were then applied to Porter’s (1998) five forces framework, a tool for evaluating the five competitive forces that shape an industry and identifying its strengths and weaknesses. The five forces are rivalry among existing competitors, the bargaining power of suppliers, the bargaining power of buyers, the threat of substitutes, and the threat of entrants. With this combination of methodologies, this study intends to investigate Iceland’s horticulture market and identify ways of bolstering the competitiveness of its domestic fresh food production. The following chapter explains the scope of the study, describes its interview process, defines competitiveness, and outlines the study’s framework, including the five forces.

3.1. Scope

This study’s scope is limited to vegetables grown for commercial purposes via indoor farming in Iceland. Five horticulture crops are considered: tomatoes, bell peppers, salads, cucumbers, and mushrooms. These are the primary vegetables commercially grown using greenhouses in Iceland and the only vegetables with relevant open access data.

3.2. Interviews

This study employs open-ended interviews with greenhouse farmers in Iceland. Interviewees were chosen among the companies with the largest greenhouses in Iceland, following the assumption that larger greenhouses and production volumes make greater contributions to the market. The data on greenhouse size come from the database created by the National Energy Authority (Orkustofnun), which collects data directly from each farm in return for energy supplies from the authority (National Energy Authority, 2017a). As there are no
official data on the number of greenhouse farms in Iceland, some farms might be left out from the database, but most greenhouse farms are included, and the leading horticultural producers certainly are. In addition to that database, information on food supplies from both Iceland and abroad taken from the website of Statistics Iceland (Hagstofa Íslands) is used to survey the market for each subject vegetable. Appendix 1 was reproduced based on data provided by the Horticultural Association (Samband garðyrkjubænda), yet data on factors that could affect the sales and/or marketing of local greenhouse farms were not accessible.

To encompass all the major market players, each farm was asked in an interview to provide their annual vegetable production and the names of their main competitors in the domestic market. The farms that took part in the interviews are all treated anonymously in this study. Aside from the questions on annual production and competitors, ten other questions were asked in the interviews (see Appendix 2). Interviews were conducted from January to June 2019 by phone and via email with 11 greenhouse farms in Iceland. The interviewees were either farm owners or managers of the farm’s primary crop. Of the interviewed companies, three produce food items that are outside the study’s scope. Although details on these companies are omitted, inputs acquired from them through the interviews are utilized to gain insight into the industry. In addition to the interviews conducted through communication media, several farm visits were also arranged for interviews when circumstances permitted.

### 3.3. Competitiveness

Competitiveness has been brought to the forefront by governments and industries in every nation, as competitiveness is ‘the driving force behind markets’ (Godfrey, 2008, p. 3). Some companies and nations develop and prosper, while others fail. Competitiveness is considered a key to a ‘success story’, but what is competitiveness?

Though widely understood in general terms, competitiveness has yet to be clearly defined in economic theory (Wijnands et al., 2015; Ketels, 2016). There is no accepted definition of competitiveness that is applicable to every social group. Thus, this study defines competitiveness in a way that fits this case study; the definition is applied to measure the
competitiveness of the horticulture industry. This section will clarify what ‘competitiveness’ means in the context of this study, based on previous studies on competitiveness.

The concept of competitiveness first appears in the 16th century. Mun (1664), a mercantilist, views the competitiveness of nations as a positive balance of trade between nations. Smith (1776) analyses a nation’s trade relations with other nations in more detail, arguing that, to have an absolute advantage over other nations, a nation should import goods that require higher costs to produce at home, indicating that competitiveness is linked to the nation’s ability to produce goods at the lowest costs. On the other hand, Ricardo (1817) discusses a comparative advantage that encourages nations to engage in international trade despite their disadvantage relative to other international competitors; an opportunity cost of producing goods that is lower than that of other nations is an advantage. Heckscher (1919) and Ohlin (1933) reinforce Ricardo’s theory by citing the relative endowments of production factors such as land, labour, and capital. They argue that the availability of relative endowments affects a nation’s comparative advantage; thus, goods produced using an adequate amount of locally available resources should be produced domestically while those that require locally scarce resources for production should be imported.

Moving on from mercantilism to microeconomic concepts, von Mises (1940) introduces market competition within a dynamic process. The strength of its capabilities and market needs are critical factors for a firm’s competitive position. List (1841), Weber (1947), and Buchanan and Tullock (1962) address the impacts of social institutions on a firm’s competitiveness. For example, laws and regulations not only regulate business activities but also provide protection to incumbents. Clark (1940) argues that extremes – when competitiveness is either too strong or too weak – will not motivate firms to achieve innovation. As innovations prompt technological development and economic growth in a country, he emphasizes the importance of workable competition that encourages firms to compete with each other to gain competitive advantage.

Given the concepts of competitiveness discussed above, the term is defined as the ability of a firm to supply goods to meet local demand and making good use of the resources that are available to the firm.
Using this definition, this study measures the competitive capacity of the horticulture industry in Iceland by examining the data and inputs obtained from the interviews. The following section describes how the study measures the horticultural industry’s competitiveness.

3.4. Porter’s five forces

Following prior studies on competitiveness, this study employs Porter’s model to measure the competitiveness of Iceland’s horticultural industry. Harvard Business School professor Michael E. Porter (1998) formulated a comprehensive business analysis model of competitiveness using five forces that determine industry competitiveness in 1979. Porter identifies the five permanent forces in an industry’s structure, capturing the core competitive elements of an industry while excluding variables and temporary elements that also affect competitiveness such as industry growth rates and technical innovation. The five forces are used worldwide as a business strategy tool for analysing industrial structures and adopting corporate strategies. The five competitive forces are rivalry among existing competitors (1), the bargaining power of both suppliers and buyers (2 and 3), and the threats of substitutes and new entrants (4 and 5). Analysing each of the forces leads to a thorough understanding of an industry – both its weaknesses and strengths – and measures its long-term profitability. In laying out the future direction of the industry, Porter’s model can also help in determining a corporate strategy as well.

The five forces model is designed for industry analysis. As the horticultural industry in Iceland is still in the developing stage, there seems to be considerable potential for growth. By applying this method, this study intends to measure the industry’s profitability and competitive strength. Each force is briefly described below.
3.4.1. Rivalry among existing competitors

This force concerns the current competitiveness of the marketplace. The number of existing competitors and each competitor’s ability to produce products or services determine the intensity of the market. Low competitive rivalry can be favourable to a company because it then has a stronger power over prices than suppliers and buyers do. Consequently, low-intensity rivalry can make an industry more attractive. The concentration ratio of an industry can serve as an indicator of competitive rivalry. The higher the ratio, the more it is likely to spur an intense battle over prices between competitors, which benefits customers. A higher ratio could also threaten the business continuity of companies, especially small ones. Rivalry factors include the following:

- Number of competitors
- Diversity of competitors
- Industry concentration and balance
3.4.2. Bargaining power of suppliers

Bargaining power is suppliers’ ability to charge higher prices or secure more favourable terms for their products or services. In either case, when suppliers gain more of the value for themselves, industry profitability declines. In assessing the power of suppliers, all of the input costs required to create a product or service should be taken into account. The major factors in this power are the number of suppliers, the uniqueness of the supplies, and the costs of switching from one supplier to another. When there are few suppliers, companies are more likely to depend on a single supplier; thus, suppliers are more likely to drive up input costs and increase their revenue to the detriment of the companies. By contrast, when suppliers are numerous and/or switching costs are low, a company can suppress costs while increasing its profits. The factors in the bargaining power of suppliers include the following:

- Number of suppliers
- Size of suppliers
- Supplier concentration
- Availability of substitutes for the supplier’s products
- Uniqueness of supplier’s products or services (differentiation)
- Switching cost for supplier’s products
- Supplier’s threat of forward integration
- Industry threat of backward integration
• Supplier’s contribution to quality or service of industry products
• Importance of volume to supplier
• Total industry cost contributed by suppliers
• Importance of the industry to supplier’s profit

3.4.3. Bargaining power of buyers

This force concerns the buyers’ ability to force down prices. A high power could imply an increased demand from customers or buyers to add more value to the incumbent products or services. In either case, the more powerful the buyers, the less profitable the industry, as buyers are likely to reap more of the value. The factors that can affect this power include the number of buyers, the significance of each buyer, and the opportunity costs of finding new buyers or markets. Product delivery channels are as critical as the end-users of the products, as they can exert a significant influence on customers’ purchase decisions; for example, influential retailers such as Home Depot have enormous power to negotiate for lower prices and better deals directly with suppliers. On the other hand, when the buyers comprise many small individuals, a company can charge higher prices to increase profitability. However, this is not the case when product quality trumps price. The factors in the bargaining power of buyers include the following:

• Buyer volume (number of customers)
• Size of each buyer’s order
• Buyer concentration
• Buyer’s ability to substitute
• Buyer’s switching costs
• Buyer’s information availability
• Buyer’s threat of backward integration
• Industry threat of forward integration
• Price sensitivity
3.4.4. Threat of substitutes

This force refers to the possibility that other products or services may meet the basic needs the industry’s products provide but in a different way. Substitutes are not direct rivals, as they do not provide the same value as the industry’s products. However, products with shared boundaries can increase customers’ willingness to switch to alternatives. The main factors in substitute threat are as follows:

- Number of substitute products available
- Buyer’s propensity to substitute
- Relative price performance of substitutes
- Perceived level of product differentiation
- Switching costs
- Substitute producer’s profitability and aggressiveness

3.4.5. Threat of entrants

Newcomers can expand the overall market or acquire a certain share of the existing market, which eventually affects incumbents’ power in the industry. The threats new entrants pose to the industry vary greatly depending on the entry barriers that thwart their intention to enter an industry. The stronger the barriers, the easier it is for incumbents to charge higher prices and receive favourable terms. Barriers include high capital requirements such as enormous investments, practical experience in the field, government policies, economies of scale, customer identification with existing brands, and access to distribution channels. Entry barriers factors include the following:

- Economies of scale
- Product differentiation
- Brand identity/loyalty
- Access to distribution channels
- Capital requirements
- Access to latest technology
- Access to necessary inputs
● Absolute cost advantages
● Experience and learning effects
● Government policies
● Switching costs
● Expected retaliation from existing players

3.5. Limitations of this method

In preparation for the study, data on crop production were collected through government websites. However, these were insufficient for examining the competitiveness of the industry; thus, interviews were also conducted in English. Most of the questions asked in the interviews were open-ended. Therefore, the answers differ in terms of weight of opinion depending on the interviewee.

Regarding this study’s framework, Porter acknowledges that not all of the factors determining the five forces may be applicable to every industry; and yet, some of them definitely affect the industry. In this case study, the elements were carefully chosen based on data availability. However, some crucial elements may not be covered due to a lack of data.

Each force is evaluated in terms of the five signs. The results are not always straightforward. Some exceptions may not be properly reflected in the evaluation.
4. Results of interviews

This section provides data obtained from the interviews with local growers. Of the 11 companies that agreed to be interviewed, the interview results of nine companies are described in detail. The rest of the companies mainly produce horticultural crops that are outside the scope of the study, such as strawberries and herbs; thus, data obtained from them are used only to enhance the quality of the industry analysis.

Table 1 combines data from the National Energy Authority (Orkustofnun) and Statistics Iceland with the results of the interviews with Icelandic farmers. It consists of five sections for each vegetable item; each section has one or several companies. The list does not cover all of the contributors to the horticultural industry because reaching all of the growers of the five vegetable items was difficult. The number of companies can vary depending on the vegetable sector, as some companies are dominant for certain vegetables. Due to the monopolized market share, some sections have only one or a few companies. As this study intends to paint a picture of Iceland’s domestic vegetable supply, interviews were conducted only with farms featuring a large steady production.

To analyse the horticultural crop industry, 12 questions were asked in the interviews about the following: the key to success, the selling channel for their produce, whether there is a secondary use of their grown vegetables, and the most significant expenses. Other questions were asked to determine how the growers see their role as part of the horticultural industry (see Appendix 2).

Table 1. Breakdown of major crop production

<table>
<thead>
<tr>
<th>Producers</th>
<th>Founded</th>
<th>Area</th>
<th>Production (tonnes/year)</th>
<th>Key to success</th>
<th>Channel</th>
<th>Processed food</th>
<th>Biggest costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Company</td>
<td>Year</td>
<td>Region</td>
<td>Employees</td>
<td>Industry</td>
<td>Horticulturists’ Sales Company</td>
<td>Labour cost</td>
<td>Electricity</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
<td>----------</td>
<td>-----------</td>
<td>--------------</td>
<td>--------------------------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Company 1</td>
<td>1946</td>
<td>Southern</td>
<td>Over 300</td>
<td>Tourism</td>
<td>Yes</td>
<td>Used at its restaurant and its store</td>
<td>(ketchup and sauce)</td>
</tr>
<tr>
<td>Company 2</td>
<td>1904</td>
<td>Northeastern</td>
<td>330</td>
<td>Luck</td>
<td>No</td>
<td>Sold directly to restaurants and stores by themselves</td>
<td>Electricity</td>
</tr>
<tr>
<td>Company 3</td>
<td>1980</td>
<td>Southern</td>
<td>300</td>
<td>Hard work</td>
<td>No</td>
<td>Sold directly to restaurants and their stores</td>
<td>Electricity</td>
</tr>
<tr>
<td>Company 4</td>
<td>1977</td>
<td>Southern</td>
<td>100</td>
<td>Conscious consumers</td>
<td>No</td>
<td>Sold directly to</td>
<td>Yes</td>
</tr>
<tr>
<td>Company 5</td>
<td>1944</td>
<td>Southern</td>
<td>120</td>
<td>Good planning</td>
<td>Local stores</td>
<td>Yes</td>
<td>Labour cost</td>
</tr>
<tr>
<td>-----------------</td>
<td>------</td>
<td>----------</td>
<td>-----</td>
<td>---------------</td>
<td>--------------</td>
<td>-----</td>
<td>-------------</td>
</tr>
<tr>
<td>Company 6</td>
<td>1965</td>
<td>Southern</td>
<td>700</td>
<td>Hard work</td>
<td>Sold to restaurants</td>
<td>No</td>
<td>Electricity</td>
</tr>
<tr>
<td>Company 2</td>
<td>1904</td>
<td>Northeastern</td>
<td>150</td>
<td>Luck</td>
<td>Sold directly to restaurants and stores by themselves</td>
<td>No</td>
<td>Electricity</td>
</tr>
<tr>
<td>Company 7</td>
<td>1986</td>
<td>Southern</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Electricity</td>
</tr>
</tbody>
</table>

**Cucumber**

**Mushroom**


<table>
<thead>
<tr>
<th>Company 4</th>
<th>?</th>
<th>Southern</th>
<th>600</th>
<th>Bell pepper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company 4</td>
<td>?</td>
<td>Southern</td>
<td>120</td>
<td>Horticulturists’ Sales Company</td>
</tr>
<tr>
<td>Company 2</td>
<td>1904</td>
<td>Northeastern</td>
<td>22</td>
<td>Luck</td>
</tr>
<tr>
<td>Company 8</td>
<td>1979</td>
<td>Capital</td>
<td>400</td>
<td>Experience</td>
</tr>
</tbody>
</table>

**Note.** Adapted from the interviews conducted with local growers in Iceland.

### 4.1. Company 1

This farm produces an annual amount of over 300 tonnes of four types of tomatoes: regular tomatoes, grape tomatoes, plum tomatoes, and piccolo tomatoes. The last two varieties are cultivated all year round at this farm. This farm is situated in southern Iceland and was established in 1946. Their produce is delivered to stores and restaurants through the
Horticulturists’ Sales Company (Sölufélag Garðyrkjumanna ehf.). It is one of the biggest distributing companies in Iceland and gives almost 90% of the product’s price back to its producers by using an efficient marketing system (Horticulturists’ Sales Company, 2019). Food loss from their production is almost nil, since the second-class tomatoes are processed into ketchup and sauces and sold at the restaurant and a store located on the greenhouse farm. The main feature of this farm is that they combine their horticulture business with tourism. Using part of the farming facility as a restaurant and store allows them to show tourists what they grow and how in the greenhouse and allow the tourists try their products on the spot.

This company has been steadily growing due to the drastic growth in tourism over the years, but the volume of their produce is not much different from that of other tomato-producing companies. However, they are distinctive in focusing on local production for local consumption. Employing the local production/local consumption model in their business, they apply the market-oriented production method to avoid having surplus tomato produce and do not intend to export their products due to the ecological footprint caused by transport. Although they are technically capable of producing more, they put more effort into producing higher-quality products than in expanding production. While they believe Iceland could supply fresh vegetables with local produce, they also see a need for growers coming from among the younger generations.

4.2. Company 2

Company 2 has 11 greenhouses, with a total area of 7,642.5 square meters, which makes it the second-largest greenhouse farm in Iceland. It is one of the three biggest tomato-producing companies. They also grow cucumbers and bell peppers in their greenhouses, though their yields are not as high as those for tomatoes. About 500 tonnes of vegetables are produced by this company each year and distributed through the Horticulturists’ Sales Company. Aside from that channel, company 2 (located in north-eastern Iceland) delivers directly to nearby restaurants and stores by themselves as well. They have been doing a remarkable job of producing almost no food waste at the production site. Additionally, they
make an effort to reduce food loss by taking part in a project called Matartiminn with schools and pre-schools wherein the second-class vegetables are used for school lunches. This project not only allows growers to reduce food loss but also encourages communities to use more local food and provides schoolchildren with a higher standard of healthy foods.

Three decades after the foundation of the company in 1904, they switched their main crops from potatoes to tomatoes and built their first greenhouse. Tomato cultivation has been ongoing since then. They have been expanding their business slowly but steadily with an increasing number of greenhouses, with the newest one built in 2015. Since the current owner is a fourth-generation grower, he is experienced and sufficiently knowledgeable about horticultural operations, which they believe helped them succeed. They also see the constant care they give to the crops as a critical factor in their success.

Their biggest competitors are foreign importers of vegetables that offer cheaper products. One of the things they find challenging is personnel wages and wage-related fees, since Iceland has some of the highest labour costs in the world. Additionally, because of the unfavourable environment for agriculture, horticultural equipment requires high maintenance in Iceland, which comes with high associated costs, particularly for electricity. Given these expenses, Icelandic produce has very little chance of competing with imports in price. Increasing yields is not difficult, but selling all of their produce is. Foreign markets are enormous, and offer tremendous opportunities, yet it is unrealistic for Icelandic farmers to cultivate a market abroad given the higher prices of produce and the greenhouse gas emissions caused by transport.

4.3. Company 3

Company 3 is one of Iceland’s biggest tomato-producing companies. A married couple who both grew up accustomed to horticultural practices established their first greenhouse in southern Iceland in 1980. They have eight greenhouses; the latest one was built in 2004. They always go for the newest greenhouse model each time they purchase a new one and build according to what is popular at the time. When they built the first greenhouse, which
is 900 square meters, they thought it would suffice. However, as demand has increased significantly, the greenhouses total 5,100 square meters.

The main products of this farm are four variants of tomatoes: regular tomatoes, grape tomatoes, and large and small lycopene tomatoes. The farmers cultivate cucumbers and a small number of bell peppers as well. Production from this farm totals about 400 to 450 tonnes per year, most of which is delivered to stores and restaurants by the Horticulturists’ Sales Company. As company 3 is also a part of Matartíminn, some of their vegetables are used for that programme. Additionally, they have a side-business with a small cafeteria and sell the rest of the products at the farm. Hence, nothing goes to waste.

The prices of vegetables usually vary during the summer as production increases. When there is a plentiful harvest, they tend to lower the price. More importantly, however, it is all about demand. Company 3 finds electricity to be the most substantial burden when it comes to horticultural farming in Iceland. They believe that, once the price of electricity falls, it will be possible to lower the prices of vegetables too. Though vegetables grown in Iceland are more expensive than imported ones, increasing domestic products is not a hopeless task, particularly if the younger generations become more interested in farming. However, they see little possibility of growing fruit in Iceland at this point. Regarding exports, they export some of their products to the Faroe Islands and Denmark during the winter. If they produced more, they would be able to export more to other countries.

4.4. Company 4

Company 4 is a mushroom-producing company founded in 1984 in southern Iceland. The owner of the farm runs another farming facility built in 1977 in the same area, cultivating tomatoes and bell peppers in 4,500 square-metre greenhouses. Therefore, this is not one company, but two. Each year, they produce 100 tonnes of tomatoes, 600 tonnes of mushrooms, and 120 tonnes of bell peppers. They grow five different brands of mushrooms: white common champion mushrooms, sliced champions, brown chestnut mushrooms, brown Portobello, and flat white Portobello. They do not sell processed foods made from
mushrooms; however, they sell lower-quality mushrooms as second-class produce. Third-class mushrooms do not go to consumers; instead, they go to composts, which are essential for making mushrooms. Hence, the process of growing mushrooms is a circular system. For the other vegetables, they sell processed foods at their store and also use them at the restaurant located on the farm. Of their produce, 99% is sold through the Horticulturists’ Sales Company.

As the only mushroom company in Iceland, Company 4 has been quite successful in this sector. They believe the key to success is the quality of their products. Imported mushrooms are usually grown with chemical pesticides. Icelandic producers are known for using organic products, compost, and bees (e.g. for tomato production) – ecological methods of production. For mushrooms, they use only freshwater and compost. Because of their high quality and safe agricultural products, customers are fond of Icelandic products, and imported mushrooms are often leftover unsold at stores. Thus, they believe that conscientious, loyal, and environmentally friendly customers are another key to their success. Lacking such high consumer conscientiousness, trading firms tend to make exclusive agreements with stores and therefore have the power to control what is sold in shops. This power could lower consumers’ willingness to buy local products rather than imported ones.

They believe it important to increase local production, as Iceland is a remote island where most of the living necessities are imported. Many are concerned not only about the risks of supply restriction but also about the possibility of diseases from other countries infecting Iceland’s livestock and environment.

4.5. Company 5

This company mainly produces tomatoes and a small number of cucumbers on 3,808 square metres of greenhouses located in southern Iceland. The amount produced totals over 120 tonnes per year, and there is little waste. While almost all of the production is distributed through the distributing company, the Horticulturists’ Sales Company, a small amount of the production is sold to a nearby store. A married couple runs the company, which they bought
from the wife’s father, and run four greenhouses. They bought their first greenhouse in 1994 and the others in 1997, 2001, and 2005. While the first greenhouses are of an Icelandic design, the newest greenhouse was imported from the Netherlands.

They believe local production of vegetables could be increased. However, production costs are a growing concern, and it is difficult to lower the prices of local vegetables. As a consequence, prices have generally increased. When Costco Wholesale came to Iceland in 2017, they wielded a significant impact on the market, as locally produced vegetables are more expensive. Now that Costco Wholesale buys more from local producers in Iceland, this is an excellent opportunity for local producers to grab a larger market share. Moreover, the amount of local produce is too small for export. To be able to export Icelandic products, they think the amount of produce has to be increased. They also claim that greenhouses in Iceland are too small to increase production. Hence, the bigger the greenhouses, the more likely companies are to export.

4.6. Company 6

Company 6 is a cucumber farm dating back to 1965. By 1977, full-scale development was ongoing. They imported a greenhouse from the Netherlands to fulfill their needs. Once a lighting system was installed in the greenhouse, year-round cucumber production became possible. Since then, their production has increased and currently totals 700 tonnes per year. In terms of volume, company 6 has the most significant production among cucumber producers. Their success is the result of tireless work and patience. Instead of trying to take giant leaps in growth, they have built up their business slowly but surely over time since 1977. They increased the number of greenhouses in 1999 and 2007 and built their own warehouse for packing and cooling their produce in 2012.

Their produce is sold through the Horticulturists’ Sales Company. The distribution company comes to pick up cucumbers four times a week and delivers to grocery stores such as Bonus (Bónus), Kronan (Krónan) and Costco. As they sell all of their products through the distribution company, they are neither making processed food nor have any plans to expand
into the business of processed food. The products are mainly for the domestic market, but they also export to Denmark and the Faroe Islands during the winter. However, they acknowledge that exporting is difficult due to the difference in production costs between local producers and international competitors. Occasionally, imported produce manufactured with natural light and heat is imported and sold in Iceland. Icelandic farmers cannot compete with those. Electricity costs have been an enormous burden for them; on top of that, the equipment required for growing cucumbers is expensive. They can increase their production only when the supply meets the demand. If they ever faced a need to reduce prices, they would require government intervention to lower production costs.

4.7. Company 7

This farm’s primary production is herbs; they also produce cucumbers and flowers during the summer and turnips during the winter. Company 7 is the top herb producer, growing 17 types of herbs. Most of their production goes to stores and restaurants through the Horticulturists’ Sales Company, and some products are sold at the farm directly for a limited time only. Company 7 does not sell processed food. However, they intend to develop products utilizing the company’s resources in the near future.

The prices of their products remain the same throughout each year but increase from one year to the next. Electricity in Iceland is often considered to be reasonably priced, but horticulture farmers are inclined to disagree, since they need to use extensive amounts of energy for their business. Company 7 acknowledges that Icelandic crops are not really economical but are essential to Iceland, especially due to the popularity of local food among Icelanders. These farmers feel that the prices of produce is less of an issue that dependency on imports. They feel the government should be more involved in these issues and help farmers find solutions.
4.8. Company 8

Company 8 runs a salad farm based in the Reykjavík area. This farm has by far the largest cultivation area in Iceland, with two greenhouses totalling an area of 11,944.6 square meters. Their business started with outdoor cabbage production. After the installation of a greenhouse in 1979, they switched their production to salad. Now they produce eight varieties of salad, for a total production of 400 tonnes per year. Their products are sold through distribution companies such as Bananar ehf., Innes ltd., and Kronan. In addition to the selling channel, they offer direct delivery to restaurants and stores, a privilege of being located in the most heavily populated area in Iceland. Their products are delivered to 40 sales destinations using their own cars, which allows them to respond flexibly to meet individual needs. The direct selling system not only provides their clients with flexibility but also gives the company an opportunity to connect with and learn about consumers.

There is no official regulation regarding pricing; it is entirely up to sellers to set the price. Considering that cheaper imported products are available, however, the price is likely to be affected by external factors. They seem to have found a price level acceptable to consumers, and it has remained stable for producers. The farmers feel confident that the quality of the produce justifies the price and makes them more competitive against imported goods.
5. Application of five forces to industry

This study examines competitiveness among Iceland’s greenhouse farms and the competitiveness of the Icelandic horticultural industry against imported products, which account for a large share of the horticultural crop market. This is undertaken using Porter’s five forces framework.

As this study is qualitative, it conducts statistical analysis of its data and interviews. Basic information regarding greenhouses in Iceland is collected mainly from the websites of national institutions, such as the Food and Agriculture Organization of the United Nations (FAO), Statistics Iceland (Hagstofa Íslands), and the National Energy Authority (Orkustofnun). In addition to the data collected through the literature review, interviews conducted with the local farmers are drawn from as well. Based on this information, the market for the five horticulture crops is examined in terms of Porter’s five forces to identify the weaknesses and strengths of the industry.

Each force is evaluated on a scale of five signs: --, -, O, +, and ++. A single + sign is used when the power of the force is moderately high and ++ when the power is very high. While o indicates a neutral force, - indicates low power, and -- indicates even lower power.

5.1. Rivalry

This section examines rivalry among existing competitors in the horticulture industry. It is considered that strong rivalry creates a competitive environment, which incites a price war. Firms are then more likely to increase profit potential when the intensity of competitive rivalry is low. The elements used to assess this force are 1) the industry concentration ratio for each vegetable sector of the domestic market, 2) exit barriers, 3) competition between farms, and 4) fixed and marginal costs. The evaluation results for each element will be shown using ++ when the rivalry is high, + when it is moderately high, o when it is neutral, - when it is relatively low, and -- when it is low.
5.1.1. Number of companies and market share

This section examines the number of competitors in the horticulture industry and the market share of each company in the five vegetable sectors. When an industry consists of a large number of companies and each competitor has an equal market share, rivalry becomes high. Since high-intensity rivalry decreases the profit potential of the existing companies, the power affecting each sector will be shown as ++ when rivalry is high, + when it is moderately high, o when it is neutral, - when it is moderately low, and -- when it is low. The evaluation of the two elements is shown in Table 2 at the end of this section. The evaluation is later assessed along with the other three elements in subsequent sections.

Figures 23, 25, 27, 29, and 31 show the market trends from 2007 to 2017. The markets of each of the five vegetable sectors consist of two segments, indicated in blue and red. The blue segment shows the amount of domestic production, the red segment shows the amount of imports, and the bold red line indicates the size of the market. To illustrate the market share of the domestic products in each sector, the figures show the percentage of the market share for each year on the bold blue line. Figures 24, 26, 28, 30, and 32 show the domestic market for each vegetable sector, along with the market share of each company.

5.1.1.1. Tomatoes

Iceland produced about 70% of the entire tomato market in Iceland, and production increased up until 2012 (see Figure 23). Since then, domestic production has declined, and was less than 50% in 2017. By contrast, the market itself has been expanding since 2012, when domestic production reached its highest level. The continuously increasing number of tourists in Iceland is one factor that may be contributing to the expansion of the market. The number of foreign visitors totalled 488,600 in 2010 and has been growing at an average annual rate of 24.3%, reaching up to 2,224,600 in 2017 (Icelandic Tourist Board 2018). This rationale can also be applied to the other vegetable sections as well.
Figure 23. Transition of amount of imported and domestic tomato from 2007 to 2017.

Figure 24 gives a breakdown of the tomato producers contributing to the domestic tomato market. The production of tomatoes totalled 1,334 tonnes in 2017. This chart was generated based on the results of the interviews, as there are no official data on the total number of tomato farms in Iceland. Despite the uncertainty about the exact number of horticultural farms, Figure 24 covers the largest tomato producers in Iceland and offers a comprehensive picture of the tomato industry. Concerning the ‘others’ segment, it is unclear how many companies are contributing to the market. What is clear is that, company 1, 2, and 3 are the largest tomato producers, accounting for approximately 70% of the domestic market, and each market share is roughly equal among the three companies [++] . In addition to the three companies, as two more companies with stable annual production compete for a larger share in the market [++] , the rivalry among the competitors in the tomato sector is higher than in the other vegetable sectors.
5.1.1.2. Bell peppers

Domestic production of bell peppers is much lower than that of the other vegetables produced in Iceland. Production has remained stagnant for at least a decade. As seen in the tomato trend, the total supply of bell peppers is also increasing, likely due to Iceland’s growing tourism (see Figure 25).
Bell pepper production totalled 191 tonnes in 2017, the lowest among the five vegetables grown in Iceland. There is no large company specializing in this vegetable species as its main cultivation. Bell peppers are more popular as side cultivation along with main vegetables such as tomatoes. Thus, the bell pepper produce from each farm is small-scale.
As it accounts for only a tenth of the entire market share (see Figure 25), domestic production should be able to acquire a greater share, as far as the market allows. Seen in Figure 26, company 4 has more than half of the domestic market share, and each of the other two large companies claims only 10% of the market. Given that more than four companies, including competitors in the other segment, compete in the limited market, the bell pepper sector has many competitors [•], but the companies have unequal market shares [---].

5.1.1.3. Salad

As seen in Figure 27, the supply of salad dropped when the Icelandic financial crisis struck in 2008, though, interestingly, no similar decrease in supplies occurred for other sectors. Since that year, the market has been expanding. Due to the increase in supply, the local production of salad has increased as well. This sector is a little confusing, as salad is not explicitly defined, though cabbage and similar products are excluded.
Figure 27. Transition of amount of imported and domestic salad from 2007 to 2017.

This sector is more or less monopolized by company 8, which has a dominant share of the market. Although it is not known how many companies are included in the other segment, company 8 referred to imports as being the main competition in the interview. Of its total salad production of 530 tonnes in 2017, company 8 produced three-quarters of the total domestic market. This monopolistic situation clearly shows the low intensity of the rivalry [--].
5.1.1.4. Mushrooms

Local producers of mushrooms have been able to maintain a stable supply and have secured more than 70% of the market. However, the escalating demand since 2012 has surpassed its production capacity; thus, the market share of domestic production is declining.
The mushroom sector is an absolute monopoly, producing 580 tonnes in 2017. The growing process of mushrooms is different from that of the other vegetables, which can create an environment that discourages mushroom cultivation in Iceland. This monopolistic situation is convenient for the company, but it can be a threat to consumers because it can be easier for them to control the prices [---].
5.1.1.5. Cucumbers

Like with mushrooms, cucumber production has maintained a stable supply and is almost self-sufficient in the country. One difference from the other vegetable sectors is that cultivation has kept up with the increased demand. Not only do they maintain production to meet the demand, but they are also capable of increasing the total output of cucumbers.
Figure 31. Transition of amount of imported and domestic cucumbers from 2007 to 2017.

Unlike the other sectors, the cucumber sector is not occupied by comparatively large companies. It seems that opportunities are equal for all producers, including small companies. Several small companies produced more than half of the total production of cucumbers (1,857 tonnes in 2017). Even with the uncertainty about the other segment, several companies must be producing amounts that are more or less the same as those produced by company 2 and 3 given that company 6 is the largest bell pepper producer. Considering that approximately 65% of the market is composed of small companies with a similar market share, the cucumber sector has a relatively high rivalry intensity, with several competitors [+] and equal market shares [++].
Figure 32. Market share of companies in cucumber sector.

Table 2. Overall evaluation for market concentration.

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Bell pepper</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>competitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market share</td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>No data</td>
<td>++</td>
</tr>
</tbody>
</table>

5.1.2. Exit barriers

The higher the exit barriers, the more difficult it is for companies to leave the industry. As rivalry affects an industry's profitability, it is better for existing companies if the number of competitors is kept as low as possible. Therefore, the higher exit barriers, the more intense the rivalry.
Crop production in the horticultural industry requires specialized assets, such as artificial lighting, ventilation, watering, and computer processing. Greenhouses with fully installed equipment are hard to sell, as few people are interested in purchasing and using a facility that has been used. Indeed, some of the interviewed greenhouse farmers expressed grave concerns about the difficulty of finding a successor for the business or selling their assets.

A strawberry greenhouse in Iceland was purchased by another greenhouse owner two years ago. When a facility is attractive enough to buy, as is the case of the strawberry farm, exit barriers will become lower. However, the horticultural industry in general maintains high exit barriers. Farms, especially small ones, that are not profitable enough to maintain their business have no choice but to fall into bankruptcy.

This can be prevented by changing the crops being cultivated in the greenhouse; this is painless compared to selling out assets. However, switching to a different type of crop might be of little help for Icelandic growers, as their operation and maintenance costs, particularly rising electricity costs, are a major concern for most growers. If they are earning low returns on investment, raising profit margins in these circumstances will be a formidable undertaking.

High exit barriers are maintained in this industry because horticultural practices require substantial advance investments in assets that perform specific functions [++]]. This applies to the threat of new entrants (among the five forces), given the requirement for a large advance investment.

5.1.3. Competition between farms

Irrational, aggressive rivals are almost non-existent in Iceland. Since Iceland is a small island featuring cooperative group living, people – especially those involved in agriculture – have helped each other build a thriving industry and pursue food security. All of the interviewed growers hoped for strengthened national food security.
Most Icelandic farmers belong to the Farmer’s Association of Iceland (Bændasamtök Íslands), a domestic organizing body for all legal entities involved in farming, including various associations and unions (Farmer’s Association of Iceland, 2019b; Butrico, 2013). The Union of Horticulturists (Samband garðyrkjubændà) is a member association. The Farmer’s Association collects data regarding food production and submits them to Statistics Iceland. The collected data are then used to analyse agricultural output trends.

Amid the cooperative nature of Iceland’s agricultural industry, the horticultural industry seems to consist of relatively rational competitors rather than winner-take-all ones. The mushroom sector is, however, a monopoly of Company 4, which does not necessarily mean that the company outmanoeuvred all their rivals in the sector; there is simply just one company that produces mushrooms in Iceland. Nevertheless, the rivalry in the other vegetable sectors must be slightly more intense than that in the mushroom sector. To differentiate among rivalry levels, the monopolised sector receives [---] and the rest [-].

5.1.4. Fixed costs and marginal costs

When fixed costs account for a large proportion of total costs in an industry, companies are inevitably compelled to cut prices to marginal cost levels to maintain volume, or lose competitiveness. The higher the fixed costs in an industry, the more intense the rivalry.

Icelandic horticulture farms require large investments in equipment for crop growth in the early phase of their business. As most horticultural companies in Iceland receive a long-term loan to finance their initial costs (R. thorarinsdottir, personal communication, April 26, 2019), investment costs can be counted as part of the fixed costs. Once the companies recoup the costs of the initial investment, a significant proportion of the fixed costs can be eliminated. In addition to the fixed costs, variable costs also raise companies’ marginal costs. To win market share in this industry, companies need to reduce variable costs by developing and implementing innovative solutions [+].

5.1.5. Evaluation for rivalry
Intense rivalry puts each firm under pressure and can lead to a price war. Due to their high number of competitors and company market shares, the tomato and cucumber sectors have the most intense rivalry within the horticulture industry. While both the salad and mushroom sectors are nearly monopolies (clearly indicating low-intensity rivalry), the number of bell pepper producers is relatively high given the market share fairly provided to domestically produced bell peppers.

Though the tomato and cucumber sectors have similar rivalry intensities, there is a significant difference between the two. While locally cultivated cucumbers occupy a large share of the cucumber market, the local tomato supply accounts for only half of the tomato market. As three of the largest tomato producers account for approximately 70% of the domestic market share, competitiveness is high within the domestic tomato market. However, the market share represented by the big three totals only about 35% of the tomato market, including imports. Despite the potential for an increase in locally produced tomatoes, local tomato producers hardly seem to see this as a market opportunity. Company 1 is reluctant to expand their business abroad as they are pursuing local production for local consumption. Company 2 considers it unrealistic to export abroad because their prices are too high compared to those of foreign products. While company 3 has exported some of their products, the volume of their production is so small that they export only during the winter or when they have a surplus.

Taking into account the growers’ perspectives about tomato production and despite the tremendous opportunities for local providers to increase tomato production, tomato production in Iceland is unlikely to increase in the short term. Given all of the largest tomato companies are satisfied with their current position, rivalry should limit competitors’ profit potential, but it does not seem to be functioning that way in this case.

Table 3. Overall evaluation for rivalry

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Pepper</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of competitors</td>
<td>++</td>
<td>+</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>Market share</td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>No data*</td>
<td>++</td>
</tr>
<tr>
<td>--------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>---------</td>
<td>----</td>
</tr>
<tr>
<td>Exit barriers</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Competition</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>--</td>
<td>-</td>
</tr>
<tr>
<td>Fixed costs</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Average</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>--</td>
<td>++</td>
</tr>
</tbody>
</table>

* Market share of mushroom sis excluded from the average calculation due to the monopoly situation

### 5.2. Power of suppliers

The substantial bargaining power of suppliers can shrink industry profitability by pressuring companies to raise prices or reduce quality. In such cases, [+] or [++] will be assigned to the inputs that are examined in the following sections. Supplier power in the horticulture industry is assessed by examining the inputs required for indoor farming. Initial start-up for cultivating crops inside a greenhouse requires large advance investments to purchase greenhouse equipment. In addition to the initial costs, the operation and management costs for electricity, hot water, labour, and materials are also incurred as operations begin. This section assesses the supplier’s power, balanced between a company (buyer from the suppliers) and the inputs conventionally required for crop cultivation using greenhouses. This section examines 1) electricity; 2) water supply; 3) human resources; and 4) materials, including the greenhouse, lighting equipment, and pipes.

Iceland’s local growers have either very few or many suppliers depending on the supplies. As the supplies required differ subtly between competitors in the horticultural industry, this force will be assessed in terms of input sources. Therefore, on the assumption that a similar level of supplier power is exerted on each competitor (buyer), the same evaluation signs will be given to all five sectors (with a few exceptions).
5.2.1. Electricity

Indoor farming in Iceland is an energy-intensive industry. Machine equipment – such as ventilation, automatic watering systems, and computer processing – requires electricity to run in the greenhouse. Moreover, during the wintertime, electricity is used to provide crops with artificial light due to the lack of natural sunlight.

Although crop production in Iceland requires extensive consumption of energy, Iceland has an abundant, self-sufficient supply of renewable energy sources. National Energy Authority data show that electricity produced in Iceland totalled 18,549 GWh in 2016 – with 73% coming from hydropower, about 27% from geothermal power, and a small percentage from fuel and wind (National Energy Authority, 2017b). The consumption of electricity eliminated energy losses totalled 18.060 GWh in 2016, only 1.3 % of which was consumed in the agricultural industry (including animal husbandry); 77% went to the aluminium industry (National Energy Authority, 2017c; Williams, 2017). Thus, only a small amount of electricity is used for horticulture.

The Icelandic electricity market may be subdivided into the production of electricity (electricity generation), transmission, distribution, and retailing (Hreinsson, 2008). While there is competition in both production and retailing, only one publicly owned firm is involved in transmission, and distribution is in the hands of state-owned or locally owned firms (Christensen, 2016). Electricity users – both households and firms – can switch between providers, but the difference in price is usually small. However, large users with an annual electricity consumption of at least 80 GWh (e.g. aluminium smelters) obtain a long-term power purchase with transmission costs included in the power price through a contract with, Landsvirkjun, the national power company.
Electricity users can choose their supplier from among seven retailers: Orkubú Vestfjarða, Fjarðabyggð, Orkusalan, Orka náttúrunnar, HS Orka, Fallorka, and Orka heimilanna. Electricity prices vary slightly depending on the company and the region where the electricity is being supplied. Despite the slight differences in price between suppliers, electricity prices for transmission and distribution are regulated as a public service. The bargaining power of electricity suppliers is thus low.

5.2.2. Water supply

Iceland is so rich in water resources that there is no need to be concerned about alternatives to water supplies, as long as the water quality remains secure. Though a decentralized public administration is responsible for providing water utilities, municipalities have the substantial obligation to supply water to all their residents in densely populated urban areas (Pietila et al., 2009). In rural areas, water distribution is handled by privately owned but consumer-managed water suppliers. Since Iceland has not experienced a water supply problem in decades, the nation is unlikely to have to rely on external water supplies (WHO/UNICEF, 2010; Butrico, 2013). If it ever does, however, importing water could place an enormous
financial burden on crop producers because it would have to be transported to the island country.

A global scarcity of water could also put pressure on Iceland’s water availability. Recycling or reusing water might thus be wise for Iceland given the increasing concerns over global water scarcity. Some horticultural farms that use hydroponics such as company 8 have already begun reusing the water employed for crop production. Considering the abundant water resources in Iceland and the public administration’s careful management of supplies, water suppliers seem to pose almost no threat to the industry [--].

5.2.3. Human resources

Iceland has a high employment rate, and people in the country are generally encouraged to work. However, farm owners have been struggling to get young people involved in farming businesses. Farmer ageing is becoming a concern among growers in Iceland; most of the interviewees brought this up as a serious issue. Elderly farmers are concerned about their farming operations due to the constant hard work agricultural practices require. What is even harder for them is to find a successor to the business, as greenhouse operation requires specialized expertise and practical experience. The worst-case scenario is that elderly farmers have no alternative but to cash out of their farm or let go of it unless they find someone to take it over [++].

It can be comparatively easy to find substitute workers for simple tasks, such as sowing, harvesting, and packaging products, depending on where the farm is located: The closer to the city the farm is, the easier it is to find and hire help. It is challenging for farmers in rural areas to ensure a stable workforce that can engage in agricultural activities for a specific period. In this context, company 8 – located in the Reykjavik area – has an advantage over the other companies

Rural farms can benefit from people who show interest in learning agricultural practices or who are willing to work on farms. Iceland used to have a custom whereby parents would send their children off for farm visits during the summer and give them an opportunity to
address an essential knowledge gap about food and lifestyles in rural areas (B. Hilmarsdottir, personal communication, May 16, 2019). Some families with farm ties or relations still do this. As farming practices vary with the seasons, some farms could seek assistance only when needed.

It may be a long way off, but the emergence of artificial intelligence (AI) could bring revolutionary changes in crop production. As horticulture is an energy-intensive industry, it would be easy to use computer processing to link AI to production devices. In an example of applying AI to crop cultivation, an international autonomous greenhouse challenge at Wageningen University & Research proved the feasibility of growing cucumbers by controlling the greenhouse environment remotely. The challenge was to grow cucumbers while five live operator teams competed with each other using AI for productive performance. The results demonstrated that the use of AI algorithms in cucumber production could outperform experienced manual growers (Hemming et al., 2019). Switching from human resources to AI seems unlikely today, yet what used to be science fiction is becoming part of our daily routines.

### 5.2.4. Materials for building greenhouses

This section discusses the potential power of greenhouse equipment suppliers in the industry. Since it is hardly possible to trace how and where Icelandic growers obtain their equipment for building greenhouse farms, the interviewees were asked which country they bought their greenhouses from. While several greenhouses were built using materials purchased in Iceland, most companies purchased their greenhouses from other countries, specifically Denmark and the Netherlands. As the Icelandic climate can be rough, with high winds and volcanic ash, almost all of the greenhouses used in Iceland are of glass construction (Dillman, 2018).

Piping equipment and artificial lighting are also essential for greenhouse operations. There are countless suppliers to choose from when purchasing equipment from a foreign provider, since European markets are much larger than local ones. Therefore, the costs of switching
suppliers exert little pressure on horticultural companies in Iceland, indicating that suppliers’ power over the equipment used to build greenhouses is weak [--].

5.2.5. Evaluation for supplier’s power

As the power of suppliers is low for all vegetable sectors, the industry is likely to achieve high profits. A primary cause of the weak supplier power is the abundant natural resources and administration of utilities in Iceland. While greenhouse equipment suppliers are few in Iceland, there are innumerable options abroad. Companies can thus keep their input costs low while enjoying increased profits. It is important to understand that finding labour can be a formidable task. Swift action needs to be taken to deal with labour, such as attracting more people, particularly younger people. Using automation, rather than relying on a human workforce, is also beneficial. This not only saves input costs over the long term but also ensures product efficiency.

Table 4. Overall evaluation for suppliers’ power

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Bell peppers</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Water</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Labour</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Materials</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Average</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

5.3. Power of buyers

This section assesses how the power of buyers is likely to affect the industry’s profitability. As with the power of suppliers, there is little difference between the vegetable sectors in terms of the buyers’ power over competitors (companies). However, as the power of buyers varies considerably depending on the element affecting the buyer’s force, this force is assessed by examining 1) the number of buyers relative to suppliers, 2) the buyer’s switching costs, 3) product differentiation, and 4) price sensitivity. The evaluation results for each
element are shown with [++] when buyers are likely to exert a strong power over suppliers, [+ ] when the power is moderately high, [O] when it is neutral, [- ] when it is relatively low, and [--] when it is low. Buyers in this study consist of consumers, including tourists, restaurants, and stores in Iceland.

5.3.1. Buyer volume

Iceland has one of the smallest populations in Europe; its domestic market is thus also small. However, the increased number of tourists to Iceland has enlarged the market. Tourists increased at an average annual rate of 24.3% from 2010 to 2017 (Icelandic Tourist Board, 2018). Along with the growth of tourism, food supplies have increased. The average annual growth rates of the five vegetables from 2010 to 2017 were 21% for tomatoes, 24.6% for bell peppers, 23.3% for salad, 34% for mushrooms, and 22.2% for cucumbers (see Appendix 1). Though the population has also increased since 2010, the average growth rate during this time was so small (only 0.91%) that the population increase has likely had little effect on each of the markets. Moreover, the average length of stay for foreign visitors is 5.3 nights in the winter (December to February) and about eight nights in the summer (June to August; Icelandic Tourist Board, 2018). In addition to the growing number of tourists, the lengths of tourists’ visits can also alter food consumption volumes depending on the season. As the number of foreign visitors strongly influences the food market, tourism is a crucial factor in the power of buyers. If Iceland’s current tourism trend continues, the market will expand further.

The local consumption of vegetables also has a profound effect on this power. Despite the dietary guidelines of the Directorate of Health – proposed as ideal for ensuring an intake of at least 500 g of FV per day – nearly 90% of Iceland’s population falls outside the guidelines, of which 34.8% show zero daily consumption of FV. Thus, vegetables are likely being consumed in insufficient quantities.

The latest available data suggest that the FV supply in Iceland totalled 203.2 kg (70.1 kg for vegetables and 133.1 kg for fruits) in 2013 (OECD/EU, 2016), though those supplies may have increased since then. According to a report on food waste of the Icelandic Environment
Agency (2016), average annual edible food waste from households totalled 23 kg per person. In addition to household waste, 42,380,800 kg of annual edible food waste from companies in Iceland has also been reported. Population data for 2016 (332,529 according to Statistics Iceland) were employed to calculate per capita company food waste, as this research was conducted in 2016. Dividing the companies’ total food waste by the total population results in approximately 127 kg per person per year; 53,200 g per year is obtained after the average annual edible food waste from households is added to the total food waste from companies per person. Dividing this number by 360 days reveals that approximately 148 g of FV per person is consumed in Iceland.

Thus, buyer volume does not necessarily imply the size of the population, even though food is vital to every human being. The power of buyers is to be evaluated based on the number of buyers relative to that of suppliers. However, the power of buyers is considered to be neutral [O] as it is nearly impossible to determine how many buyers choose products provided by domestic suppliers over imports.

5.3.2. Buyers’ switching costs

Switching costs are costs incurred by buyers when changing products. Regarding time- and effort-based switching costs, similar but imported products – as substitutes for the five domestically produced vegetable species – can easily be found in stores where the Icelandic products are sold. However, it is difficult to find substitutes for Icelandic cucumbers because the cucumber market is dominated by local produce [--] (see Figure 31). Substitution is also low [-] in the mushroom market, as the domestic mushroom sector has higher production levels than the other sectors (see Figure 29).

Despite the availability of alternatives, consumers in Iceland have a penchant for local products. A study by Halldorstdottir and Nicholas (2016) on consumer behaviour regarding local food in Iceland demonstrates that 71% of participants, including foreign visitors, display positive impressions of local foods as a healthy and safe option, that 81% have purchased local food, and that most are satisfied with its taste and quality. Considering their buying behaviour, Icelandic consumers have to incur psychological switching costs when local
products are out of stock. Given the potential psychological costs, buyers’ switching costs are moderately low [+].

5.3.3. Differentiated products between domestic producers

Identifying local products among vegetables on the store shelves requires little effort because of the way they are presented: they are frequently wrapped in a plastic bag with a label showing that they are produced in Iceland. However, it is hard to differentiate between local products. As most of the products sold in Iceland are produced outside the capital area, distribution companies deliver products from the production sites to stores and restaurants, putting the same labels and prices on them. Most local products are undifferentiated during the course of distribution, and thus standardised products can motivate supplier switching [++].

Though products are barely differentiated between suppliers, tomatoes and salads come in a variety of types. Hence, suppliers are selected for a reason when customers have a preference over a particular type of vegetable product [+]. However, company 8 has 70% of the salad market; thus, the threat derived from differentiated products must be low [++].

5.3.4. Price sensitivity

Theoretically, consumers in rich countries have a relatively low price sensitivity of demand for tradable goods and are more likely to be charged higher prices for those goods (Murphy, 2013). Iceland is one of the most expensive countries to live in; it also ranked fourth in the 2018 World Happiness Report (World Population Review, 2019). Putting aside the question of whether the nation is genuinely happy, expensive tradable goods do not seem to be hampering Iceland’s standard of living. Given the nation’s low price sensitivity, buyers’ bargaining power is low [--].

5.3.5. Evaluation for buyers’ power
The availability of alternatives is the most influential factor in changes in power. The power of buyers has little impact on companies’ profitability given Iceland’s low price sensitivity and buyer volume. However, due to the high availability of alternatives to tomatoes, bell peppers, and salad, buyers’ power is stronger in those three sectors. Tomatoes in particular come in a variety of types; thus, the power in the tomato sector is lower than in the other two sectors due to the high availability of alternatives.

Table 5. Overall evaluation for buyers’ power

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Bell pepper</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Switching costs</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>Differentiated products</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Price sensitivity</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Average</td>
<td>O</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**5.4. Substitutes**

This section examines the availability of substitute products from another industry and assesses the threat those substitutes pose to the horticulture industry in Iceland. Products or services that meet the same basic needs as a substitute can be categorized into two types: close and weak substitutes. The former provide a similar texture and/or taste, but might differ in shape and/or state of conservation from the original product. The latter can look completely different from the original product and/or provide incompatible functions yet serve the consumer’s needs. While close substitutes satisfy the same need and serve the same function as the original product, weak substitutes fill the same need in a different way. This study considers only close substitutes because the weak substitute options are so diverse that they pose no conceivable threat. In addition to close substitutes, imported
products are also taken into account as another type of substitute, since this study focuses only on the domestic market.

This section assesses the threat of substitutes, imported substitutes, and close substitutes using three elements: 1) price, 2) time-based switching costs, and 3) quality. When the threat of substitutes is high, the industry may lose potential profits. As lower profit potential is a negative impact on the industry, [+] or [++] is given depending on the power of the element.

5.4.1. Imported substitutes

Imported products are generally less expensive than Icelandic products. For example, imported tomatoes cost 360 to 499 ISK/kg, while domestically produced tomatoes cost 799 to 899 ISK/kg (as of May 8, 2019) [++]]. While the prices of Icelandic mushrooms and cucumbers are broadly competitive with those of imports [O], domestic bell peppers are almost double the price [++]]. Imported bell peppers cost 580 ISK/kg on average, and Icelandic ones cost 992 ISK/kg. The prices of vegetables can vary depending on the store, yet imported products are generally cheaper than domestically produced ones. Icelandic salad is relatively more expensive than imported products, but the prices vary depending on the type of salad [+].

In addition to substitute prices, consumers’ switching costs are also low, as products are always on the shelves and available year-round, and customers can easily find substitutes right next to domestic products at the same grocery store [++].

However, product quality makes a significant difference in Iceland. Most local products are freshly cultivated and grown chemical-free due to Iceland’s cold oceanic climate. A study conducted by Halldorsdottir and Nicholas (2016) finds that customers – both Icelandic and foreign visitors – have high consumer awareness and consider quality to be the most important product attribute. Comparable price comes next, followed by convenient packaging and consumption-readiness. Two managers, one from Kronan (Krónan) and one from Bonus (Bónus), acknowledge that customers tend to prefer locally cultivated
vegetables over imported ones, though local ones are usually more expensive. Furthermore, both of the managers mention that customers – especially elderly ones – often complain when local products are out of stock (personal communication, May 17, 2019). Thus, consumers in Iceland seem to appreciate the quality of local products [-].

5.4.2. Close substitutes

In Iceland, close substitutes that provide a similar taste but have a different shape are usually inexpensive; examples of close substitutes are given in Table 6. Close substitutes are much cheaper than fresh domestic products [++] . Again, there are no time-based switching costs, as they are easily found at the same store where consumers buy domestic products [++] . Their quality can differ depending on how the substitute products are used. The quality of substitutes is generally inferior as they are likely to be processed or frozen, suggesting moderate switching costs. However, tomatoes and mushrooms are frequently used in soup or dishes that do not necessarily require fresh food, suggesting that the costs of switching to close substitutes are moderately low [+]. As salad and cucumbers are mostly consumed raw, switching costs for these two sectors are higher than for the others [-]. The uses of bell peppers are so various that the expected costs to switch products are neutral [O].

5.4.3. Evaluation for substitutes

All of the sectors are very sensitive to the threat of substitutes, chiefly because substitutes are inexpensive and switching costs are low. To reduce the threat of substitutes, producers can either enhance their product values or lower the prices. It is hardly possible for producers to increase time-based switching costs, as the products are mostly sold at grocery stores. If stands selling only locally produced fresh products are set up away from grocery stores, customers who prefer local products might go there specifically to buy those products. However, going to another place to buy particular products that can be sold together with other products at grocery stores can also raise switching costs, as this requires extra effort. Hence, it seems more reasonable for producers to lower the prices or add more value to their products.
<table>
<thead>
<tr>
<th>Imports</th>
<th>Tomato</th>
<th>Bell pepper</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Switching costs</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Quality</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Close substitutes</td>
<td>Frozen tomatoes, canned tomatoes, and processed products</td>
<td>Frozen bell peppers</td>
<td>Frozen salad (spinach)</td>
<td>Canned mushrooms, frozen mushrooms</td>
<td>Processed products</td>
</tr>
<tr>
<td>Price</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Switching costs</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Quality</td>
<td>+</td>
<td>O</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

### 5.5. New entrants

This section examines the threat posed by new entrants to existing competitors in the industry. A profitable industry will attract new entrants, who can be a threat to existing companies in the market. Therefore, the higher the entry barriers to the market, the more advantageous it is for incumbents. Remaining in the market requires adequate demand for outcomes.

To assess this threat, six barriers to market entry will be discussed: 1) economies of scale, 2) network effects of products, 3) differentiated products 4) admission price, 5) distribution channels, and 6) political restrictions.
5.5.1. Economies of scale

When industry profitability enjoys economies of scale, a low threat of entry is expected. Economies of scale are the cost advantages over proportion to inputs; they are achievable when efficiency is improved on a larger scale or with fewer input costs.

Economies of scale do exist in Icelandic horticulture, as farms with larger greenhouses have a considerable share of the market. Figure 34 shows the sizes of Iceland’s greenhouses as of 2017, and the interviewed farmers, representing one farm each, are indicated on the horizontal axis. As seen in Figure 34, the interviewees not only are among Iceland’s largest producers but have the largest greenhouses as well, indicating the existence of economies of scale in this industry.

![Figure 34. Size of indoor horticultural farming in Iceland (National Energy Authority, 2017b).](image)

As illustrated in Figure 34, the larger the production site, the larger the output volume that can be expected. However, the average cultivation area used in greenhouse vegetable production is very small in Iceland. The Netherlands, one of the world’s largest horticultural crop producers (Netherlands Enterprise Agency, 2019), has an average cultivation area of 26,000m² (Statista, 2018a), with the largest 50,300m². Iceland’s average cultivation area is 2,512 m², the largest being 11,945m², which is 10 times smaller than the Netherlands average. Moreover, the Netherlands has achieved economies of scale. Although the number
of greenhouse farms declined from 1,100 in 2012 to 850 in 2017 (Statista, 2018b), the size of greenhouses has been increasing since 2007, and the vegetable yield increased from 3,814.8 kg in 2010 to 5,552.5 kg in 2017 (Statistics Netherlands, 2019). Given the enormous initial costs required for setting up greenhousing, Dutch horticulture has likely reaped the cost advantages gained by an increased level of production.

Icelandic indoor farmers do not seem to be making the best use of their facilities despite the potential for economies of scale. All of the interviewees expressed an intention to minimize food loss from their cultivation sites, which determines the number of outputs based on the market size. Although some of the farms are surely capable of increasing their production, they are not trying to do so.

Though economies of scale can bar entry to new entrants, incumbents rarely take advantage of this. Given the market-based scheme of vegetable cultivation, the cucumber and mushroom sectors have successfully kept up with the growing demand in recent years, whereas the other sectors should be able to increase their yield. Though the salad sector has also increased its supply, imported products still account for more than half of the market.

5.5.2. Network effect

The network effect increases product values when the product is well-known and its value is shared with a large number of people in a community. Products or services that are sharable among a certain number of people (e.g. Facebook) tend to create a significant network effect. This effect can work as a barrier to new entrants.

It is hard to share the values of consumable goods such as food among a large group of people. On consuming the product, the value vanishes. Thus, the value of vegetables sold at a grocery store is less likely to create a substantial network effect among consumers. On the other hand, restaurants serve food in a way that provides additional value to plain vegetables and meat used as ingredients. Not only do restaurants enhance the value of each ingredient, but they also create a network effect through which customers can share the value.
As domestic products are barely differentiable, individual companies cannot create significant network effects. However, Iceland can lower the power of substitutes by differentiating domestic products from imports. To create a greater network effect for Icelandic products, for instance, growers cooperate with restaurants and encourage them to use more local products rather than imported products. Though local food can be a little more costly, advertising fresh local products draws the attention of tourists and of Icelandic customers who prefer locally produced food over imported food.

Thus, the threat of the network effect is neutral, as it can vary the degree of the threat depending on the buyers [O].

5.5.3. Differentiated products

Vegetables cultivated in Iceland are not differentiated between producers, which lowers the barriers to new entrants [++] . Therefore, domestically produced vegetables have established their value as being different from imported products in quality and freshness. Several types of tomatoes are produced in Iceland, but the other vegetable sectors have a limited variety of vegetable species. The horticulture industry can raise entry barriers by adding more varieties of vegetable species or creating a new vegetable brand.

5.5.4. Admission price

Since setting up greenhouse farms demands significant investment, the admission price for entering this industry is high. First, Iceland is a resource-limited island located in the middle of the ocean between the two continents of Eurasia and North America. Since most greenhouses built in Iceland are imported from the Netherlands and Denmark, transportation costs are added to every purchase of equipment from abroad. Normally, the cost of setting up a greenhouse is estimated at approximately 40,000 ISK per square metre of greenhousing and 35,000 ISK for cultivation equipment (Dillman, 2018). Considering the costs for glass greenhouse construction, as the average size of greenhousing in Iceland is
2,512 m², at least about 200 million ISK is needed as initial investment. Installing equipment such as LED lights and pipes for hot water is also required. Although these costs are less of a burden as time passes, the considerable costs in the initial stage of their business can threaten new entrants [--].

5.5.5. Distribution channels

This section examines how difficult it is for new entrants to access distribution channels. The more difficult, the weaker the threat of new entrants it gets. Icelandic farms are usually a small family business, and the successor is usually chosen from within the family. Since Iceland has a small population, people are acquainted with others living in their community and tend to establish close relationships with them. It can be tough for Icelandic newcomers who did not grow up on a farm to join the established community and obtain information. However, the Farmer’s Association of Iceland provides opportunities for farmers to gather and discuss their progress toward prosperity in agriculture (Farmer’s Association of Iceland, 2019a). Membership requires fees depending on the type of membership; there are no strict requirements, other than being older than 18, residing in Iceland, and understanding the association’s vision. Given the opportunities provided by the association, even new entrants are put on an equal footing with incumbents.

Access to distribution channels is not necessary to sell products in Iceland. Company 8, in the Reykjavik area, delivers on their own to stores and restaurants. Depending on where a farm is located, it is not necessary to rely on distribution channels to sell produce. Company 8 claims that their flexibility – delivering their products themselves – has helped them to develop the company.

To ensure distribution channels, joining the Farmer’s Association of Iceland is an option to receive assistance. Even with no distribution channels, it is possible to sell products and can be more efficient depending on where the farm is located [++].
5.5.6. Policy restricting or preventing entrants

There is no policy restricting or preventing entrants in this industry. New business entry is welcomed. Iceland ranks as one of the top countries in terms of the ease of starting a business (Invest in Iceland, 2019). Whether the business operates a farming interest or not, when it comes to establishing a business entity in Iceland, a firm has to be registered at RSK (Directorate of Internal Revenue) and given a VAT ID number. The registration applicant must fill out a two-page form and wait up to seven days for the application process to complete. Although opening up a business is not oppressive, it can be a challenge for non-Icelandic entrepreneurs since the procedures are available only in Icelandic.

Regarding governmental financial support for agriculture, Iceland is among the most farmer-friendly among OECD countries. However, the interviewees seemed to be struggling with a sense of duty as food providers, as they are unable to increase production while trying to make ends meet. Presumably, they are stuck between the price war with imports and the cost of electricity, which is the most significant cost burden. As mentioned, some of the farmers admit it is technically possible to increase production, yet they are not willing to do so, indicating a need for additional support for horticultural farmers.

There are two ways of supporting horticultural farmers: imposing taxes on imported food and subsidizing farms to encourage them to increase production (Ministry of Industry and Innovation, 2018). Concerning taxes, tariffs for imported greenhouse crops were abolished in 2002 in return for increased subsidies for indoor farming. The policy was amended again in 2007 to re-impose tariffs on imports, though imposing a 10% tax on fresh vegetables imported from countries outside the EU hardly made it easier for local producers to compete with inexpensive imports.

Regarding subsidies designed to encourage production, companies are allowed to apply for direct payments and electricity subsidies (Ministry of Industry and Innovation, 2018). However, direct payments have limited scope, targeting only tomatoes, cucumbers, and bell peppers. Of the allocated budget of 274 million ISK for 2017, 49% goes to tomatoes, 37% to cucumbers, and 14% to bell peppers. The proportion allocated to each species is reviewed
depending on the estimated sales volume reported by producers in advance, and 80% of the estimated direct payments per kg is paid to producers.

The second subsidy is for the costs of the distribution of electricity consumed for lighting (Ministry of Industry and Innovation, 2018). Producers that cultivate horticultural crops for a commercial purpose are entitled to subsidized electricity for annual lighting consumption over 100 MWh. The budgets allocated for electric power subsidies are fixed, and 278 million ISK is divided among the applicable producers by the Food and Veterinary Authority.

Despite this government support, local growers are concerned about maintaining competitive prices against imported products. In the interviews, company 4 and 8 mentioned that they found the subsidy system unfair, as they are growing vegetables that are not eligible for direct payments; they are currently in negotiations with the government. However, in an interview with Brynja Laxdal, project manager of Iceland’s Culinary Treasures, of the Ministry of Fisheries and Agriculture, she stressed that they have no immediate plans to review the subsidy programme, though it is not known exactly why only the three vegetable species are targeted for direct payments. Company 4 also pointed out that the national power company was prejudiced in favour of aluminium smelters despite their massive consumption of electricity, which is nearly 80% of the electricity consumed within Iceland. Moreover, electricity prices have been gradually rising, keeping the pressure on local horticultural producers.

The cultivation of tomatoes, bell peppers, and cucumbers is subsidized via direct payments, though most of the farmers are still concerned about high production costs [-]. Salad and mushroom production is even harder, as no assistance is given aside from the lighting subsidy. Hence, the subsidy system is not of much help to incumbents, but hampers new entrants [--].

5.5.7. Evaluation for new entrants

As there is generally very little to differentiate between vegetable items, less effort is required to enter the industry. However, the threat of new entrants is still low due to the
high entry barriers imposed by high admission prices and the requirement of economies of scale. Because of these entry barriers, the subsidies provided for growers are helpful for new entrants. Most local growers are dissatisfied with the current government assistance. It can be strenuous for new entrants to break into this industry, but it is seemingly effortless for incumbents to achieve high profitability.

Table 7. Overall evaluation for new entrants

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Pepper</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economies of scale</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Network effect</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Differentiated products</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Admission price</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Distribution channels</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Policy</td>
<td>-</td>
<td>-</td>
<td>--</td>
<td>--</td>
<td>-</td>
</tr>
<tr>
<td>Average</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

5.6. Overall evaluation

By quantifying the overall evaluation for each force, this section intends to provide a comprehensive evaluation for the five vegetable sectors. Numerical values are assigned to quantify each evaluation. While 0 is counted as zero – implying that it is neither good nor bad for the industry – a single positive sign is displayed as 1; a double positive sign is indicated by 2; a single negative sign is indicated by -1; and a double negative sign is indicated by -2. An average level for each force is calculated using the assigned numerical values (see Appendix 3). Table 8 displays the overall evaluations made based on the current situation in the horticultural industry. Red indicates a higher external power for companies and firms in the industry; green indicates a neutral position; and blue indicates a weaker
power. The more vivid the colour, the higher the power (e.g. vivid red indicates a higher power to the incumbents).

Table 8. Comprehensive evaluation for horticultural industry in Iceland

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Pepper</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivalry</td>
<td>1.20</td>
<td>0.20</td>
<td>-0.40</td>
<td>-1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Supplier</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
</tr>
<tr>
<td>Buyer</td>
<td>0.00</td>
<td>0.25</td>
<td>0.25</td>
<td>-0.25</td>
<td>-0.50</td>
</tr>
<tr>
<td>Substitutes</td>
<td>1.17</td>
<td>1.00</td>
<td>0.67</td>
<td>0.83</td>
<td>0.50</td>
</tr>
<tr>
<td>New entrants</td>
<td>-0.17</td>
<td>-0.17</td>
<td>-0.33</td>
<td>-0.33</td>
<td>-0.17</td>
</tr>
<tr>
<td>Average</td>
<td>0.29</td>
<td>0.11</td>
<td>-0.11</td>
<td>-0.30</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Three of the five vegetable sectors are red in the average column, indicating that the competitiveness of the horticultural industry is moderately high and that its degree can vary depending on what is being grown in the greenhouses. The salad and mushroom sectors are relatively low in competitiveness as they enjoy a more or less monopolistic situation in their sectors. Considering the low competitiveness in the two sectors, high profitability is more likely to be achieved growing vegetables that have not been produced stably in Iceland. Except for the rivalry and buyers forces, all of the sectors have similar powers and threats that can erode profitability: The industry is profoundly affected by the threat of substitutes, while it receives little power from suppliers and new entrants. The industry’s strengths and weaknesses are discussed below given what has been revealed through this analysis, and the implications of the results are discussed.
6. Discussion

This study measured the competitiveness of the horticulture industry in Iceland using interviews with local growers. Porter’s five forces model was used as a framework. The overall assessment of each force applied to the industry reveals that the competitiveness of the horticultural industry is slightly high, though some of the sectors have low competitiveness. Hence, competitiveness depends on the food items being cultivated in greenhouses.

Regarding the strengths and weaknesses of this industry, though there are slight differences in the power balance between the vegetable sections, the power of suppliers and new entrants is low in every sector. Supplier power is low because Iceland’s abundant and accessible natural resources allow for multiple uses: Suppliers need not depend on the horticulture industry. The power of new entrants is low mainly due to the high admission prices, which impede new industry players. The policies for horticultural activities relieve growers of some of their burden but do not necessarily encourage the industry to increase production volume or add variety. These forces act as strengths and protect industry incumbents.

On the other hand, the power of substitutes is exceptionally high, which is the weakest point of the industry. In addition to the vast quantity of inexpensive imported fresh vegetables, processed food that can replace the industry’s products apply further pressure on the horticulture industry.

We can apply these results to the notion of ‘competitiveness’ defined in this study (the ability to supply products to meet local demand for fresh food making good use of sources available in Iceland). This case study finds that the competitiveness of the industry is moderately high, which suggests the industry has the ability to meet the demand in accordance with the definition. Although the level of competitiveness can differ considerably between the vegetable items, the tomato, bell pepper, and cucumber sectors have potential sources sufficient to satisfy the market using their domestic production.
Despite the feasibility of the three sectors, imported products dominate the market in the tomato sector and in the bell pepper sector, which indicates that the high threat of substitutes outweighs the low power of suppliers and new entrants. In addition to the high threat of substitutes, other elements also seem to influence the market dominance of foreign products. Structurally speaking, the power of suppliers is low due to their low bargaining power with companies in the industry. However, as was brought up repeatedly in the interviews, food production using greenhouses entails significant costs in addition to initial greenhouse setting-up costs. Given the large expenses incurred to produce local products, it is extremely difficult to compete with imported products under the current circumstances.

As company 2 mentioned in the interview, some companies can increase their production, but they find it difficult to sell it all. However, buyers’ bargaining power appears to become high when local products are out of stock. Considering the difficulty of selling out on domestically produced vegetables, only a certain segment of customers seems to purchase local products over imported ones. A potential cause for the contradiction could be that customers are not willing to pay more for local products despite their preference for them. When the prices are higher than those of imported products, even with the increased availability of local products at a grocery store, some customers are willing to pay extra for high quality; others reluctantly choose imported products at cheaper prices. Therefore, increasing local products in the market requires lowering the prices, if producers are to meet the fresh vegetable demand from an expanded targeted customer segment.

The result of the structural industry analysis indicates that horticulture in Iceland has significant growth potential; particularly, the tomato, bell pepper and cucumber sectors are capable of satisfying the demand for local products. However, the limited selection of local vegetable cultivation never meets the demand for fresh food for the whole country. In order to increase local production, the following section offers suggestions based on the implications of the study.
6.1. Recommendations

To meet the demand of fresh food, Iceland still has to depend on imported products. Given that the strengths and weaknesses of the industry have been revealed, four suggestions are provided based on the implications.

First, the policies affecting horticultural activities are not discouraging growers, but they are not encouraging them either. The governmental support currently provided to growers enables domestically produced vegetables to compete against imports. Rather than providing countermeasures to protect local growers, measures must be implemented to increase domestic produce. Given the requirement of economies of scale in this industry, improving them can strengthen competitiveness in this industry considerably. Economies of scale increase profitability while acting as a barrier to new entrants. For example, technological innovation such as introducing AI will enable growers to replace manual tasks with automation, which will address the largest portion of producing costs. Labour costs are among the greatest burdens for growers; technological innovation can reduce this burden and boost productivity. Hence, governmental support or investments for technological equipment that improves productivity and increases profitability can support growers more effectively than direct payments or subsidies for lighting.

Second, the lower the rivalry in a sector, the more companies are likely to profit. Avoiding having too many companies or a monopoly has positive impacts on the industry. As seen in Table 8, multiple incumbents occupy a considerable share of the market in the tomato sector. The high rivalry intensity in the sector indicates that the number of competitors is sufficient for increasing local production. As higher-intensity competitiveness could reduce profits for existing companies, the public administrations should focus more on an element that upholds the level of productivity rather than supporting all players in the sectors. Since competitiveness accelerates innovation, a monopoly is not healthy for the industry either. Given Iceland’s small market, more than one company – two or three producing companies – in each vegetable sector seems ideal for both the companies and the national economy.
Third, encouraging collaborations with local stakeholders is a measure that can be taken either on a governmental level or a company level. In a country where the number of tourists surpasses its population, developing tourism resources can intensify the buyer’s motivation to buy local products. In Iceland, some restaurants claim that they use only ingredients cultivated in Iceland in order to attract foreign customers who are intrigued and seek something unique to the country. While many restaurants are apt to promote domestically raised lamb meat and locally caught seafood, locally grown vegetables have yet to be emphasized as an advertising point. Collaborating proactively with stakeholders, restaurants, and retailers can be helpful for the fledgling horticulture industry.

Lastly, for business entities, differentiating products helps growers to achieve higher profits and thus increases their production. Every existing company, irrespective of what they cultivate at their farm, receives the same amount of power and threat from the five forces. The horticulture industry is affected by the high threat of substitutes and the low power of suppliers and new entrants, though there is a slight difference between the vegetable sectors, which implies that existing companies compete with each other in a similar competitive environment. Therefore, utilising competitive advantage in the industry is key to increasing market share. For example, domestically produced vegetables have little differentiation. Creating original value for products will add extra value to established domestic brands. When products are highly differentiated, the bargaining power of buyers is lowered. Although the power of buyers in the industry is not high, the other elements comprising the power of buyers hardly differ between competitors. By lowering the bargaining power of buyers, a company with products differentiated from others will increase its profitability.

Thus, the horticulture industry in Iceland can be more attractive depending on the cultivated food items. Although substitutes for local products are aggressively competitive with inexpensive products, increased efficiency and productivity should turn the table for incumbents. A profitable industry is usually attractive to new entrants, yet the high entry barriers in the industry hinder them from gaining entry into the market. Managing a competitive environment in each vegetable sector will enable growers to meet the demand for fresh food from domestic horticulture.
6.2. Limitations of this research

This study examined multiple elements that drive the five forces suggested by Porter, but the assessment does not cover all of the elements suggested for each force. The elements composing the five forces are assessed using data acquired from accessible sources and the results of the interviews. However, due to data limitations and the inapplicability of some of the elements to this case study, the elimination of some elements might have affected the results. Moreover, though each force gives varying weights to the elements and their impact, the power balance between the forces is overlooked in this analysis. While this model enables us to depict the whole industry with the crucial forces underpinning it, it fails to reflect how each force affects the overall evaluation of the industry at different levels.

Additionally, temporary factors, also called ‘short-term factors’, are excluded from this research. One of the factors, technological innovation, is barely covered despite the significant impact of technology on agriculture and/or horticulture. Some of the interviewed farms also discussed technological developments on the farm, but the study’s focus was on the permanent core forces that underpin the industry.

Last but not least, a crucial point of this industry is insufficient data. Further research is required to increase the accuracy of the industry structure. However, a considerable amount of data are kept unavailable within the government and major related associations, or perhaps were not collected at all. Data sharing allows collaborations with other associated stakeholders and would lead to innovation and increased efficiency.
7. Conclusion

This study provides an overview of the competitiveness of the horticulture industry in Iceland. In order to evaluate the feasibility of increasing fresh food products cultivated in greenhouses in Iceland, the industry was analysed using Porter’s five forces framework. Due to data insufficiencies, interviews with 11 local growers were conducted to help enhance the quality of the analysis. The results show that the industry has slightly high competitiveness, that the high power of substitutes is a weakness, and that the low powers of suppliers and new entrants are strengths. The industry can benefit from the two low forces, but the force of substitutes is so high that it is hardly possible to increase local products under the current circumstances. If increasing the amount of local products is believed beneficial for the country, measures must be taken to help growers compete against the inexpensive imported products flooding the market. The study finds that the low powers of suppliers and new entrants are advantages. By utilizing the industry’s structural features, effective supports should be able to provide business entities with adequate production capability. In conclusion, horticulture in Iceland has hidden growth potential given the abundant natural resources and the potential for technological development. It will be feasible for Iceland to increase domestically produced fresh food products if effective measures are implemented where needed.


Davidsdottir, Brynhildur. (October, 2018). The impact of climate change on infrastructure and freshwater resources [Presentation slides].

Dillman, J. K. (2018). Profit maximization model for the cascading use of geothermal energy. Magister Scientiarum degree in Environment and Natural Resources


IPCC. (2018). Summary for policymakers In: Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to


Lane, A., & Jarvis, A. (2007). Changes in Climate will modify the Geography of Crop Suitability: Agricultural Biodiversity can help with Adaptation. *Journal of SAT Agricultural Research, 4*.


### Appendix – 1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tómatar - isl</td>
<td>1,603,00</td>
<td>1,621,00</td>
<td>1,481,00</td>
<td>1,652,00</td>
<td>1,605,00</td>
<td>1,716,00</td>
<td>1,560,00</td>
<td>1,516,00</td>
<td>1,347,00</td>
<td>1,436,00</td>
<td>1,334,00</td>
</tr>
<tr>
<td>Tómatar - innfl</td>
<td>704,88</td>
<td>646,32</td>
<td>692,26</td>
<td>583,38</td>
<td>678,30</td>
<td>445,53</td>
<td>779,49</td>
<td>869,85</td>
<td>1,097,1</td>
<td>1,204,5</td>
<td>1,371,9</td>
</tr>
<tr>
<td>Tómatar - heild</td>
<td>2,307,82</td>
<td>2,267,32</td>
<td>2,173,20</td>
<td>2,235,32</td>
<td>2,283,30</td>
<td>2,161,59</td>
<td>2,339,40</td>
<td>2,385,89</td>
<td>2,444,10</td>
<td>2,640,51</td>
<td>2,705,07</td>
</tr>
<tr>
<td>Hlutde íslenskt</td>
<td>69.50%</td>
<td>71.50%</td>
<td>68.10%</td>
<td>73.90%</td>
<td>70.30%</td>
<td>79.40%</td>
<td>66.70%</td>
<td>63.50%</td>
<td>55.10%</td>
<td>54.40%</td>
<td>49.30%</td>
</tr>
<tr>
<td>Annual growth rate (%)</td>
<td>-1.76%</td>
<td>-4.15%</td>
<td>2.86%</td>
<td>2.14%</td>
<td>-5.33%</td>
<td>8.23%</td>
<td>1.98%</td>
<td>5.33%</td>
<td>2.44%</td>
<td>8.03%</td>
<td>2.48%</td>
</tr>
<tr>
<td>Paprika - isl</td>
<td>146.70%</td>
<td>169.60%</td>
<td>177.32%</td>
<td>186.73%</td>
<td>229.42%</td>
<td>261.40%</td>
<td>243.60%</td>
<td>223.41%</td>
<td>215.00%</td>
<td>190.00%</td>
<td>191.00%</td>
</tr>
<tr>
<td>Paprika - innfl</td>
<td>1,044.67</td>
<td>1,154.37</td>
<td>1,083.67</td>
<td>1,145.37</td>
<td>1,211.93</td>
<td>1,248.78</td>
<td>1,294.61</td>
<td>1,328.80</td>
<td>1,368.54</td>
<td>1,469.37</td>
<td>1,493.29</td>
</tr>
<tr>
<td>Paprika - heild</td>
<td>1,191.37</td>
<td>1,324.19</td>
<td>1,260.95</td>
<td>1,332.15</td>
<td>1,440.91</td>
<td>1,510.18</td>
<td>1,538.26</td>
<td>1,583.55</td>
<td>1,673.95</td>
<td>1,660.37</td>
<td>1,660.37</td>
</tr>
<tr>
<td>Hlutde íslenskt</td>
<td>12.30%</td>
<td>12.80%</td>
<td>14.10%</td>
<td>14.00%</td>
<td>15.90%</td>
<td>17.30%</td>
<td>15.80%</td>
<td>14.40%</td>
<td>13.60%</td>
<td>11.40%</td>
<td>11.50%</td>
</tr>
<tr>
<td>Annual growth rate (%)</td>
<td>-11.14%</td>
<td>-4.77%</td>
<td>5.64%</td>
<td>8.17%</td>
<td>4.81%</td>
<td>1.86%</td>
<td>0.73%</td>
<td>2.20%</td>
<td>5.71%</td>
<td>-0.81%</td>
<td></td>
</tr>
<tr>
<td>Salат íslenskt</td>
<td>89,782</td>
<td>97,532</td>
<td>109,73</td>
<td>107,69</td>
<td>161,41</td>
<td>289,00</td>
<td>314,00</td>
<td>376,80</td>
<td>453,00</td>
<td>530,00</td>
<td>0</td>
</tr>
<tr>
<td>Salат innflut</td>
<td>1,579.2</td>
<td>978.80</td>
<td>1,341.1</td>
<td>1,404.2</td>
<td>1,437.0</td>
<td>1,449.5</td>
<td>1,206.3</td>
<td>1,378.5</td>
<td>1,352.9</td>
<td>1,328.8</td>
<td>1,309.3</td>
</tr>
<tr>
<td>Salат heild</td>
<td>1,669.0</td>
<td>1,076.3</td>
<td>1,450.9</td>
<td>1,504.2</td>
<td>1,544.7</td>
<td>1,610.9</td>
<td>1,495.3</td>
<td>1,692.5</td>
<td>1,729.7</td>
<td>1,781.8</td>
<td>1,839.3</td>
</tr>
<tr>
<td>Hlutde</td>
<td>5.40%</td>
<td>9.10%</td>
<td>7.60%</td>
<td>6.60%</td>
<td>7.00%</td>
<td>10.00%</td>
<td>19.30%</td>
<td>18.60%</td>
<td>21.80%</td>
<td>34.10%</td>
<td>40.50%</td>
</tr>
<tr>
<td>ild íslenskt</td>
<td>Annua l growt h rate (%)</td>
<td>Sveppi r - isl</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>34.80</td>
<td>3.67</td>
<td>2.70</td>
<td>4.28</td>
<td>-7.18</td>
<td>13.19</td>
<td>2.20</td>
<td>3.01</td>
<td>3.23</td>
<td></td>
</tr>
<tr>
<td>515,00</td>
<td>525,83</td>
<td>553,40</td>
<td>579,12</td>
<td>583,47</td>
<td>570,19</td>
<td>584,56</td>
<td>602,00</td>
<td>550,00</td>
<td>585,00</td>
<td>580,00</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sveppi r - innfl</th>
<th>170,74</th>
<th>130,41</th>
<th>54,361</th>
<th>36,706</th>
<th>44,932</th>
<th>72,608</th>
<th>82,171</th>
<th>63,679</th>
<th>175,70</th>
<th>230,82</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>6</td>
<td>54,361</td>
<td>36,706</td>
<td>44,932</td>
<td>72,608</td>
<td>82,171</td>
<td>63,679</td>
<td>175,70</td>
<td>230,82</td>
<td>244,94</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sveppi r - heild</th>
<th>685,74</th>
<th>656,24</th>
<th>607,76</th>
<th>615,82</th>
<th>628,40</th>
<th>642,80</th>
<th>666,73</th>
<th>665,67</th>
<th>725,70</th>
<th>815,82</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hlutde íslenskt</th>
<th>75.10%</th>
<th>80.10%</th>
<th>91.10%</th>
<th>94.00%</th>
<th>92.80%</th>
<th>88.70%</th>
<th>87.70%</th>
<th>90.40%</th>
<th>75.80%</th>
<th>71.70%</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annua l growt h rate (%)</th>
<th>-</th>
<th>-4.30</th>
<th>-7.39</th>
<th>1.33</th>
<th>2.04</th>
<th>2.29</th>
<th>3.72</th>
<th>-0.16</th>
<th>9.02</th>
<th>12.42</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gúrku r - isl</th>
<th>1,343,0</th>
<th>1,516,4</th>
<th>1,452,0</th>
<th>1,458,0</th>
<th>1,582,0</th>
<th>1,673,0</th>
<th>1,781,0</th>
<th>1,807,0</th>
<th>1,826,0</th>
<th>1,868,0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,857,0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gúrku r - innfl</th>
<th>211,32</th>
<th>104,54</th>
<th>151,71</th>
<th>145,91</th>
<th>91,027</th>
<th>35,755</th>
<th>25,338</th>
<th>11,406</th>
<th>7,422</th>
<th>8,466</th>
</tr>
</thead>
<tbody>
<tr>
<td>103,02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gúrku r - heild</th>
<th>1,554,3</th>
<th>1,620,9</th>
<th>1,603,7</th>
<th>1,603,9</th>
<th>1,673,0</th>
<th>1,708,7</th>
<th>1,806,3</th>
<th>1,818,4</th>
<th>1,833,4</th>
<th>1,876,4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,960,0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hlutde íslenskt</th>
<th>86.40%</th>
<th>93.60%</th>
<th>90.50%</th>
<th>90.90%</th>
<th>94.60%</th>
<th>97.90%</th>
<th>98.60%</th>
<th>99.40%</th>
<th>99.60%</th>
<th>99.50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>94.70%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annua l growt h rate (%)</th>
<th>-</th>
<th>4.29</th>
<th>-1.06</th>
<th>0.01</th>
<th>4.31</th>
<th>2.14</th>
<th>5.71</th>
<th>0.67</th>
<th>0.83</th>
<th>2.35</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix – 2

1. What kinds of vegetables/fruits do you produce?

2. How much do you produce per year (tonnes or kg)? How much do you sell out of the total production? How much goes to waste?

3. What do you think is the key to the success of your business?

4. Which country is the model of your greenhouse from? What kind of technology do you use?

5. How has your greenhouse farm been developed since the beginning of your business? Is the size of your greenhouse expanding? Has the amount of production increased?

6. How do you sell your products? Through distributing companies or directly to restaurants and stores?

7. Are you interested in adding more values to your products (e.g. processed food such as ketchup)?

8. Which farm (in Iceland) is the biggest producer of the vegetables/fruits you are growing? Where do you see your company among the competitors?

9. Does the price of vegetables/fruits vary over the year?

10. Do you think the amount of domestic products could be increased? What can you do to increase local foods? Should Iceland increase local food or just import from other countries?

11. Would you like to export your products in the future? Why is Iceland not generally exporting?

12. Do you think local food is expensive? Is it possible to lower the price? What do you think you can do to lower the price?
### Appendix – 3

<table>
<thead>
<tr>
<th></th>
<th>Tomato</th>
<th>Pepper</th>
<th>Salad</th>
<th>Mushroom</th>
<th>Cucumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivalry</td>
<td>1.20</td>
<td>0.20</td>
<td>-0.40</td>
<td>-1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Supplier</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
</tr>
<tr>
<td>Buyer</td>
<td>0.00</td>
<td>0.25</td>
<td>0.25</td>
<td>-0.25</td>
<td>-0.50</td>
</tr>
<tr>
<td>Substitutes</td>
<td>1.17</td>
<td>1.00</td>
<td>0.67</td>
<td>0.83</td>
<td>0.50</td>
</tr>
<tr>
<td>New entrants</td>
<td>-0.17</td>
<td>-0.17</td>
<td>-0.33</td>
<td>-0.33</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>0.29</td>
<td>0.11</td>
<td>-0.11</td>
<td>-0.30</td>
<td>0.02</td>
</tr>
<tr>
<td>Rivalry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of competitors</td>
<td>2</td>
<td>1</td>
<td>-2</td>
<td>-2</td>
<td>1</td>
</tr>
<tr>
<td>Market share</td>
<td>2</td>
<td>-2</td>
<td>-2 *</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Exit barriers</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Competition</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td>Marginal costs</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>0.2</td>
<td>-0.4</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>Suppliers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>Water</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Labour</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Materials</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
<td>-0.75</td>
</tr>
<tr>
<td>Buyers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Switching costs</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>-2</td>
</tr>
<tr>
<td>Differentiated products</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Price sensitivity</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0.25</td>
<td>0.25</td>
<td>-0.25</td>
<td>-0.5</td>
</tr>
<tr>
<td>Substitutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imports price</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Switching costs</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Quality</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Close substitutes price</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Switching costs</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Quality</td>
<td>1</td>
<td>0</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
<td>1.0</td>
<td>0.7</td>
<td>0.8</td>
<td>0.50</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td><strong>New entrants</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economies of scale</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Network effect</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Differentiated products</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Admission price</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
</tr>
<tr>
<td>Distribution channels</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Policy</td>
<td>-1</td>
<td>-1</td>
<td>-2</td>
<td>-2</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>-0.17</td>
<td>-0.2</td>
<td>-0.3</td>
<td>-0.3</td>
<td>-0.2</td>
</tr>
</tbody>
</table>

* Market share of mushroom is excluded from the calculation