QATAR UNIVERSITY

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HOW QATAR'S FOOD SYSTEM HAS IMPACTED BY BLOCKADE? A GLOBAL TRADE AND SUPPLY CHAIN ANALYSIS

BY

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ABSTRACT

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Due to the fact that most of the food in Qatar are imported from different countries around the world, and given the so-called GCC crisis in 2017, there is a strong need to focus on sustainability impacts of the embargo in term of food security, sustainability and climate impacts in Qatar. This thesis presents an analytical approach to analyze Qatar's food trade for the period between 2013 and 2018. Furthermore, measuring and managing the CO_2 emission and equivalences from freight transport operations for the period 2015 to 2018. The carbon footprint was calculated using the transport CO_2 emission analysis and a global Multi-Region Input-Output (MRIO) analysis. The data was carefully stored on a database using MySQL. Then, the data was retrieved using the data visualization tool, the Microsoft Power BI. The results indicate that imported food to Qatar was highly dependent on Saudi Arabia and the United Arab Emirates over the past years. However, there was a huge reduction in the supply chain from those countries after the embargo. Consideration of the supply chain design network that takes global CO_2 emission into account is important. There was a significant change in trade data. On the other hand, the total amount of carbon footprint decreased from 2015 to 2018 with around 320,000 tons of CO_2 emission. The consumption of MRIO-Raw milk and MRIO-Dairy decreased as well from 2015 to

2018. However, the CO_2 emission using the air mode increased sharply from 2015 to 2017.

DEDICATION

I dedicate this thesis to my parents, Abdulla AL Abdulmalek and Fowzeia Abdulrahmanm who have offered me unwavering encouragement and support during master's degree journey.

To my siblings, Hamad, Fatima, Maryam, and Abdulrahman, who has been inspiring me and being there for me throughout the entire master's program.

To my best friends who have supported me through the process. I will always appreciate all they have done and never left my side.

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CHAPTER 1: INTRODUCTION

1.1 Background

In line with Qatar's national vision 2030, food security is a key development priority for Qatar and is one of the essential pillars of the security and economic independence of the country in terms of meeting the need of future generations. Furthermore, the importance of the food supply chain is an integral part of all countries around the world as it might affect food security positively and negatively (Al-Kuwari, 2019; Sruc, 2012). On another hand, the changes that have been occurred to the supply chain in Qatar have directly affected the carbon emission and equivalence which the direct cause of global warming. The focus of this study will be address and highlight how carbon emission and equivalence were changed due to a huge change in the food supply chain (Al-Thani, 2019).

The 17 Sustainable Development Goals which were established by the United Nations tackle important challenges worldwide (Kutty et al. 2020). The challenges including the topic of poverty, inequality climate changes, environmental degradation, peace and justice, and the SDGs are presented in Figure 1 (United Nations Environmental Program, 2020).

Figure 1. Sustainable Development Goals

1.2 Problem Statement

As the awareness of the concept of food security and food supply chain is increasing, analyzing and understanding the changes that have been made during the blockade in terms of food security, food supply chain and sustainable carbon emission becomes a crucial subject. Presenting Qatar's accomplishments in the areas of food security, supply chain, and sustainability. Which encourages different companies and government to implement several projects to reduce harmful carbon emission in term of sustainability, and to invest more in the strategic inventories for food security. Besides, as a result of the embargo, the global supply chain has been affected. For example, a regional trans-shipment hub in Qatar is relocated. Also, the global supply chains of food imports and its association with environmental impacts in terms of CO_2 emissions have been changed. This research involves performing an analysis of the sustainable carbon emission in term of transportation imports in Qatar to illustrate the change before and after the blockade and figure out if it's considered as threat or opportunity from an environmental perspective, (mainly from carbon emissions) secondly, preforming a supply-chain analysis to illustrates how the blockade affected the food supply chain and overall carbon emissions.

1.3 Objectives

The main objectives of this research study are listed below:

1. Using different data analytics and visualization statistics tool to investigate Qatar imported food from 2013 to 2018, and results.
2. Illustrate how does the blockade affect food supply in Qatar in term of two things:
    - First, how the countries who are exporting the food to Qatar have changed in terms of value.

- Second, how the imported items have changed between the years 2013 to 2018 in terms of value.

3. Identify how the blocked affected food supply chain from an economic, distance, and social side.

4. Define food security and its importance to Qatar.

5. Define food supply chain and sustainability and how it changes after blockade in Qatar.

6. Use different data analytics and visualization statistics tools to measure and manage CO_2 Emission from freight transport operation for dairy products using different transportation mode from 2015 to 2018, and interpretation of the result.
7. Measure the carbon footprint for dairy products using the MRIO data and CO_2 emission from freight transport operations.
8. Illustrates how the carbon footprint has been changing before and after blockade for the period between 2015 and 2018.
9. Address the effects of carbon emission and carbon equivalence using three different modes of transportation and compare the effects between them.

1.4 Scope

The scope is dominated by the availability of the provided data from the Ministry of Development Planning and Statistics and General Authority of Customs. Therefore, the scope was narrowed down to include all food imports and value for all countries from 2013 to 2018 and the imports according to the port type from 2015 to 2018. Using this data, the method was implemented, and the data was analyzed and visualized. The system boundary of carbon footprint emission analysis is defined following supply chain logic, including all phases from raw material and dairy

production which has been calculated using MRIO analysis, then the transportation-related footprint is calculated using three different transportation modes according to each country and type of import from each country. Therefore, the scope of the analysis is considered as global not regional. The transportation and storage related carbon emissions in Qatar are excluded since the model analysis is used only for dairy products, which have identical impacts in Qatar related to inside transportation and storage.

MRIO software is used to calculate raw milk production and dairy product production. MRIO software which has been developed by different researchers. This MRIO program calculates country-specific impacts such as carbon, energy, etc. First, the raw milk production related emission from a raw milk production perspective, once this raw milk is produced it comes to the factory, and in the factory, the dairy products are produced. So basically, there are two sectors, one is raw milk production, another one is dairy milk production. So, these two productions are coming from MRIO analysis. After that, the product is transported to Qatar using the transportation mode which is using land, sea, and air till it reaches Qatar physical boundary

The supply chain inside which is happening inside Qatar is excluded from the system as it is shown in Fig 2. This is because in this model the global production and transportation relating differences need to determine, so to differentiate between the country of origin of production and transportation-related impacts.

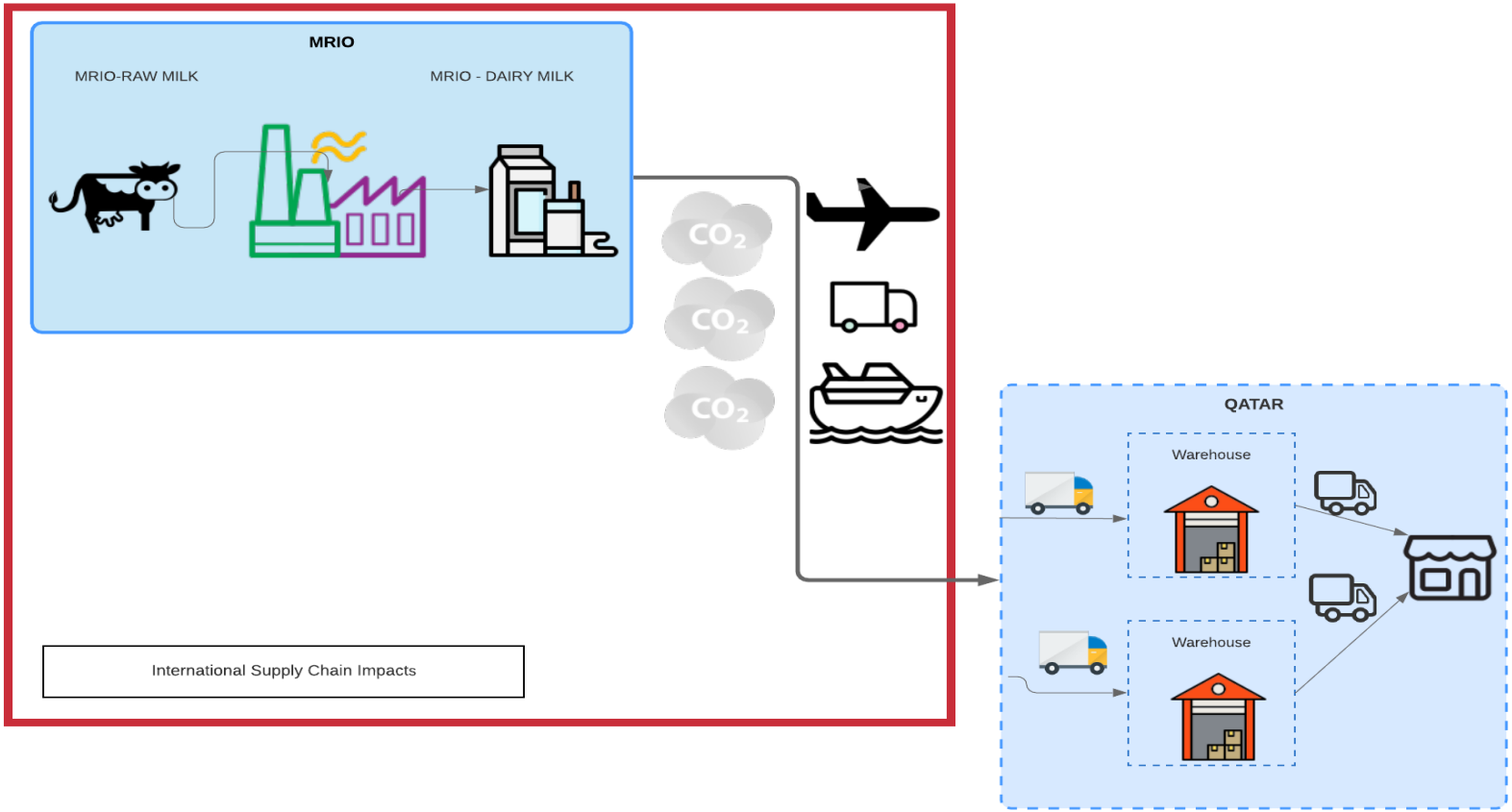


Figure 2. System boundary

1.5 Outline of the Thesis

The scope is dominated by the availability of data that has been provided by both Ministry of Development Planning and Statistics and the General Authority of Customs. Therefore, the scope was narrowed down to include the analysis and visualization of available provided data during the data collection stage. Six chapters are included in the report.

The first chapter includes a general introduction to the research study. It explains the study's objective, scope, and problem.

The second chapter is the Literature review. The importance of food security in the word is addressed in this section and how it affects economic growth and poverty. Furthermore, the food supply chain and sustainability are discussed and the sustainability assessment methods for production and consumption such as MRIO are addressed.

Next, chapter 3 discuss the study case of Qatar and how the food security trade in gulf cooperation council countries has been changed. Also, how the blockade affected the food industry and supply chain in Qatar.

Chapter 4 presents the methodological approach for estimating transportation and production-related carbon footprint for imported food products to Qatar. It also discussed the method for collecting the data and how the data is structured. In chapter five, two main topics are discussed. The first topic is the result and discussion on value changes in food categories and how supply chain product has been changing during the period from 2013 to 2018. Secondly, the result and discussion on transportation and how the carbon footprint has been changing during the period 2015 to 2018.

In the end, in chapter six, the main key findings and summary of the paper, as well as future work, are discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 The Importance of Food Security in the World

Food security refers to a situation where people can access food for consumption. Notably, the occurrence of food insecurity in some regions in the world is the reason why it is essential to study food security. A situation where food insecurity is faced means that the people do not have an opportunity to access food, thus increasing the possibilities of suffering from hunger. Therefore, the paper will discuss food security, pointing out poverty reduction as one of the main advantages. For households, food security is only achieved when family members have something to eat on all occasions. Nevertheless, it is also impossible to make food security in homes without the existence of supply chains. It would be essential even to discuss the details regarding food supply chains and sustainability. While the supply chains are concerned with food distribution, they must ensure that the food is safe. The literature review will also discuss some of the best food sustainability practices that will better the situation. Various authors have discussed food security in the past, hence the need to refer to their pieces of literature. The achievement of food security and sustainability will make the world a better place, thus indicating that it is a crucial area of study.

Food security is vital in the world since it helps in poverty reduction (Yu et al., 2016). The first possible means that food security ensures that poverty is dealt with is through sales. Many people depend on farming or agricultural products as their primary sources of livelihood. Therefore, this means that food security creates a much better source of livelihood for the concerned parties. Notably, slight food insecurity will deny such individuals an opportunity to earn from agriculture (Abdella et al., 2020). Second, food security is also essential in ending poverty since it creates a chance for people to concentrate on their works and accomplish economic growth. It is realistic to claim that

people can't work hard and better the economy when they are hungry. Lack of food in any society will deny the people a chance to work, thus implying that they will continue to suffer from poverty. The need to end poverty in the world is enough reason why food security should be encouraged and achieved.

Furthermore, job creation and economic growth are also achieved through food security, thus confirming its importance (Al-Attiyah, 2018). The previous section indicates that the food industry is broad, thus implying that it also creates job opportunities. For instance, the food supply chain is one of the cases that generate employment in the food production industry. The reality is that there are increased job opportunities when more food is produced. An increase in food security implies that more people are needed to accomplish food supply (Al-Saidi and Saliba, 2019). Subsequently, employment is created, and that results in the achievement of economic growth. Moreover, the other advantage of food security in the world is that it will limit conflicts between different communities. Many societies have engaged in wars in the past, and this was caused by food insecurity. For instance, it is common to come across situations where one community has attacked the other and taken their properties. The existence of such differences is a matter of concern since every nation is interested in accumulating more wealth. The reality is that food security is one of the possible means that the world can stop experiencing communal wars.

Notably, food security is also a gateway to good health, thus indicating why it is needed in the world (Anuradha, 2019). Arguably, malnutrition is one of the leading health problems in third world countries. It is because of food scarcity that most children suffer from malnutrition in third world countries. Apart from bad health, some people have even died because of food scarcity in some parts of the world. Therefore, this means that the healthcare industry also has to use more funds to offer medication

to such individuals. Nevertheless, the reality is that it is possible to avoid issues such as malnutrition through food security. Food security achievement will create an opportunity for children and even adults to remain healthy and prevent malnutrition. Subsequently, healthcare practitioners will manage to concentrate on the much-complicated ailments since they will not have to handle malnutrition cases.

Food security is also crucial for the world since it will create trade opportunities. There are various types of goods that nations can trade with, and food is the best example. A country that manages to achieve higher food security also creates more trading opportunities. For instance, a nation that produces wheat can engage in trade with another one that produces sorghum. There are various advantages that countries will gain from trading activities, and economic prosperity is the best example (Castellani, 2019). Additionally, it is also possible for nations to achieve peace and coexistence if they have food security. The reality regarding trading activities s that they increase interactions between international communities. Subsequently, these traders manage to learn different things about each other, hence achieving economic prosperity. The provided facts regarding food security are the reason why each government in the world should support farming. The world is a better place with food security.

2.2 Food Supply Chain and Sustainability

A food supply chain refers to the process of moving the food from the producer to the consumer. While it is crucial to achieving food security, the reality is that it is impossible to satisfy the people without the presence of a food supply chain. There are three different food supply chains that producers can use to deliver their goods to the consumers (Dixon and Ricahrds, 2016). Notably, the existing food supply chains

include the direct, extended, and final supply chain. First, the direct supply chain is the simplest form of food distribution. The details indicate that direct supply chains involve three people, and this is the supplier, central company, and the consumer. Some various advantages and facts are attached to the use of the direct food supply chain. For instance, the reality regarding this process is that it ensures that food is delivered on time. Furthermore, one of the main reasons why food supply chains exist is the need to deliver food to consumers (Egilmez et al., 2014). Therefore, many people will agree that the shorter the supply chain, the better the case, and this mostly applies to perishable goods. Thus, this also confirms that one of the main advantages of food supply chains is that they ensure that perishable goods are delivered on time. Most suppliers or producers would have found it impossible to meet the consumer's demands without the existence of a supply chain.

An extended supply chain is different since it includes more persons (Ferjani and Mann, 2018). For the extended supply chain, it features the supplier, central company, consumer, and the supplier's supplier. Therefore, this means that more parties must handle the goods before they reach consumers. Nonetheless, the main concern is that the extended food supply chain might face various challenges as compared to the use of direct supply (Gartaula and Patel, 2017). For instance, there are increased possibilities that the goods will fail to reach the buyer on time. Food materials must be delivered on time to ensure that food security is maintained. Therefore, the decision to extend the supply chain is not right. Moreover, the other concern regarding the extended supply chain is that it might increase the food prices as compared to the direct system. Each off the involved middle person in the food supply chain is interested in earning from the activity. Nonetheless, they will only gain from the process by increasing food prices. The truth is that the extended food supply chain might limit the urge to achieve

food security in the world. The final supply chin features the supplier, the central company, the consumer, the ultimate supplier, and the last buyer.

It is crucial to state that various advantages are attached to the existence of the food supply chain, and the best example is sustainability (Kucukvar and Samadi, 2015). Most food materials that are consumed across the world are perishable. Moreover, the other concern is that the producers cannot handle everything by themselves. Nevertheless, the existence of intermediaries in the market has created an opportunity to deliver food materials on time. Therefore, the reality is that the food supply chain is also laying a role in ending food scarcity in the world (Notarnicola, et al. 2017). The other advantage that is attached to the supply chain is that it creates an opportunity for food producers to concentrate on their central role. The need to maintain high food production is the reason why farmers should have a chance to focus on one activity. It is from this argument that one notes that farmers need the middlemen to deliver the food materials to consumers. However, it is crucial to note that food supply chains also create disadvantages because of the price increase. The involved parties should ensure that they do not exaggerate their prices to make the food supply chain remain sensible. Then, the primary step is continuing to support the existing food supply chain so that consumers are satisfied.

2.3 Sustainability Assessment Methods for Food Production and Consumption

MRIO method is used to assign land use for development throughout the global supply chains to final consumption (Feng et al., 2016). Also, it’s used to determine human-environmental problems such as carbon dioxide emission and water use. A study was conducted on china (Feng et al., 2016) for Tracing the agricultural land use along global supply chains and examining the impact of China's future consumption of

food on global land use in 2030 against various socioeconomic and technological scenarios, the study uses the global multiregional input-output (MRIO) model and found that China would need to import large quantities of foreign crops to meet its rising demand for food in the future as a result of population growth, urbanization, income growth and related lifestyle changes (Feng et al., 2016). Therefore, to achieve sustainable consumption there should be sustainable development for economic, environmental status, and social. For instance, best farming and conscientious food consumption may reduce the environmental impact of human society and improve the quality of life (Brinzan et al. 2012).

MRIO approach can be used also to address the value-added accounting of CO_2 emissions. Several studies have been conducted on the topic of carbon leakage and put forward the consumption-based CO_2emission accounting system. These studies were performed with the help of the MRIO Model (Liu and Fan, 2017). Another application of the MRIO Model is assessing the global virtual water flows of goods and services within and between countries. The Model is used to track the direct water consumption, place of consumption, and indirect waster requirements. The water type can be classified as embedded water types which are in global trade such as rainwater evapotranspiration from fields and plantations, ground and surface water that can be used for agricultural production and the water which required to pollutants to such an extent that the quality of water remains above certain water quality standard (Feng and Hubacek, 2015).

On the other hand, the achievement of sustainability would imply that the world can offer enough food to the people (Onat et al., 2019). There are various methods that the world can engage in to achieve sustainability in food production and consumption. First, the use of fertilizer is one of the best ways that can ensure sustainability

achievement in food production. Lack of fertilizer in farming is one of the main reasons why some people fail to achieve high yields. There are limited chances that crops will have high productivity when farmers do not use fertilizer (Wald, 2016). The need to better production and achieves sustainability in production is the reason for encouraging the use of fertilizers. Fertilizers make the crops mature faster and increase the yields. Subsequently, this ensures that everyone has a chance to access food, thus confirming the achievement of sustainability in production. Nevertheless, food organizations across the world must ensure that farmers are using the right fertilizers. There are situations where farmers fail to use the right fertilizers, and this causes more harm than help in crop production.

Another method that is widely used that assesses the potential environmental impacts and resources is a Life Cycle Assessment (LCA). It assesses the material acquisition, production, and end of life phases which was proposed in the early 1990s. also, it calculates the energy and carbon footprints of the food production sector over its entire life cycle (Kucukvar and Samadi, 2015). It was proposed as a realistic tool for evaluating the possible environmental impacts of goods and procedures, policies to minimize the cumulative adverse effects of supply chain operations need to be used (Egilmez et al., 2014).

Data Envelopment Analysis (DEA) is a non-parametric linear programming-based benchmarking model that has been applied in different studies assess the environmental impact sustainability performance (Egilmez et al., 2014; 2013). Recently, LCA and DEA are integrated to assess the environmental efficiency of different systems. On the other hand, DEA has major limits. The first limit addresses the question of whether or not a unit is effective but makes no distinction between units that are considered effective. The second limit is about efficiency ratings are extremely

sensitive to the input and output numbers (Galán-Martín et al., 2016).

The move to better water production through irrigation is yet another approach regarding sustainability achievement (Wellesley, 2019). Many farmers across the world are facing challenges in food production since they lack enough water. For instance, it is wholly to achieve high yields in arising and semi-arid regions in the world. Nonetheless, it is possible to overcome the challenge through irrigation, as that will increase water supply. The initiation of irrigation projects in the affected parts will ensure that farmers have an opportunity to cultivate their products. Moreover, an increase in water supply also increases the yields, and this proves sustainability in production (Gartaula and Patel, 2017). The concerned food organizations should also offer farmers with education concerning the right crops to grow in their regions. While the previous argument is that irrigation will help, the reality is that there is some crop that can also do well in the dry areas. Therefore, farmers must receive comprehensive education on the right crops that they need to cultivate. The other suggestion is that they should also reduce the supply chains as a means of achieving sustainability. The main concern with food supply chains is that some of them are long, thus limiting the time that is taken before the food reaches the consumer. An increase in time also means that the food might get spoilt, and this results in wastage. The best solution is that the supply chain should be shorter to ensure that the food reaches the consumers on time.

A move to close the yielding gap will also ensure that sustainability is achieved in food production. The reality of food security is that the world population is increasing. An increase in the world population means that there is also a need to increase production. One of the possible means that will ensure closure of the yielding gap is through converting more natural land into farms. The creation of more farming land will mean that farmers will have an opportunity to produce more yields, thus

achieving food security (Abdella et al., 2020). Arguably, reducing food waste is yet another possible means of achieving sustainable food consumption. It is impossible to make food security when food is wasted. Whereas farmers might increase or better their production in the future, there is also a need to take care during consumption. Consumers must be educated about some of the approaches that they can take to save food. For instance, people must ensure that they only prepare what they can consume within that day, as that creates a chance to save more food. There are situations where the yields might decline, but the people will still have something to consume if they did not waste it. Research indicates that the reduction of food wastage in India, China, and the United States could help feed millions of people across the world.

CHAPTER 3: QATAR CASE STUDY

3.1 Food Security and Trade in Gulf Cooperation Council Countries

The food security of the Gulf Cooperation Council countries such as Qatar, Bahrain, Saudi Arabia, the United Arab Emirates, and Oman, depends on international trade hugely (Willoughby, 2019). Also, a more discipline of opportunities is offered to the local and international food corporations because of the diverse demographics, which is resembled in hosting a growing population of expatriates, which boosts up the macroeconomic factors. While the growing global prices of food is still a concern, government initiatives have paid attention to include food security over different means, which resulted in constant imports from agricultural producing regions (GCC Food Industry, 2015). According to the Global Food Security Index (GFSI) 2018, Qatar ranked as the first as the most secure Arab country among other countries and the 22nd globally. Followed by Kuwait, Oman, and the rest of the GCC countries. However, securing the food does not mean that the country is self-sufficient (Ben Hassen and El Bilali, 2019).

Development in the sector is going to be advantageously affected by inflated non-public sector investment, a decent regulatory structure, and a clear set of state incentives for the brand spanking new venture. Trends in this sector widely arise from a modification in uptake habits. Greater disposable incomes combined with the health-conscious younger generation have junction rectifier to an increment in consumption of healthy foods with higher values of nutrients. The need for poultry products, wheat, and low-fat variants is observed to be expanding. On another hand, the demand for convenience foods such as bakery products, fast food, and ready to cook items have been increasing at a quicker pace as twice revenue. Family is searching for convenient and time-saving options to fit in their busy lifestyles. These alternating food preferences

accompanied by a need for enhancing food security within the country provides new opportunities in the Gulf Cooperation Council countries (GCC Food Industry, 2015).

The evolvement of a domestic food system should be considered, accompanied by agro-investment and continued activity in the international market, all as critical ingredients in any ultimate food security strategy. Therefore, Qatar's national food security core is illustrated by sustainable local production (Al-Ansari, 2011).

According to the International Food Policy Research Institute, as interpreted by the United Nations Committee, food security is the condition of having economic, physical and social access by all people, to sufficient notorious and safe food that satisfy their dietary demands and nutrients preferences for a continuously healthy active life (Al-Kuwari, 2019; IFPRI,2020). It is forecasted that the upcoming decades would face an expanding population, an alternating climate, arising in food cost, and a stressing environmental condition; all of these are predicted to have a tremendous yet highly uncertain influence on food security. Meanwhile, food insecurity is in the opposite context, it exists when there is not any sufficient social, economic, and physical access to food as elucidated previously. Food security within a global perspective will remain a worldwide concern for the upcoming 50 years or beyond. However, the current global agricultural output is convenient for the meantime to feed most of the population, within purely arithmetical terms at least. Nevertheless, a statistic of one out of nine people globally does not get sufficient meals throughout their day. Therefore, to have access to sufficient food with convenient quality, this should be entrenched and bonded with terms and international law in the social and cultural rights of the International Covenant on Economic (Federal Ministry of Food, 2015). Food security and sustainability are critical topics in the literature. Several papers analyzed the environmental impacts of food production and consumption using regional and global

supply chain-linked models (Egilmez et al., 2016; Park et al. 2017; 2016; Kucukvar et al., 2019; 2018; 2015; Onat et al., 2017; Abdella et al., 2020).

On a domestic scale, the Government of Qatar has escalated upon an ambitious quest to enhance the production of domestic food for the sake of self-sufficiency fulfillment. Qatar's National Food Security Program (QNFSP), which was initiated first in 2008, is promised to be utilized for the country to seek a domestic supplement to cover up 40 percent of its local food consumption by 2030. The so-called 'Master Plan' of QNFSP necessitates applicable solutions as a priority to feed security throughout investing in technological and scientific development illustrated in four keys: agricultural production, desalination, and water management, sustainable energy, and food processing and management. Moving to food trade, by Food security, trade, and its impacts. Many benefits can be obtained from exploiting the globalization, both in terms of conquering to food that can be produced more efficiently and cheaply elsewhere, or those that might be obtained seasonal - especially veggies and fruits-but which is needed year-round. In steady world conditions, it is more reasonable for a country to grow the few food products they are able and best suited to produce, export what they are capable of and competitive at, and import what they are not able to grow locally. This is a central tenant and a "comparative advantage" of the theory of economy. Comparative advantage, accompanied by a group of policy levers to support production, boost the scales and production concentrations for some areas to become "breadbasket" for the remaining parts of the world. This, as a result, leads to a reduction in price and improved efficiencies. Therefore, through trade, the globalization system is more able to provide cheaper and accessible food for all; it also permits countries with a considerable agricultural economy to export and profit from this system.

As an example of effective food trade, there were rates of growth in exports and

imports after the Second World War for some individual countries. For instance, Chile exported more food in 1990 than in 1970 by 36 times. Also, Malaysia reported an increase in exports by 13-fold. Lastly, Thailand achieved more food export in 1990 than in 1970, by a rate of 1178 % (Benton, 2018).

In the state of Qatar, the government peruses to double the number of farms as well as domestic production as a part of the national food security program. Also, the government of Qatar has suggested plans to institute a new port, to turn the state into a regional as well as an international trading hub for commodities of food. This would consider a portion of the imported food to be re-exported again to the markets in the surrounding. This will boost and encourage food security both domestically and regionally by ensuring the presence of multiple sources of supply for imports, as well as minimizing the vulnerability to disruptions of supply. Moreover, inconvenient logistical facilities limit the ambition of the nation to become an international trade hub for commodities of food. Currently, the country struggles to offer adequate services for storage and transport for its stocks of food and therefore these facilities must be built to be able to receive and store expanded imports of food commodity (Benton, 2018).

It is important to note that Qatar's blockade has started in May 2017, which led to food security concerns and enhanced the production of food on a domestic scale. As announced by Chairman of Qatar Trade Chamber Sheikh Khalifa Bin Jassim Al Thani in 2017, “Once again, Qatar’s economy proved that it has been strong enough and resilient against economic crises and headwinds”. Meanwhile the crises, Qatar managed to produce 24% of vegetables, 80% dates, 50% fodder, 80% fish, 82% milk, and 98% poultry of its need in one year only (Gulf Times, 2018; Al Thani,2017; Ismail,2015).

Resource dependent Qatar is highly dependent on foreign food products to meet growing demand fueled by economic growth. Over 90% of Qatar’s food is supplied by

foreign countries, particularly from the Gulf States including Saudi Arabia and the United Arab Emirates (QNFSP, 2012). However, after a recent Gulf crisis followed by the so-called Arab Blockade, the security of Qatar's food industry is under a serious threat, which resulted in a tremendous change in food supply chains and transportation (Al Jazeera,2017). The Qatar government sees this crisis as 'a wake-up call 'towards transforming their food industry into a more resilient and self-dependent structure. According to the Qatar National Research Funds' research priority under Energy, Sustainability and Resource Sustainability, food security of Qatar should be further investigated to foster self-dependence and strengthen long-term sustainability for food within the country (Research for the Future, 2014). With this motivation in mind, this current project will provide vital guidance for decision-makers towards achieving the long-term economic and environmental sustainability of the food industry, particularly after the embargo on Qatar's import and export in the Gulf region.

Qatar food industry becomes heavily discussed topic, especially after the embargo can be grappling with the challenge of food shortage for Qatar. Issues such as increasing population, water scarcity, and environmental degradation continue to become critical for the nation's food security. While food manufacturing occur in some parts of the world, production and consumption fall out in other parts of the world (Kucukvar and Samadi, 2015; Egilmez et al., 2016). Hence, to implement and examine the sustainable supply of food products, the international supply chain needs to be taken into consideration (Egilmez et al. 2014; Kucukvar et al., 2015; 2016).

3.2 Blockade in Qatar and Impacts on Food Industry

Sustainable consumption and production are a practical approach to achieving an economic, social, and environmental status of sustainable development. Best farming practices and conscientious food consumption may reduce the environmental impact of

human society and improve the quality of life (Brinzan et al., 2012). The food security supply is heavily dependents on imports of food products. Food security known as the ability of the system performs under rising risks (Al-Saidi and Saliba, 2019). Some of the risks are increasing productivity and efficiency. Those issues are a key measure to ensure global food security of expanding population. Food security on GCC countries faces many internal threats such as system coupling which brings both risks and opportunities, demographics, and growth which, determines the size and capacity of the water, energy, and food supply system on GCC countries, scale, and planning. Ultimately, for many reasons, participation in the GCC's water, energy, and food supply is restricted (Al-Saidi and Saliba, 2019). In the past years, policymakers focused on the agriculture sector because of the increase in food consumption and price inflation. As the population and disposable income grow the consumption of food will increase as well. Whereas, domestic agriculture yields are decreasing which will result in increasing the dependency of imports. In 2007, imports as a proportion of consumption were 93% for the dairy products, compared to other GCC countries Qatar was the biggest importer for dairy products (Kotilaine, 2010). Middle East countries face difficulties in the production of food crops due to the limitations of the water supply and the lack of availability of arable land (Katkhuda, 2014). Where, GCC countries are not self-sufficient in the production of food (Woertz et al., 2008). The largest importers of cereal in the world are Arab countries. For example, all the Arab countries are considered as a net importer of grains, while small GCC countries are fully dependent on imported grains (Katkhuda, 2014). Further, GCC countries face global threats such as technological and market-driven change, climate change, and state-based security (Al-Saidi and Saliba, 2019). When the blockade was imposed in June 2017, it threw into sharp relief the vulnerability of Qatar's domestic food supply. Qatar is unfit for

growing food. The desert country is ranked among the world's most water-stressed. Trade is vital to feeding the nation as one of the hottest, most arid countries in the world; more than 90% of its food supply is imported (Wellesley, 2019). However, this crisis has had a positive impact on the economy of Qatar, the most significant of which is the growth of domestic production and Qatar's strategy to achieve food security self-sufficiency (Al-Attiyah, 2018).

CHAPTER 4: METHODOLOGY

The methodology of this thesis work started with collecting Qatar food data from both Ministry of Development Planning and Statistics and General Authority of Customs. In this step the cleansing of data also achieved. Followed by designing the entity-relationship diagram then implemented it on the SQL database using Microsoft Management server studio. After creating the database, integration of the database to the Microsoft Power BI software and visualized using different interactive dashboards was achieved. Next, the MRIO model was developed and the carbon emission is estimated. All data was imported from the MRIO model in an excel sheet to PowerBI. Then all equations and codes were constructed using DAX coding to build up the model to calculate the MRIO RAW milk and MRIO dairy and estimate the global carbon emission to each country. Then, the model of transport emission using different transportation modes is developed and estimated by combing it with the previous model. Lastly, the conclusion is addressed. Including the summary of the paper. Which discussed and the impact of the embargo on Qatar food trade and supply chain, and the opportunities that have been experienced in Qatar. The methodology is summarized as shown in Fig 3.

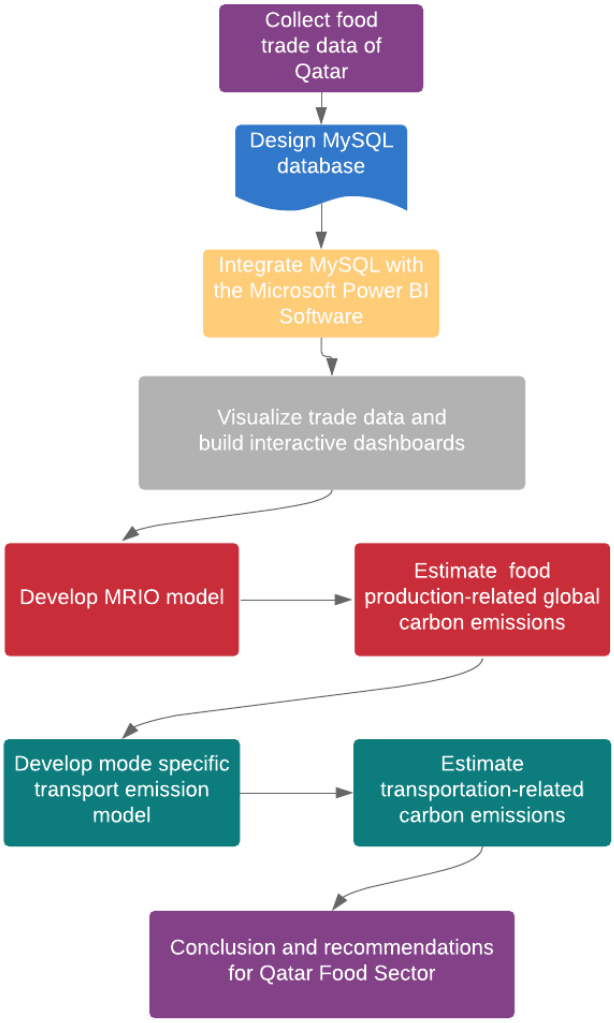


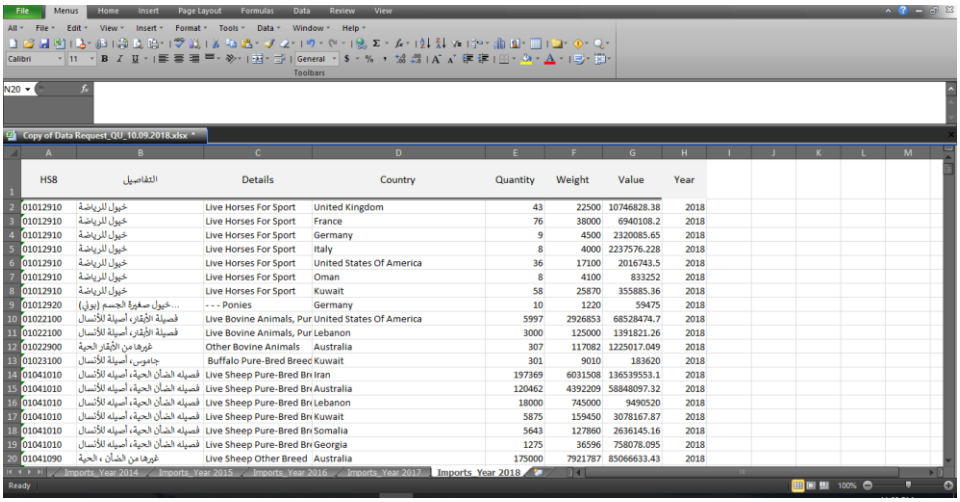
Figure 3. Research methodology- main stages

4.1 Data Collection and Visualization for Food Imports between 2013 and 2018

Understanding data needs different degrees of mental operations to be done depending on the nature of the used language. Visual languages are a powerful tool that reduces the cognitive loads for understanding complex data. Data visualization is a representation to assist people to easily comprehend the data to understand the insight of it by making the trends and patterns explicit. Visualization tools deal with raw data. On the other hand, data analytics deals with cleaned data. One of the popular data

visualization tools is Power BI which is affiliated to Microsoft to provide business analytics services. It offers interactive visualization together with capabilities of self-service business intelligence, where the end-users can create dashboards and reports by themselves, without depending on the database administrators or the information technology staff.

In this study, the data of Qatar's imported food statistics were collected from the Ministry of Trade and Commerce from 2013 to 2018. The data consists of details about the quantity, weight, and value of imported food from different origins and countries. The type of food was specified in English and Arabic, quantity is weighed using units of kilograms and the corresponding price is specified in Qatari Riyals. Fig 4 shows a brief representation of the data spreadsheet.



HS8	التفاصيل	Details	Country	Quantity	Weight	Value	Year
01012910	خيول للرياضة	Live Horses For Sport	United Kingdom	43	22500	10746828.38	2018
01012910	خيول للرياضة	Live Horses For Sport	France	76	38000	6940108.2	2018
01012910	خيول للرياضة	Live Horses For Sport	Germany	9	4500	2320085.65	2018
01012910	خيول للرياضة	Live Horses For Sport	Italy	8	4000	2237576.228	2018
01012910	خيول للرياضة	Live Horses For Sport	United States Of America	36	17100	2016743.5	2018
01012910	خيول للرياضة	Live Horses For Sport	Oman	8	4100	833252	2018
01012910	خيول للرياضة	Live Horses For Sport	Kuwait	58	25870	355885.36	2018
01012920	خيول صغيرة الجسم (بوني)...	- - - Ponies	Germany	10	1220	59475	2018
01022100	فصيلة البقر، أصيلة للأنسان	Live Bovine Animals, Pur	United States Of America	5997	2926853	68528474.7	2018
01022100	فصيلة البقر، أصيلة للأنسان	Live Bovine Animals, Pur	Lebanon	3000	125000	1391821.26	2018
01022900	غيرها من البقر الحية	Other Bovine Animals	Australia	307	117082	1225017.049	2018
01023100	جاموس، أصيلة للأنسان	Buffalo Pure-Bred Breed	Kuwait	301	9010	183620	2018
01041010	فصيلة الضأن الحية، أصيلة للأنسان	Live Sheep Pure-Bred Bri	Iran	197369	6031508	136539553.1	2018
01041010	فصيلة الضأن الحية، أصيلة للأنسان	Live Sheep Pure-Bred Bri	Australia	120462	4392209	58848097.32	2018
01041010	فصيلة الضأن الحية، أصيلة للأنسان	Live Sheep Pure-Bred Bri	Lebanon	18000	745000	9490520	2018
01041010	فصيلة الضأن الحية، أصيلة للأنسان	Live Sheep Pure-Bred Bri	Kuwait	5875	159450	3078167.87	2018
01041010	فصيلة الضأن الحية، أصيلة للأنسان	Live Sheep Pure-Bred Bri	Somalia	5643	127860	2636145.16	2018
01041010	فصيلة الضأن الحية، أصيلة للأنسان	Live Sheep Pure-Bred Bri	Georgia	1275	36596	758078.095	2018
01041090	غيرها من الضأن ، الحية	Live Sheep Other Breed	Australia	175000	7921787	85066633.43	2018

Figure 4. Data Spreadsheet of Qatar Imported Food Statistics from 2013 to 2018

In this analysis, the data was cleansed and Entity Relationship Diagram (ERD) was drawn using the Lucid Chart to find the relationships between the tables. For

creating the database, the updated excel sheet was uploaded into MySQL, and finally data visualization and analyzing dashboards have been accomplished using the Power BI as shown in Fig 5.

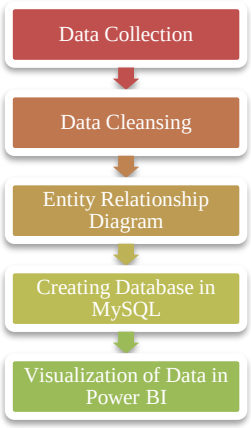


Figure 5. Flow Chart of Data Visualization

4.2 Analysis Methodology

Entity Relationship Diagram (ERD) is a type of structural diagram for use in database design. An ERD consists of entities, attributes, and relationships, and different symbols and connectors (Bagui and Earp, 2011). Fig. 6 illustrates the relationships of Qatar imported food data in the excel sheet in an organized way. ERD contains three tables: food, country, and batch. Each table has its attributes, primary key, and foreign key. Furthermore, minimum and maximum cardinality have been identified in each relationship.

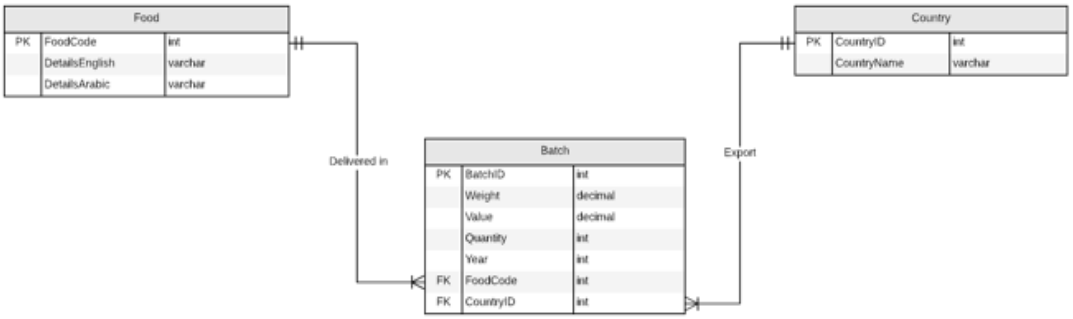


Figure 6. Entity Relation Diagram of Qatar Imported Food

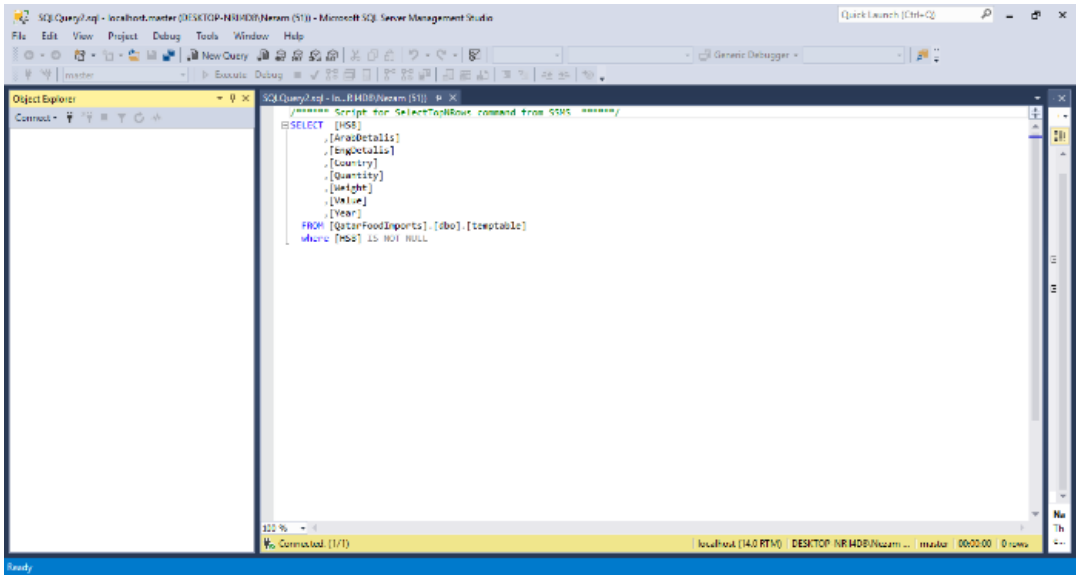


Figure 7. MySQL Server

The database was created in MySQL. Firstly, the code was exported from the ERD and has been modified to allow MySQL to read the code as it is represented in Fig 7. Secondly, the data spreadsheet has been uploaded to MySQL to generate the database.

Microsoft Power BI is a business analytics service provided by Microsoft. It provides collaborative visualization with self-service business intelligence capabilities, where end users can create different and multiple reports and dashboards (Rouse, 2018). For

visualizing and picturing the data and analyzing the information, the Power BI was used, and multiple dashboards have been created.

4.3 Data Visualization for Long-Lasting Milk Products between 2015 and 2018, Including Transport Modes

Fig 8 illustrates the entity-relationship diagram, the data was imported from several Excel data source such as MRIO-VALUE, Transport mode, etc. Which then has integrated with the previous database to get a clear visualization for calculating the carbon emission and footprint.

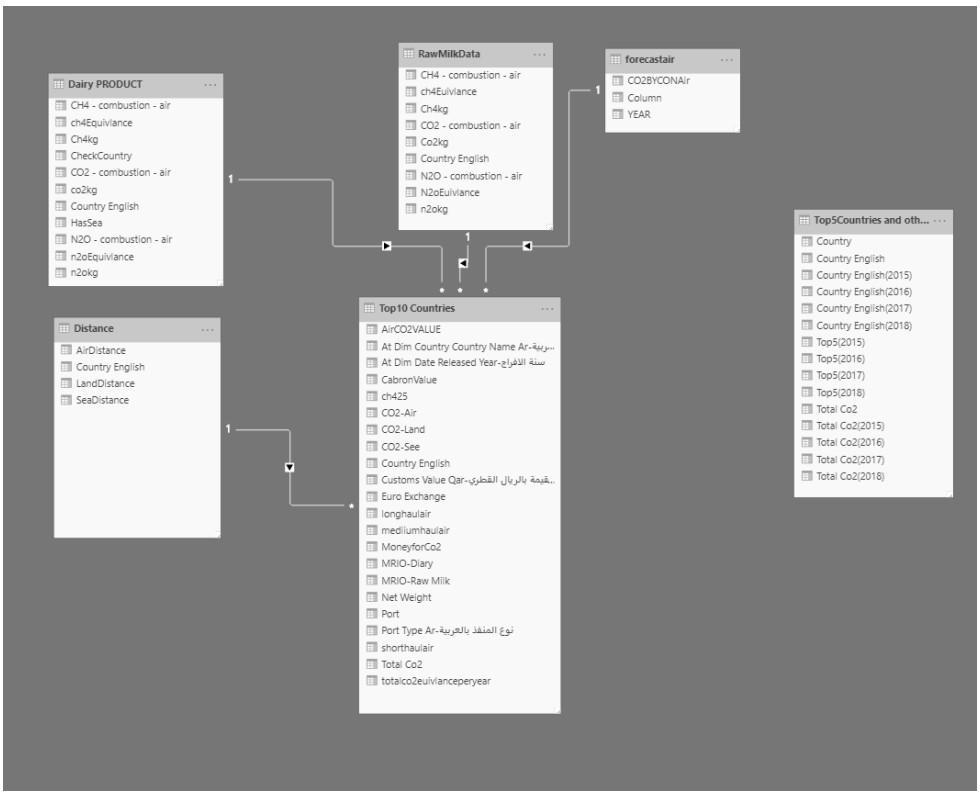


Figure 8. ERD from the Microsoft PowerBi for Transportation Visualization.

4.4 Method to Measure and Manage CO_2 Emission and Equivalence from Freight Transport Operations

4.4.1 Data Preparation

The factor that has been used for each pollutant of the global warming potential (GWP) which involves direct carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions of each sector is calculated by multiplying the total GHG emission of each sector. The GWP results are presented in terms of metric tons of CO_2-equivalent (mt CO_2-eq). Table 1 presents the GWPs of GHG emissions relative to CO2 for a 100-year time horizon (Kucukvar et al., 2016).

Table 1. Direct global warming potentials relative to CO_2

Common name	Chemical formula	Conversion factors of GWP for a 100-year time horizon
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298

4.4.2 General Formulation

There are two methods for calculating the CO_2 emission from freight transport. The first one is based on the level of transport activity and the second approach is on energy consumption (McKinnon and Piecyk, 2009). This study uses the based activity approach to calculate the CO_2 emission by applying a simple formula:

$$[Tonnes\ CO2\ emissions\ =\ tonnes\ x\ km\ x\ g\ CO2\ per\ tonne-km\ /\ 1.000.000]$$

$$CO2\ emssion = \frac{w\ \times d\ \times c}{1.000.000}$$

$$w = Transport\ volume\ by\ transport\ mode\ in\ Tonnes$$

$d = average\ transport\ distance\ by\ transport\ mode\ in\ km$

$c = average\ CO2 - emission\ factor\ per\ tonnes$ (g CO2 per tonne − km)

Choosing the carbon emission factors for each mode is one of the hardest issues to resolve to apply the activity-based approach because several factors are affecting the emission factors for chemical transport operations such as greenhouse gasses to be included, transport mode to be covered, energy supply chain, nature of the product, logistical operations at different levels in the chemical supply chain and geographical variability (McKinnon and Piecyk, 2009). This is expressed as grams of CO2 per tones-km

$\boldsymbol{Average\ CO2\ emssion}_{\boldsymbol{air\ mode}}$:

$if\ d < 1000\ km\ , c = 1752.5\ \mathrm{gCO2/tonne - km}$

$if\ d > 1000\ km\ , c = 602\ \mathrm{gCO2/tonne - km}$

$if d > 1000\ and\ d < 4000\ km\ , c = 780\ \mathrm{gCO2/tonne - km}$

$\boldsymbol{Average\ CO2\ emssion}_{\boldsymbol{sea\ mode}}$

$c = 16\ \mathrm{gCO2/tonne - km}$

$\boldsymbol{Average\ CO2\ emssion}_{\boldsymbol{Land\ mode}}$

$c = 62\ \mathrm{gCO2/tonne - km}$

4.4.3 Calculating carbon footprint

$M = Total\ money\ per\ million\ euros$

$$MRIO_{Diary} = M\ \times [\sum n2o + \sum ch4 + \sum co2]$$

$$MRIO_{Raw\ Milk} = M\ \times [\sum n2o + \sum ch4 + \sum co2]$$

$$CO2_{equivalence} = CO2\ emssion_{air\ mode} + CO2\ emssion_{land\ mode} + CO2\ emssion_{sea\ mode} + MRIO_{Diary} + MRIO_{Raw\ Milk}$$

4.4.4 MRIO Analysis

From the EXIOBASE 3.4 database is obtained symmetric industry-by-industry input-output table at core prices and related economic transactions for world economies including the Middle East as a region. The database covers 43 countries, 5 rest of the world regions, and 163 sectors, representing nearly the entire economy of the planet. The MRIO datasets of EXIOBASE are developed using the Supply and Use Tables at current prices with a fixed product sales assumption and consisting of national and global IO tables and collecting raw data from the UN National Account, Comtrade and Eurostat databases (Sen et al. 2019. Multipliers of carbon footprint are determined by multiplying each sector's production by its effect category per economic performance (Kucukvar, 2019; Sen et al. 2020). A global MRIO model has been used in this paper to measure the upstream carbon emissions globally from long-lasting milk production. The MRIO analysis is used in this research as MRIO has the benefit of offering a more detailed and reliable image of a local economy since most economies are not contained within a single region. An MRIO analysis helps to preserve the first region's Multiplier identity while also seeing how activity in that area where the Direct Impact occurs), influences other regions within a functional economy (Clouse, 2020). Overall, the key benefits of MRIO methodology are improving regional specificity and reducing aggregation bias, analyze the interconnectivity of multiple regions and monitor leaks from a study area, and to assess their impacts in other regions (Clouse, 2019).

In the model presented, input-output display monetary flows within an economy

between industries, i.e. inputs and outputs, using the inverse formula of the Leontief:

$x = (I - A) - 1\, y$

In the equation $x = (I - A) - 1\, y$, an output vector, x is defined as a function of I, A, and y, where y is the column vector of total demand (in M.Eur). I is the identity matrix and x is the column vector of total output (in M.Eur) and A is the input-output coefficient matrix (in M.Eur/M.Eur). The expression $(\mathbf{I} - \mathbf{A})^{-\mathbf{1}}$ is defined as the Leontief inverse, also denoted as capital **L** indicating the total requirements matrix.

Using the EXIOBASE 3.4 complete requirement matrix and sector-specific environmental satellite accounts (such as electricity usage, water use, carbon emissions, resource use, etc.). And socio-economic accounts (such as taxes, wages, profits, value-added, etc.), production units of a sector, as well as indirect impacts arising from the industry's foreign supply chains are measured. B is defined as follows by the vector of the environmental, economic, and social impacts produced by each industry (sectoral and country-specific environmental satellite accounts) per unit of economic production (M. Euro).

$B = E * (diag(x)) - 1$

Where we can denote the sums with x (in M. Euro) and with letter E the satellite accounts. Hence B is the strength matrix in terms of per M. Euro. showing with diagonal that the vector x must be diagonal. By the multiplication of B, L, and y.

$r = BLy$

For this equation, the r vector is determined by multiplying L by B (intensity matrix per output unit) and further multiplying by y representing each sector's total output (final output vector). By using $r = BLy$, **r** vector quantifies the direct plus indirect carbon footprints of raw milk and dairy product production. To this end, $r = BLy$ enables us to continue monitoring sustainability impacts across the global and international supply

chains. A Python programming language is used to measure and process large matrix data to perform all matrix operations, and to obtain sector multipliers for sectors such as raw milk processing and milk production.

CHAPTER 5: RESULTS AND DISCUSSION

All visualization and graphs were implemented using the Microsoft Power BI. All graphs are implemented to be viewed dynamically. The dashboards are published and can be viewed upon request.

5.1 Result and Discussion on Value and Changes of Food Categories

Fig 9 will illustrate how the blockade does affect food supply in Qatar in terms of two things. First, how the countries who are exporting the food to Qatar have changed in terms of value. Second, how the imported items have changed between the years 2013 to 2018 in terms of value.

Fig 9a represents the value of food imports by country in 2013. The imported food value in each country in 2013. Qatar paid to Saudi Arabia and the United Arab Emirates the highest amount of money with 29.17% and 20.51%, respectively.

Fig 9b shows the value of food imports by the country in 2014. Likewise, Saudi Arabia was in the first place. However, India becomes second place followed by the United Arab Emirates with 29.93%, 19.97%, and 18.66% respectively. However, other countries such as Germany, France, Jordan, Egypt, and Belgium are found to have a lower contribution to total food imports of Qatar in 2014. The results also show that the value of food exports to Qatar from Saudi Arabia reached 2.02 billion QR in 2014. This value is followed by India and Emirates with 1.32 and 1.26 billion QR, respectively.

Fig 9c represents the amount of money that is paid to another country in 2015. There is no significant difference comparing to the previous years. Qatar paid to Saudi Arabia, the United Arab Emirates, and India the highest amount of money with 1.9, 1.37, and 1.1 billion Qatari riyals respectively. However, other countries such as

Germany, France, Pakistan, Egypt, and Turkey are found to have a lower contribution to total food imports of Qatar in 2015. The results also show that the value of food exports to Qatar from Saudi Arabia reached 1.91 billion QR in 2015. This value is followed by Emirates and India with 1.37 and 1.10 billion QR, respectively.

Fig 9d shows the value of food imports by the country in 2016. 1.64, 1.5, and 1.1 billion were paid to Saudi Arabia, the United Arab Emirates, and India which shows a slight decrease of about 0.26 billion for Saudi Arabia, a slight increase of about 0.13 billion for the United Arab Emirates and India remained the same comparing to the previous year. However, other countries such as Germany, France, Jordan, the United Kingdom, and Belgium are found to have a lower contribution to total food imports of Qatar in 2016. The results also show that the value percentage of food exports to Qatar from Saudi Arabia reached 25.1% in 2016. This value is followed by Emirates and India with 22.88% and 16.76%, respectively.

Fig 9e illustrates the value of food imports by country in 2017. It clearly shows that the United Arab Emirates and Saudi Arabia moved to third and fourth place with 14.18% and 12.88%, respectively, which explains the embargo that happened in 2017. While India and Australia had the largest imported food value with 24.28% and 16.63% respectively. Turkey was in 5th place with a contribution of 11.76% followed by the United States of America with a contribution of 10.34%. However, other countries such as Germany, Belgium, France, Netherlands, and Brazil are found to have a lower contribution to total food imports of Qatar in 2017. The results also show that the value of food exports to Qatar from India reached 1.42 billion QR in 2017. This value is followed by Australia and Emirates with 0.98 and 0.83 billion QR, respectively.

Fig 9f represents the value of food imports by country in 2018. It's clearly shown that India and Australia had the highest amount of imported food value with 24.28% and 16.63%, respectively. Furthermore, Turkey experienced a considerable increase in value compared to previous years with 11.75%. Although the countries that imposed the blockade in Qatar are not shown, the imported food value of those countries decreased sharply with a very small percentage comparing to the previous year. This can be attributed to the fact that some contracts cannot be rescinded. However, other countries such as the United Kingdom, Belgium, France, Sudan, and Oman are found to have a lower contribution to total food imports of Qatar in 2018. The results also show that the value of food exports to Qatar from India reached 1.53 billion QR in 2018. This value is followed by Australia and Turkey with 1.17 and 0.69 billion QR, respectively.

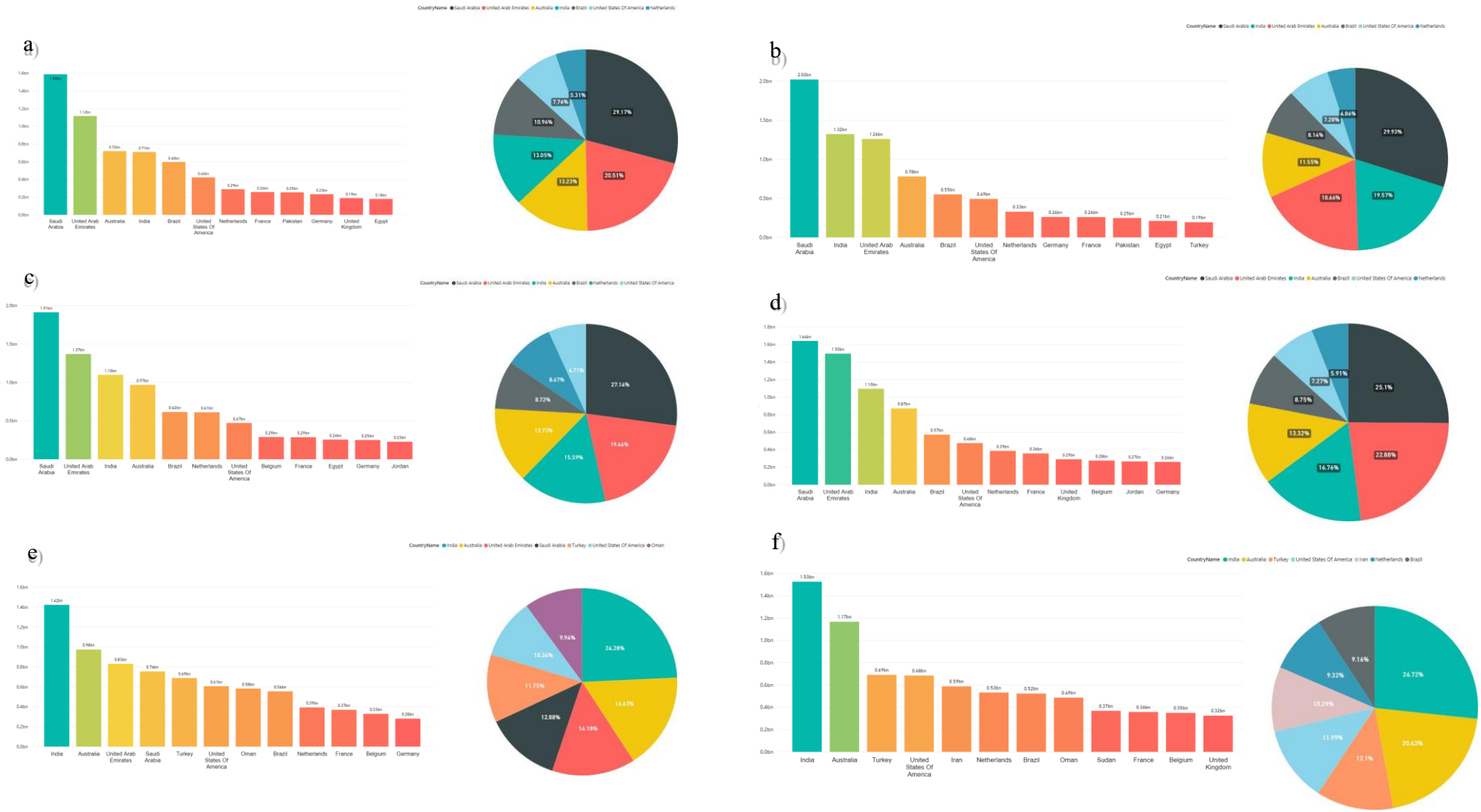


Figure 9. Power BI Screenshot Summarizes the Value of imports by country from 2013 to 2018 a) 2013 b) 2014 c) 2015 d) 2016 e) 2017 f) 2018

As shown in table 2, the top 5 imported items in the years 2013 to 2014 were the same. While the top 6 items in the year 2013 replaced cigarettes containing tobacco with carcass and half carcasses of lamb for the year 2014. The top 7 imported item remains the same for the year 2013 and 2014. The top item during the years 2013 and 2014 were dairy products. Poultry products were the third and fourth highest products in the years 2015 and 2016.

Table 2. Result of top 7 imported item in term of value between 2013

Top 7 Imported Items in term of Value in Year 2013	Top 7 Imported Items in term of Value in Year 2014
Semi Milled Or Wholly Milled Rice, Whether Or Not Polished Or Glazed	Semi Milled Or Wholly Milled Rice, Whether Or Not Polished Or Glazed
Poultry, Not Cut In Pieces, Frozen	Poultry, Not Cut In Pieces, Frozen
Poultry, Cuts And Offal, Frozen	Poultry, Cuts And Offal, Frozen
Live Sheep Other Breed	Live Sheep Other Breed
Concentrated, Milk	Concentrated, Milk
Cigarettes Containing Tobacco	Carcasses And Half Carcasses Of Lamb, Fresh Or Chilled
Camels And Other Camelids (Camelidae)	Camels And Other Camelids (Camelidae)
Top 7 Imported Items in term of Value in Year 2015	**Top 7 Imported Items in term of Value in Year 2016**
Yogurt, Whether Or Not Concentrated Or Containing Added Sugar	Yogurt, Whether Or Not Concentrated Or Containing Added Sugar
Semi Milled Or Wholly Milled Rice, Whether Or Not Polished Or Glazed	Semi Milled Or Wholly Milled Rice, Whether Or Not Polished Or Glazed
Poultry, Not Cut In Pieces, Frozen	Poultry, Not Cut In Pieces, Frozen
Poultry, Cuts And Offal, Frozen	Poultry, Cuts And Offal, Frozen
Live Horses For Sport	Live Horses For Sport
Leeks & Other Alliaceous Vegetables, Fresh Or Chilled	Cigarettes Containing Tobacco
Camels And Other Camelids (Camelidae)	Carcasses And Half Carcasses Of Lamb, Fresh Or Chilled

Table 3 indicates the top imported item in 2017 was semi milled to wholly milled categories. Poultry categories occupied the second and third place. Furthermore, Table 3 points out that all imported items were similar, but the ranking of each item was changed from 2013 to 2017. In 2018, all imported ranking is similar. However, bran sharps & other residues of wheat have been added to this list.

Table 3. Result of Top 7 Imported Item in Term of Value in 2017 and 2018.

Top 7 Imported Items in term of Value in the Year 2017	Top 7 Imported Items in term of Value in the Year 2018
Semi Milled Or Wholly Milled Rice, Whether Or Not Polished Or Glazed	Semi Milled Or Wholly Milled Rice, Whether Or Not Polished Or Glazed
Poultry, Not Cut In Pieces, Frozen	Poultry, Not Cut In Pieces, Frozen
Poultry, Cuts And Offal, Frozen	Poultry, Cuts And Offal, Frozen
Live Sheep Other Breed	Live Sheep Other Breed
Concentrated, Milk	Cigarettes Containing Tobacco
Cigarettes Containing Tobacco	Carcasses And Half Carcasses Of Lamb, Fresh Or Chilled
Carcasses And Half Carcasses Of Lamb, Fresh Or Chilled	Bran, Sharps & Other Residues, Of Wheat

The stacked area chart in Fig 10 shows the top 7 food items that were imported to Qatar over a year. The items are camels and other camelids, carcasses and half carcasses of fresh lamb or chilled, cigarettes containing tobacco, live horses for sport, poultry both cut and not cut and semi milled or wholly milled rice. The items are the contribution of each food category to the total spend price is shown in a different color. As the figure shows, the highest amount of imported food category was for (semi milled or wholly milled rice) while the lowest amount was for camels and camelids category. In 2013, both semi-milled or wholly milled rice and camels' category are slightly more than other food categories. In 2014, all food categories show a slight increase but then

moving to 2016, all categories showed a dip in value. However, camels' category showed a bigger dip compared to other categories at that year. In 2017, all categories have a slight increase. However, in 2018, not only all categories had a significant increase, but the poultry category by itself shows a slight increase when compared to other categories.

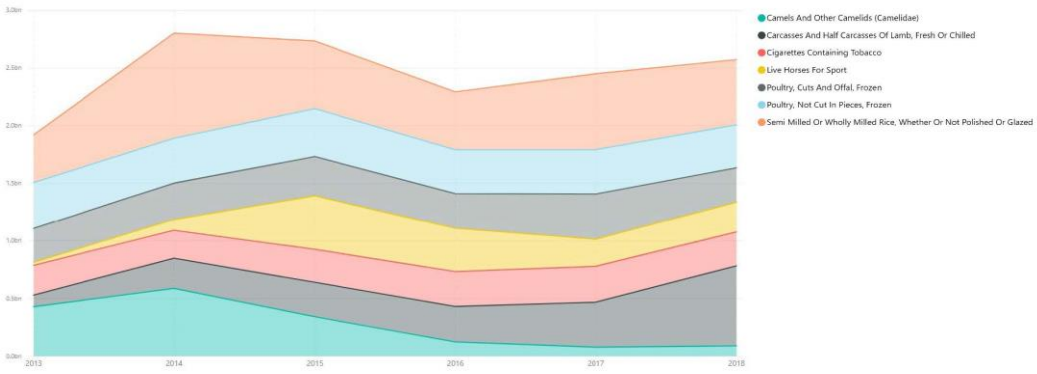


Figure 10. The Price of the Top 7 Imported Food Categories Per Year

Fig 11 to Fig 16 will show the top 5 food categories from 2013 to 2018 depending on value. Those top categories were chosen depending on the highest amount Qatar paid to different countries. The countries were limited to the top 5 countries that exported to Qatar depending on the highest value. All value is in Qatari Riyal. The rest of the country's contribution is shown as "other" on the legend.

Fig 11 shows the imported categories in 2013. The percentage is calculated based on Qatari riyal value. The first imported category is camels and camelids which were imported by Saudi Arabia with 68.40%. The second category is Semi or wholly milled rice. The top 2 highest countries were India

with 49.19% and Pakistan with 35.82%. 79.33% was paid to Brazil for the Poultry category and 78.85% was paid to Australia for Live sheep. Lastly, concentrated milk was imported from Saudi Arabia and Australia. The value contribution is 53.59% and 30.77% respectively.

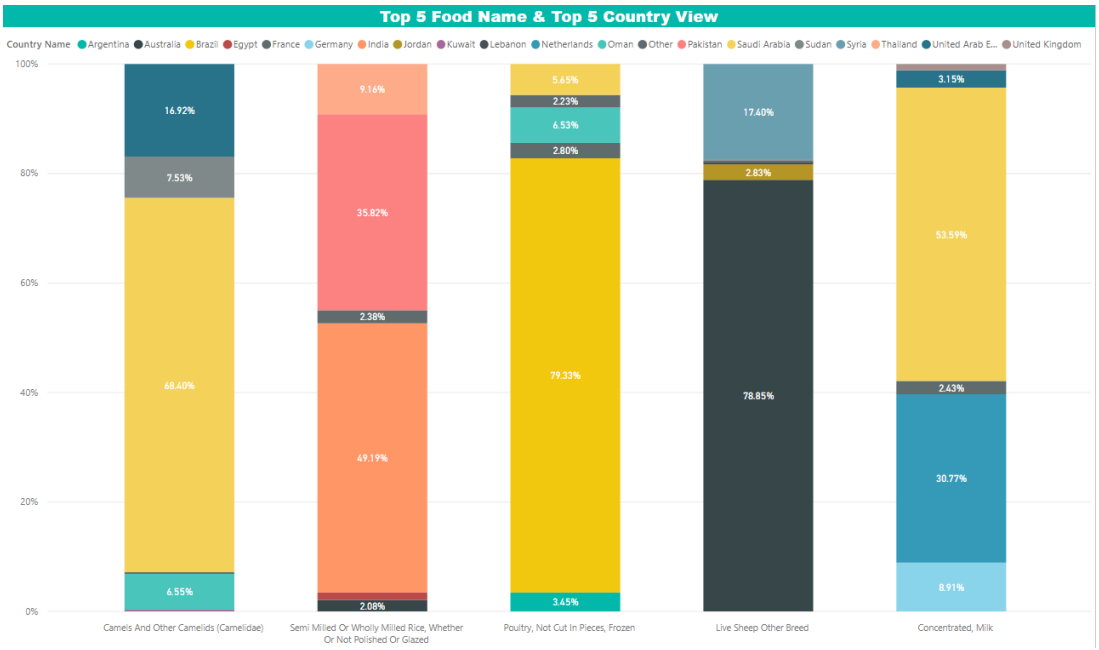


Figure 11. PowerBI screenshot for countries and categories based on the value in 2013.

Fig 12 shows the top five imported categories in 2014. The percentage is calculated based on Qatari riyal value. Similarly, to Fig 11 all top 5 imported categories are the same except for one which Concentrated in 2013 and replaced by Frozen Poultry cuts and offal in 2014. The highest contribution for by Frozen Poultry cuts and 0ffal category was from Brazil with 53% followed by the United States of America with 32.1% followed by the United Arab Emirates

with 8.82%. Noticeably, a slight change in the contribution of countries compared to the previous year. For example, in 2013 the semi and wholly milled rice were imported from India and Pakistan. However, in 2014 India was dominating with 75.65%, Pakistan reduced to 17.6% and the least contribution was for Thailand with 3.15%.

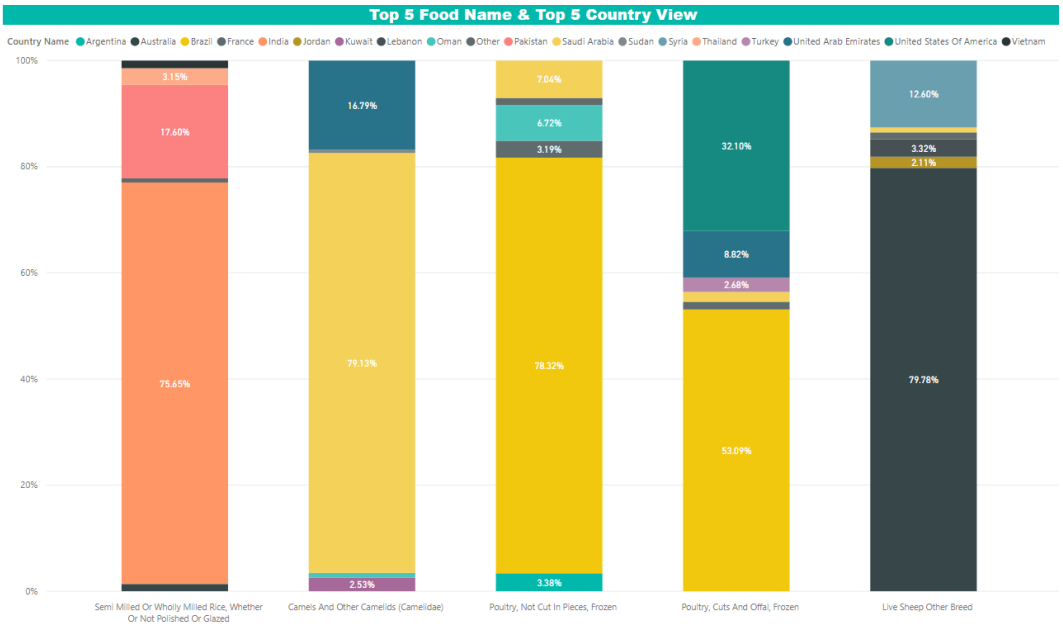


Figure 12. PowerBI screenshot for countries and categories based on the value in 2014.

Fig 13 shows the imported categories in 2015. The first imported category is Semi or wholly milled rice the contribution of countries was the same as last year but with slight changes. The second category is live forces for sport, which have a significant change comparing to 2014, in 2015 both the Netherlands and Belgium were dominating with 43.25% and 42.25% respectively. The third

category is Poultry, Not cut in pieces, Frozen, which was imported by Brazil with 78.76% and followed by Saudi Arabia with 6.71%, and the remaining percentage was distributed for other countries such as Argentina and France. Leeks and other alliaceous vegetables were replaced by offal poultry. This category is imported from India with 37.9% 29.21% for other countries. Lastly, the United Arab Emirates increased its contribution to camels and Camelidae's category comparing to the previous year by around 10%, and 67.12% is contributed by Saudi Arabia for the same category.

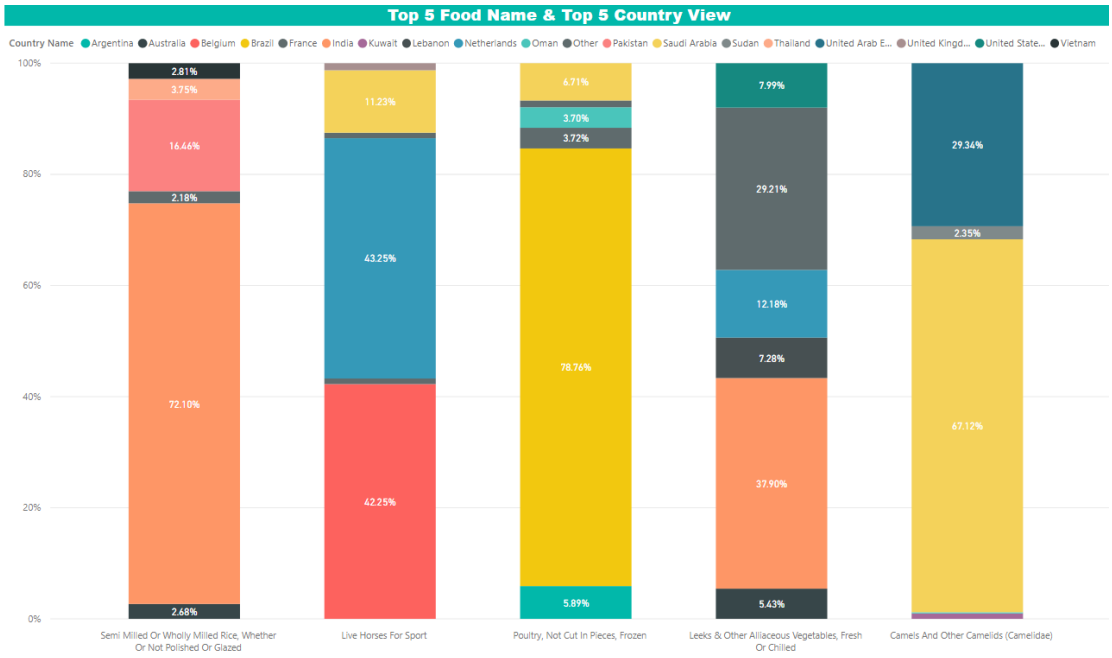


Figure 13. PowerBI screenshot for countries and categories based on the value in 2015.

Fig 14 shows the imported categories in 2016. Noticed, the new two categories are comparing to the previous year which is yogurt and carcasses. Yogurt, whether

concentrated or containing added sugar or other favoring or containing added fruit or coca was imported from Saudi Arabia with 91.98% followed by the United Arab Emirates with 6.91%. The second new category is carcasses and half carcasses lamb or chilled. Australia is dominating this category with 97.74%. Life horses for the sport were imported from Belgium with 50.46%, followed by the United Kingdom with 33.48% which shows a difference with the Netherlands from the previous year. Frozen poultry is still imported from Brazil with 79.89%. Also, Semi or wholly milled rice is still imported from India and Pakistan the same as the previous year with 73.85% and 14.18% respectively.

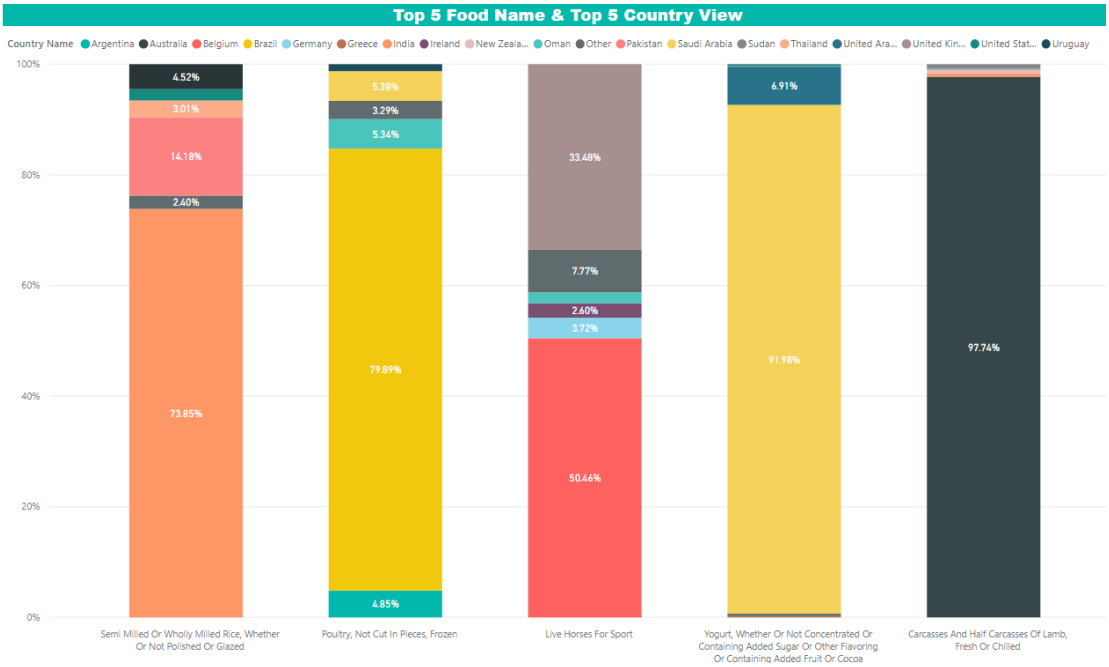


Figure 14. PowerBI screenshot for countries and categories based on the value in 2016.

Fig 15 shows the imported categories in 2017. Noticed, there is a new category

comparing to the previous year which are Cigarettes containing tobacco. Also, the contribution of Saudi Arabia and the United Emirates was decreased significantly comparing to the previous years. Cigarettes containing tobacco were contributed by Germany, turkey, Switzerland, and other countries with 42.93%, 23.77%, 15.19%, and 8.10% respectively. Poultry Not Cut in pieces, frozen is still imported from Brazil with 72.58% and 9.93% goes to France. Similarly, to last year carcasses and half carcasses lamb or chilled is imported from Australia and it's dominating with 95.37% but showed a very slight decrease compared to the last year. Lastly, the Semi or wholly milled rice was imported from India with 80.05% which shows around 7% increase comparing to last year. 9.73% was imported from Pakistan for the same category.

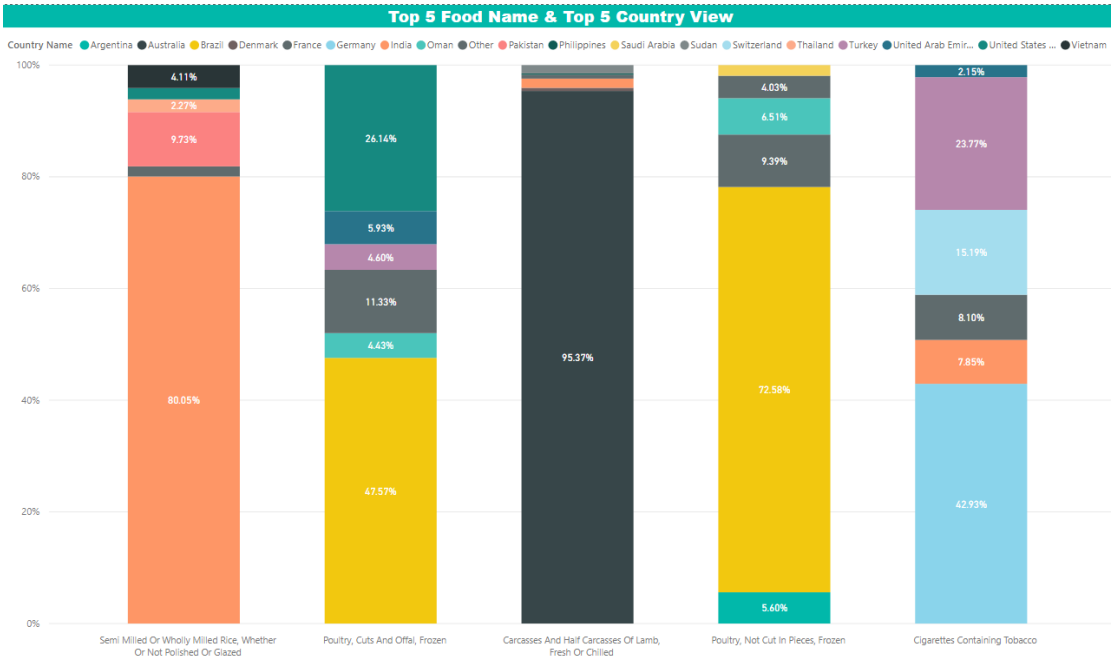


Figure 15. PowerBI screenshot for countries and categories based on the value in 2017.

Fig 16 shows the imported categories in 2018. As shown there is a huge difference between the countries compared to the previous year as the result of the embargo and as can been seen on the legend of the graph. The first imported category is carcasses and half carcasses of fresh lamb or chilled. Australia was dominating this category with 97.96 % of value contribution. The second category is semi milled or wholly milled rice which was contributed by mostly India with 80.97%. It is noticeable the live sheep were imported from Iran and Australia with 65.44% and 21.28 % respectively. A new category appeared on this year comparing to all previous year which is bran, sharps & other residues of wheat. Sudan took a huge amount of contribution to this category with 64.95%, followed by Tanzania with 22.73% and followed by Uganda with 4.83%.

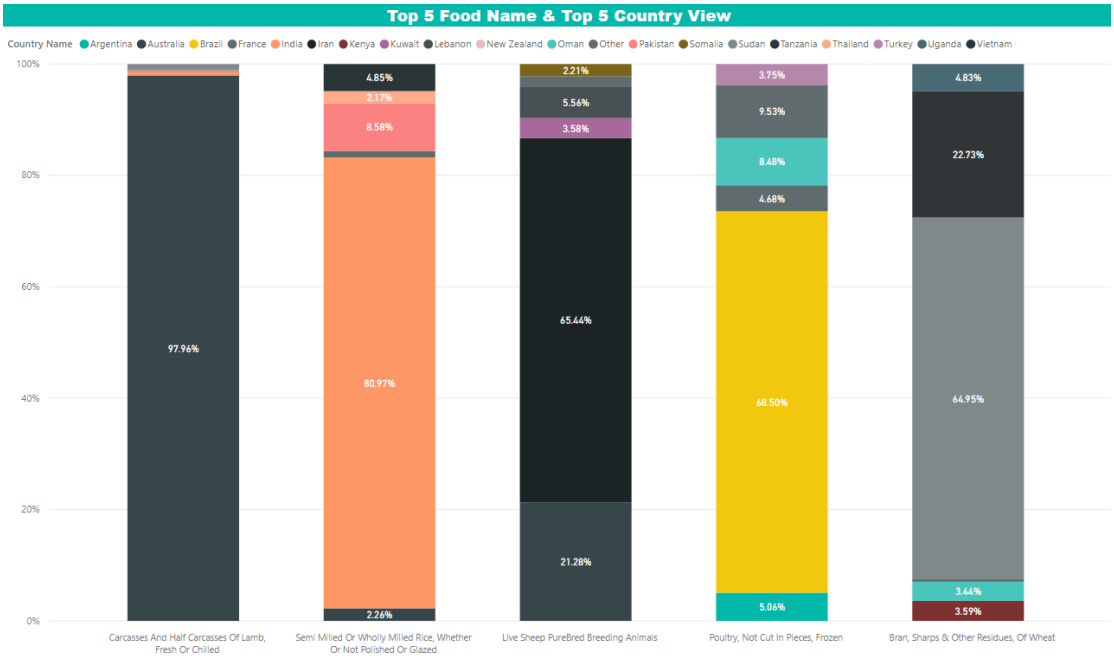


Figure 16. Power BI screenshot for countries and categories based on the value in 2018.

Fig 17 illustrates the top 4 items which have been imported to Qatar deepening on the quantity. It noticed the there is a fluctuation in the long-life milk. Furthermore, imported vegetables fats and oils were decreased from 2016 to 2018.

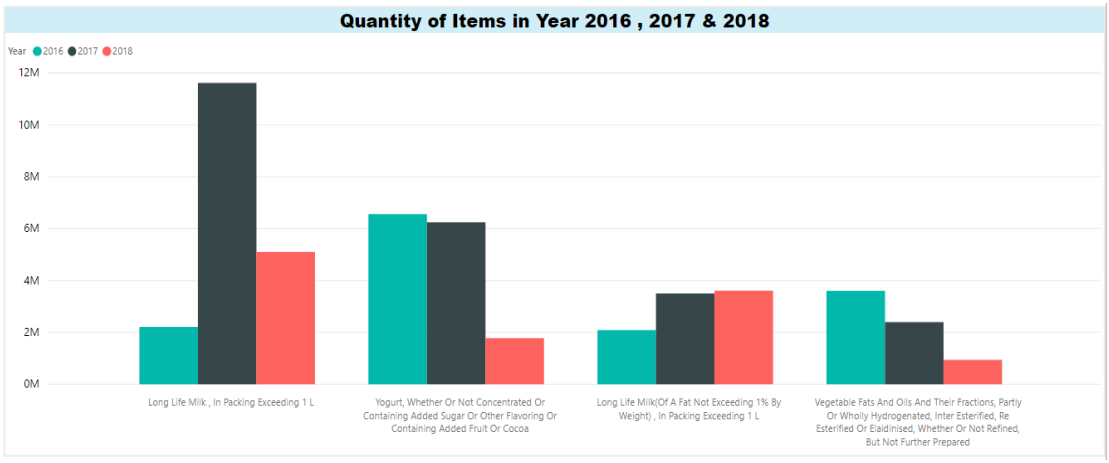


Figure 17. Top 4 imported items based on quantity from 2016 to 2018.

Fig 18 illustrated the contribution of Top 10 countries depending on the value 2013 to 2018. From 2013 to 2016 there were slight changes in the percentage but there were no changes in countries' contribution. On the other hand, in 2017, new countries were replaced comparing to previous years. The countries are Oman, Turkey and the contribution of Saudi Arabia decreased by around 10% whereas the United Arab Emirates decreased from 22.88% to 14.18% going from 2016 to 2017. In 2018, Iran and Brazil were replaced by some other countries. Overall, the amount which was paid to GCC countries disappeared gradually in 2018.

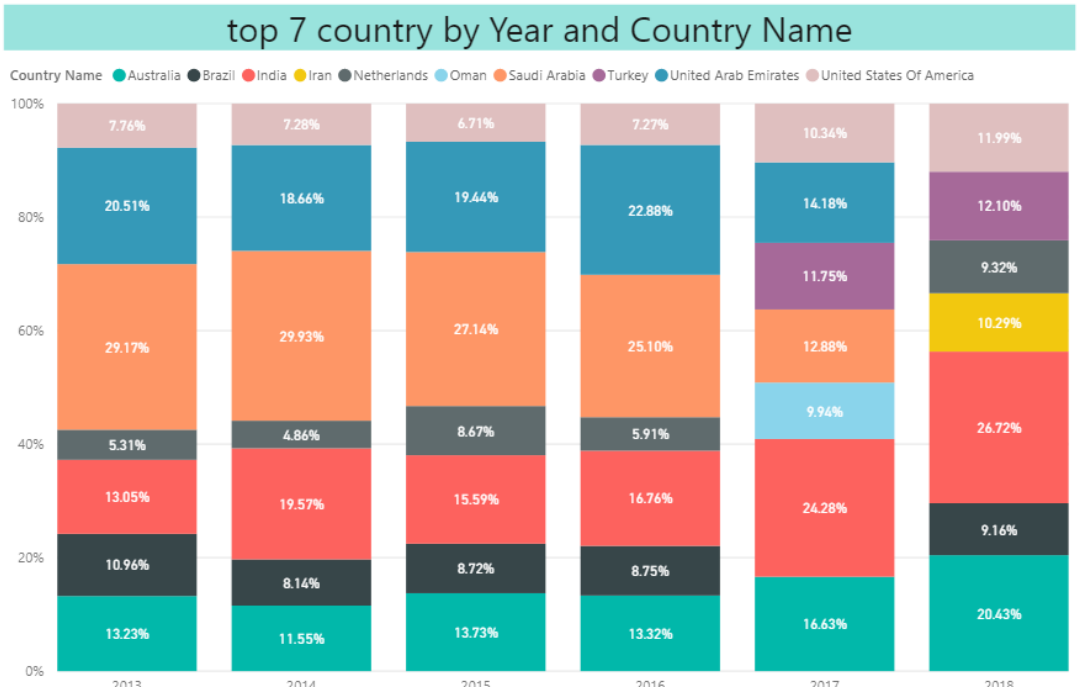


Figure 18. Contribution to countries depending on the value from 2013 to 2018.

5.2 Result and Discussion on Transportation

Fig 19 shows the imported long-lasting milk weight in kilograms of long-lasting milk to Qatar by three mode type from 2015 to 2018. The three mode types are land, air, and sea. The imported weight increased slightly from 121 million kg to in 2015 to 126 million kg in 2013 but then dropped sharply to around 54 million kg in 2017. In 2018, Qatar did not import any long-lasting milk using land mode. On the other hand, importing from seaport remained stable between 2015 and 2016 which is around 600 thousand kg. Then it increased moderately to 14 million kg in 2017 but then decrease to 1.6 million in 2018. However, sea mode rises sharply from around 30.9 million kg in 2015 to around 77 million kg in 2018.

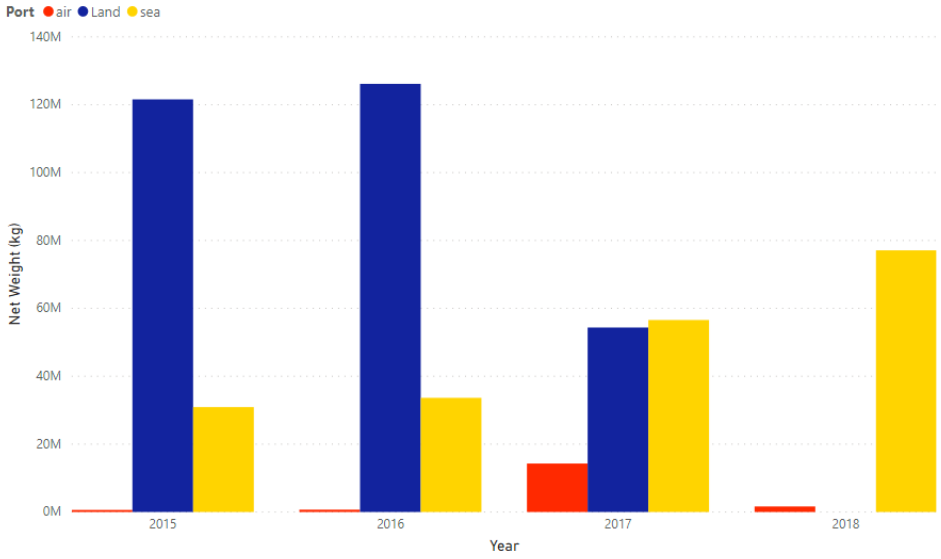


Figure 19. Imported weight in kilograms of long-lasting milk.

Fig 20 will represent the contribution of a carbon footprint per Tones (MRIO-Raw Milk, MRIO-Dairy product, CO_2-Sea, CO_2-Air, and CO_2-Land) by country from 2015 to 2018.

In Fig 20a, the highest country that produced the most carbon footprint per Tones in 2015 is Saudi Arabia. Also, Saudi Arabia dominated all different types of carbon footprint with 142k of MRIO-Dairy and 219k MRIO-Raw milk. One of the reasons is Qatar was paying to Saudi Arabia the most among other countries. The second highest country is UAE with 27k of MRIO-Dairy and 41k MRIO-Raw Milk noticing that CO_2 emission from land is very small compared to other type of emissions. The Netherlands is in third place with 18k of MRIO-Dairy, 20k of MRIO-Raw Milk and around 4048 of CO_2 emission from the sea. Egypt is in fourth place followed by Turkey with a very small amount of carbon footprint comparing to KSA.

Like Fig 20a, Fig 20b almost has the same results of countries ordering in 2015 comparing to 2016. In 2016, KSA is in the first place with slight increase comparing to

the previous year with 150k of MRIO-Dairy, 232k MRIO-Raw milk and 6096 that CO_2 emission from the land. The second highest country is UAE with 24k of MRIO-Dairy and 36k MRIO-Raw Milk noticing that CO_2 emission from land is very small compared to other types of emissions. Also, it decreases as a total comparing to the previous year which can explain the increasing amount from Saudi Arabia. The Netherlands is in third place with 18k of MRIO-Dairy and 19k MRIO-Raw Milk. Followed by Egypt and France. Notching Turkey become in the 6th place compared to the previous year with 3799.94 of MRIO- Raw Milk, 3662.5 MRIO-Dairy, 218.78 CO_2 emission from the sea, 13.8 CO_2 emission land and 29.29 CO_2 emission from the air.

Comparing Fig 20a and 20b to 20c, it is clear that there has been a huge increase in carbon footprint in the different country and the countries' order has been changing compared to the previous year. Saudi Arabia's carbon footprint falls considerably. However, it is still taking the 1st place with 103k of MRIO-Dairy, 66k MRIO-Raw Milk, 2645 of that CO_2 emission from land and 3.93 that CO_2 emission from the sea. The emission of the sea is not clearly showing in the graph because it's so small compared to other sources of emission. Turkey jumped readily to the 2nd in 2017 with 36k of MRIO-Raw Milk, 35k of MRIO-Dairy, 22k CO_2 emission from air and 2257 CO_2 emission per Tones from the sea. UAE declined to the 3rd place with 24k of MRIO-Raw Milk and 15k of MRIO-Dairy. Followed by the Netherlands with 14k of MRIO-Raw Milk and 15k of MRIO-Dairy. France was in 5th place followed by Belgium and the USA.

Fig 20d illustrates that there has been a considerable change in both countries' ordering and carbon footprint emissions in 2018. Also, new countries are appearing comparing to all previous years. The Netherlands becomes the most dominant in producing carbon footprint per ton sourced by sea transport. With 24k of MRIO-Raw

Milk, 26k of MRIO-Dairy, 6k of CO_2 emission from the sea and around 356 CO_2 emission per tones from the air. Oman was in the 2nd place with 17k of MRIO-Raw Milk, 11k of MRIO-Dairy. 3rd place goes to Morocco with 15k of MRIO-Raw Milk, 10k of MRIO-Dairy, around 925 of CO_2 emission using air mode and around 333 of CO_2 emission using sea mode. Turkey is in 4th place with 12k of MRIO-Raw Milk, 11k of MRIO-Dairy and 2k of CO_2 emission using sea mode. 5th place goes for Kuwait followed by France, Belgium, and Denmark.

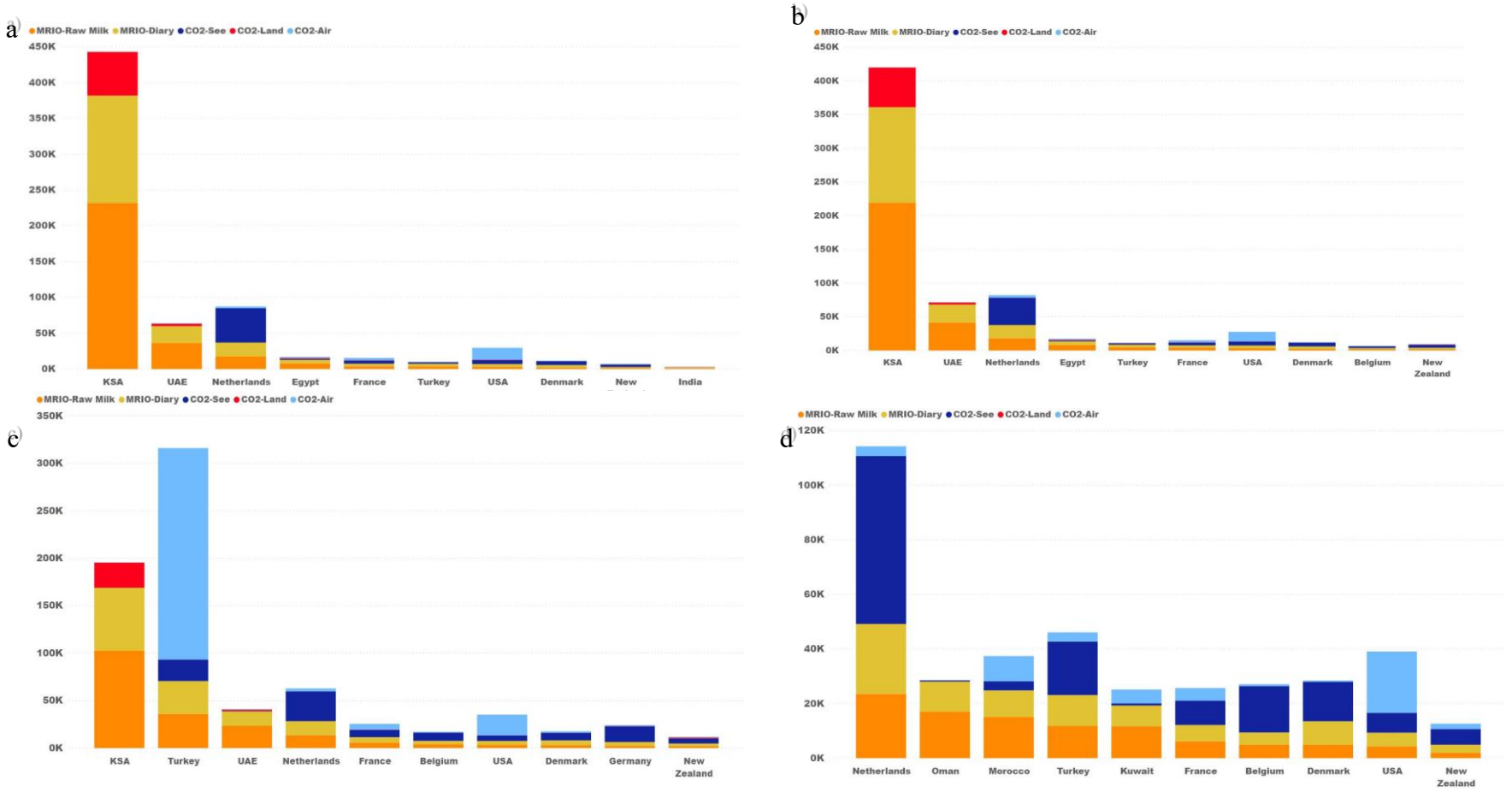


Figure 20. Carbon footprint per Tones from 2015 to 2018 a) 2015 b) 2016 c) 2017 d) 2018

Fig 21 presents the percentage contribution of carbon dioxide emission per tones that have been produced by the top 5 countries using sea, land, and air mode from 2015 to 2018. In Fig 21a, b both KSA and the Netherlands had the highest percentage among other countries. Followed by the USA, other countries, France, and Denmark for both years. In 2017 as shown in Fig 21c Turkey produced the highest amount of carbon dioxide per ton among other countries, which can be also noticed in fig 20c that Turkey consumed the CO_2 using air mode. However, in 2018, as Fig 21d shows, the Netherlands and other countries become the most dominant comparing to the previous year with 34.16% and 21.07% respectively, followed by the USA, Turkey, and Belgium, which also can be shown in Fig 20d using both sea and air modes.

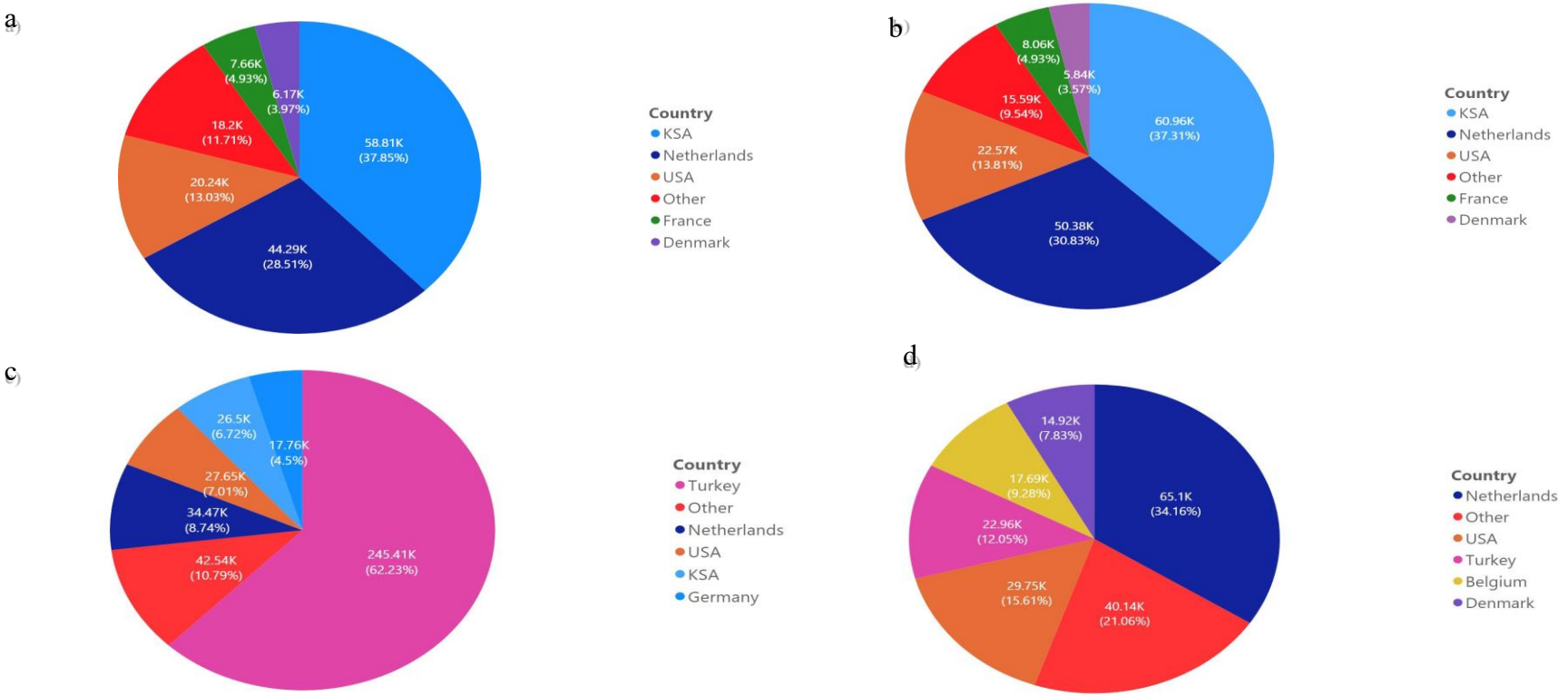


Figure 21. CO_2 emssion per tonnes for Top 5 countries from 2015 to 2018 a) 2015 b) 2016 c) 2017 d) 20

Fig 22 represents the total carbon footprint contribution from 2015 to 2018 using the three-transport mode and the MRIO Model. Which is the contribution of a carbon footprint per Tones (MRIO-Raw Milk, MRIO-Dairy product, $C0_2$ -Sea, $C0_2$ -Air, $C0_2$ -Land). In 2015, the consumption of MRIO-Raw Milk was 0.30 million per tonnes and the consumption of MRIO-Dairy was 0.12 million per tones. The carbon emission using sea, land, and air was 0.07, 0.06, and 0.02 million per Tones respectively. Similarly to 2015, in 2016 the consumption of MRIO-Raw Milk is 0.31 Million, 0.22 Million for MRIO-Dairy, 0.07 million goes for $C0_2$ using sea mode, 0.07 million for $C0_2$ using land mode and 0.03 million for $C0_2$ using air mode. Overall, there is a huge decrease comparing 2015 to 2018. As in 2015 more than 0.5 million tonnes of carbon footprint were produced whereas less than 0.4 million tonnes in 2018 were produced. However, the huge slight increase in 2017 was due to the period of crises as of the two weeks when the crises happen. The government started to address the temporary slight shortage of dairy products in the country by importing the products from several countries such as Turkey and Iran using Air mode transport which illustrates the huge amount of $C0_2$ emission at that year (Bukhari, 2017).

On the overhand, the reduction of the carbon footprint in 2018 was not only because the food supply chain is changing including transportation mode but also because the crisis pushes Qatar to become self-sufficient. Many companies in Qatar started to increase their production. For example, the production of Dandy Company increased from 30138414 Liter to 58794966 Liter from 2016 to 2018. Furthermore, Baladna Company started to cover all the demand of Qatar markets within a short period also it has one of the biggest state-of-the-art farms in the Middle East (Voice of America, 2020).

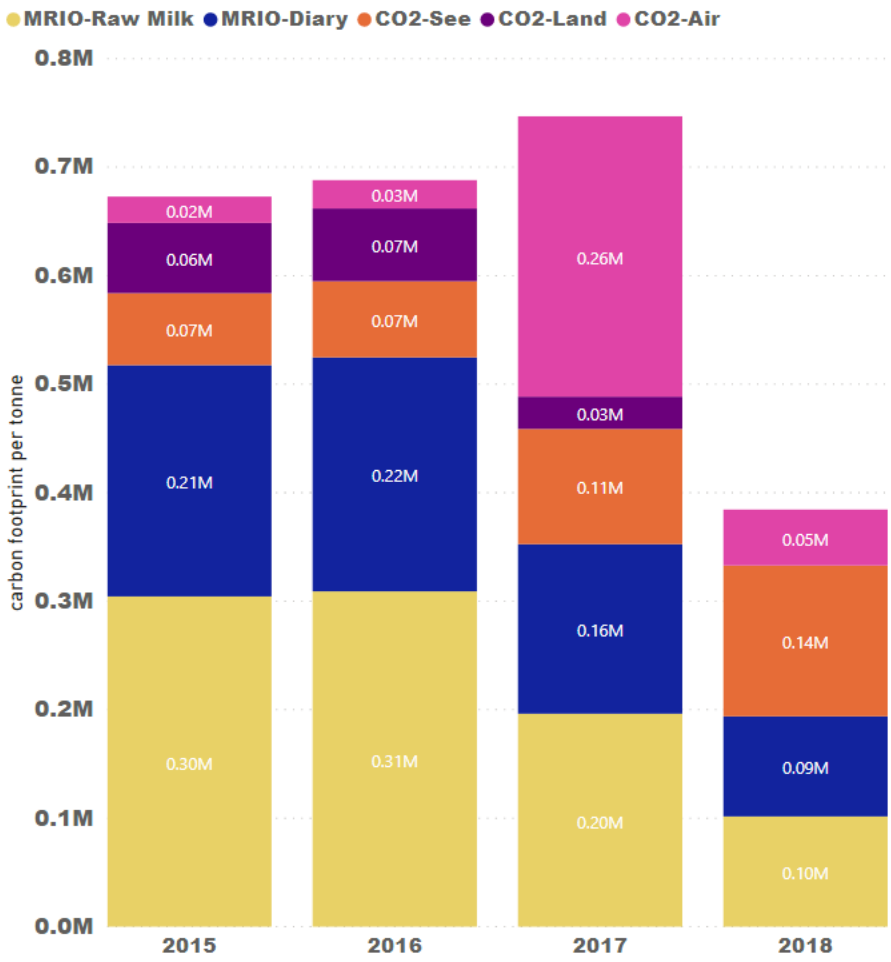


Figure 22. Total carbon footprint from 2015 to 2018.

CHAPTER 6: CONCLUSION AND FUTURE WORK

6.1 Summary of Research

In this paper, the impacts of the embargo on Qatar food trade and security are presented. This study also gave some examples of changes in food supply chains in different countries for multiple periods. Moreover, it analyzed historical data of food imported to Qatar from 2012 to 2016. Taking into consideration, the cost of importing food and the top imported food. Some of the critical conclusions are presented as follows:

- Financially, the analysis showed that Qatar has paid around 5-7 billion Qatari Riyals to Saudi Arabia and the United Arab Emirates, respectively, from 2012 to 2016. After blockade been imposed in mid-2017, targeting the food supply chain in the first place as a key human need. There was a clear change in data, as India took over the first place with around 1.4 Billion in 2017. Moreover, Oman, for instance, was not among the top 10 before, but it came in 7th place in 2017.
- Viewing this data from a different dimension, the top value-imported food remained almost the same. In other words, blockade did not cause an unexpected-high cost to import one food type, but what used to be the top expensive remained the same and been satisfied with diversified suppliers. As per the intelligence unite at The Economist; Qatar has marked slight-higher score in Food Global Security Index (FGSI) in 2018 compared to 2017. Whereas in 2017 Qatar's score was 73.3 and 76.5. However, this increment took Qatar from the 29th place globally to the 22nd ("Building Resilience",2018;" Measuring Food Security", 2017). There is no doubt that the challenges faced by Qatar after the famous blockade resulted in a positive

impact on the food security index. In December 2017, Qatar Finance Minister mentioned in The Euro money Qatar Conference that Qatar was avoiding putting itself in competition with GCC countries when it comes to food and medicine. Moreover, he mentioned that in the future the policies' focus would differ especially in food security and he gave an example of the dairy products and said the country is 40% self-sufficient (Al Thani, 2017; "Measuring Food Security", 2017).

- From an economic perspective, the selection of suppliers, relationship with the supplier, supply plan, and transportation became more critical ("Measuring Food Security", 2017). Furthermore, the selection of food suppliers now becomes much diversified, having a more flexible and win-to-win relationship and new plans in place considering more disruption risks. Only transportation remains as a weak key, as longer distance traveled means higher cost.
- Long traveling distance will also have an impact on environmental costs, as it will increase CO_2 emissions into the air.
- According to Baladna, which is a Qatari leading and largest dairy producer, the blockade was an opportunity to fulfill the demand of the local market. Before the blockade, 18% of milk was produced locally and 82% was imported from outside. However, the production of milk from 2016 through 2019 was 9.80, 150, and 380 tons, respectively. The demand of the local market is between 130 and 150 ton.
- The blockade had segregated families; violated freedom of movement rights and many other human rights. However, the target of food shortage has not been reached, and this made the people in Qatar secured. It is worth noting that during the blockade, Qatar possesses better food security compared to 99

countries including the four Arab countries involved in the blockade with UAE ranking at 31, Saudi at 32, Bahrain at 41 and Egypt at 61. (Building Resilience,2018; Measuring Food Security,2018; Kanady,2017)

- Considering the dynamic structure of the problem, food security should also include the complex interactions between the important parameters of the system. (Onat et al., 2016; Kelly et al., 2019; Kelly et al., 2019). System dynamics modeling can greatly serve for this purpose as it can capture the dynamic relationships between important variables in any system (Onat, 2014; Ercan, 2017a; Alirezaei et al., 2017; 2016a).
- Finally, considering that the sustainability impacts usually have conflicting objectives, integrating multi-criteria decision-making approaches is vital to provide a compromised solution (Sen, 2016; Onat, 2018; Kucukvar, 2018; 2019ab). For example, selecting one country as a supplier of a certain food product might be beneficial for reducing the environmental impacts (carbon emissions, air pollution, etc.), but on the other hand, it might hinder the resilience or might have further cost from an economic perspective. In such cases, multi-objective optimization models can greatly serve for providing compromised solutions where each of the objectives is met at the certain degree (Onat et al. ,2015,2016,2019; Noori et al., 2015; Egilmez et al., 2016)

6.2 Key Findings

- There has been a significant change in dairy product imports. Land transport, which was the most popular before the blockade, turned out to take a descending trend on the transportation of dairy during the entire period while sea and airport which were the least popular mode before blockade saw a big jump after the blockade.

- During the blockade, Qatar still imported some dairy products, this is because of contracts and subcontracts between Qatar and siege countries.
- Qatar shipped dairy products from Turkey and Iran since Saudi Arabia and Emirates suspended diplomatic ties.
- The Hamad International Port opened in 2017, which become Qatar's main gateway to the world trade and ensured uninterrupted supply to all different sectors.
- Qatar has made significant progress in food production in the past two years as local production of dairy products.
- Despite the embargo, the carbon footprint decreased sharply after the blockade which explains that the impact on global warming has been changed after the embargo.
- Specialized companies for food were established in Qatar during the last period. Also, different agricultural project investments to the private sector investors were presented, in addition to several other strategic projects to produce vegetables using greenhouses. Those projects, measurements, and programmers consistent with its determination to achieve self-sufficiency in food ensure food security, and secure the food suppliers (Gulf Times, 2020).
- Qatar placed in the first position among Arab countries and 13th globally according to food security index (GFSI) data, which is aligning with Qatar's strategy in achieving food security. This illustrates that Qatar overcomes all the threats and turning it to opportunities.

6.3 Recommendations

According to the world shipping council organization, sea shipping transport is more efficient than road or air transport in terms of consuming carbon emissions. Air transport consumes the highest carbon emission comparing to other modes of transport which can be also noticed on the results of this research paper (WSC, 2014). As in mid of 2017, when the blockade imposed in Qatar, Turkey, Iran, and many other countries gave aid to Qatar. Those countries have sent cargo planes of food to Qatar and continue sending to Qatar until Qatar stabilized and secured all supply chain again (VOA News, 2017). Turkey has sent more than 200 cargo planes to Qatar. Those factors led to increasing the $C0_2$ emission of freight transport in a short period in 2017. As this regard, using the sea transport mode for freight transport is the most recommended transport among other transportation modes to reduce the $C0_2$ emission international impacts.

On the other hand, Food security is an issue that is at the leading edge of Qatar's development-level priorities, as it plays an important role in state economic independence, and it is also important to realize Qatar's national vision for 2030. The country's strategy focuses on expanding local agricultural and food production which has a comparative advantage in Qatar. So different food sector companies need to focus on increasing production in the various food sector (Gulf Times, 2020). So, the country becomes self-sufficient and the initiative needs to align with the country's food security policy, and the Ministry of Trade and Industry's efforts to enhance cooperation between the public and private sectors to develop Qatar as one of the region's most prominent countries in that regard (Gulf Times, 2020).

Furthermore, extending this research by developing a global multi-regional econometric model of food trade and supply chain of Qatar based on real trade data

obtained from different databases and combine with the ministries databases is recommended. This can help in forecasting and managing the food supply chain if a crisis occurs in the future. For example, COVID 19 is threatening food security worldwide. It is recommended to create a fueled decision analytics platform for responding to such crises on Qatar's food supply chain from sustainability and food security perspective.

6.4 Future work such as social, economic and environmental analysis

The analysis can be further expanded by the inclusion of triple bottom line impacts, as the three important pillars of sustainability (Onat et al., 2014, 2015, 2017, 2019; Zhao et al., 2016; Tatari et al., 2015). Triple bottom line account can greatly serve for public policymaking and further estimations for the sustainability impacts of changes in the supply-chain of the food industry (Onat et al., 2020, 2019, 2018, 2017; Kucukvar et al., 2015, 2017; Tatari and Kucukvar, 2012; Shaikh et al., 2017). As the structural changes occur in the food supply chain of Qatar, quantification of these impacts is extremely important to understand the true benefits of reshaping and diversification of the supply chain from multiple angles (triple bottom line impacts) (Kucukvar et al. 2014). This approach has been applied in the literature for mainly to investigate the impacts of emerging technologies, how would they affect environment, society, and economy when they enter the market (Noori et al., 2016; Abdella et al., 2020; Aboushaqrah et al., 2019; Sen et al., 2019).

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