Limestone analytics

Business Case Report

Production of Plant-Based Meat Alternatives

Prepared for: Impossible Foods
Date: September 15, 2021

200 Princess Street, Kingston ON, K7L 1B2
www.limestone-analytics.com

Table of Contents

Authors & Acknowledgements

Limestone Analytics

Limestone is a consulting firm based in the US and Canada, specializing in the evaluation of public policy, social programs, and international development projects. The firm is recognized for combining academic rigor, state-of-the-art methods, and international development experience to provide customized evaluation and analysis services and to help their clients incorporate evidence to improve the design, financing, and implementation of their projects. Information about our current and past projects can be found at: limestone-analytics.com.

Authors

Bahman Kashi, PhD
President, Limestone Analytics

Sarah Carello, MA
Project Coordinator, Limestone Analytics

Kaitlyn Vanderwees, MA
Analyst, Limestone Analytics

Acknowledgements

The authors would like to thank Chris Cotton, Rebekah Moses, Chris Davis, and Nick Toma for their insight and support for this project.

Acronyms

BRL	Brazilian Real
CBA	Cost-Benefit Analysis
CNY	Chinese Yuan
IRR	Internal Rate of Return
kg	Kilograms
NPV	Net Present Value
NGN	Nigerian Naira
PBM	Plant-Based Meat
PPP	Purchasing Power Parity
USD	US Dollars
UNDP	United Nations Development Programme
VND	Vietnamese Dong

Executive Summary

According to the International Panel on Climate Change, raising livestock to produce meat and other animal products causes up to 14% of worldwide greenhouse gas emissions. With similar nutritional qualities to animal meat, plant-based meat (PBM) offers consumers alternative food products that may be significantly better for the environment than animal meat. However, the market for PBM is young and remains relatively small compared to animal meat.

Considering the potential impact of PBM on reducing greenhouse gas emissions, donors and international development organizations are interested in learning about the barriers to the global growth of PBM. This study aims to understand the financials of PBM production in alternative settings and assess how comparable costs, revenues, and risks are across countries. This study does not consider the social or environmental feasibility of plant-based meat production.

The initial intention of this study was to report the financial viability of the investment using current prices and an assumed sales volume. Therefore, the scope of the study did not include a detailed market study. However, one of the main takeaways from this analysis was that the sales price and sales volume are the most critical parameters in determining the financial viability and risk profile of the investment.

To conduct the study, the team uses cost-benefit analysis in a project financing setting to assess the financial viability of a typical processing facility constructed to produce frozen PBM and sell it in the local urban market. A local urban market is selected to ensure cold chains exist to handle the distribution. Since PBM is considered a substitute for animal meat, the study does not consider any investment in additional cold chain and cold storage facilities. The study assumes a life of 18 years for the investment and integrates inflation and real growth of food prices into the analysis.

Production of PBM can follow different recipes. The recipes used in each country vary based on the available sources of protein and their market prices. The sales volume and unit price of PBM are also different based on the country's industrial average plant utilization rates and current average prices of PBM and animal meat. Demand for the product was assumed to be fixed, meaning that all products produced would be consumed at the assumed market prices. The assumptions on sales price and volume are major limitations of this research. The key assumptions are summarized below.

Table ES.1: Key Assumptions Across Countries

Country	Plant capacity in kg (in lbs.)	Plant output in kg (in lbs.)	Sales price (USD/250g)†
Brazil	90,718,474 (200,000,000)	58,858,145 (129,759,997)	$9.40
China		55,156,832 (121,599,999)	$6.50
Nigeria		33,021,524 (72,799,998)	$12.20
Vietnam		57,914,673 (127,679,998)	$3.50

† These are the starting prices. The study assumes that the price of PBM in each country changes over ten years to match the price of animal meat.

While the results suggest that at current prices the investments are feasible across all four countries, the authors believe further research on the PBM market can drastically improve the accuracy of financial feasibility measures. Due to the heterogeneity of plant-based meat markets, research is necessary to rigorously forecast the sales price and sales volume in each country.

The results of this study and its analytical model can help donors and institutions interested in expanding the production and consumption of PBM in two primary ways:

1. Providing a better understanding of opportunities for private participation in the production of PBM in different contexts
2. Establishing a transparent basis for negotiation when setting rates and other parameters in blended and innovative financing arrangements

Considering all the assumptions in place, this study finds the investment feasible in all four countries. However, there are key lessons and insights discussed below.

1- The unit cost and business environment risk significantly vary by country. The study uses the current market price of inputs to the production process, plant utilization rate, and other costs, including taxes, to estimate the unit cost. The inputs vary slightly based on the recipes in each country. Figure ES.1 shows the makeup of unit cost by country in a typical year excluding taxes.

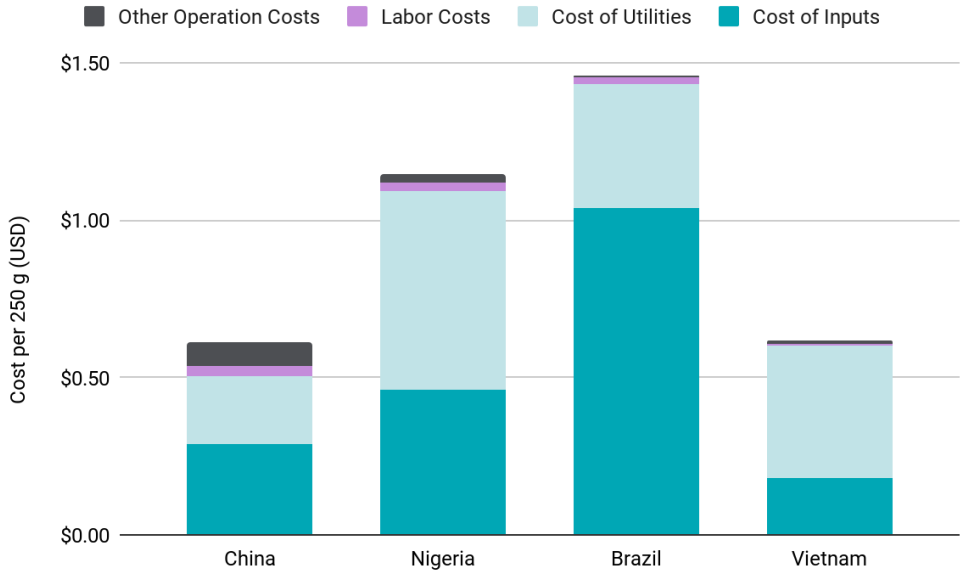

Figure ES.1: Unit Costs Across Countries

The business environment risk relates to the quality and cost of infrastructure, the rule of law, and political stability. Some of these parameters are covered by the Doing Business Report.

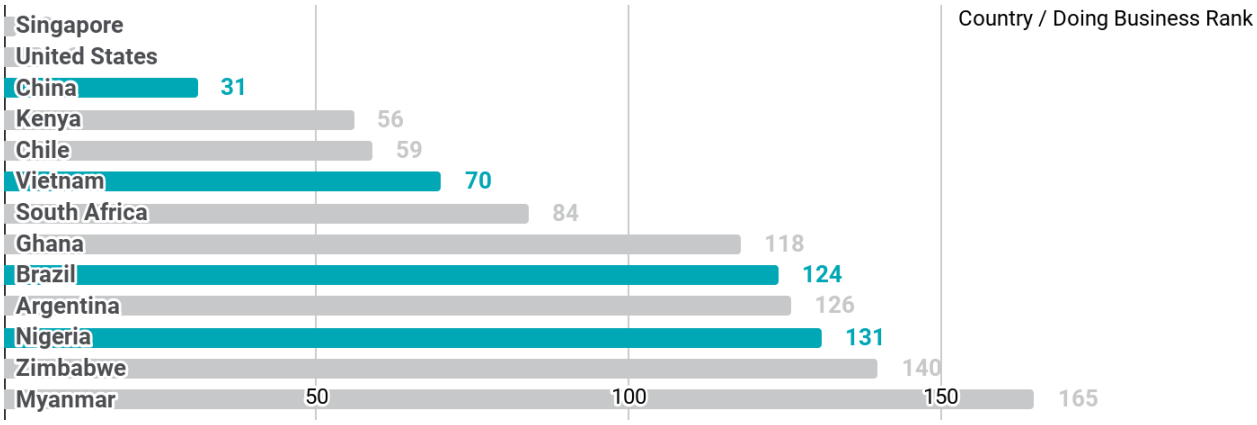

Figure ES.2: Doing Business Rankings Across Countries[1]

Other sources of data, such as S&P's country risk ratings can help with other measures of stability and country risk.

2- There is no one single dominant cost item. The cost of inputs is the main driver of costs in China, Nigeria, and Brazil. Vietnam is an exception where utility costs occupy the larger share. The required inputs vary by recipe, and the recipes use a variety of inputs where no single input is dominant. Furthermore, most raw materials are internationally traded, and

[1] World Bank (2020) "Ease of Doing Business Rankings." www.doingbusiness.org/en/rankings

their availability and price are less volatile than non-tradable commodities. Therefore, the unit costs estimated by this study are more certain compared to the revenue projections.

3- The assumptions on sales volume and sales price are the main sources of risk. This study considers market price and sales volume as the key sources of risk. This is especially a concern in Nigeria due to the limited presence of a plant-based meat market and uncertainty about how the products will be accepted by the population of Nigeria.

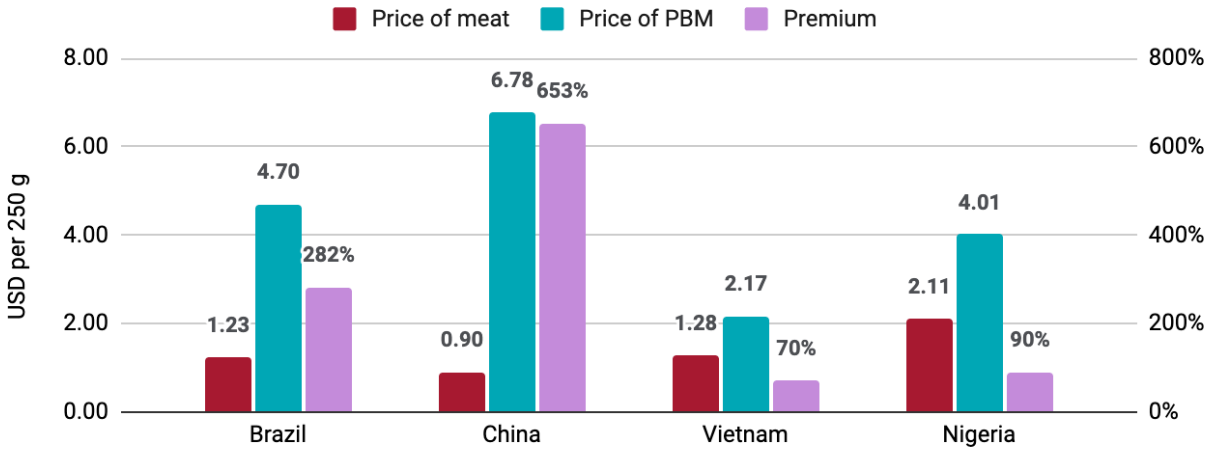

Figure ES.3: Price of Plant-Based Meat Across Countries

The market conditions (price and volume) are unique in each country. The authors believe that the nature of the PBM market in these four countries can vary significantly. PBM as a commodity can be marketed in a variety of forms, from a luxury commodity priced at a premium and consumed by a few, to a less expensive alternative to animal meat that can increase the protein consumption for those who cannot afford animal meat. This study uses three indicators to summarize the diversity of the market in the four countries: current meat consumption, current meat prices, and population. These indicators help answer the following questions:

- How important is meat consumption in the country's average diet?
- How affordable is meat at its current price?
- How big can the PBM market get?

To make the meat price comparable from an affordability perspective, we have adjusted the prices in each country with purchasing power parity (PPP) using international dollars.

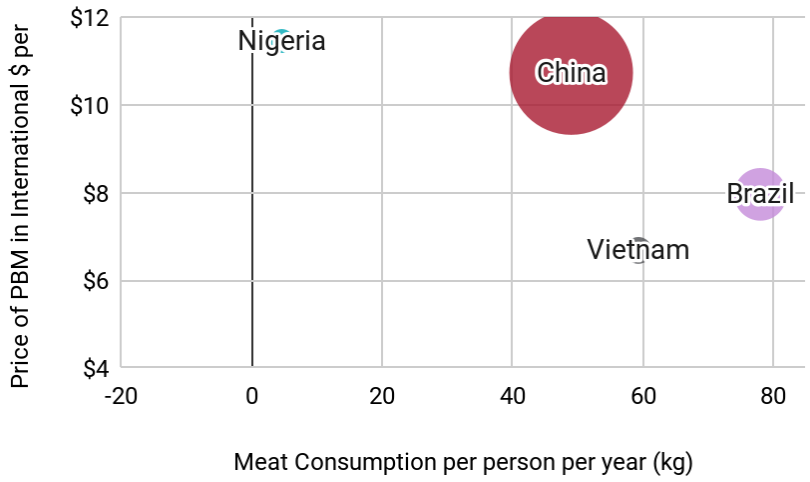

Figure ES.6: Meat Consumption, Price of PBM per 250g, and Population

This chart provides an overview of the indicators that can help appreciate the diversity of the criteria that play a role in projecting the market price and sales volume for PBM. The horizontal axis indicates the average meat consumption per person, the vertical axis indicates the price of plant-based meat (PBM), and the size of the bubble indicates the population in the top ten most populous cities. This diversity highlights the need for in-depth analysis and further research on market models for PBM and their expected evolution over time in different socio-economic settings.

4- The investments look viable even at lower market prices. Even if PBM was sold at the current animal meat prices from the start, the overall benefits of the investment would outweigh its costs in all countries except for China. Figure ES.7 shows the gross margin in a typical year in the scenario where prices match those of animal meat when entering the market.

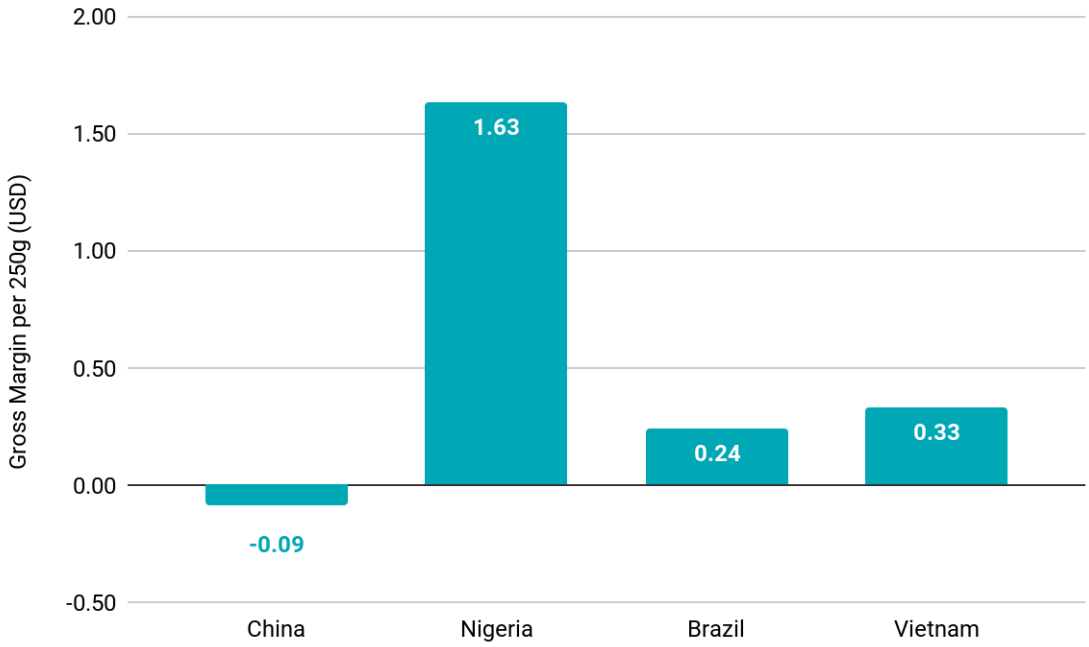

Figure ES.7: Gross Margin in a Typical Year at Price Parity with Animal Meat

5- Affordability adds more insight into the price variation across countries. The price of meat and PBM differs from one country to another. However, once affordability enters the picture, the differences get even larger. Meat is more affordable in Brazil and China, compared to Vietnam and Nigeria, due to differences in average income. Figure ES.4 shows how the prices of meat compare in current U.S. Dollars and in international U.S Dollars. International U.S. Dollars are adjusted for purchasing power parity.

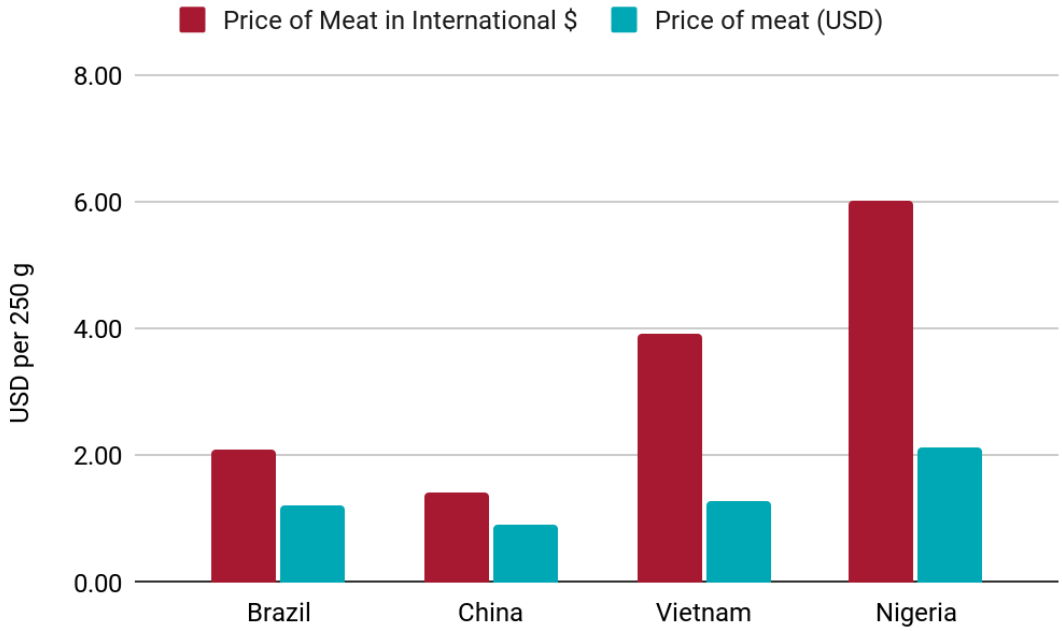

Figure ES.4: Cost of Meat Across Countries

6- PBM is currently considered a luxury good in many markets. If there is to be a significant transition from animal meat to PBM, the price must become more affordable to a wider population. The premium charged for PBM over animal meat in the four countries varies from 70% in Vietnam to 653% in China. Such a premium indicates the current market structure where PBM is a luxury item with limited consumption.

7- The results of this analysis highlight the limitations of a one-size-fits-all approach across contexts. This analysis has found interesting results in terms of estimating costs across contexts and the financial viability given certain assumptions around sales volume and price. However, the study also found that the costs and the revenues can significantly differ from one context to another. The shape and future path of the PBM market in every country can be unique based on the available resources, income level, cultural attributes, population density, and business environment. Therefore, although the production process is very similar, the analysis required to assess the financial feasibility of PBM production cannot be replicated from one context to another without a rigorous analysis of the PBM market.

8- The market risk creates a case for the use of blended finance. Conducting financial and risk analysis simultaneously allows the team to comment on the financing options required to promote the piloting and scaling of PBM production internationally. This study identifies market price and sales volume as the main sources of risk. Furthermore, the study finds that the investment cost is relatively small compared to operating costs. Figure ES.4 shows the operational costs in a typical year and upfront investment costs in each country. Therefore, the upfront capital cost is not a major barrier to private investment in PBM

production. Assuming that the social and environmental benefits of PBM production and sales justify the engagement of impact-driven actors such as donors, governments, and international development agencies, various forms of off-take contracts can reduce the market risks and make such investments more attractive. While grants and concessional loans can transfer the risk to other parties and cover the upfront cost or the working capital needs, off-take contracts can help reduce the market risk for the early years in operation. Please note that this financing narrative is only a high-level insight and a more detailed analysis of financing options will be required before any concrete recommendations are made.

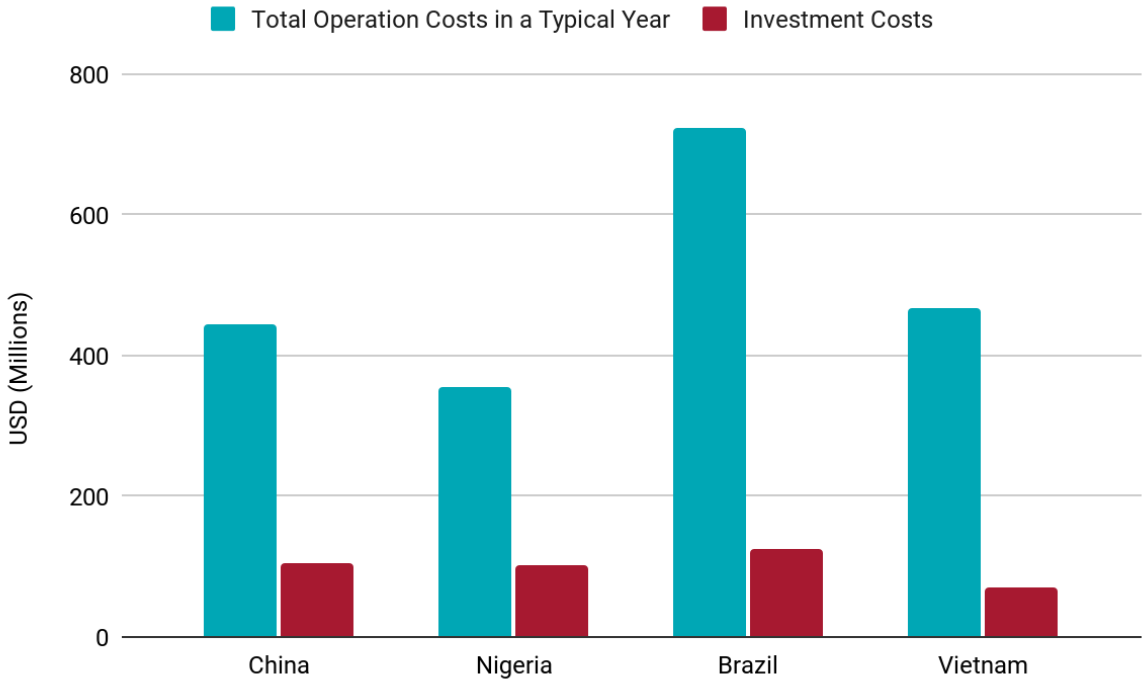

Figure ES.6: Total Investment Costs and Operating Costs in a Typical Year

Future research should help better estimate the revenue of plant-based meat production as well as impacts outside the producer. Such **market research** can better forecast how the price and volume of plant-based meat sold will change across time and contexts. Another area for future research includes an **integrated cost-benefit analysis** of plant-based meat production where social and environmental impacts are also in the picture. Such analysis can summarize the impact on stakeholders beyond just the investors. The transition from meat consumption to plant-based meat proposed in this research will impact each country's environment, employment, and health and nutrition. The impact of plant-based meat on populations needs to be further studied and can be evaluated through a cost-benefit analysis looking at the total impact on society.

Introduction

Plant-based meat has been a growing market, with many new companies beginning production around the world. According to the International Panel on Climate Change, raising livestock for the purpose of producing meat and other animal products causes up to 14% of worldwide greenhouse gas emissions (Masson-Delmotte et al., 2019). With similar nutritional qualities to animal meat, plant-based meat offers consumers alternative products that are significantly better for the environment. The research conducted by International Institute for Applied Systems Analysis in 2021 shows how transitioning to plant-based meat will improve land use, water use and reduce greenhouse gas emissions.

Given the environmental impacts of reducing meat consumption in countries around the world, Impossible Foods asked Limestone Analytics to complete a financial analysis of investment in producing and selling plant-based meat in four low or middle-income countries. This research aims to define and estimate the resources required to begin and operate large-scale production of plant-based meat in these countries and to forecast the revenue that can be generated over time. The countries chosen for analysis are Brazil, Vietnam, Nigeria, and China.

The investment being analyzed in each country includes the purchase of a meat processing plant that is then retrofitted to produce plant-based meat. The manufacturing plant is assumed to be located in a central city with a large urban population and capable of producing 200 million pounds of plant-based meat per year. The utilized capacity was estimated from the average in each country. Impossible Foods supplied recipes for plant-based meat products, including recipes for chicken, pork, and beef. Recipes were chosen to be nutritionally equivalent to meat and to create diversity of inputs. Within each country, one chicken, beef and pork recipe was chosen from the provided list based on domestic availability of inputs.

Demand for the product was assumed to be fixed, meaning that all products produced would be consumed. This is a major limitation of this research. Price data was collected in each of the countries that had existing plant-based meat markets, and it was assumed that over a period of ten years, the prices would fall to price-parity with meat. Sales of the products were assumed to be to grocery stores and food distributors in the top ten most populous cities in each country. Operation costs include inputs, utilities, freight, labor, taxes, disposal costs, and working capital. The analysis reports the internal rate of return and the net present value from the model, as well as the revenue, costs, and gross margin over time. Sensitivity analysis was conducted to test how parameters such as the price of plant-based meat, utilized capacity, price of inputs, inflation, and exchange rates impact the investment criteria.

This analysis contributes to this context by providing financial analysis of investing in the production and sale of plant-based meat alternatives in Brazil, China, Nigeria, and Vietnam.

This paper first covers the context of each of the countries analyzed, including an overview, the impact of COVID-19, and the business environment. It will then detail the methodology of the financial analysis and the analysis of critical parameters. Finally, the paper will discuss the results of the analysis, the areas for future research, and their limitations.

Country Context

General Economic Overview

Brazil

Brazil is the largest country in South America and the fifth-largest in the world, with a population of approximately 211 million (*Brazil | History, Map, Culture, Population, & Facts*, n.d.). Brazil is divided into 27 federative units, with 26 states and one federal district. The federative units are independent subnational entities (independent governing, legislative and tax entities) with their own governments and constitutions that together form the Federative Republic of Brazil. The currency is called the real (*USD to BRL Exchange Rate*, n.d.). In 2021, the exchange rate from USD to BRL was around 5.26 reales.

The country is rich in natural resources, including rainforest, freshwater, agricultural land, and minerals. Once highly dependent on agricultural exports such as sugar, coffee and rubber, Brazil's service and manufacturing industries have expanded exponentially in the past century. The two sectors account for over 80% of annual GDP (*Brazil - Share of Economic Sectors in the Gross Domestic Product 2010-2020*, n.d.). However, agriculture in Brazil continues to play a significant role in Brazil's economy and employs nearly one-tenth of the total labor force (*Brazil | History, Map, Culture, Population, & Facts*, n.d.). Beyond being self-sufficient in basic foodstuff, Brazil is one of the world's largest exporters of soybeans, corn, coffee, poultry and beef. The country also has a large mining industry, but its production is largely utilized by domestic markets.

Brazil has been and continues to be one of the most unequal countries in the world. Though the country has made significant progress in reducing inequality in the past decades (World Bank 2016), progress on improving socio-economic conditions has begun to be reversed due to the economic recession it faced in 2014 and the ongoing COVID-19 pandemic. In Brazil, the top 10% of the population make over half the country's wealth, making it the seventh most unequal country in the world, according to a UNDP 2018 Report (Conceição & United Nations Development Programme, 2019).

China

With over 1.4 billion people, China has the largest population in the world (*China | Culture, History, Maps, & People*, n.d.). China is divided into 22 provinces, 5 autonomous regions, and 4 municipalities. China also oversees 2 special administrative regions, Hong Kong and Macau. Beijing, one of the municipalities and the capital, is the political centre of China. National bureaucracies extend down from Beijing to local levels by territorial and functional boundaries. The official currency in China is called the renminbi, and the yuan is a unit of the currency. In 2021, the exchange rate from USD to CNY was around 6.67 yuan (*USD to CNY Exchange Rate*, n.d.).

China has the most natural resources in the world, with an estimated value of USD$23 trillion(Anthony, 2021). This wealth of natural resources is composed of fossil fuels, mineral deposits, freshwater, forest cover, and aquaculture(Blaettler, 2018). Since the opening up of the economy in the late 1970s, GDP growth has averaged nearly 10 percent a year (*Overview*, n.d.). This growth has been primarily fueled by resource-intensive manufacturing, exports, and low-paid labor. Industry and manufacturing accounts for more than 40% of GDP, and agriculture accounts for nearly 8% (*China GDP - Composition by Sector - Economy*, n.d.). Currently, China plays a major role in the production of a number of agricultural products, including rice, wheat, corn, soybeans, peanuts and cotton. It is also an important producer of coal and crude oil (*China | Culture, History, Maps, & People*, n.d.).

The rapid growth in China's economy has lifted more than 800 million people out of poverty but has also led to high social and economic inequality and environmental degradation (*Overview*, n.d.). China emits a quarter of the world's greenhouse gases, contributing to high levels of air pollution and higher than average rising temperatures and sea levels. The main cause of these emissions is the energy sector, particularly coal production and consumption. The pay gap between skilled and unskilled workers and disparity in education and technology between rural and urban areas are the drivers of increasing inequality (*Inequality in China | Bruegel*, 2018). Addressing social inequities and climate change will be at the forefront of domestic policy in the coming years.

Vietnam

Located on the eastern coast of mainland Southeast Asia, Vietnam stretches 1,650 kilometres from north to south and is only 50 kilometres wide at its narrowest part (*Vietnam | History, Population, Map, Flag, Government, & Facts*, n.d.). Vietnam has a population quickly approaching 100 million, across more than 60 provinces. Two decades of war and political turmoil severely stunted economic growth in the 20th century, but economic liberalization in the 1980s has turned Vietnam into an emerging market economy. The currency in Vietnam is called the dong. In 2021, the exchange rate from USD to VND was around 23,000 dongs (*USD to VND Exchange Rate - Bloomberg Markets*, n.d.).

Vietnam's economy is characterized by state-owned industry including textiles, food, plastics and tourism (*Vietnamese Economic Outline - Santandertrade.Com*, n.d.). Economic growth in Vietnam is driven by service and industry sectors, though the energy sector has seen significant growth in the past few years. The service sector, which primarily consists of tourism and telecommunication industries, and accounts for over 40% of Vietnam's GDP employs over a third of Vietnam's workforce. Industry and manufacturing account for over a third of Vietnam's GDP and employ more than a quarter of the Vietnamese workforce. The Vietnamese oil industry is the third largest of the Southeast Asian countries. While agriculture only accounts for 14% of GDP, it is the largest sector in terms of employment. Main crops include rice, coffee, cashew nuts, corn, pepper, sweet potatoes, peanuts, cotton, rubber and tea.

Some of the issues that Vietnam will be dealing with over the next few years are lack of modern infrastructure, waste management and pollution challenges (*Overview*, n.d.). These issues are further compounded by rapid population growth, as Vietnam's population is expected to grow over 20% in the next few years, hitting 120 million people by 2025. Vietnam's current physical capital investment as a percentage of GDP is one of the lowest in the region. Increased rates of urbanization are taxing current infrastructure systems. Furthermore, waste generation is expected to double in the next fifteen years. If waste management systems are overwhelmed, this could lead to further climate and public health concerns, such as water contamination. Already, the Mekong River in Vietnam is a large contributor to global marine plastic pollution. More climate concerns include Vietnam's unsustainable exploitation of many of its natural resources, and extensive use of fossil fuels for energy, which have led to high levels of air pollution.

Nigeria

With over 202 million people, Nigeria has the largest population in Africa (*Nigeria | History, Population, Flag, Map, Languages, Capital, & Facts | Britannica*, n.d.). Nigeria has 33 states and over 250 diverse ethnic groups. Nigeria has a constitutional government similar to that of the United States, with a bicameral national assembly and federal, state and local governments. The currency is called the naira. In 2021, the exchange rate from USD to NGN was around 400 naira (*USD to NGN Exchange Rate*, n.d.).

Nigeria has a large supply of natural resources, consisting mainly of fossil fuels, mineral deposits and arable land (*Nigerian Economic Outline*, 2021). It is the largest economy in Africa and the 30th largest in the world by GDP volume. The largest sector by GDP in Nigeria is services, which accounts for half of GDP and workforce. Industry accounts for over a quarter of the GDP and 12.2% of the workforce. As the world's 13th largest oil producer, crude oil alone accounts for 10% of GDP and 70% of government revenue. Agriculture accounts for another quarter of GDP and a third of employment, though most of it is subsistence farming. Main crops include yam, rice, maize, sorghum, millet, rice, livestock farming, beans, sesame, cashew nuts, cassava, cocoa beans, rubber, soybeans, and bananas.

Nigeria faces serious developmental challenges, including insufficient infrastructure, political instability, economic diversification, and severe inequality (*Nigeria Overview*, 2020). Currently, Nigeria's Human Capital Index is one of the bottom ten countries in the world. Official efforts to improve infrastructure often fail due to negligence and corruption (Akinwale, 2010). Nigeria's dependency on oil means that social welfare is highly susceptible to changes in prices, and is in need of diversifying its economy (*Nigeria Overview*, 2020). Nigeria is also facing extreme income inequality due to poor wages and unemployment. Prior to the pandemic, already 40% of Nigerians lived below the poverty line and another 25% were considered vulnerable. It was expected that another 2 million Nigerians would fall below the poverty line in 2020, though this number is likely greater due to the pandemic.

COVID-19

COVID-19 has posed a significant economic and public health challenge to all countries in this business case. Economic recovery will depend on how well the countries are able to respond and contain new variants. The figure below displays confirmed deaths from COVID-19. A caveat to these figures is that the estimate for confirmed cases is strongly impacted by the availability of testing. In Brazil and Nigeria, where there is limited testing available, it is likely that the figures for both confirmed cases and death could be much higher (Baker, 2020) (Veiga e Silva et al., 2020).

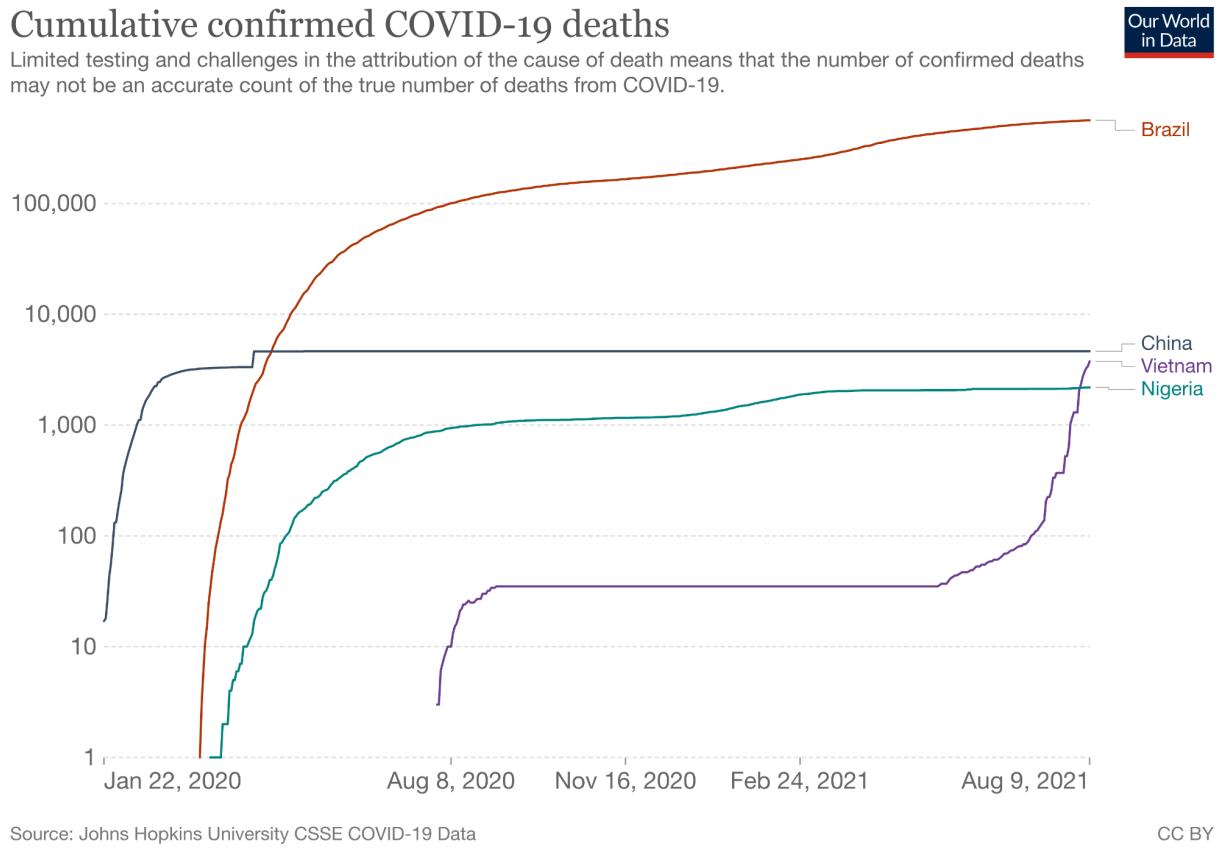

Figure 1.1: Confirmed (logged) Deaths from COVID-19

Brazil

As of May 2021, the country has experienced the world's second-largest number of COVID-19 related deaths and the third-largest number of confirmed Covid-19 cases (Lee, 2021b). To combat the COVID-19 pandemic, the government released a large fiscal stimulus bill in 2020, slowing the contraction of the economy to 4.1% (*Brazil Overview*, n.d.). Even so, Brazil fell from the world's 9th largest economy to the 12th in 2020, the only country to fall out of the top ten (Lee, 2021b). Along with a decline in GDP, Brazil is also currently facing inflation and currency weakness (Barua & Samaddar, 2021). In April 2021, inflation hit a four

year all-time high of 6.76%, changes in prices of food and beverages accounting for over 12% of the increase (*Brazil Inflation Rate*, n.d.). Since February 2020, the Brazil Real has fallen near 23% compared to the U.S. dollar (Barua & Samaddar, 2021). How well the government is able to control the pandemic will greatly affect the country's economic recovery.

China

Despite being the epicentre for Covid-19, China managed to report positive economic growth in 2020, an outlier among the major economies (*China Overview*, n.d.). Reporting GDP growth of 2.3% in 2020, China is expected to make a full economic recovery by 2021 due to growth and exports, strict containment measures and proactive fiscal responses. Even so, this is the lowest reported growth for China in the past four decades (Vaswani, 2021). Impacts of the pandemic are still affecting domestic consumers, with household consumption still lower than pre-pandemic levels. Additionally, rising public and private debt as a result of the pandemic could have a delayed impact on the Chinese economy (*China Overview*, n.d.).

Vietnam

Vietnam's GDP grew by 2.9 percent during 2020 in spite of the pandemic, the highest of all Asian countries and one of the highest growth rates in the world for 2020 (Lee, 2021). This is the result of a combination of effective COVID-19 containment and growth in the manufacturing sector for exports. Despite this, household income declined by 45 percent in 2020 compared to 2019, mostly due to the sharp decline in the goods and service sector driven by a drop in tourism (*Vietnam Overview*, 2021). However, recovery in domestic demand and manufactured exports have put Vietnam's GDP on track to grow by 6.6 percent in 2021.

Nigeria

The Covid-19 pandemic had a two-pronged effect on Nigeria. With the first case appearing in January, Nigeria was one of the first countries in Africa to which Covid-19 spread (*Nigeria Overview*, 2020). Lockdowns were put into place restricting travel, however, the response was insufficient to contain the virus. Currently, Nigeria is facing its third wave of Covid-19 despite increased efforts at vaccination (Onyeji, 2021). In addition, the 60% decline in oil prices had disastrous effects on the economy, increasing the fiscal deficit and pushing unemployment to over 30% (*Nigeria Overview*, 2020). The combined economic and public health crises threaten to put even more Nigerians into poverty.

Business Environment

Every year, the World Bank ranks economies based on the ease of doing business (*Rankings*, n.d.). In particular, countries are rated based on the ease of starting a business, dealing with construction permits, getting electricity, registering property, and getting credit. The figure below displays the ranking of countries based on these indicators for 2020, with the case study countries in teal and regional economies in grey for comparison.

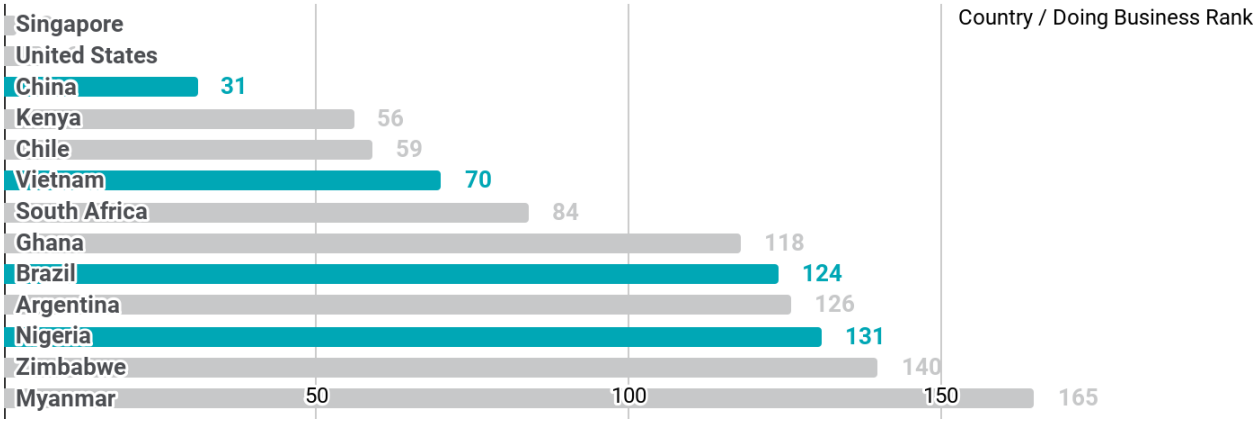

Figure 1.2: Doing Business Rankings Across Countries[2]

Brazil

In recent decades, Brazil has made several improvements in their business environment. Taking advantage of abundant rivers and rainfall, Brazil has constructed several hydroelectric dams that supply 90% of the country's electricity (*Brazil*, n.d.). Currently, customers in Sao Paulo can expect an average of 3.5 power interruptions during the year with average duration of around 6.3 hours (DBI Brazil, 2020). For comparison, the averages in North America are 1.1 yearly interruptions with durations of around 1.5 hours (DBI United States, 2020). Brazil also recently invested in new highway construction so that paved highways now connect all major points in the country (*Brazil*, n.d.). Some issues that still remain include the high cost of finance, the state of physical infrastructure, domestic regulation that limits competition, and barriers to export.

The table below shows costs associated with starting and running a business in Brazil. Overall, Brazil ranks 124th in the world for its ease of doing business indicators (DBI Brazil, 2020). In the Latin America and Caribbean Region, Brazil ranks 4th.

[2] World Bank (2020) "Ease of Doing Business Rankings." www.doingbusiness.org/en/rankings

Table 1.1: Cost of Doing Business in Brazil 2020

Indicator	Days Required	Cost	Rank
Starting a business	21.5	5.1% of annual income per capita	138
Dealing with construction permits	384	1.3% of warehouse value	170
Getting electricity	132	333% of income per capita	98
Registering property	24.5	3.6% of property value	133
Paying Taxes	188 (per year)	35% of profit	184

Source: Doing Business Report 2020

China

With an abundance of labor and strong levels of infrastructure, China has been an attractive location for businesses for many years (*The Economic Context of China*, 2021). To ensure a sustainable growth path, China will need to address the following issues: an ageing population combined with a shrinking workforce, the lack of a clear government strategy on arbitrating between reform and growth, high corporate indebtedness, and issues of competitiveness (*China*, n.d.).

The table below shows costs associated with starting and running a business in China. Overall, China ranks 31st in the world for its ease of doing business indicators (DBI China, 2020). In East Asia and the Pacific Region, China ranks sixth. Currently, customers in Shanghai can expect an average of 0.2 power interruptions during the year with average duration of around one hour.

Table 1.2: Cost of Doing Business in China 2020

Indicator	Days Required	Cost	Rank
Starting a business	9	1.1% of annual income per capita	27
Dealing with construction permits	111	2.8% of warehouse value	33
Getting electricity	32	0.0% of income per capita	12
Registering property	24.5	3.6% of property value	28
Paying Taxes	18 (per year)	62.6% of profit	105

Source: Doing Business Report 2020

Vietnam

A significant challenge to continued economic growth in Vietnam is the lack of human capital and infrastructure (Dione, 2020). While Vietnam has made huge strides in providing technical training and postsecondary education and the development of roads, ports and airports, population growth is growing faster than investment. Despite economic liberalization in the last decades, private companies in Vietnam still face several hurdles. Lack of access to credit has posed a severe constraint on independent businesses.

The table below shows costs associated with starting and running a business in Vietnam. Overall, Vietnam ranks 70th in the world for its ease of doing business indicators (DBI Vietnam, 2020). In East Asia and the Pacific Region, Vietnam ranks seventh. Currently, customers in Ho Chi Minh City can expect an average of 1.6 power interruptions during the year with a duration of around 2.1 hours.

Table 1.2: Cost of Doing Business in Vietnam 2020

Indicator	Days Required	Cost	Rank
Starting a business	16	5.6% of annual income per capita	115
Dealing with construction permits	166	0.5% of warehouse value	25
Getting electricity	31	994.2% of income per capita	27
Registering property	53.5	0.6% of property value	64
Paying Taxes	48 (per year)	35% of profit	109

Source: Doing Business Report 2020

Nigeria

Despite being the epicentre for economic activity in Africa, Nigerian businesses face several challenges. Lack of access to credit is the most significant challenge for entrepreneurs in Nigeria ("5 Major Challenges Of Doing Business In Nigeria," 2018). Despite the government implementing financial programs to assist businesses, financial capital is not readily available. Another major challenge is an inadequate power supply. In Lagos, companies connected to the government-run electrical grid can expect several outages every day. Relying on generators to supplement electricity during outages can run companies' power bills eight times more expensive than the monthly electricity bill from the government (McDonnell, 2019). Other significant challenges include bureaucracy and red tape along with corruption and bribery ("5 Major Challenges Of Doing Business In Nigeria," 2018).

The table below shows costs associated with starting and running a business in Nigeria. Overall, Nigeria ranks 131th globally for its ease of doing business indicators (DBI Nigeria, 2020). Out of the Sub-Saharan African countries, Nigeria ranks 17th.

Table 1.3: Cost of Doing Business in Nigeria 2020

Indicator	Days Required	Cost	Rank
Starting a business	7	26.2% of annual income per capita	105
Dealing with construction permits	111	4.8% of warehouse value	55
Getting electricity	119	297.9% of income per capita	169
Registering property	105	11.1% of property value	183
Paying Taxes	44 (per year)	34.8% of profit	159

Source: Doing Business Report 2020

Methodology

Revenue

The scenario being considered is a processing plant capable of producing approximately 90 million kilograms of plant-based meat (200 million pounds) per year. The plant will produce three recipes using a rotating schedule. The production dedicated to each recipe is based on each country's current consumption of beef, pork, and chicken. Utilized capacity is estimated using the average industrial capacity utilization in each country.[3] Using the average utilized capacity across different countries captures the differences in production across countries in terms of availability of utilities and labor. The largest difference is in Nigeria, where the average utilized capacity in the country is 46%, leading to lower production levels in Nigeria than in other countries. Each plant's utilized capacity increases throughout the first year and then remains constant. A percentage of the plant's production will be lost due to processing inefficiencies, losses to bad batches and post-production losses. Losses are expected to be high throughout the first year of operation and decrease to 20% of utilized capacity by the second year and then remain constant.

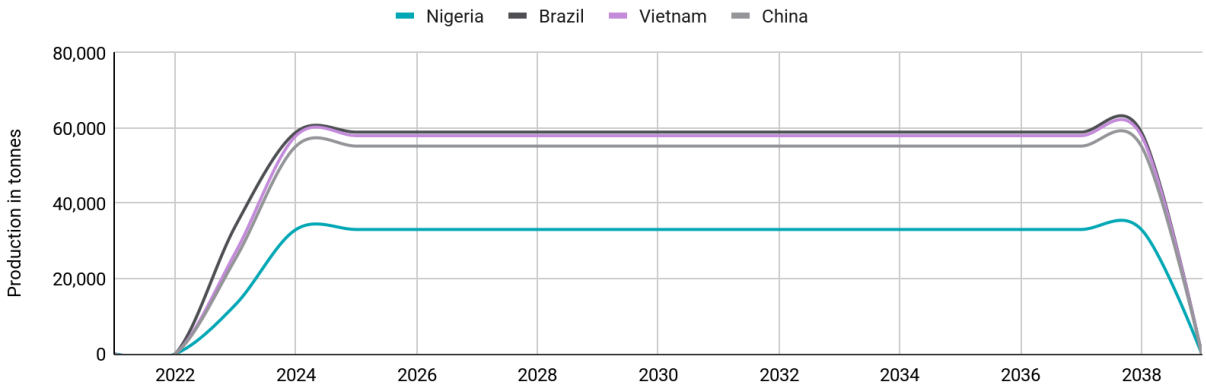

Figure 2.1: Production across countries

Pricing

The beef, pork, and chicken recipes are all expected to be priced differently. There is also a price differential between sales to grocery stores and to restaurants (or distributors). An average weighted price is estimated which takes into account the shares of production dedicated to different market segments and recipes, and how prices vary across recipe and market segments.

[3] https://tradingeconomics.com/country-list/capacity-utilization

Prices are estimated in the first year based on the average price premium for plant-based products above meat. Prices then converge towards the price of meat over a period of ten years. The share of production for each recipe is modelled after the percentage intake of beef, pork and chicken in the average person's diet living in each country.

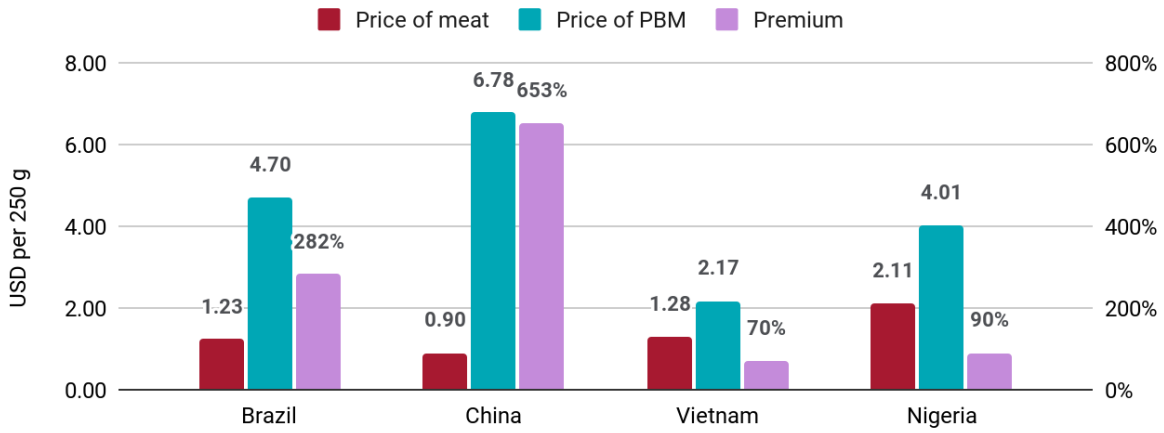

Figure 2.2: Pricing of Meat and Alternatives Across Countries

This technique has limitations. The first is that it depends on an existing plant-based meat market and how comparable these products are to conventional meat. The second is that the average price for meat and plant-based meat products is calculated using a weighted average of beef, pork, and chicken consumption. Therefore, the existing consumption levels for plant-based meat are not factored in. The third is that this approach does not consider how the change in prices will impact demand, which is a major limitation to this research.

To better understand the relationship between the price and quantity consumed, measures of affordability must enter the picture. This issue is discussed more in the subsection "Market for Plant-Based Meat." However, to illustrate the impact of this adjustment on prices, you can see the prices adjusted by purchasing price parity (PPP) in Figure 11.

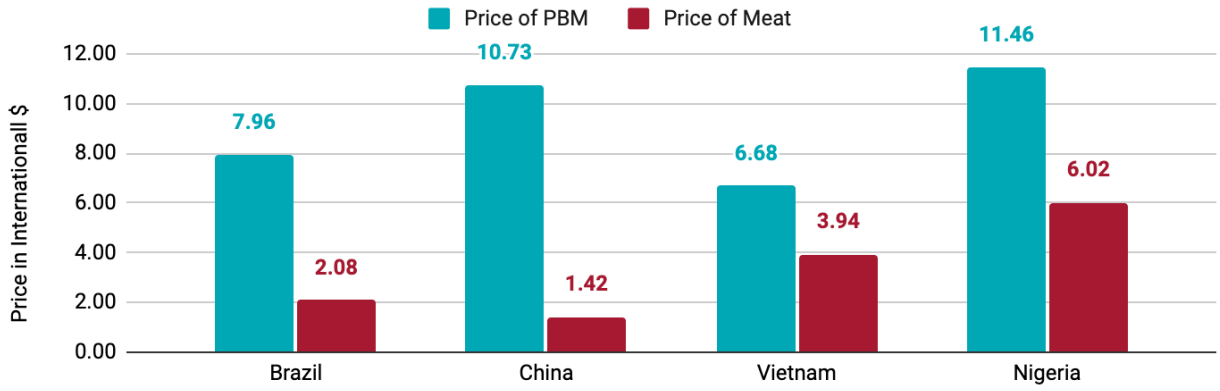

Figure 2.3: Price per 250 g Across Countries in International Dollars

Investment Costs

The investment costs include the purchase of a meat processing facility which would then be retrofitted to be able to produce plant-based products. The retrofitting cost is assumed to be approximately 63 million USD based on estimations from Impossible Foods. The cost of the meat processing plant is based on the cost of a hypothetical pork packing plant in the United States (National Pork Producers Council, 2001) and is then adjusted to accommodate construction and land costs in each country. This estimate includes the construction and purchase of all factory equipment for a 43,000 square meter plant. The investment period is assumed to be two years in length, with the investment costs split evenly across the two years. The cost of starting a business, setting up utilities and other administrative costs are also included in investment costs.

Operational Costs

Operational costs include inputs, utilities, labor, freight, disposal costs, any franchising fees, and taxes. To estimate the cost of utilities, the total amount of water and electricity used were multiplied by their respective prices in each country. Electricity and quantity of water used to produce one unit were adapted from the life cycle assessments for Impossible Foods and Beyond Meat in the United States. Quantity of water includes both the amount of water used in production and used as an input in the recipes. The comparison of these costs across countries in a typical year (2024) is shown below.

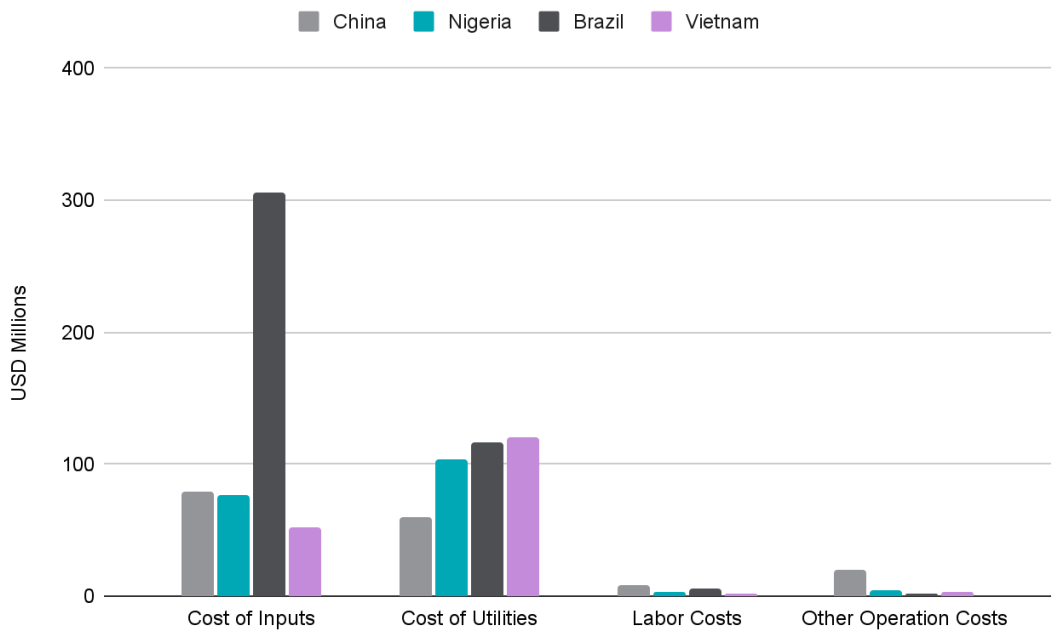

Figure 2.4: Comparison of Costs in 2024 Across Countries

Inputs

Impossible Foods provided the team with multiple recipes for each product. Recipes were then selected for financial analysis in each country based on domestic availability, cost, and diversity of inputs.

Table 2.1: Recipes and inputs in each country

Recipe	Ingredients	Brazil	China	Vietnam	Nigeria
Beef 1	Soy Protein Isolate Rapeseed Oil Dried Sweet Potato		✓	✓	
Beef 2	Soy Protein Isolate Palm Oil Cassava	✓			✓
Pork 1	Dry Beans Soy Protein Isolate Sorghum Flour Groundnut Oil		✓	✓	
Pork 2	Soy Protein Isolate Wheat Palm Oil	✓			✓
Chicken 1	Chickpea Protein Isolate Soy Protein Isolate Wheat Flour Palm Oil		✓		
Chicken 2	Soy Protein Isolate Sweet Potato Groundnut Oil	✓		✓	✓

Cost calculations were based on wholesale price estimates for the ingredients listed above. As the plant-based market is new in many countries, inputs may not be available domestically and may have to be imported. For inputs that need to be imported, the international FOB price was used. If domestic wholesale prices were not available, cost calculations were made by calculating the markup for derivative goods or retail prices from the input in question in a country with similar production capacities. The markup was then deducted from the domestically available derivative or retail prices to create a benchmark estimate for wholesale prices. The real price of food is assumed to grow in Brazil as the food price inflation rate has been consistently higher than the general inflation rate for the past 20 years. In the remaining three countries, food inflation was not significantly different from general inflation, so the real price of food remained constant across years.

Taxes

The cost of income tax was estimated by calculating the annual gross revenue and deducting allowable costs and depreciation of assets. Once taxable income was calculated, the effective tax rate was applied. Value-added tax is calculated by finding the difference between nominal revenue and nominal costs. The rate of value-added tax is then applied to the difference. Property taxes are calculated as a percentage of the value of property value. The property value is estimated from the cost of the meat processing plant. The estimations for taxes assumed that the corporation producing plant-based products is located domestically in Brazil. They may however be paying a franchising fee to an established company for R&D and marketing.

Table 2.2: Taxes Across Countries

Tax Rates	Brazil	China	Vietnam	Nigeria
Income tax	34%	25%	34%	30%
Value-added tax	18%	13%	10%	8%
Property tax	1.5%	1.2%	0.03%	3%

Working Capital

Working capital captures the impact of delayed payments to and from the producer, accounts receivable and accounts payable, respectively. Changes to accounts receivable impact the investment through inflation and are a cost. Changes to accounts payable are a benefit to the producer through the impact of inflation. Working capital also includes cash balance which is the amount of money needed on hand each year and is estimated as a percentage of operating costs.

Analysis of Key Parameters

Inflation

Inflation in the case study countries can impact how prices of plant-based meat and input prices change over time. Compared to inflation in OECD countries, all countries but China have experienced volatile inflation in the past two decades.

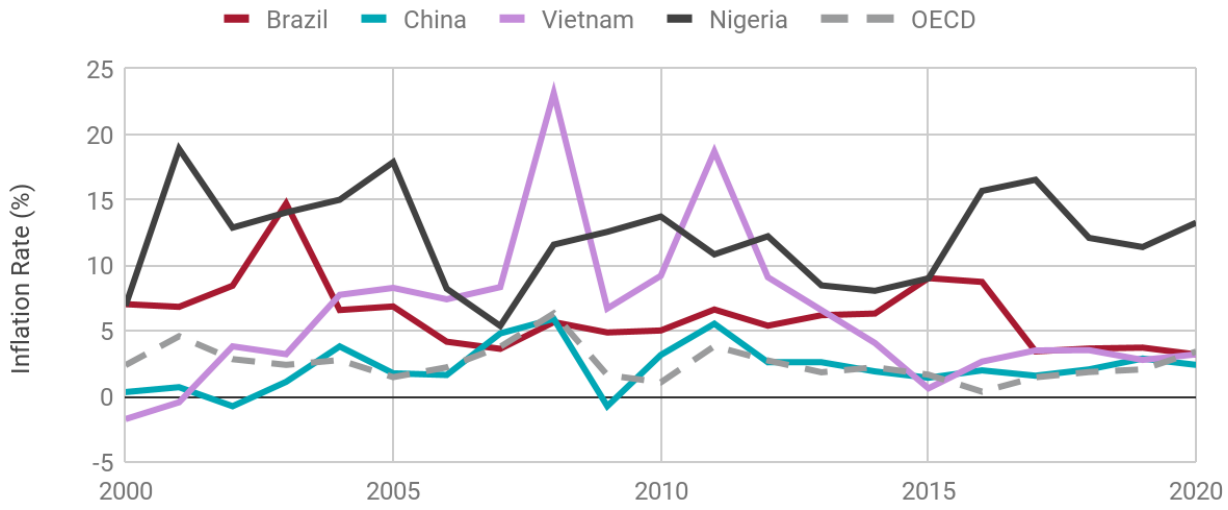

Figure 3.1: Annual Inflation measured by CPI[4]

Brazil

Brazil continuously struggles to control inflation, experiencing two episodes of hyperinflation in the late 1980s and early 1990s. Causes for high inflation include the government's policies of deficit spending, restricted domestic credit, and Brazil's status as a relatively closed economy (Barua & Samaddar, 2021). Since exports and imports only make up one-third of Brazil's GDP, prices are much more sensitive to domestic supply shocks (*Brazil Trade Statistics | WITS*, n.d.). Foodstuffs, which account for 26% of Brazil's consumer price index, are particularly susceptible to inflation (*Brazil Consumer Price Index*, n.d.). In Brazil, most foodstuffs produced for local consumption come from small farms that rely on manual labor and are highly susceptible to weather patterns (*Brazil Food Demand*, n.d.). Unable to compete with the manufacturing and service sector wages, these small farms have difficulty recruiting workers, particularly during periods of low unemployment (Stauffer & Cascione, 2013). Additionally, unpredictable weather patterns and diseases are responsible for driving up prices when harvests are low. Currency weakness, which can drive up international demand for Brazilian foodstuffs and lead to higher prices on

[4] World Bank Data (https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?end=2020&locations=BR&start=2000)

imported food, is another factor in volatile food prices. Other factors that have historically affected food prices in Brazil include transport restrictions and gaps between wholesale and consumer prices.

China

Inflation in China has been fairly stable over the last few decades, matching the trend for OECD countries. Deviations from the OECD trendline are largely the result of volatility in food prices, as food components make up around a third of the CPI basket in China (Day, 2017). Like Brazil, foodstuffs in China are largely susceptible to supply-side shocks. The last two major spikes in food inflation in 2011 and 2019 were due to sudden rises in pork prices. In China, pork products account for a third of the food CPI and a tenth of the overall CPI basket, so even slight changes in prices for pork can have significant income effects on households (Ma, 2011).

Vietnam

Vietnam has suffered from extreme bouts of inflation in the last two decades. One of the contributory factors to the high inflationary period in 2008 were high grain prices, which increased by nearly 70% in 2008 (Kazmin, 2008). Grain is a staple in Vietnam, accounting for nearly half of the Vietnamese CPI basket. Government spending and private credit growth were also responsible for the upward pressure on prices during 2008 and 2011 (Bland, 2011). The tightening of monetary and fiscal policy assisted in the recovery of both inflationary periods. High inflation in Vietnam has contributed to social instability. Between 2008 and 2011, laborers concerned about the rising cost of living took part in more than 2,000 sanctioned labor strikes (Bland, 2012). While the government responded by increasing the minimum wage, the unsanctioned strikes threaten Vietnam's political stability as a one-party state and reduce investment opportunities from manufacturing companies.

Nigeria

Controlling inflation in Nigeria has been a pervasive issue for decades (Soto, 2021). This has led to an increase in poverty and criminal activity as Nigerians seek to supplement their falling incomes with other earnings. These concerns are particularly pertinent in the next few years as inflation is predicted to grow further due to the pandemic and falling oil prices.

Market for Plant-Based Meat

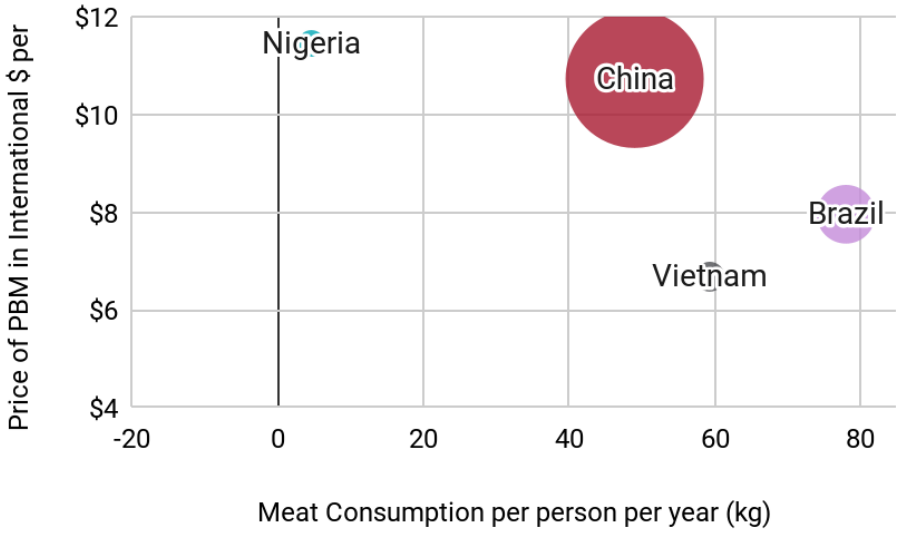

Figure 3.2: Meat Consumption, Price per 250 g of PBM and Population

Impossible's goal in producing plant-based meat in these countries is to contribute to the replacement of meat. It is therefore important to target markets with high levels of meat consumption. This chart provides an overview of the indicators that can help assess the financial attractiveness of countries for investment in PBM production. The horizontal axis indicates the average meat consumption per person, the vertical axis indicates the price of plant-based meat (PBM), and the size of the bubble indicates the population in the top ten most populous cities. Furthermore, the chart shows the diversity of underlying indicators from one country to another, highlighting the need for in-depth analysis and further research on market models for PBM in different countries.

The figure below shows the average price of plant-based meat and meat products in 2020 international dollars. The adjustment to international dollars allows us to look at prices that control the purchasing power parity of local currency. The purchasing power parity conversion factor is the number of units of a country's currency required to buy the same amount of goods and services in the domestic market as a U.S. dollar would buy in the United States (*PPP Conversion Factor, GDP*, 2019). This allows us to not only look at prices that are the same currency but in dollars that can buy the same amount of goods in each country.

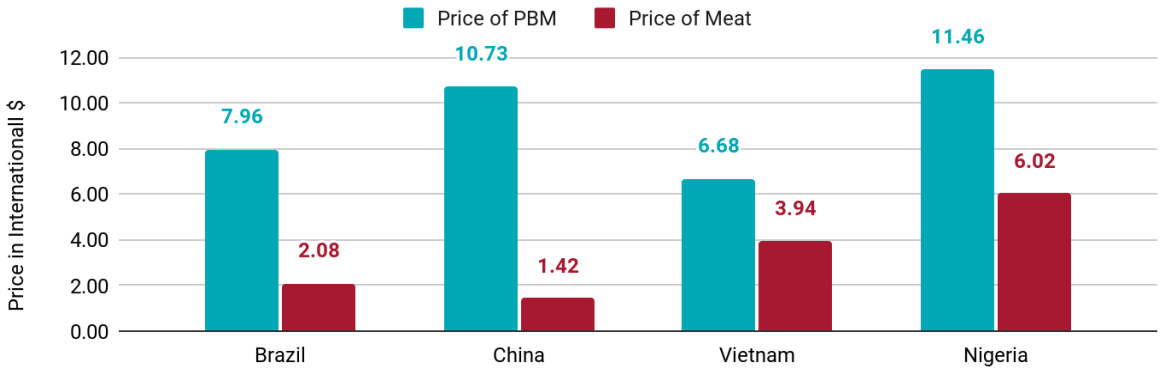

Figure 3.3: Prices of Meat and PBM in International Dollars

Brazil

Brazil is the world's second-largest producer of beef, the third-largest producer of poultry and the third-largest consumer of animal meats (Arnoff, 2020). It is also the world's largest exporter of beef and poultry, exporting over 20% of its production (Ermgassen et al., 2020). However, attitudes towards meat consumption in Brazil are changing. Survey data from 2018 shows that over one-seventh of the population, or thirty million people, consider themselves vegetarian, a 75% increase from 2012 (*IBOPE Survey Shows Historical Growth in the Number of Vegetarians in the Country*, 2018). Furthermore, according to a 2017 survey conducted by Datafolha, over 60% of Brazilians would like to reduce their meat consumption.

These dietary trends are supported by emerging companies specializing in plant-based products. Two of the largest local companies are Fazenda Futuro and New Butchers, which were launched in 2019. Fazenda Futuro, also known as Futuro Farm, has begun to expand into American and European markets and is estimated to be worth R$715 million (around US$135 million) as of 2020 (Vegconomist, 2020). Both these companies sell the majority of their products through grocery store chains like Pão de Açúcar, Oba and Angeloni, in addition to health food stores or plant-based focused stores. According to a Good Food Institute survey, the most common location for consumers buying plant-based meats was supermarkets (GFI, 2018). Growing demand for plant-based alternatives has attracted foreign companies as well. Beyond Meat, an American plant-based meat company, began selling their products in the Brazilian market in mid-2020, offering their products in 19 locations across Sao Paulo (Arnoff, 2020).

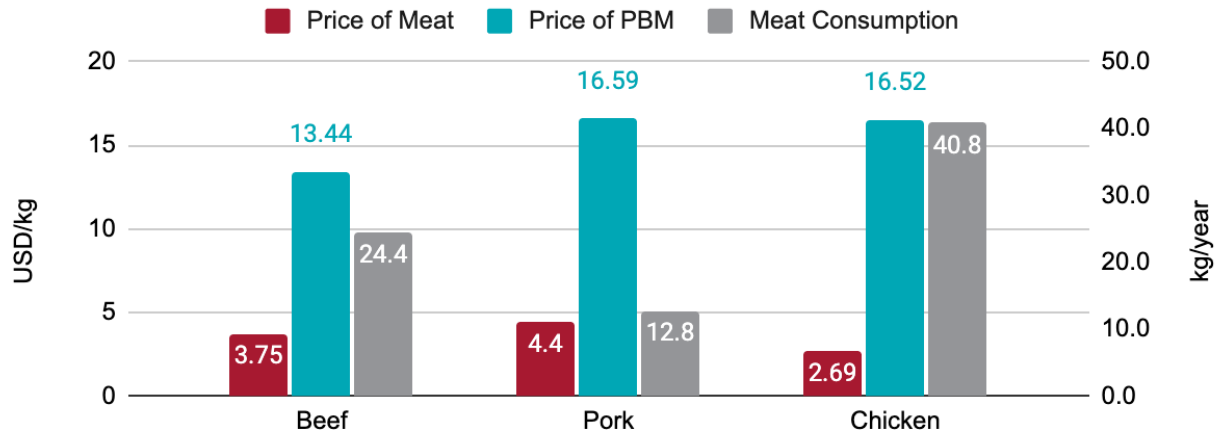

Figure 3.4: Price of Meat and Meat Consumption in Brazil[5]

China

China currently consumes 28% of global meat production and is responsible for half of the world's pork consumption (Campbell, 2021). Per capita meat consumption in China has more than tripled since the late 1980s, from 20 kilograms per capita to 63 kilograms per capita. However, attitudes towards meat consumption are changing due to desires to eat healthier and concerns over animal welfare and the environment. In 2018, China's plant-based meat market was estimated to be worth around $910 million and projected to grow around 20% to 25% annually. In comparison, the market for plant-based meat in the United States was worth $684 million during the same year. Most of this growth comes from the major cosmopolitan cities in China.

The major domestic players in the domestic- market for plant-based meat are Omnifoods, Zhenmea, Starfield and Z-Rou (Campbell, 2021). These companies specialize in making products for restaurant chains, grocery stores and school lunches. There are also over 30 other Chinese startups that are attempting to enter the plant-based protein market. Other foreign companies involved in the plant-based meat market in China include East Just and Beyond Meat. In January of 2021, Chinese fast-food franchise Dicos replaced all real eggs in its breakfast burgers with Eat Just's plant-based egg alternative Just Egg. Beyond Meat recently opened a production facility outside of Shanghai and sells its products in chains across several major cities in China, such as Starbucks, KFC, and Alibaba's Hema supermarket (Liao, 2021).

Current challenges facing the plant-based meat market in China are taste, texture and price (Campbell, 2021). Chinese meat consumers are accustomed to a much greater variety of meat and meat products than western countries. Recreating the taste and texture of these is one of the greatest challenges facing plant-based meat companies. Furthermore, the price differential between grocery store prices of meat and plant-based meat is still

[5] Prices obtained from three grocery stores: SuperNossa, CarreFour, and Pao de Acucar

significant, averaging a difference of over 600% for plant-based meat products at the grocery store (Green Commons, n.d). However, meat prices have been fairly volatile in the past few years, due to sudden increases in feed prices and epidemics like the avian flu and African swine flu that can decimate animal stocks (Campbell, 2021). If plant-based meat can decrease and maintain a relatively stable price, it could make it a more attractive option to Chinese consumers.

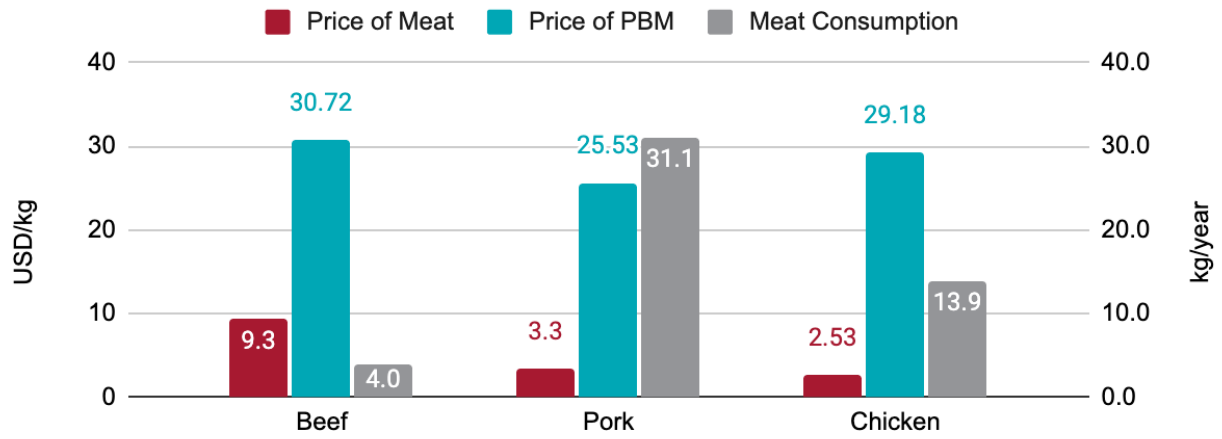

Figure 3.5: Price per kg for Meat and Alternative Products in China[6]

Vietnam

Meat consumption in Vietnam has been on the rise in the past few decades due to growth in income and population (Nguyen & Ngo, 2016). Currently, pork makes up around two-thirds of all meat consumption in Vietnam, followed by poultry and beef. Despite this, at 33.5 kilograms of meat per capita, meat consumption in Vietnam is still relatively low compared to other countries like China or the United States. Because of its vegetarian leaning Buddhist population, Vietnam has had a rich history in producing plant-based proteins. In 2020, the plant-based protein market in Vietnam was worth $249 million and is expected to double by 2025 ("Vietnam's Growing Alternative Protein Market Is Gaining Attention," 2021). The shift to vegan and vegetarian protein options in Vietnam is driven primarily by health concerns, followed by ethical and environmental concerns.

In addition to a wide variety of plant-based proteins available at most grocery stores, vegan and vegetarian restaurants and health food stores are relatively common across Vietnam. Aulac Food Vegetarian Trade Manufacture Co. Ltd, offers a wide variety of mock meats ranging from whole chickens to several varieties of fish, which can also come in frozen, canned or dried forms (*About Us - Thực Phẩm Chay*, n.d.). Currently, the spotlight in the Vietnamese plant-based meat market is on international companies such as ADM, Beyond Meat, VBites, Amy's Kitchen, and Quorn Foods, who have all recently entered or are seeking

[6]Prices for plant-based meat obtained from Green Commons online store

to enter the domestic market in Vietnam ("Demand for Plant-Based Foods, Fake Meats on the Rise," 2021).

Barriers to the success of plant-based meat in Vietnam include underdeveloped domestic supply chains, wider consumer acceptance, taste and price. While Vietnam has significant agricultural potential, the supply chains for the agricultural inputs and technology for processing inputs for plant-based meat are still in their early stages. Most of the current demand for plant-based meat in Vietnam comes from the cosmopolitan areas. Breaking into more rural areas will require more consumer education to increase awareness about the benefits and desirability of plant-based meat (Oei, 2020).

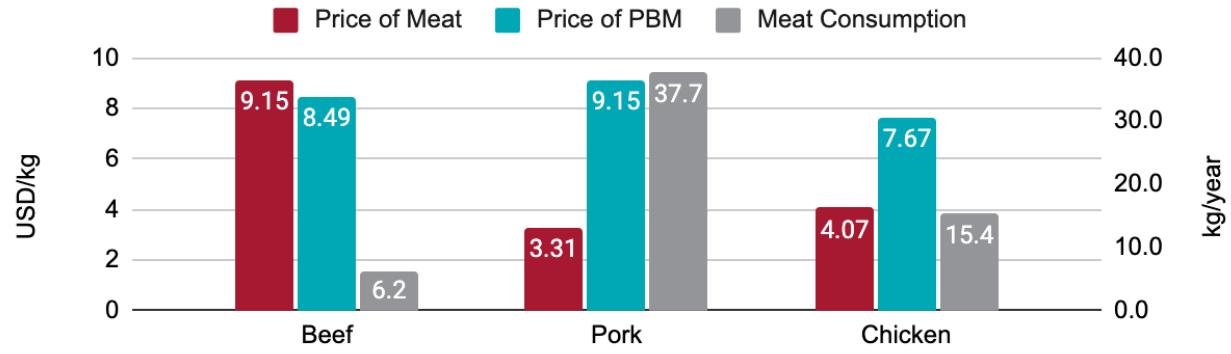

Figure 3.6: Price per kg for Meat and Alternative Products in Vietnam[7]

Nigeria

Meat consumption in Nigeria is very low at around 5 kilograms per capita (*Meat Consumption (Indicator)*, 2021). However, demand for meat is growing, and beef consumption alone is expected to double by 2050 (*Nigeria, Consumes 360,000 Tonnes of Beef Each Year*, 2019). Currently, most of the demand for meat is met by the domestic market. In recent years, beef production, in particular, has received a lot of attention. Confrontations between the nomadic beef herders and sedentary farmers have claimed 7,000 lives between 2014 and 2019 and cost the Nigerian economy around $13 billion. To date, most vegetarian and vegan consumers in Nigeria are foreign-born or Nigerians who have spent time abroad (Enjoli, 2020). There is some evidence of older Nigerians giving up meat on certain days of the week for health reasons.

As of 2021, only one plant-based meat company exists in Nigeria, VeggieVictory, which started selling products in grocery stores in 2016 (*VeggieVictory – Nigeria's First Plant-Based Food Tech Company*, n.d.). Its product, Vchunks, is a dehydrated wheat-based protein made to capture the taste and nutrition of animal meat once cooked. Currently, the product is sold in 12 of the 36 provinces in Nigeria. Prices are around US $4.00 for a 150-gram package, around 90% more expensive than an equivalent serving size of conventional meat. However, VeggieVictory has stated that their goal is to undercut the

[7] Prices for plant-based meat were based off domestic products sold in Dai An Vegan online store

price of meat in Nigeria. VeggieVictory is preparing to become one of the top producers of plant-based meat in all of Africa and has recently received angel investments (Ho, 2020). There are currently no publicly available figures on the market revenue or sales. Chi Farms Limited, a company that has largely focused on poultry production and services in Nigeria, had released plans to launch a plant-based burger across Nigeria in 2020, though no news of the roll-out has since come out (Enjoli, 2020).

A large barrier to the success of plant-based meat in Nigeria is the lack of consumer acceptance. Consuming meat in Nigeria is seen as a status symbol, and refusing to eat meat can be seen as a religious offense. The complexity of this relationship with meat may prove a challenge in increasing the consumption of plant-based meat.

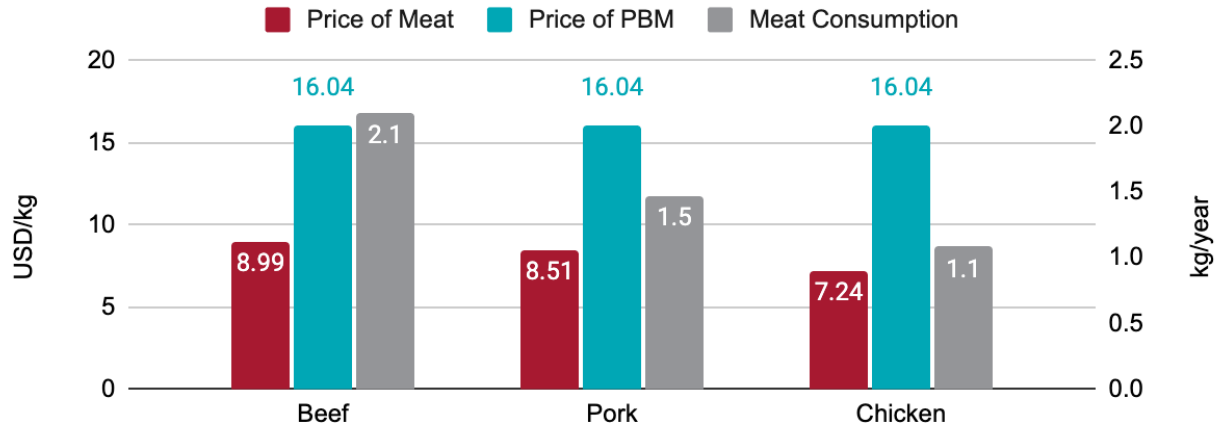

Figure 3.7: Price per kg for Meat and Alternative Products in Nigeria[8]

Supply of Inputs

Brazil

Brazil is well equipped to supply soy protein concentrates and isolates, the main source of protein in several plant-based meats. Archer Daniels Midland (ADM), the current supplier of ingredients for Marfrig and Burger King's vegetarian burger, and Bremil, which has traditionally specialized in additives for meat products, are two local suppliers of a wide range of soy derivatives for plant-based meat production (ADM, 2021).

However, there is still a need for innovation in Brazil relating to manufacturing and ingredient varieties. This means that plant-based meat companies in Brazil may need to import equipment and ingredients that may not be available in the domestic market. Fortunately, the market for plant-based meat ingredients in Brazil is quickly expanding. Milhao, a Brazilian supplier that has typically focused on corn products, and ADM are two

[8] Prices for plant-based meat based off of cooked weight of VeggieVictory Chunks

companies that have begun research into local production of pea-protein concentrate and isolates as well as other high protein flours and pulses (Michail, 2019).

China

Due to social and cultural factors like the prominence of Buddhist vegetarians, imitation meat has been produced in China for centuries (Siu, 2019). In the present day, China is the major supplier of plant-based proteins around the world. Currently, one province in China processes 70% of soy isolate, one of the primary ingredients in many plant-based foods. China also has the capacity to process 50% of the world's pea protein. Other ingredients used in plant-based products, such as mung bean and wheat gluten, are also produced domestically.

Vietnam

While Vietnam does not have a developed domestic supply chain for plant-based proteins, several foreign and domestic companies have met Vietnam's growing demand for plant-based alternatives (*Vietnam Meat Substitutes Market Size, Share & Forecast*, n.d.). These include international firms Sonic Biochem Limited, MGP Ingredients, The Nisshin Ollio Group and domestic firm Bewina Company. Vietnam already produces several agricultural crops often used in plant-based meat, such as jackfruit, konjac and dry peas, though not at a large scale (Huling, 2020). Investment in the production of agricultural inputs for plant-based meat could be spurred by economic programs put in place by the government. Currently, a variety of tax incentives are offered to entities focused on clean, high-tech, and eco-friendly agriculture. In addition, Vietnam is looking to expand its agricultural and aquaculture sectors, with an aim to attract $8 billion in foreign direct investment by 2030. Bewina Company has stated that they are hopeful to source all ingredients domestically in the future ("Demand for Plant-Based Foods, Fake Meats on the Rise," 2021).

Nigeria

Nigeria does not have any established supply chains for plant-based meat, however, it does have the capacity to produce many of the raw agricultural inputs often used in plant-based meat. As of 2018, Nigeria contributed around 5% of the total plant protein market in the African region, with an estimated value of $29.50 million (*Nigeria Plant Protein Market*, 2018). Currently, the majority of growth in the plant-based protein industry comes from dietary supplements sought out by gym-goers and athletes. The main sources of protein came from soy, pea and wheat derivatives. Challenges to the growth in the plant-based protein industry in Nigeria include low infrastructure development, limited foreign investment, technological skills, and few domestic players.

Results

The analysis found that investment in plant-based meat processing and sales has positive returns in each country. Due to the heterogeneity of the contexts across countries, it should be noted that IRR and NPV alone are not the best indicators for presenting the results of this analysis. From this research, the author's found the most meaningful results were in the estimates of costs and the sensitivity analysis which found that the investment is feasible under many price and volume scenarios. More research is needed to identify the most likely scenarios for plant-based meat prices and sales in the future.

The revenue in a typical year outweighs the cost of operating in a typical year (costs and revenues in 2024 are seen in the figure below). This revenue is also significant enough to pay back the investment costs within the first five years (this varies across countries and price scenarios). Brazil has the highest revenue but also has the highest operating costs.

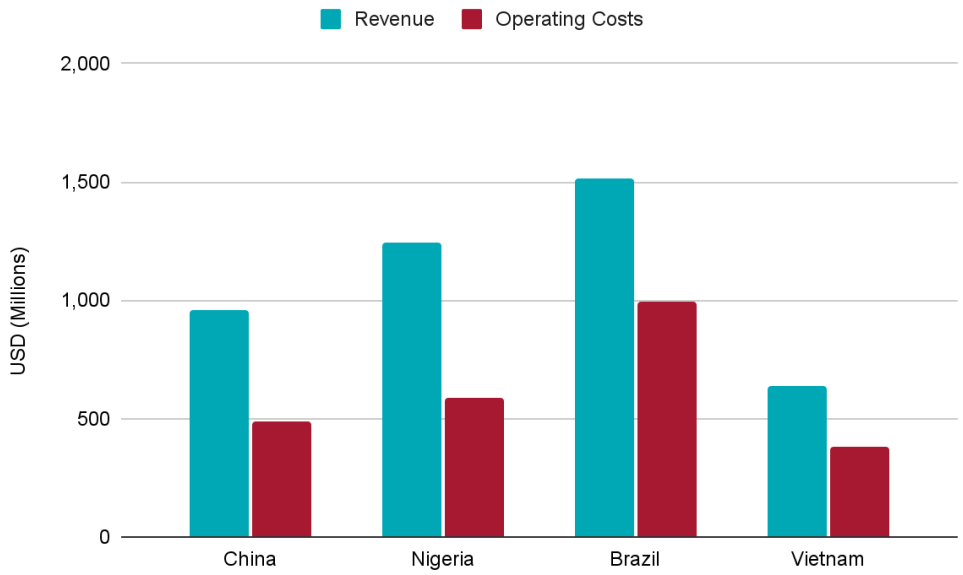

Figure 4.1: Cost and Revenue in a typical year (2024)

The analysis also looked at how the gross margin per 250g changed throughout the years of operation. The main change in gross margin over time is due to the reduction in price in plant-based meat over time. The gross margin per unit in China once plant-based meat reaches price-parity with meat is 0, most likely due to the low price of meat in China. Therefore, it does not seem sustainable to sell plant-based meat at this price. However, meat prices have been volatile in recent years due to supply shocks, and there is reason to believe that meat prices may increase in the future, making it possible for plant-based meat to compete with meat on prices.

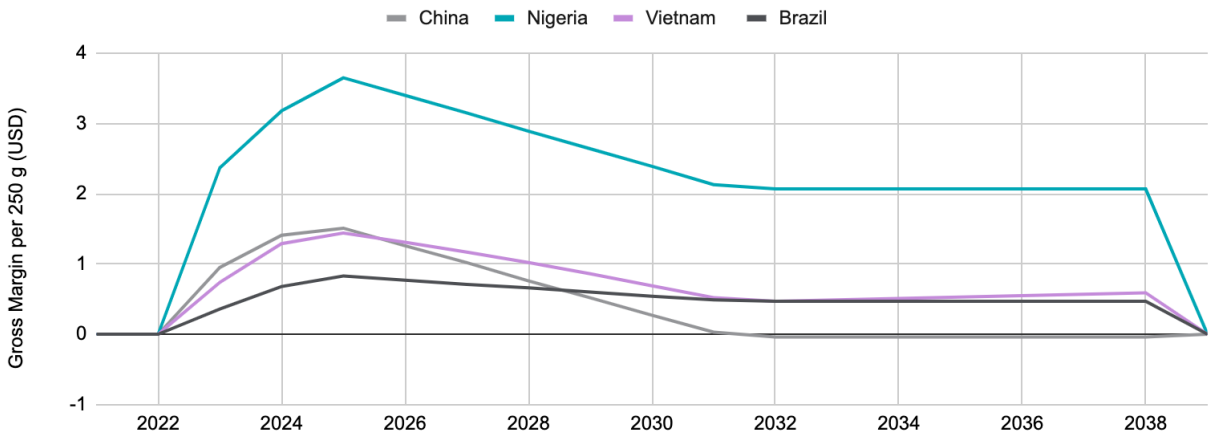

Figure 4.2: Gross Margin per Unit Across Countries

Sensitivity Analysis

This analysis is based on the expected values for sales volume and price based on market information in each country and assumptions by the authors. Due to the uncertainty around the future of the plant-based meat market and to test certain assumptions of the authors, sensitivity analysis was conducted. The results of the sensitivity analysis showed that market price and sales volume are key sources of risk. Despite the uncertainty around these numbers, the sensitivity analysis shows that the investment criteria remain positive across most scenarios.

In order to test the impact of changing critical parameters, sensitivity analysis was conducted. Utilized capacity was a key parameter for sensitivity analysis due to this model's assumption of fixed demand. The analysis assumes that whatever is produced is sold. To test the sensitivity to this assumption, the team looked at scenarios where the plant produced lower levels due to lower than expected demand. Even when utilized capacity is at 30% of installed capacity all countries maintain internal rates of return above 50%. In order to maintain an IRR of over 30%, the utilized capacity only had to reach 13% in Vietnam, 15% in China, 4% in Nigeria, and 5% in Brazil.

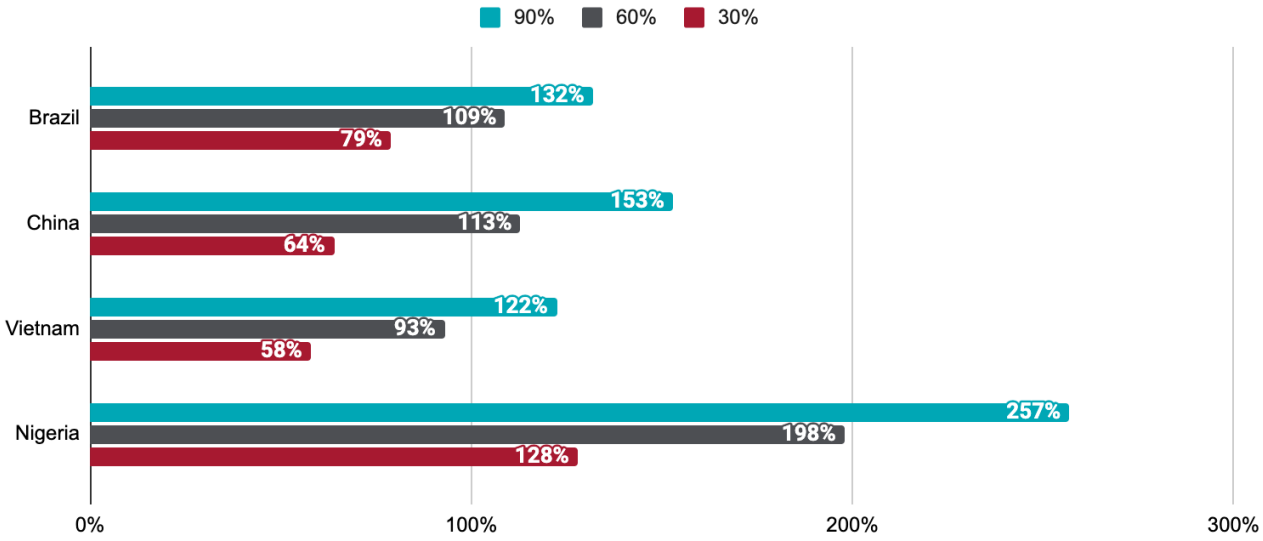

Figure 4.3: Internal Rate of Return and Utilized Capacity

Scenarios were also created looking at how quickly the price of plant-based meat will reach price parity with meat. The most notable result out of this analysis is that it is not feasible to enter the market and match the current price of meat in China. However, plant-based meat may be able to compete with meat with a slower decrease over time, especially given the recent volatility of meat prices. The highest rate of return is in the scenario with 15 years to price parity, however, a major limitation of this model is that it does not capture how consumers respond to price decreases. The other consideration that could justify increased speed to price parity is competition between firms. When all countries reach price parity within five years, they all maintain significantly positive internal rates of return.

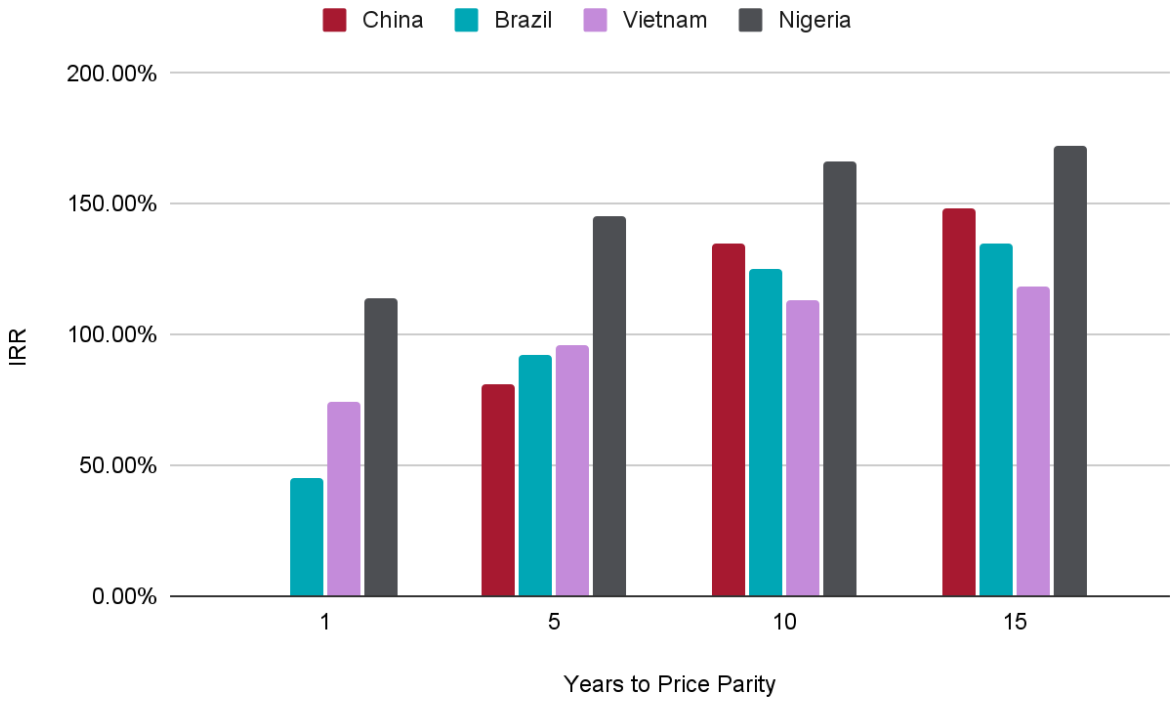

Figure 4.4: IRR and Price Scenarios

Across all countries and recipes, increasing the prices of individual inputs by 100% had only marginal impacts on the investment criteria, with impacts of less than 1% on IRR. Across scenarios for real exchange rate and inflation, all countries maintained an IRR of over 100%. The results of this analysis highlight that the risk of this investment is not primarily in the cost of inputs but rather in the price and sales volume of the outputs.

Discussion & Conclusions

The initial intention of this study was to report the financial viability of the investment using current prices and an assumed sales volume. However, one of the main takeaways from this analysis was that the sales price and sales volume are the most critical parameters in determining the financial viability and risk profile of the investment. Due to the heterogeneity of plant-based meat markets, research is necessary to rigorously forecast the sales price and sales volume in each country. While the results suggest that at current prices the investments are feasible across all four countries, the authors believe further research on the PBM market can drastically improve the accuracy of financial feasibility measures. This section will detail the main findings from this research.

The unit cost and business environment risk significantly vary by country. The study uses the current market price of inputs to the production process, plant utilization rate, and other costs, including taxes, to estimate the unit cost. The inputs vary slightly based on the recipes in each country. Figure ES.1 shows the makeup of unit cost by country in a typical year excluding taxes.

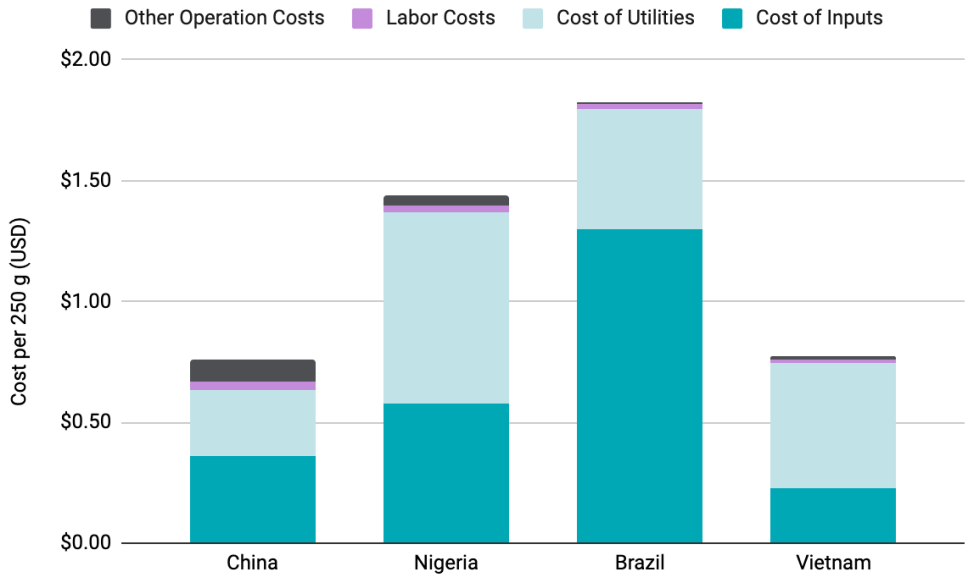

Figure 5.1: Unit Costs Across Countries

The business environment risk relates to the quality and cost of infrastructure, rule of law, and political stability. Some of these parameters are covered by the Doing Business Report. Other sources of data, such as S&P's country risk ratings can help with other measures of stability and country risk.

There is no one single dominant cost item. The cost of inputs is the main driver of costs in China, Nigeria, and Brazil. Vietnam is an exception where utility costs occupy the larger

share. The required inputs vary by recipe, and the recipes use a variety of inputs where no single input is dominant. Furthermore, most raw materials are internationally traded, and their availability and price are less volatile than non-tradable commodities. Therefore, the unit costs estimated by this study are more certain compared to the revenue projections.

The assumptions on sales volume and sales price are the main sources of risk. This study considers market price and sales volume as the key sources of risk. This is especially a concern in Nigeria due to the limited presence of a plant-based meat market and uncertainty about how the products will be accepted by the population of Nigeria.

The market conditions (price and volume) are unique in each country. The authors believe that the nature of the PBM market in these four countries can vary significantly. PBM as a commodity can be marketed in a variety of forms, from a luxury commodity priced at a premium and consumed by a few, to a less expensive alternative to animal meat that can increase the protein consumption for those who cannot afford animal meat. This study uses three indicators to summarize the diversity of the market in the four countries: current meat consumption, current meat prices, and population. These indicators help answer the following questions:

The investments look viable at lower market prices. Even if PBM was sold at the current animal meat prices from the start, the overall benefits of the investment will outweigh its costs in all countries except for China. Figure ES.7 shows the gross margin in a typical year in the scenario where prices match those of animal meat when entering the market.

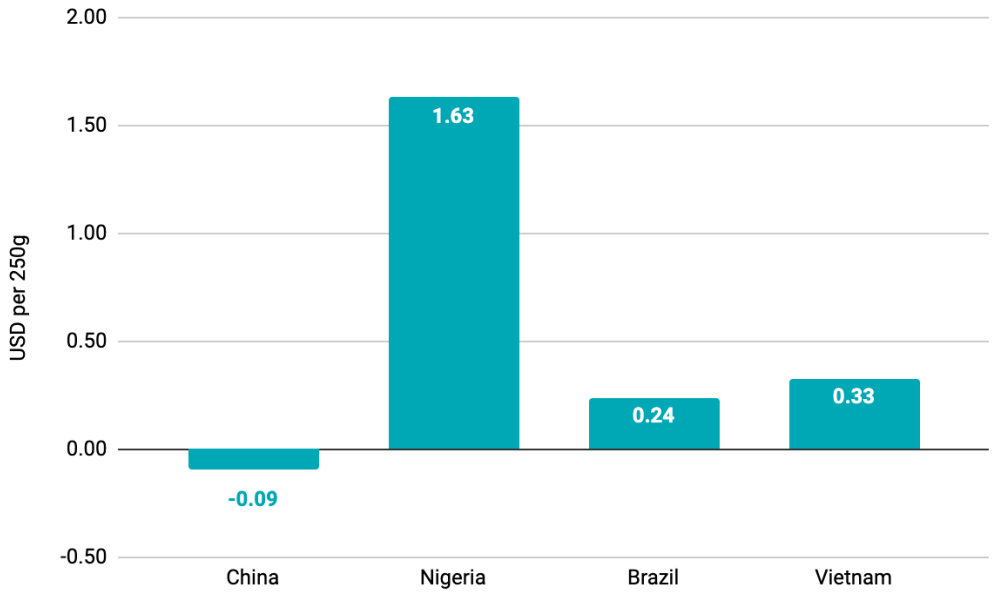

Figure 5.2: Gross Margin in a Typical Year at Price Parity with Animal Meat

5- Affordability adds more insight into the price variation across countries. The price of meat and PBM differs from one country to another. However, once affordability enters the

picture, the differences get even larger. Meat is more affordable in Brazil and China, compared to Vietnam and Nigeria, due to differences in average income. Figure ES.4 shows how the prices of meat compare in current U.S. Dollars and in international U.S Dollars. International U.S. Dollars are adjusted for purchasing power parity.

PBM is currently considered a luxury good in many markets. If there is to be a significant transition from animal meat to PBM, the price must become more affordable to a wider population. The premium charged for PBM over animal meat in the four countries varies from 70% in Vietnam to 653% in China. Such a premium indicates the current market structure where PBM is a luxury item with limited consumption.

The results of this analysis highlight the limitations of a one-size-fits-all approach across contexts. This analysis has found interesting results in terms of estimating costs across contexts and the financial viability given certain assumptions around sales volume and price. However, the study also found that the costs and the revenues can significantly differ from one context to another. The shape and future path of the PBM market in every country can be unique based on the available resources, income level, cultural attributes, population density, and business environment. Therefore, although the production process is very similar, the analysis required to assess the financial feasibility of PBM production cannot be replicated from one context to another without a rigorous analysis of the PBM market.

The market risk creates a case for the use of blended finance. Conducting financial and risk analysis simultaneously allows the team to comment on the financing options required to promote the piloting and scaling of PBM production internationally. This study identifies market price and sales volume as the main sources of risk. Furthermore, the study finds that the investment cost is relatively small compared to operating costs. Therefore, the upfront capital cost is not a major barrier to private investment in PBM production. Assuming that the social and environmental benefits of PBM production and sales justify the engagement of impact-driven actors such as donors, governments, and international development agencies, various forms of off-take contracts can reduce the market risks and make such investments more attractive. While grants and concessional loans can transfer the risk to other parties and cover the upfront cost or the working capital needs, off-take contracts can help reduce the market risk for the early years in operation. Please note that this financing narrative is only a high-level insight and a more detailed analysis of financing options will be required before any concrete recommendations are made.

Areas for Further Research

Further research is needed in this space to estimate likely scenarios for plant-based meat to estimate the expected consumption and price of plant-based meat in different contexts. A particular area of interest is whether there are any lessons that can be learned in countries that have well-established plant-based markets, such as Vietnam.

This research identified that a key area for further research is how the supply chains of inputs to plant-based meat will develop in the upcoming years. Throughout this project, we found that the countries of interest had the raw materials needed; however, these raw materials need to be processed before being used to produce plant-based meat. There is developing processing for these inputs in Brazil and China, but it will be needed at a much larger scale in the future. In countries like Nigeria, scaling up this processing would require a large investment in infrastructure and a stable supply of raw materials that meet the required quality standards to support the processing and sale of these goods.

Another area for future research will be the costs and benefits of plant-based meat production for stakeholders beyond the investors. The transition from meat consumption to plant-based meat proposed in this research will impact each country's environment, employment, and health and nutrition. The impact of plant-based meat on populations needs to be further studied and can be evaluated through a cost-benefit analysis looking at the total impact on the economy.

Limitations

This section will discuss the main limitations of this study. The main goal of this research initially was to assess the feasibility of investment across four countries. Assumptions were made throughout this analysis due to data availability or to simplify the analysis process. The assumptions with major implications for the results of the analysis are those surrounding price and volume of sales. There is more research needed in this area to determine the future likely scenarios for these values. The remaining limitations are surrounding the estimation of costs. These are not a major concern, through sensitivity analysis it was found that changes to costs in these areas only lead to small changes in the investment criteria.

The baseline assumption that the company will not face marketing costs is most likely unrealistic. These costs would be included under the costs of the franchising fee; however, this figure was not estimated by the authors. Brazil, China, and Vietnam already have several plant-based meat companies competing for grocery shelves and restaurant contracts, in addition to large meat companies coming out with their own vegetarian lines. Given the increasing level of competition in the plant-based meat market in these countries, a marketing budget may be necessary to obtain a market share large enough for the scale of production in question. The model also assumes that there is no corporate management. One way to address these issues is the franchising fee, which was left at 0 in the original analysis but can be used for sensitivity analysis.

Another key assumption is that all products are sold in the ground form. However, most plant-based meat companies in Brazil, Vietnam, and China sell their products in several factor forms, such as patties, meatballs, sausages, and more. If this were the case, operating costs might increase due to more specialized machinery and longer production times. In addition, input costs could increase due to differentiated packaging and the inclusion of other ingredients.

This model assumes only three to four inputs per recipe. A more realistic recipe would include many more additives, spices, and preservatives. Including these additional ingredients would increase input costs in the model and affect net cash flows. Other standard operation costs such as insurance, laboratory testing and quality control were not included in this model due to data availability.

Annex

Price of Inputs

For all inputs, costs were calculated in the local currency as a price per kilogram. When a range of prices were available, the average estimate was used. When an input was not domestically available, the international FOB price was used. Exceptions to this method were when it was understood that an input was produced domestically but there was no publicly available information on its bulk pricing. For these situations, the methods used to obtain domestic price estimates are outlined below. Sensitivity analysis was performed on the input prices by observing how the internal rate of return and the net present value would change when input prices fluctuated by 40% in either direction.

Soy Protein Isolate

There are a couple known producers of soy protein isolate in Brazil and Nigeria, however there is no publicly available data on their bulk prices. To calculate the price of soy protein isolate per kilogram, the price differential between international FOB prices for soybeans and soy protein isolate was obtained as a percent and applied to the price of soybeans in Brazil and Nigeria to estimate the price of soy protein isolate produced in corresponding countries.

Table A.1: Price Differential from Soybeans to Soy Protein Isolate (SPI)

Element	Amount	Unit	Source of verification
FOB Price per ton of Soybeans	USD $582.92	ton	*Commodity Prices, n.d.*
FOB Price per ton of SPI	USD $2,150	ton	*EC21 Products Directory, n.d.*
Price differential	368.8%	%	*Calculation*
Brazilian Price per ton of Soybeans	R $276.5	ton	*MF Rural, Brasil, n.d.*
Estimated Price per ton of Brazilian SPI	R $1022	ton	*Estimate*
Nigerian Price per ton of Soybeans	NGN $160,000.00	ton	*Lewis Ray Law, 2021*
Estimated Price per ton of Nigerian SPI	NGN $590,132.44	ton	*Estimate*

Peanut Oil

Peanut oil is produced in Brazil, however, there is little publicly available bulk pricing information. Retail prices from grocery stores can easily be obtained. To calculate what the

bulk price for peanut oil would be, the price differential between bulk and retail prices in the United States was calculated as a percent and was applied to the retail price of peanut oil in Brazil.

Table A.2: Price Differential from Bulk Prices to Retail Prices for Peanut Oil

Element	Amount	Unit	Source of Verification
FOB Price per ton of Peanut Oil	USD $1,880	ton	*Commodity Prices, n.d.*
Retail Price in United States	USD $5.65	ton	*Walmart.com., n.d.*
Price differential	300.5%	%	*Calculation*
Retail Price in Brazil	R $61.84	kg	*Aroma e Amor Essência, n.d.*
Estimated Price per ton of Brazilian Peanut Oil	R $2058	ton	*Estimate*

Packaging Costs

Packaging materials needed per 250 grams of product were calculated using data from Impossible Food Life Cycle Assessment for the Impossible Burger in the United States. It is assumed that the packaging used will be the same in all case study countries. International FOB prices for the different packaging materials were combined to create a single cost estimate for packaging per unit. The final cost per unit was converted into each country's currency using the current nominal exchange rate.

Table A.3: Price of Packaging in USD

Element	Amount	Unit	Source
Price of Plastic film	$2,200	USD/ton	*US$2,170-2,200/tonne of plastic wrap in 2021*
Amount of Plastic film	2.30	grams per kilogram of product	*IF LCA*
Price of Cardboard	$785	USD/ton	*Dezember, 2021*
Amount of Cardboard	10.00	grams per kilogram of product	*IF LCA*
Packaging costs per unit produced	$0.0129	USD/kilogram	*Calculation*

Disposal Costs

When possible, disposal costs were incorporated into the model as a cost per kilogram of waste. Annual waste was calculated using losses based on full capacity operations. The utilized capacity during ramp up and relagular production years was applied to the total disposal costs to capture the differences in production capacity and actual production over time.

Brazil

An estimate for disposal cost per kilogram in Brazil was obtained from a report by the IADB (Solid Waste Management, n.d.). This estimate is reflective of all of Brazil, which requires the assumption that rates in Sao Paulo are approximate of the national average.

China

Disposal costs were not publicly available for Shanghai, the location of the plant in China. Instead, the model uses an estimate for disposal costs per kilogram in Hong Kong, another major cosmopolitan city in China (Wong, 2021).

Vietnam

In Ho Chi Minh City, the location of the plant in Vietnam, disposal fees are collected monthly by the city according to a rate schedule last updated in 2008. It is known that the rate schedule will be changing to reflect updated costs, though the updated rate schedule has not yet been released. To reflect how prices are likely to change, the monthly cost in 2008 is multiplied by the CPI differential between 2008 and 2020. The updated monthly cost is then multiplied by twelve to obtain the annual disposal cost which was used in the model.

Table A.4: Calculations for disposal costs in Vietnam

Element	Amount	Unit	Source of verification
Monthly Cost in 2008	$176,800	VND	*Ihueze, 2015*
CPI Differential between 2008 and 2020	0.91	#	*Calculation*
Monthly Cost in 2020	$337,688.00	VND	*Calculation*
Annual Cost	$4,052,256.00	VND	*Calculation*

Nigeria

In Nigeria, waste collection services are commonly provided by private companies. An estimate for the cost charged per run by a private tipper truck was used to calculate the annual cost. Since this cost estimate was from 2014, it was first updated to reflect inflation.

The number of small tipper trucks needed was then calculated using the maximum cargo weight of the tipper truck and the annual waste of the plant operating at full capacity. The estimate for the annual cost was then obtained from the estimated cost per run of a tipper truck in 2020 and the annual runs needed. From this figure, the average cost per kilogram of waste was calculated.

Table A.5: Calculations for disposal costs in Nigeria

Element	Amount	Unit	Source of verification
Cost per run in 2014	$8,000	NGN/tipper truck	*Ihueze, 2015*
CPI Differential between 2014 and 2020	0.72	#	*Calculation*
Cost per run in 2020	13,760.00	NGN/tipper truck	*Calculation*
Maximum cargo weight of a small tipper truck	7.00	ton	*How Much Can a Dump Truck Carry?, n.d.*
Estimated annual tons of waste	9,906.46	ton	*Input Estimate*
Annual Runs needed	1,416	tipper trucks	*Calculation*
Annual Cost	$11,328,000	NGN	*Calculation*
Cost per kilogram	1.14	NGN/kg	*Calculation*

Freight Costs

It is assumed that Impossible Foods will be transporting their products to the top ten most populous cities in each case study country. The proportion to each city is determined by the size of its population. The number of refrigerated freight trucks needed per city is then calculated, using the maximum weight of a five-axle refrigerated freight truck and the full capacity production volume. Distance between cities was estimated using Google Maps. For the city in which production is located, it is assumed that inner-city travel will be equivalent to 50 kilometers. The utilized capacity during ramp up and regular production years was applied to the total mileage to capture the differences in production capacity and actual production over time. If rates on refrigerated trucks were not available, it was assumed that refrigerated trucks would have a similar rate as regular trucks, the closest alternative.

Brazil

Given that minimum freight rates per kilometer and axle in Brazil decrease with distance, the average distance per trip is used to get a point estimate. Brazil was the only country with publicly available data on rates for refrigerated trucks. Given the average trip distance, the freight rate for refrigerated trucks was equivalent to US $0.13 (ANTT Publishes New Freight Rates, 2019).

Figure A.1: Brazil's Ten Largest Cities by Population

Table A.6: Freight Distance Calculations for Brazil

City	Population (#)	Population (%)	Amount of product (kg)	Distance (km)	# Delivery Trucks	Total Mileage (km)
Sao Paulo	10,021,295	31.38	28,463,046	50	784	39200
Rio de Janeiro	6,023,699	18.86	17,108,849	435	471	204885
Salvador	2,711,840	8.49	7,702,321	1965	212	416580
Fortaleza	2,400,000	7.51	6,816,615	3165	188	595020
Belo Horizonte	2,373,224	7.43	6,740,564	587	186	109182
Brasilia	2,207,718	6.91	6,270,485	1018	173	176114
Curitiba	1,718,421	5.38	4,880,756	408	135	55080
Manaus	1,598,210	5.00	4,539,326	3873	125	484125
Recife	1,478,098	4.63	4,198,177	2648	116	307168
Belem	1,407,737	4.41	3,998,334	2905	110	319550
Total	31,940,242	100	90,718,474		2500	2706904
Average distance per trip:						1082.76

China

Average freight rates per kilometer in China were calculated based off of a round-trip between Zhengzhou and Guangzhou (Huifeng, 2020). This resulted in an estimate equivalent to US $0.93 per kilometer. This estimate was then multiplied to the total annual mileage to create an estimate for annual freight costs.

Figure A.2: China's Ten Largest Cities by Population

Table A.7: Freight Distance Calculations for China

City	Population (#)	Population (%)	Amount of product (kg)	Distance (km)	# Delivery Trucks	Total Mileage (km)
Shanghai	23,400,000	19.29	17,500,514	50	482	24100
Beijing	18,000,000	14.84	13,461,933	1,214	371	450394
Tianjin	12,800,000	10.55	9,572,930	1,086	264	286704
Shenzhen	12,700,000	10.47	9,498,142	1,480	262	387760
Guangzhou	11,600,000	9.56	8,675,468	1,438	239	343682
Chengdu	10,200,000	8.41	7,628,429	1,964	210	412440
Chongqing	8,500,000	7.01	6,357,024	1,674	175	292950
Dongguan	8,300,000	6.84	6,207,447	1,471	171	251541
Shenyang	7,900,000	6.51	5,908,293	1,753	163	285739
Wuhuan	7,900,000	6.51	5,908,293	840	163	136920
Total	121,300,000	100.00	90,718,474		2500	2872230

Vietnam

Average freight rates per kilometer in Vietnam were calculated based on a trip between Ho Chi Minh City and Hanoi (Ishida Masami et al, 2019). This resulted in an estimate equivalent to US $1.24 per kilometer. This estimate was then multiplied to the total annual mileage to create an estimate for annual freight costs.

Figure A.3: Vietnam's Ten Largest Cities by Population

Table A.8: Freight Distance Calculations for Vietnam

City	Population (#)	Population (%)	Amount of product (kg)	Distance (km)	# Delivery Trucks	Total Mileage (km)
Ho Chi Minh City	8,598,700	35.93	32,597,099	50	898	44900
Hanoi	7,520,700	31.43	28,510,473	1593	786	1252098
Hai Phong	2,013,800	8.42	7,634,182	1654	210	347340
Cần Thơ	1,569,301	6.56	5,949,116	170	164	27880
Biên Hòa	1,104,495	4.62	4,187,067	35	115	4025
Đà Nẵng	1,080,700	4.52	4,096,862	840	113	94920
Nha Trang	792,397	3.31	3,003,924	434	83	36022
Vinh	490,000	2.05	1,857,557	1295	51	66045
Hải Dương	403,893	1.69	1,531,131	1608	42	67536
Đà Lạt	356,393	1.49	1,351,062	308	37	11396
Total	23,930,379	100.341226	91,028,029		2499	1952162

Nigeria

Estimates for freight costs in Nigeria were based on transport costs between Lagos and Kano for cattle (Coste, 2014). It is assumed that costs for a refrigerated truck would be similar. This resulted in an estimate equivalent to US $1.70 per kilometer. This estimate was then multiplied to the total annual mileage to create an estimate for annual freight costs.

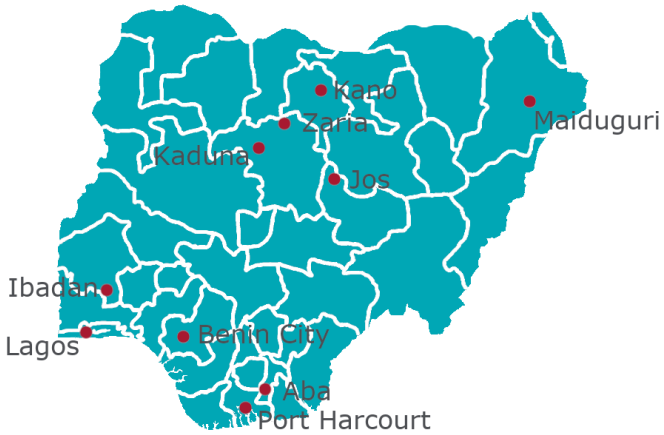

Figure A.4: Nigeria's Ten Largest Cities by Population

Table A.9: Freight Distance Calculations for Nigeria

City	Population (#)	Population (%)	Amount of product (kg)	Distance (km)	# Delivery Trucks	Total Mileage (km)
Lagos	9,000,000	37.74	34,234,822	50	1712	85600
Kano	3,626,000	15.20	13,792,829	991	690	683790
Ibadan	3,565,000	14.95	13,560,793	130	678	88140
Kaduna	1,582,000	6.63	6,017,721	847	301	254947
Port Harcourt	1,149,000	4.82	4,370,646	618	219	135342
Benin City	1,125,000	4.72	4,279,353	1018	214	217852
Maiduguri	1,112,000	4.66	4,229,902	1531	211	323041
Zaria	975,000	4.09	3,708,772	837	185	154845
Aba	898,000	3.77	3,415,874	608	171	103968
Jos	817,000	3.43	3,107,761	957	155	148335
Total	23,849,000	100	90,718,474		4536	2195860

Inflation and Exchange Rates

To accommodate the impact of investments made in the case study countries for investors from the United States, the analysis incorporates the impact of inflation and the exchange rate. The real economic value of revenue and costs are not impacted by inflation, however, a firm can be impacted by inflation through accounts receivable and accounts payable. To forecast how inflation will change over the next 20 years, the analysis looked at the historical data for inflation in case study countries and the United States in the past 20 years. The average change was used as a forecast for future years and it was assumed that inflation would remain constant over the next twenty years. Revenue and costs are calculated in the currency of the case study country and converted to US Dollars using the real exchange rate. In order to forecast the exchange rate over the next twenty years, the historical data of the past twenty years was analysed to look for a trend.

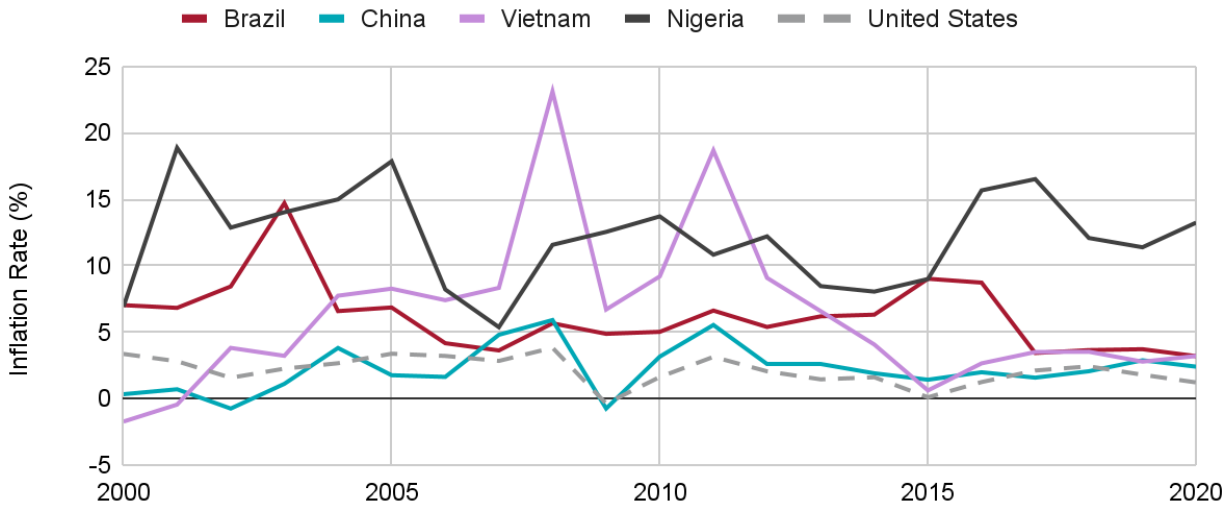

Figure A.5: Inflationary Trends for United States and Case Study Countries[9]

Brazil

Over the past twenty years in Brazil there has been a small upward trend in the nominal exchange rate for Brazil as seen in the chart below. The upward trend is particularly evident after 2012. The real exchange rate over the past twenty years has averaged 2 BRL per USD. In recent years, the real exchange rate has been closer to 3 BRL. Due to the changes in the exchange rate, the sensitivity analysis incorporates two scenarios into the model. The first scenario and the baseline scenario, assumes that the exchange rate will remain at the higher level of 3 BRL per USD. The second scenario assumes the exchange rate returns to 2 BRL per USD.

[9] World Bank Data (https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG?end=2020&locations=BR&start=2000)

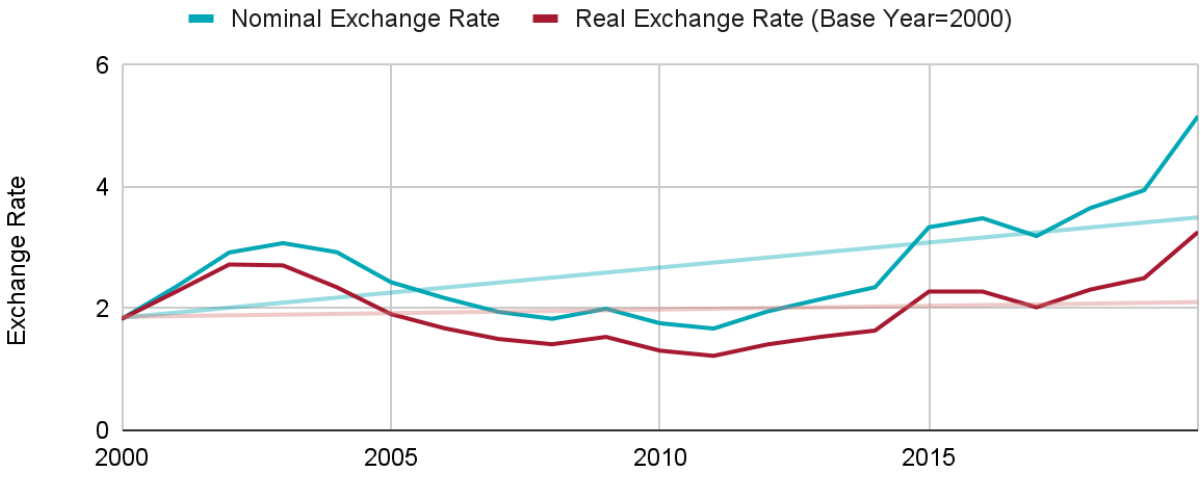

Figure A.6: Historical BRL to USD Exchange Rate

China

In contrast to Brazil, the nominal exchange rate in China demonstrates a small downwards trend in the real exchange rate. However, in the last five years, the trend has been reversed as the nominal and real exchange rates have converged. The real exchange rate over the past twenty years has averaged 6.67 CNY per USD. In the last 5 years, the real exchange rate has been closer to 6.73. The ten year average for the real exchange rate is slightly lower than the two other averages at 6.57. We opted to use the five year average as the baseline scenario for the model, and incorporated the ten and fifteen year average into the sensitivity analysis.

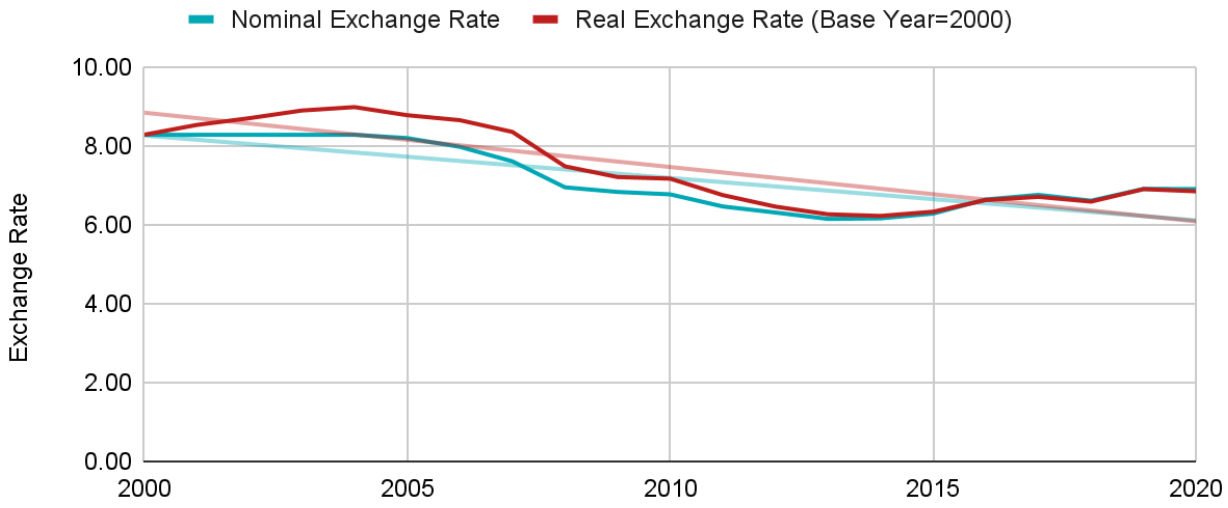

Figure A.7: Historical CNY to USD Exchange Rate

Vietnam

There is a strong upward trend in the nominal exchange rate for Vietnam from 2000 to 2020. During this time the nominal exchange rate increased by over 60%. During the same period, the real exchange rate maintained a slight downward trend, though in the last two years, it has surpassed the baseline value in 2000. The real exchange rate over the past twenty years has averaged 18,745.19 VND per USD. In the last 5 years, the real exchange rate has been closer to 22,633.15. The ten year average for the real exchange rate is slightly lower than the two other averages at 21,828.25. We opted to use the five year average as the baseline scenario for the model, and incorporated the ten and fifteen year average into the sensitivity analysis.

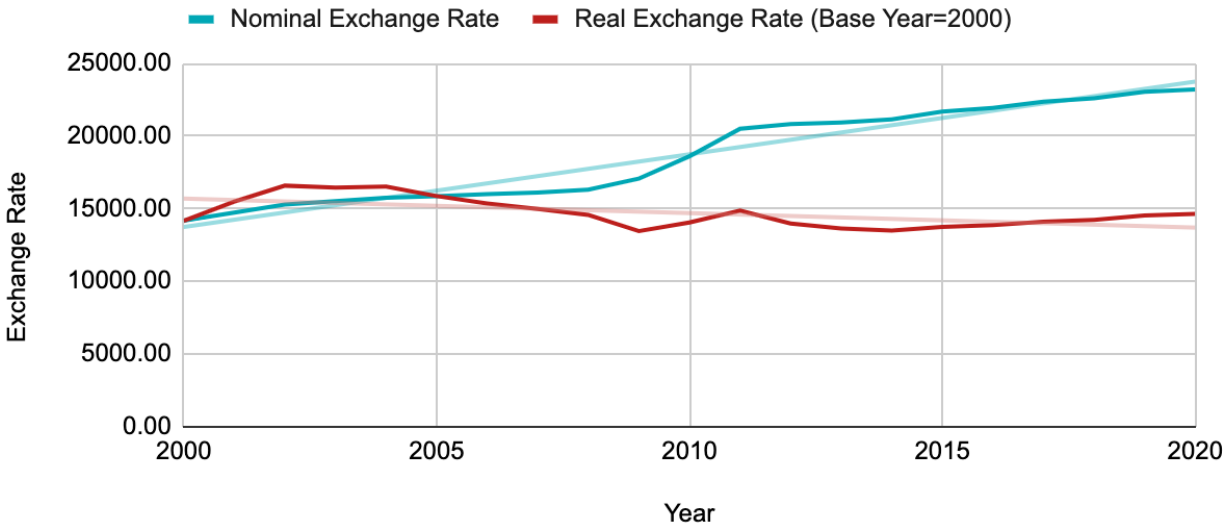

Figure A.8: Historical VND to USD Exchange Rate

Nigeria

Similar to Vietnam, there is a strong upwards trend in the nominal exchange rate in Nigeria. Between 2000 and 2020, the nominal exchange rate more than tripled from 101.70 NGN to USD to 358.81 NGN to USD. The real exchange rate had an upwards trend that was much more stable than the nominal exchange rate. The real exchange rate over the past twenty years has averaged 99.76 NGN per USD. In the last 5 years, the real exchange rate has been closer to 135.20. The ten year average for the real exchange rate is slightly lower at 109.53. We opted to use the five year average as the baseline scenario for the model, and incorporated the ten and fifteen year average into the sensitivity analysis.

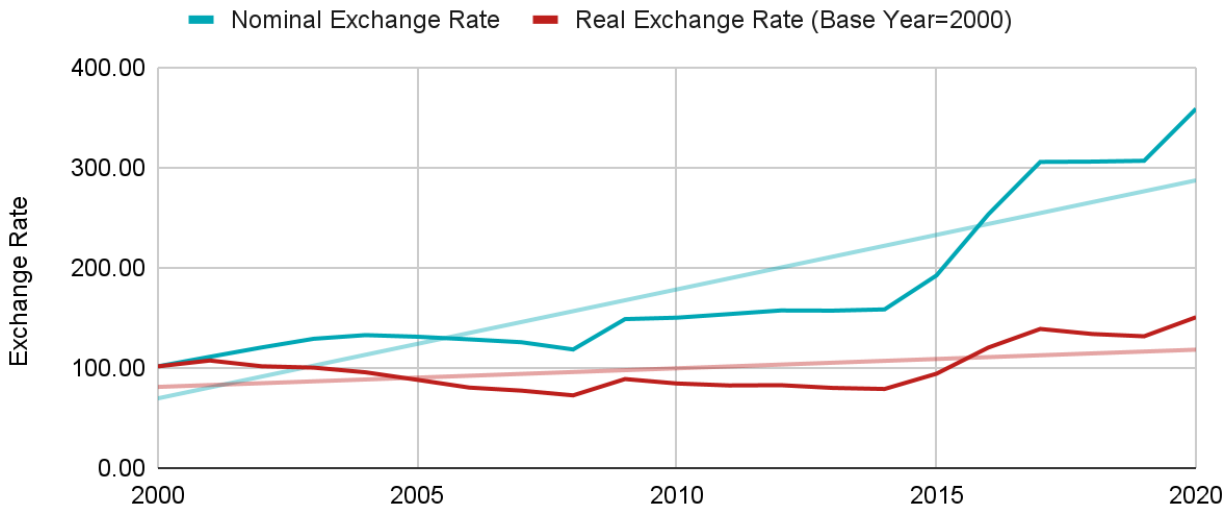

Figure A.9: Historical NGN to USD Exchange Rate

Sources

5 Major Challenges Of Doing Business In Nigeria. (2018, June). *Invoice*. https://invoice.ng/blog/challenges-of-doing-business-in-nigeria/

ABOUT US - *Thực Phẩm Chay*. (n.d.). Retrieved August 10, 2021, from https://aulac-vegan.com/en/about-us/

ADM. (2021, August 10). *Products and Services* (https://www.adm.com/) [Text/html]. ADM; ADM. https://www.adm.com/adm-worldwide/brazil/products

Akinwale, A. (2010). The Menace of Inadequate Infrastructure in Nigeria. *Undefined*. https://www.semanticscholar.org/paper/The-Menace-of-Inadequate-Infrastructure-in-Nigeria-Akinwale/0cc821d9d6407f6cc2a403a5a8dc62769d1bc012

Anthony, C. (2021). *Which 10 Countries Have the Most Natural Resources?* Investopedia. https://www.investopedia.com/articles/markets-economy/090516/10-countries-most-natural-resources.asp

Arnoff, A. (2020). *Beyond Meat Announces Brazil Market Entry*. https://www.beyondmeat.com/wp-content/uploads/BYMT-x-Brazil-Market-Entry-Press-Release_July-2020.pdf

Baker, A. (2020). *Why Africa's COVID-19 Outbreak Hasn't Been as Bad as Everyone Feared*. Time. https://time.com/5919241/africa-covid-19-outbreak/

Barua, A., & Samaddar, M. (2021). *Brazil Economic Outlook*. Deloitte Insights. https://www2.deloitte.com/us/en/insights/economy/americas/brazil-economic-outlook.html

Blaettler, K. (2018). *A List of China's Natural Resources*. Sciencing. https://sciencing.com/list-chinas-natural-resources-5375735.html

Bland, B. (2011, February 11). Inflation fears as Vietnam devalues dong. *Financial Times*. https://www.ft.com/content/233c8170-35a1-11e0-b67c-00144feabdc0

Bland, B. (2012). *Vietnam's factories grapple with growing unrest—The Globe and Mail*. https://www.theglobeandmail.com/report-on-business/international-business/vietnams-factories-grapple-with-growing-unrest/article536292/

Brazil | History, Map, Culture, Population, & Facts. (n.d.). Encyclopedia Britannica. Retrieved August 9, 2021, from https://www.britannica.com/place/Brazil

Brazil Consumer Price Index (CPI) | 1979-2021 Data | 2022-2023 Forecast | Historical. (n.d.). Retrieved August 9, 2021, from https://tradingeconomics.com/brazil/consumer-price-index-cpi

Brazil Economic Outlook. (n.d.). Deloitte Insights. Retrieved August 10, 2021, from https://www2.deloitte.com/us/en/insights/economy/americas/brazil-economic-outlook.html

Brazil Food Demand. (n.d.). Adama. Retrieved August 9, 2021, from http://www.adama.com/en/our-commitment/global-farming/farming-stories/brazil-food-demand

Brazil Inflation Rate | 1980-2021 Data | 2022-2023 Forecast | Calendar | Historical. (n.d.). Retrieved August 10, 2021, from https://tradingeconomics.com/brazil/inflation-cpi

Brazil Overview. (n.d.). [Text/HTML]. World Bank. Retrieved August 10, 2021, from https://www.worldbank.org/en/country/brazil/overview

Brazil Trade Statistics | WITS. (n.d.). Retrieved August 9, 2021, from https://wits.worldbank.org/countryprofile/en/bra

Brazil—Share of economic sectors in the gross domestic product 2010-2020. (n.d.). Statista. Retrieved August 9, 2021, from https://www.statista.com/statistics/254407/share-of-economic-sectors-in-the-gdp-in-brazil/

Campbell, C. (2021). *How China Could Change the World By Taking Meat Off the Menu*. Time. https://time.com/5930095/china-plant-based-meat/

China. (n.d.). Coface for Trade. Retrieved August 10, 2021, from https://www.coface.com/Economic-Studies-and-Country-Risks/China

China | Culture, History, Maps, & People. (n.d.). Encyclopedia Britannica. Retrieved August 9, 2021, from https://www.britannica.com/place/China

China Overview. (n.d.). [Text/HTML]. World Bank. Retrieved August 10, 2021, from https://www.worldbank.org/en/country/china/overview

Conceição, P. & United Nations Development Programme. (2019). *Human development report 2019: Beyond income, beyond averages, beyond today: inequalities in human development in the 21st century*.

Day, I. (2017). Underlying Consumer Price Inflation in China | Bulletin – December Quarter 2017. *Bulletin*, *December*. https://www.rba.gov.au/publications/bulletin/2017/dec/4.html

Demand for plant-based foods, fake meats on the rise. (2021a). *Viet Nam News*. https://vietnamnews.vn/economy/914896/demand-for-plant-based-foods-fake-meats-on-the-rise.html

Demand for plant-based foods, fake meats on the rise. (2021b). *Viet Nam News*. http://vietnamnews.vn/economy/914896/demand-for-plant-based-foods-fake-meats-on-the-rise.html

Dione, O. (2020). *Vietnam: Doing Business 2020, Challenges and Solutions* [Text/HTML]. World Bank. https://www.worldbank.org/en/news/speech/2020/01/08/speech-by-ousmane-dione-world-bank-country-director-for-vietnam-at-the-event-vietnam-doing-business-2020-challenges-and-solutions

Editor, C. (2021, July 7). Current Price of Soybeans Per Ton in Nigeria (July) 2021. *LewisRayLaw*. https://lewisraylaw.com/soybeans-prices-nigeria/

Enjoli, A. (2020, March 19). *Vegan Nigerian Burgers Are Launching Across the Country*. LIVEKINDLY. https://www.livekindly.co/vegan-nigerian-burgers-are-launching-across-the-country/

Ermgassen, E. K. H. J. zu, Godar, J., Lathuillière, M. J., Löfgren, P., Gardner, T., Vasconcelos, A., & Meyfroidt, P. (2020). The origin, supply chain, and deforestation risk of Brazil's beef exports. *Proceedings of the National Academy of Sciences*, 117(50), 31770–31779. https://doi.org/10.1073/pnas.2003270117

George, L. (2020, February 6). Vegans see green shoots in meat-loving Nigeria. *Reuters*. https://www.reuters.com/article/us-nigeria-food-vegans-idUSKBN20022D

Ho, S. (2020, August 6). Nigeria's First Plant-Based Company VeggieVictory Attracts Angel Investment. *Green Queen*. https://www.greenqueen.com.hk/nigeria-first-plant-based-company-veggievictory-attracts-angel-investment/

Huling, R. (2020). *Vietnam could grow key ingredients for plant-based meat—VnExpress International*. VnExpress International.

https://e.vnexpress.net/news/perspectives/vietnam-could-grow-key-ingredients-for-plant-based-meat-4204723.html

IBOPE survey shows historical growth in the number of vegetarians in the country. (2018). Sociedade Vegetariana Brasileira. https://www.svb.org.br/2473-vegetarians-in-brazil

Inequality in China | Bruegel. (2018). https://www.bruegel.org/2018/09/inequality-in-china/

Kazmin, A. (2008, May 27). Vietnam's inflation rate surges above 25%. *Financial Times.* https://www.ft.com/content/674849da-2c03-11dd-9861-000077b07658

Lee, Y. N. (2021a, January 28). *This is Asia's top-performing economy in the Covid pandemic—It's not China.* CNBC. https://www.cnbc.com/2021/01/28/vietnam-is-asias-top-performing-economy-in-2020-amid-covid-pandemic.html

Lee, Y. N. (2021b, April 21). *Here are the 10 biggest economies in the world—Before the pandemic vs. Now.* CNBC. https://www.cnbc.com/2021/04/21/coronavirus-worlds-10-biggest-economies-before-covid-pandemic-vs-now.html

Liao, R. (2021). Beyond Meat opens its first production plant in China. *TechCrunch.* https://social.techcrunch.com/2021/04/07/beyond-meat-opens-its-first-production-plant-in-china/

Ma, D. (2011, July 12). *The Meat of China's Inflation Problem.* The Atlantic. https://www.theatlantic.com/international/archive/2011/07/the-meat-of-chinas-inflation-problem/241777/

Masson-Delmotte, V., Portner, H.-O., Skea, J., Zhai, P., Roberts, D., & Shukla, P. (2019). *Climate Change and Land: An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* (p. 874). IPCC. https://www.ipcc.ch/site/assets/uploads/2019/11/SRCCL-Full-Report-Compiled-191128.pdf

McDonnell, T. (2019, November 24). The Powerlessness Of Nigeria's Tech Startups. *NPR.* https://www.npr.org/sections/goatsandsoda/2019/11/24/781132932/the-powerlessness-of-nigerias-tech-startups

Meat consumption (indicator). (2021). OECD. https://data.oecd.org/agroutput/meat-consumption.htm

Michail, N. (2019). *'Giving consumers the power of choice': Marfrig and ADM partner for plant-based burger.* Food Navigatot Latam. https://www.foodnavigator-latam.com/Article/2019/08/06/Marfrig-and-ADM-to-launch-plant-based-burger-in-Brazil

Nguyen, D., & Ngo, K. (2016). *Vietnam's Meat Market: Mind the Gap!* Ipsos. https://www.ipsos.com/en/vietnams-meat-market-mind-gap

Nigeria | History, Population, Flag, Map, Languages, Capital, & Facts | Britannica. (n.d.). Retrieved August 9, 2021, from https://www.britannica.com/place/Nigeria

Nigeria, consumes 360,000 tonnes of beef each year. (2019, June 26). Vanguard News. https://www.vanguardngr.com/2019/06/hunger-for-beef-offers-rewards-and-risks-for-nigerias-pastoralists-2/

Nigeria Overview. (2020). [Text/HTML]. World Bank. https://www.worldbank.org/en/country/nigeria/overview

Nigeria Plant Protein Market—Size, Trends, Competitive Analysis and Forecasts (2018-2023). (2018). Research and Markets. https://www.researchandmarkets.com/reports/4614998/nigeria-plant-protein-market-size-trends

Nigerian economic outline. (2021). Santander Trade Markets. https://santandertrade.com/en/portal/analyse-markets/nigeria/economic-outline

Oei, V. (2020). *Plant-based Meat Alternatives Set to Thrive in the Next Five Years*. Dupont Nutrition and Biosciences. https://www.dupontnutritionandbiosciences.com/news/plant-based-meat-alternatives-set-to-thrive-in-the-next-five-years.html

Onyeji, E. (2021, August). COVID-19: 3rd wave hits harder as Nigeria records highest daily infection in six months. *Premium Times Nigeria*. https://www.premiumtimesng.com/news/headlines/477617-covid-19-3rd-wave-hits-harder-as-nigeria-records-highest-daily-infection-in-six-months.html

PPP conversion factor, GDP. (2019). Index Munid. https://www.indexmundi.com/facts/indicators/PA.NUS.PPP

Rankings. (n.d.). [Text/HTML]. World Bank. Retrieved August 10, 2021, from https://www.doingbusiness.org/en/rankings

Siu, E. (2019). *Discovering China's role in growing the global plant-based industry—The Good Food Institute*. Good Food Institute. https://gfi.org/blog/chinas-role-in-the-plant-based-industry/

Soto, A. (2021). *Surging inflation in Nigeria fuels crime wave, says World Bank*. Aljazeera. https://www.aljazeera.com/economy/2021/6/15/surging-inflation-in-nigeria-is-fueling-crime-wave-world-bank

Stauffer, C., & Cascione, S. (2013, May 3). Brazil's food inflation: Don't blame it all on the weather. *Reuters*. https://www.reuters.com/article/us-brazil-inflation-idINBRE9420Q120130503

The economic context of China—Economic and Political Overview—Nordea Trade Portal. (2021). Nordea Trade. https://www.nordeatrade.com/en/explore-new-market/china/economical-context

U.S., Vietnam Reach Accord on Currency, Easing the Dispute. (2021, July 19). *Bloomberg.Com*. https://www.bloomberg.com/news/articles/2021-07-19/u-s-vietnam-reach-accord-on-vietnam-s-currency-practices

USD to BRL Exchange Rate. (n.d.). Bloomberg.Com. Retrieved August 9, 2021, from https://www.bloomberg.com/quote/USDBRL:CUR

USD to CNY Exchange Rate. (n.d.). Bloomberg.Com. Retrieved August 9, 2021, from https://www.bloomberg.com/quote/USDCNY:CUR

USD to NGN Exchange Rate. (n.d.). Bloomberg.Com. Retrieved August 9, 2021, from https://www.bloomberg.com/quote/USDNGN:CUR

USD to VND Exchange Rate—Bloomberg Markets. (n.d.). Retrieved August 9, 2021, from https://www.bloomberg.com/quote/USDVND:CUR

Vaswani, K. (2021). *Covid-19: China's economy picks up, bucking global trend—BBC News*. https://www.bbc.com/news/business-55699971

Vegconomist. (2020, September 3). Fazenda Futuro Raises US$22.5 Million in Funds as Plant-Based Industry Grows in Brazil. *Vegconomist- the Vegan Business Magazine*. https://vegconomist.com/companies-and-portraits/fazenda-futuro-raises-us22-5-million-in-funds-as-plant-based-industry-grows-in-brazil/

VeggieVictory – Nigeria's First Plant-Based Food Tech Company. (n.d.). Retrieved August 10, 2021, from https://veggievictory.com/

Veiga e Silva, L., de Andrade Abi Harb, M. D. P., Teixeira Barbosa dos Santos, A. M., de Mattos Teixeira, C. A., Macedo Gomes, V. H., Silva Cardoso, E. H., S da Silva, M., Vijaykumar, N. L., Venâncio Carvalho, S., Ponce de Leon Ferreira de Carvalho, A., & Lisboa Frances, C. R. (2020). COVID-19 Mortality Underreporting in Brazil: Analysis of Data From Government Internet Portals. *Journal of Medical Internet Research*, 22(8), e21413. https://doi.org/10.2196/21413

Vietnam | History, Population, Map, Flag, Government, & Facts. (n.d.). Encyclopedia Britannica. Retrieved August 9, 2021, from https://www.britannica.com/place/Vietnam

Vietnam Meat Substitutes Market Size, Share & Forecast | TechSci Research. (n.d.). Techsi Research. Retrieved August 10, 2021, from https://www.techsciresearch.com/report/vietnam-meat-substitutes-market/2139.html

Vietnam Overview. (2021). [Text/HTML]. World Bank. https://www.worldbank.org/en/country/vietnam/overview

Vietnamese economic outline—Santandertrade.com. (n.d.). Retrieved August 9, 2021, from https://santandertrade.com/en/portal/analyse-markets/vietnam/economic-outline

Vietnam's Growing Alternative Protein Market is Gaining Attention. (2021, May 19). *Asia Perspective*. https://asiaperspective.net/2021/05/19/vietnam-growing-alternative-protein-market-gaining-attention-foreign-investors/