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Leveraging Climate Stabilization Investments to Enhance Agricultural Productivity in Singapore:

In an era where climate change is becoming increasingly apparent, its unpredictable effects on agriculture are causing concern among investors and farmers alike. Worldwide, it is common for investors to rely on predictable seasonal patterns to know when to make consistent profits or when to cut losses. In more recent times, the erratic change in climate poses a significant threat to farmers in terms of their livelihood, and investors who rely on both the weather and farmers to support their investments. This inconsistency introduces additional risk, making agriculture less attractive as an investment for both investors and farmers without a stable way of insuring such losses. However, this leads to the production of financial instruments that could potentially help curb such weather variability in the future, providing a more stable climate for agriculture production. In this essay, I will run through the history behind commodities trading in Chicago alongside Singapore, and how climate refuge cities such as them are still negatively affected by climate change in the long run. I will then explore how investments in climate stabilization technologies could lead to more consistent weather patterns, allowing for better predictions by investors. By investigating the technologies, I aim to demonstrate the potential benefits of stabilizing the climate to enable these investment strategies. These technologies aim to reduce the financial risks associated with unpredictable weather by providing a more stable climate for agricultural production. By mitigating these risks, investors are more likely to invest in local agriculture. This increased investment can lead to enhanced farm productivity and sustainability, as farmers will have the necessary resources to implement advanced agricultural practices and technologies. Ultimately, stabilizing the climate and attracting investment will support a more resilient and productive agricultural sector in Singapore.

Although both Singapore and Chicago may initially seem unrelated in the field of commodities trading, both cities are now widely known as financial hubs, despite their emphasis differing. Chicago being the founder of commodities trading, has its roots and initial growth of grain trade and farmland processing being an outcome of taking advantage of the Civil War (Davis, 2024), whereas Singapore being a trading port, had its economy heavily reliant on global trade due to its lack of natural resources and great location, along the historical maritime trading route between China and Europe (Hirschmann, 2023). Agriculturally, each city sees vastly different outcomes. Chicago has had a flourishing agricultural scene throughout history, whereas Singapore is more well-known for being an importer of goods and having little to no natural resources. In the past, Singapore held a rather thriving agricultural commodities trading scene, around the 1980s and 1990s, where agrotechnology parks were developed to aid in the production of commercial farms (Food for Thought, 2015). However, in 2020, there was a collapse of Hin Leong Trading, an oil trading firm, one of Asia's largest oil traders, amounting to around $800 million (Bloomberg, 2020), debt of nearly $4 billion to over 20 banks (The Straits Times, 2020), and severely affected the viability of commodities trading in Singapore. The Hin Leong Trading crash resulted in the tightening of commodities trading practices in Singapore, reducing the growth and liquidity of the market.

Both Chicago and Singapore are often considered climate havens, as they are less severely affected by the adverse impacts of climate change, such as extreme weather events, temperature fluctuations, and variations in rainfall. This relative stability supports consistent and sustainable crop yields, providing a more predictable environment for living and economic activities, which in turn bolsters their commodities trading sectors. However, despite their geographical advantages, these climate havens are not immune to the global phenomena of climate change. In recent years, Chicago has experienced its warmest periods since the late 1990s, contrasting sharply with the coldest periods recorded around the late 1870s (National Weather Service, 2024). Figure 1 illustrates the rising average temperatures in Chicago. Figure 2 consolidates temperature data to enable an overarching linear regression model, which demonstrates a statistically significant coefficient for the time variable in the time-series analysis. This indicates an average annual increase of 0.05 degrees Fahrenheit, underscoring that even climate havens are warming. Similarly, Figures 3 and 4 replicate this analysis for Singapore, showing a general upward trend in temperatures over time. However, in Singapore's case, the p-value, of 0.12, indicates that there is a 12% probability that the results observed are attributed to random chance if the null hypothesis, that there is no increase in temperatures over time, is true. Likewise, there would be an 88% confidence that the observed raise in temperatures over time is not due to random chance. This difference can be attributed to Singapore's equatorial location, which results in a more tropical rainforest climate with relatively stable temperatures year-round. In contrast, Chicago's seasonal variability results in more pronounced trends in temperature data, leading to more statistically significant results in linear regression analysis.

In the midst of commodities trading exists a subset that can be considered more volatile, but exists as an extension of their own individual market. This is but of course agriculture commodities. Such commodities are necessary for society to function, with their addition to commodities trading acting as an extension of the production of their goods. Such commodities are easily affected by numerous factors, from day-to-day weather conditions to seasonal patterns (Alliance Knowledge Partners, 2023). Such seasonal patterns greatly benefit agriculture commodities traders, allowing them to capitalize on seasonal price differentials (SwissFT, 2024), possibly by purchasing commodities at lower prices when higher demand or lower supply is expected or by selling commodities at higher prices when lower demand or higher supply is expected. Additionally, the renewable nature of products like coffee and grain ensures a sustainable supply. However, the unpredictability of climate poses significant risks, especially as global demand for these essential commodities remains constant due to their importance for daily sustenance. In Singapore, soybeans are a commonly produced and locally consumed crop, largely due to the dietary preferences of the Chinese population, for whom soybeans are a staple. Although soybeans ideally grow between 22 and 35 degrees Celsius (Cherlinka, 2024), a range that includes Singapore’s typical temperature, the crop is sensitive to heat stress. Constant air temperatures above 30 degrees Celsius can negatively impact the health and growth of soybeans. Singapore's natural temperature often hovers around this critical margin, and unless farmers transition to more controlled environments, such as agritech farms, they will face detrimental consequences for their soybean crops. This possibility, however, is not accessible to everyone as such high-technology farms require significant investment in attaining and maintaining, along with the additional expensive expertise to do so. In recent news, Venture capital investments into the agri-tech space in Singapore have declined by 60% since late 2021 (Loh, 2024), this is established not just in more complex agriculture like livestock or fish, but also in less complex agriculture such as crops.

In such uncertain situations, investors may choose to invest in financial assets that pose a positive impact on the climate in the long run. From more energy-efficient technologies to green bonds (which are fixed-income securities designed to fund projects with positive environmental benefits), and even investing in stocks of companies that seek positive climate change such as sustainable transportation (like electric vehicles) to reduce carbon emissions. In terms of green bonds, investors are able to purchase government-issued green bonds to aid in their projects to launch nationwide sustainability measures. Within the Singaporean government themselves, they have allocated funding for various green projects, from clean transportation, to waste management and green buildings. In terms of sustainable transportation, the government set projects such as expanding various lines across the country to encourage commuters to adopt public transport, increasing their convenience by making such transport more sustainable. Mass Rapid Transit (MRT) lines are the most optimal, being able to carry large numbers of people, it is able to significantly reduce carbon emissions, even more so than its public transport alternative of buses (which can easily be reduced based on frequency), and even more so when compared to private internal combustion engine (ICE) cars. Lines such as the Thompson East Coast Line is able to cover the eastern stretch of the country, which was originally dominated by buses and cars to cover the stretch. However, now with the Thompson East Coast Line, commuters are given another option to commute, reducing carbon emissions even further as the convenience and air-conditioning the system provides, make a more comfortable experience. Future projected MRT lines such as the Jurong Region Line and the Cross Island Line are estimated to result in a total carbon savings of more than 100,000 tonnes of CO2 equivalent annually, which approximates to reducing the Singaporean car population by about 22.000 cars, reducing emissions of 81% compared to baseline scenarios (Rajah, 2023). Investing in such bonds may initially be seen as a purely secure financial decision due to the reliability of the government, however, they provide many positive externalities for not just the environment, but society as well. Investors looking for higher returns may also consider individual green bonds launched by corporations and non-government entities such as Apple Inc., Starbucks, or similar transport institutions such as Toyota Motor Corporation and Volkswagen Group. However, investing in such corporations would lead to higher risk, albeit still relatively safe due to the nature of bonds having priority in reparations that corporations have to fulfill, which investors would have to consider. Other than specific technologies, investors are also able to invest in specific company's stocks if their practices and product align with what is environmentally sustainable.

Other than carbon-reducing technologies that certain companies pioneer such as Tesla with their electric vehicles, alternatives would be stocks in companies such as Olam Group that deal with the buy-side of commodities trading and have deployed various means to reduce their costs. Such projects they undergo include the training of farmers in developing countries who do not have access to as much education as those in developed countries (Greene, 2021). Although the main goal of such projects is to ultimately reduce the cost of production of such farmers and in turn, reduce the price that the Olam Group commodity traders have to fork out, such projects themselves are able to ensure higher-quality and higher-yield crops through their training in organic crop maintenance, correct irrigation techniques and biosecurity measures. Not to mention, reaffirming their supplier to prevent them from turning to another competing company, along with being able to propagate such sustainability practices. Investing in companies with strong Corporate Social Responsibility (CSR) and Environmental, Social, and Governance (ESG) criteria is becoming increasingly important for investors as well. Companies that prioritize sustainability and ethical practices often benefit from enhanced brand loyalty, reduced regulatory risks, and long-term resilience against climate impacts. That, along with CSR being a form of improving brand reputation, would introduce much scrutiny by the public and compliance institutions, ensuring higher standards in conducting such practices. Improvement of brand reputation brings along other perks such as stronger brand loyalty, which can translate into better market positioning, increasing consumer demand and thereby, driving profitability and shareholder value for traders invested in their stocks. Such companies also have an innate necessity to adhere to sustainability practices (especially large conglomerates with a significant percentage of market share), with unsustainable actions easily leading to more scarce products, decreasing supply, and increasing costs for themselves. And this is applicable to not just soft commodity distributors such as Olam Group which mostly functions at the buy-side, but also producers that own such farms and aim to sell their raw soft commodities, at the sell-side of commodities trading.

When it comes to investment strategies that commodities traders can undertake to make use of such weather-stabilizing investments, in terms of green bonds, investors may consider purchasing government-issued green bonds as a means to diversify from the relatively higher-risk soft commodities, while continually investing in the usual forwards or futures market for shorter term gains. Forwards, also known as forward contracts, are an over-the-top agreement to purchase a certain amount of underlying assets at a stipulated time. It is the most common form of investing for commodities traders as commodities traders are able to use seasonable patterns to predict the prices of such commodities. For example, nearing monsoon season or winter, when an investor would expect the supply of such crop to drop and thus the price would increase, the investor would sign a forward contract to purchase that specific crop during that period at a lower price. Upon maturity, if the market price of that crop is higher than what was agreed upon in the contract, the investor would earn the difference. A futures contract has the same underlying concept but is standardized and tends to occur in much higher quantities, increasing the risk of already risky products such as crops. Purchasing Green bonds would act as a safe, stable means of diversifying while enabling commodities traders to carry on making riskier trades with the selling of futures, knowing that they have the means to hedge or insure their losses in case of an undesirable event. Investors are also able to make more optimal hedging by purchasing green bonds that involve the underlying crop, like Exchange-Trade Funds (ETFs) that self-diversity for crops such as coffee, before they decide to sell coffee, in case their predictions were wrong, are able to cut their losses through their purchased ETFs. For longer-term investments, investors may still consider purchasing green bonds as a means of stable diversification but are able to consider stocks for sustainability companies as assets that contain higher risk, and higher rewards. Similar to short-term strategies, they are able to hedge or insure their investments by taking the opposite stance of the underlying asset. For example, if they were to predict a decrease in Olam Group or Nestle stocks, considering such companies deal with the distribution of coffee and sugar, the investor could consider purchasing ETFs such as iPath Series B Bloomberg Coffee ETN (JO) or iPath Series B Bloomberg Sugar ETN (SGG) to offset any possible increase in Olam Group or Nestle stocks. As a whole, investors would look into diversifying a building a balanced portfolio of long-term and short-term strategies. Incorporating green bonds or investing in stocks of companies that contribute to sustainability and climate stabilization is able to not just aid in diversification to reduce risks involved in commodities trading, but also provide positive externalities that may contribute to society and the environment in the near future.

In the process of investing in stocks of companies that focus on sustainability and green bonds not only generates financial returns but also has a profound impact on the agricultural sector. Over time, these investments fund projects and support companies actively engaged in research and development, with a strong emphasis on innovative solutions to enhance agricultural productivity. Through continuous R&D efforts, these companies can develop and commercialize advanced farming technologies that were previously too expensive or inaccessible for many farmers. Even in Singapore, where it is generally unexpected due to the significantly high prices of land, many would expect smaller sized farms or multi-layered farms to be predominant to save on land, such an industry is expanding rapidly, with an expected approximately double in market revenue by 2030 (Next Move Strategy Consulting, 2023). In relation to agriculture technology, precision agriculture tools such as remote sensing technologies using satellites and unmanned aerial vehicles (UAVs), as well as sensors and the Internet of Things (IoT), have become significantly more affordable and widely available due to investments in tech-driven agricultural companies (Meddeb, 2021). These technologies enable farmers to monitor crop health, optimize resource use, and improve yields with greater accuracy and efficiency. Moreover, differing business models have emerged to increase accessibility to smaller farms. An example of this is the "Agriculture Robot as a Service" model, where farmers can access crop-spraying robots without the need for significant upfront investment (Meddeb, 2021). This model allows farmers to benefit from cutting-edge technology while managing costs effectively. These advancements not only contribute to reduced production costs and increased crop supply but also support the sustainability and growth of the agricultural sector. By enabling farmers to adopt innovative practices and tools, investments in sustainable companies and green bonds play a crucial role in building a more resilient and productive agricultural industry.

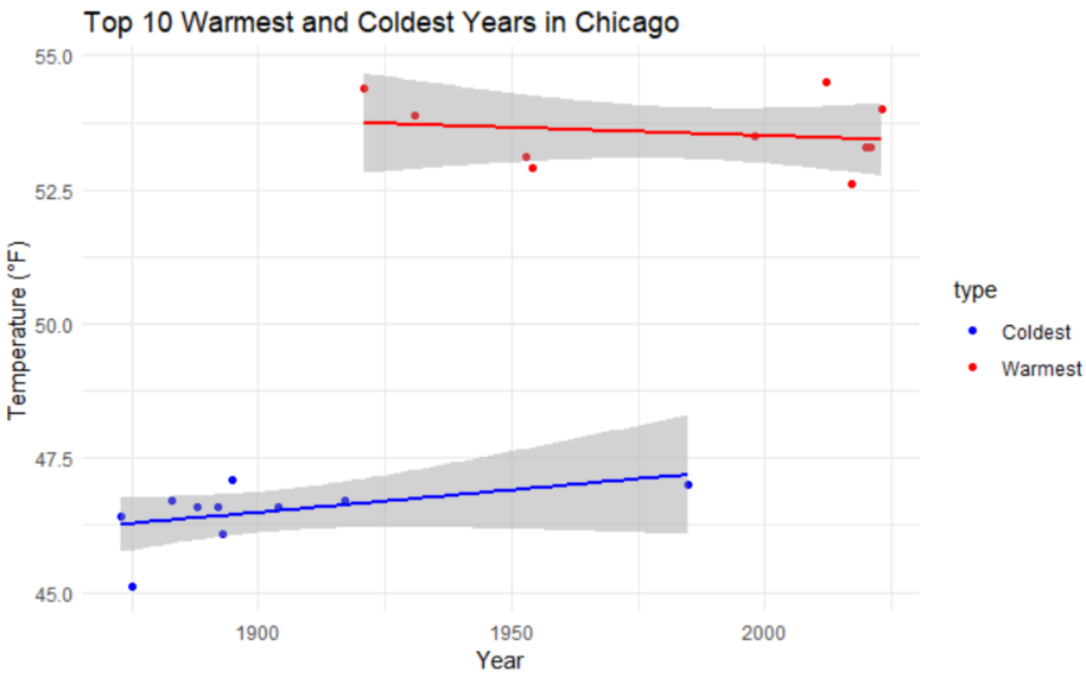
Singapore, with its status as a strong commodities trading hub due to its tropical, temperature-invariant climate and its position as a climate haven, would be able to attract more investors into the community. This attraction would grow as the agricultural sector expands, especially if stable weather patterns are predicted and investors play a significant role in contributing to this growth.

In conclusion, although climate havens like Singapore and Chicago are generally less affected by climate changes compared to other countries, they are not immune to the long-term negative impacts that can cause significant repercussions to their agricultural landscapes. These cities face increasing temperature trends, which can undermine agricultural productivity and stability. To address these challenges, it is essential to leverage climate stabilization investments and high-tech farming tools. These investments present a promising pathway to enhance agricultural productivity in Singapore. By supporting sustainable practices and reducing production costs, such investments can help create a resilient and productive agricultural sector that is better equipped to withstand the adverse effects of climate change. Looking ahead, continued innovation and strategic investments in climate stabilization technologies will be vital in addressing future challenges. Ongoing research and development in agricultural technology, coupled with supportive governmental projects, can further enhance the resilience and productivity of Singapore's agricultural sector. By fostering a collaborative environment and prioritizing sustainability in investments, we can create a robust agricultural industry that thrives in the face of climate change.

Word Count: 2954

Appendix:

Figure 1 (National Weather Service, 2024):



R Code:

```
library(ggplot2)


# Warmest years and temperatures

warmest <- data.frame(

  year = c(2012, 1921, 2023, 1931, 1998, 2021, 2020, 1953, 1954, 2017),

  temperature = c(54.5, 54.4, 54.0, 53.9, 53.5, 53.3, 53.3, 53.1, 52.9, 52.6),

  type = "Warmest"

)


# Coldest years and temperatures

coldest <- data.frame(

  year = c(1875, 1893, 1873, 1904, 1892, 1888, 1917, 1883, 1985, 1895),

  temperature = c(45.1, 46.1, 46.4, 46.6, 46.6, 46.6, 46.7, 46.7, 47.0, 47.1),

  type = "Coldest"
```

)

Combine warmest and coldest data

chicago_temps <- rbind(warmest, coldest)

Plot with custom colors for warmest (red) and coldest (blue)

ggplot(chicago_temps, aes(x = year, y = temperature, color = type)) +

geom_point() +

geom_smooth(data = subset(chicago_temps, type == "Warmest"), method = "lm", se = TRUE, color = "red") +

geom_smooth(data = subset(chicago_temps, type == "Coldest"), method = "lm", se = TRUE, color = "blue") +

labs(title = "Top 10 Warmest and Coldest Years in Chicago",

x = "Year", y = "Temperature (°F)") +

scale_color_manual(values = c("Warmest" = "red", "Coldest" = "blue")) +

theme_minimal()

Figure 2 (National Weather Service, 2024):

```
Call:
lm(formula = temperatures ~ years, data = data)

Residuals:
    Min      1Q  Median      3Q     Max 
-5.1426 -1.1509 -0.5193  0.7040  5.4740 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) -47.62235   18.06944  -2.636   0.0163 *  
years         0.05026    0.00931   5.398 3.29e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.341 on 19 degrees of freedom
Multiple R-squared:  0.6053,	Adjusted R-squared:  0.5845 
F-statistic: 29.14 on 1 and 19 DF,  p-value: 3.292e-05
```

R Code:

```
# Load necessary library
library(ggplot2)

# Data: Annual average temperatures in Chicago (warmest and coldest years)
years <- c(2012, 1921, 2023, 1931, 1998, 2021, 2020, 1953, 1954, 2017, 1875, 1893, 1873,
1904, 1892, 1888, 1917, 1883, 1985, 1895, 1885)
temperatures <- c(54.5, 54.4, 54.0, 53.9, 53.5, 53.3, 53.3, 53.1, 52.9, 52.6, 45.1, 46.1, 46.4,
46.6, 46.6, 46.6, 46.7, 46.7, 47.0, 47.1, 47.1)

# Create a data frame
data <- data.frame(years, temperatures)

# Fitting a linear model
model <- lm(temperatures ~ years, data=data)
summary(model)
```

Figure 3 (World Bank Group, 2021):

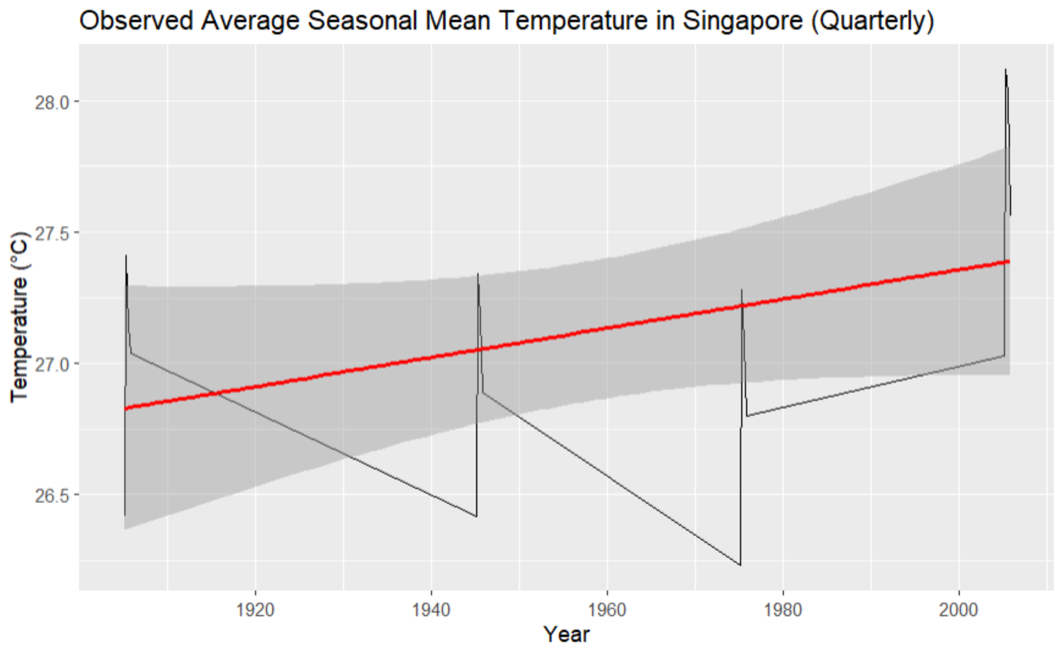


Figure 4 (World Bank Group, 2021):

```
Call:
lm(formula = ts_data ~ time)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.98837 -0.36868  0.09299  0.29236  0.73343 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 2.719e+01  1.305e-01 208.337   <2e-16 ***
time        1.523e-05  9.184e-06   1.658     0.12    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4964 on 14 degrees of freedom
Multiple R-squared:  0.1641,	Adjusted R-squared:  0.1044 
F-statistic: 2.749 on 1 and 14 DF,  p-value: 0.1196
```

R Code (Figure 3 & Figure 4:

```
# Sample data, representing mid-points of each period (e.g., 2005 for 1991-2020)

data <- data.frame(

  year = c(1905, 1945, 1975, 2005),  # Midpoints of each period

  DJF = c(26.42, 26.42, 26.23, 27.03),

  MAM = c(27.41, 27.34, 27.28, 28.12),

  JJA = c(27.14, 27.18, 27.08, 28.03),
```

```
  SON = c(27.04, 26.89, 26.8, 27.56)
)
library(tidyr)
long_data <- pivot_longer(data, cols = DJF:SON, names_to = "season", values_to =
"temperature")

# Assign each season a quarterly offset in a year (DJF -> Q1, MAM -> Q2, etc.)
long_data$quarter <- match(long_data$season, c("DJF", "MAM", "JJA", "SON"))

# Calculate the date for each entry, assuming each period represents a year in the middle of
the 30-year range
long_data$date <- as.Date(paste(long_data$year, long_data$quarter * 3 - 1, "01", sep = "-"),
"%Y-%m-%d")
library(zoo)
# Sort by date and create a time series
long_data <- long_data[order(long_data$date), ]
ts_data <- zoo(long_data$temperature, order.by = long_data$date)
time <- as.numeric(time(ts_data))  # Convert dates to numeric time
model <- lm(ts_data ~ time)
summary(model)
library(ggplot2)
ggplot(long_data, aes(x = date, y = temperature)) +
  geom_line() +
  geom_smooth(method = "lm", se = TRUE, color = "red") +
  labs(title = "Observed Average Seasonal Mean Temperature in Singapore (Quarterly)",
       x = "Year", y = "Temperature (°C)")
```

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