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RESERVES, PRICES, AND POLICY: AN EMPIRICAL ANALYSIS OF STRATEGIC CROP RESERVES IN ARAB NATIONS

REZERWY, CENY I POLITYKA: EMPIRYCZNA ANALIZA STRATEGICZNYCH REZERW UPRAW W KRAJACH ARABSKICH

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zaplanowanie badań
B. Data collection/entry
zebranie danych
C. Data analysis/statistics
dane – analiza i statystyki
D. Data interpretation
interpretacja danych
E. Preparation of manuscript
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Abstract

Subject and purpose of work: In recent years, global food systems have faced challenges like disasters, extreme weather events, and market fluctuations, such as the Ukraine-Russia conflict. This study analyses strategic crop reserves, specifically for wheat and rice, in Arab countries. It examines the objectives and obstacles associated with these reserves.

Materials and methods: different statistical methods have been used, including regression analysis and neural network prediction models.

Results: Findings reveal significant agricultural production deficits in Arab economies. However, some countries maintain substantial crop reserves. We found an inverse relationship between wheat reserves and wheat prices. Additionally, energy prices correlate positively with agricultural commodity prices. Forecasting models anticipate short-term global grain stock stability but predict short-term increases in agricultural price indices (until 2024) followed by long-term decreases (by 2030).

Conclusions: Policymakers should support agricultural strategies, particularly for strategic crops. To address current challenges, we suggest securing long-term contracts for strategic crops, diversifying suppliers, and avoiding reliance on a few sources.

Keywords: strategic food, food reserve, food security, Arab countries

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Streszczenie

Przedmiot i cel pracy: W ostatnich latach globalne systemy żywnościowe stanęły w obliczu wyzwań, takich jak katastrofy, ekstremalne zjawiska pogodowe i wahania rynkowe, np. takie jak konflikt między Ukrainą a Rosją. Niniejsze badanie analizuje strategiczne rezerwy upraw, w szczególności pszenicy i ryżu, w krajach arabskich. Badane są cele i przeszkody związane z tymi rezerwami.

Materiały i metody: Zastosowano różne metody statystyczne, w tym analizę regresji i modele predykcyjne sieci neuronowych.

Wyniki: Wyniki wskazują na znaczne deficyty produkcji rolnej w gospodarkach arabskich. Niektóre kraje utrzymują jednak znaczne rezerwy upraw. Stwierdzono odwrotną zależność między rezerwami pszenicy a jej cenami. Co więcej, ceny energii korelują dodatnio z cenami towarów rolnych. Modele prognostyczne przewidują krótkoterminową stabilność światowych zapasów zbóż, jak również krótkoterminowe wzrosty wskaźników cen rolnych (do 2024 r.), a następnie długoterminowe spadki (do 2030 r.).

Wnioski: Decydenci polityczni powinni wspierać strategie rolne, szczególnie w odniesieniu do upraw strategicznych. Aby sprostać obecnym wyzwaniom, sugeruje się zabezpieczenie długoterminowych kontraktów na strategiczne uprawy, dywersyfikację dostawców i unikanie polegania na kilku źródłach.

Słowa kluczowe: żywność strategiczna, rezerwy żywności, bezpieczeństwo żywnościowe, kraje arabskie

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Introduction

Storage has been indispensable throughout history for human survival. Institutions and enterprises in all nations require storage to ensure the seamless production and distribution of their goods. For countries, storage is not merely an economic and societal necessity; it has evolved into a paramount obligation. This responsibility takes on heightened significance for nations heavily reliant on agricultural staples such as wheat, barley, rice, and legumes to feed their people (Fraser, Legwegoh, KC, 2015). During evolving economic frameworks, the intricate entwinement of international relations, and the emergence of conflicting interests within foreign trade, the task of securing the supply of agricultural commodities has become an increasingly formidable challenge for numerous countries, particularly those grappling with frailties and susceptibilities in the performance of their agricultural sectors.

The issue of public food reserves has been the subject of controversy among nations, organizations, and stakeholders across both global and local markets. Previously, during the ascendancy of neoclassical economic thought, notably championed by the Chicago school, the it was believed that state intervention in the economy, including price regulation, had limited advantages and could have potentially detrimental repercussions on overall economic performance. Nevertheless, in the wake of economic upheavals and unforeseen price oscillations, the strategy of stockpiling agricultural crops by public entities underwent re-evaluation and modernization. This strategy is now acknowledged as a proactive stance to shield local consumers from the adverse effects of such upheavals. This paradigm shift underscores the evolving comprehension of the role played by public food reserves in alleviating risks and ensuring food security (Murphy, 2009).

Strategic reserves of vital agricultural staples like wheat, rice, and barley have become increasingly important within the economies of the Arab region. Governments and regional entities, including the Arab Organization for Agricultural Development (AOAD), have displayed interest in these stockpiles. The significance arises from the fact that these crops constitute the principal sustenance source for the populace, notwithstanding the limited availability of lands on which they are cultivated. Nonetheless, the production levels and efficiency of the cultivation of these crops within the Arab region are poor in contrast with global output standards. According to data provided by the Arab Organization for Agriculture, the region's contribution to global production was a mere 1.94% in 2019. In stark contrast, the collective grain imports of the region constitute 16% of the world's grain imports, indicating that the economies of the region import eightfold more grain than they produce. This marked incongruity places an obligation on decision-makers to systematically address this structural shortfall each year.

In recent times, more precisely from the end of 2019 up to the present day, two global crises have profoundly heightened the focus on strategic reserves of food commodities. The initial crisis stems from the worldwide health predicament triggered by the Covid19 outbreak, which has created supply disruption and a reduction in global production (Laborde et al., 2020). The second crisis pertains to the ongoing Russian-Ukrainian conflict, with both nations being key producers and exporters of essential agricultural resources. This conflict has contributed to an upsurge in the volatility of agricultural prices, disruptions in supply chains, and the devastation of crucial agricultural storage facilities and ports (Behnassi, El Haiba, 2022). These circumstances have further added to the pressure on Arab economies, triggering inflation in the local costs of agricultural commodities. Consequently, need to establish a strategic stock capable of mitigating the repercussions of such crises and uncertainties over an extended span has become unequivocal.

Our study lies within the broader framework delineated above, encompassing multiple objectives across various dimensions. The first involves an in-depth exploration of the existing state of agricultural production and food security within Arab economies. The second concentrates on a meticulous analysis of the global inventory levels of agricultural commodities, with a special emphasis on countries that are key producers. The third examines the objectives underlying strategic stocks of agricultural crops, specifically aimed at ameliorating price fluctuations. To accomplish this, we have employed statistical models to predict the dynamics of prices and agricultural indicators. The fourth is an examination of what has impeded the establishment of strategic crop stocks in the Arab region. Finally, the fifth explores prospective solutions and future avenues for cultivating a sustainable strategic inventory of agricultural crops within the Arab region.

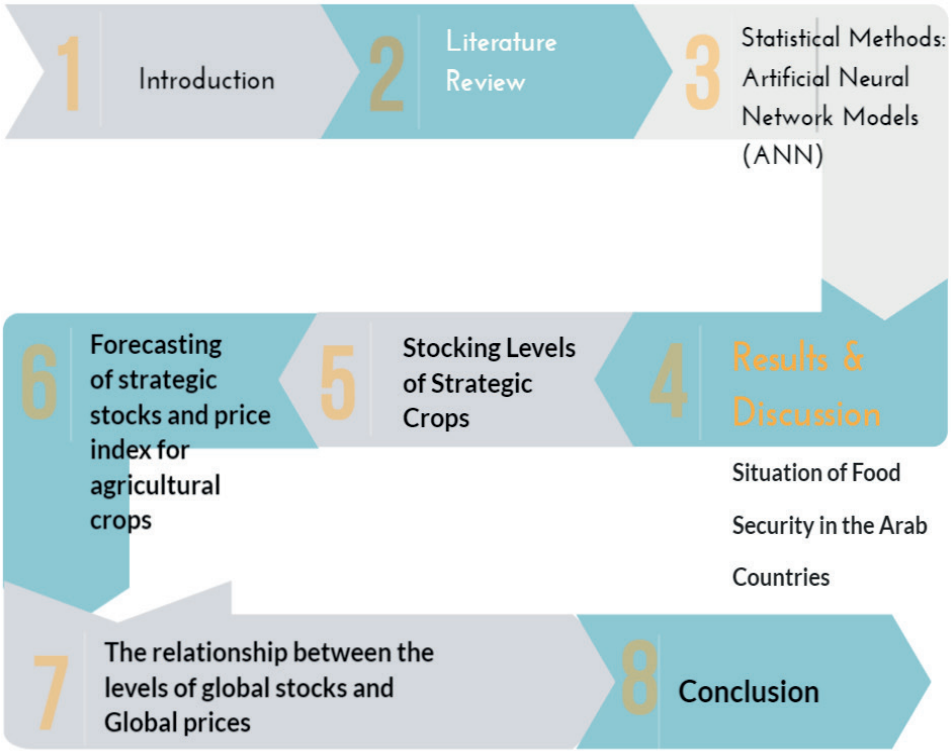

Figure 1. Research paper organization

Background

The significance of strategic food reserves in safeguarding food security and alleviating price volatility has been recognized. This review of the literature meticulously assesses numerous studies centred on the functions of grain stocks, strategic reserves, and food reserve entities across diverse regions, with a particular spotlight on their relevance to Arab nations. Through pinpointing the prevailing research issues and investigating prospective additional contributions, this comprehensive review substantiates the need for extended investigations into strategic food reserves within Arab countries.

Murphy (Murphy, 2009) discussed the resurgence of interest in food reserves within the food security dialogue. It highlights the importance of food reserves in addressing chronic hunger, foreign land acquisitions, childhood obesity, and climate change impacts on agriculture. The paper reflects the increasing attention given to food reserves as a means of enhancing global food security. Wiggins and Keats (Wiggins, Keats 2010) reviewed the role of grain stocks in the 2007/08 spike in world food prices and their potential for mitigating future food price volatility. It discusses the importance of stocks, historical experiences of price stabilization schemes, and current proposals to stabilize prices internationally. The study utilizes data from published statistics, academic literature, and interviews with key informants. In the same topic, Wright and Cafiero (Wright, Cafiero, 2011) have examined the decline of grain stocks to minimal levels in 2007-2008 and its impact on price sensitivity to shocks such as drought and biofuel demand. They highlight the importance of strategic reserves, self-sufficiency, and foreign land acquisition in ensuring grain supplies for domestic consumption. The article emphasizes the need for targeted distribution and efficient strategies to maintain food security in the MENA region.

The study of Mason and Myers (Mason, Myers, 2013) highlights the effects of the Food Reserve Agency (FRA) on maize market prices in Zambia. The study indicates that the FRA's activities have contributed to price stabilization in the maize market. However, the price-raising effects primarily benefit surplus maize producers, while negatively impacting net buyers such as urban consumers and the rural poor. The findings suggest that the increase in maize price stability resulting from FRA policies may not substantially improve the welfare of poor households.

The study of Laio et al. (Laio, Ridolfi, D'Odorico 2016) analyses 50 years of aggregated food reserves globally and regionally, challenging the perception that food reserves are shrinking. The authors find that per-capita food stocks are stationary, but there is a 20% probability of halving global per-capita stocks by 2050. Regional differences are observed, with varying probabilities and stock levels across different continents. Lassa et al. (Lassa, Teng, Caballero-Anthony, Shrestha 2019) examined emergency food reserve policies in Indonesia,

the Philippines, and Malaysia, emphasizing the role of reserves in disaster preparedness and climate change adaptation. They highlight the importance of buffer stocks in stabilizing national food prices and trade disruptions during emergencies.

Recent studies in the context of the COVID-19 pandemic have also been made. For example, Mogues (Mogues, 2020) addressed the potential impacts of COVID-19 on food markets and food security. The article discusses the similarities and differences between the current pandemic and the global food price crisis of the past decade. It emphasizes the need for tailored expenditure policies to mitigate the risks of rising hunger and malnutrition, particularly in low-income countries. In addition, Falkendal et al. (Falkendal et al., 2021) focused on the impacts of COVID-19 on international agricultural supply chains and the potential risks of grain export restrictions on global food security. It highlights the importance of maintaining open trade and avoiding precautionary purchases that could lead to food price spikes and local food shortages.

This literature review highlights the significance of grain stocks in mitigating food price spikes and ensuring food security. It emphasizes the importance of strategic reserves, international trade, price stabilization schemes, and targeted distribution to address vulnerabilities in global food markets. Additionally, it underlines the challenges posed by external factors such as climate events and pandemics, which require adaptive policies and interventions to strengthen food access and security. By addressing the research gaps identified in previous studies and focusing on the specific context of Arab countries, this research will add value by offering insights tailored to the region's unique challenges and opportunities. Exploring the socioeconomic determinants, regional nuances, and climate-related susceptibilities, with Arab nations being notably exposed to climatic events like droughts and water scarcity, will aid in formulating robust policies and strategies to bolster food security across the Arab world.

Methods

To analyse the data across the different aspects of the study, we use mainly descriptive statistics, linear regression models and Artificial Neural Network (ANN) models, (Khashei, Bijari, 2010). Accordingly, the R (V.4.1.1) and Eviews (11) programs have been used. In this study, we have consciously chosen not to dive into the intricacies of basic regression models. These well-established methods are widely known and extensively covered in existing literature, requiring no in-depth explanation. Our primary attention is directed solely toward the fascinating world of neural network forecasting techniques, where we examine their applications and complexities.

Artificial Neural Network (ANN) models

In the realm of predictive modelling, Artificial Neural Networks (ANNs) have emerged as a compelling and versatile tool. Inspired by the intricate workings of the human brain, ANNs have gained prominence in recent decades for their ability to decipher complex patterns and relationships within data (Rumelhart, Hinton, Williams 1986). These computational models possess a remarkable capacity to capture both linear and non-linear dependencies, rendering them exceptionally adept at forecasting tasks across various domains.

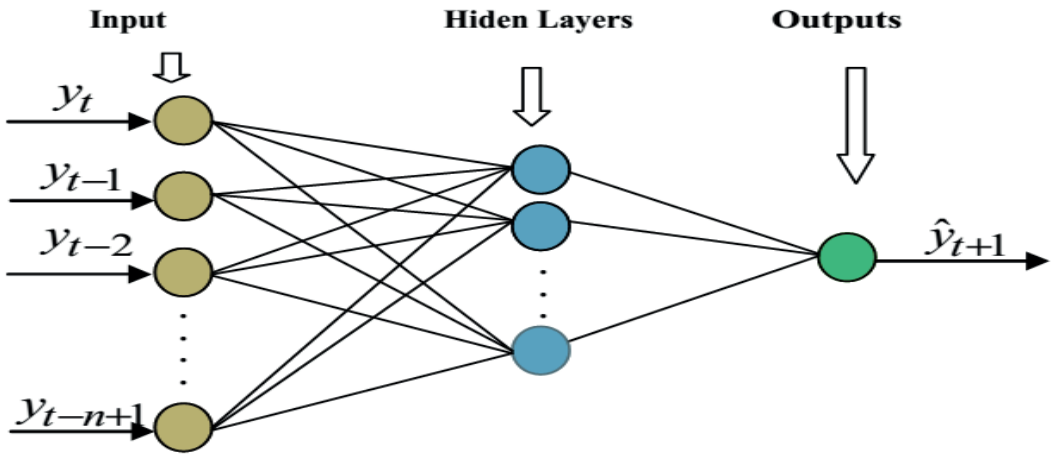

Figure 2. Architecture of a Single Hidden Layer Artificial Neural Network (ANN)
Source: Own elaboration.

The architecture of an ANN consists of interconnected layers of artificial neurons, each equipped with a set of weights and biases. These neurons employ mathematical activation functions, such as the sigmoid function (σ), to process and transmit information (Bishop, 1995). Through a process of iterative training, ANNs adjust these weights and biases, optimizing the network's ability to approximate complex functions (LeCun et al., 2015). The number of *input* neurons is equal to the number of lagged observations ($y_t, y_{t-1}, y_{t-2}, \dots, y_{t-n+1}$) that are considered and can be selected based on significant *partial autocorrelations.*

In this section, we outline the methodology employed to develop and train the Artificial Neural Network (ANN) forecasting models. Our approach encompasses data preprocessing, model architecture, training process, and performance evaluation.

Data Pre-processing

To prepare the input data for the ANN, we follow a series of pre-processing steps:

Data Collection: We gather historical time series data for the target variable(s) and relevant predictor(s). Let Y_t represent the target variable at time *t*, and $X_{1,t}, X_{2,t}, \dots, X_{n,t}$ denote the *n* predictor variables at the same time *t*.

Normalization: To ensure numerical stability and convergence during training, we normalize all variables to have a mean (μ) of 0 and a standard deviation (σ) of 1:

$$Z_{i,t} = \frac{(X_{i,t} - \mu_i)}{\sigma_i}$$

Where $Z_{i,t}$ represents the normalized value of predictor χ_i at time *t*, and μ_i and σ_i denote the mean and standard deviation of X_i, respectively.

Sequence Generation: We create sequences of input data by selecting a fixed window size (*w*) of lagged observations. For each time step *t*, the input sequence consists of $Z_{i,t-w+1}, Z_{i,t-w+2}, \dots, Z_{i,t}$ for all predictor variables X_i.

Target Variable Preparation: The target variable sequence comprises the corresponding values of the target variable at each time step *t*, denoted as $(Y_{t-w+1}, Y_{t-w+2}, \dots, Y_t)$.

Training Process: To train the ANN, we utilize the back-propagation algorithm with a selected optimization method (e.g., stochastic gradient descent). The objective is to minimize the loss function *L(0)* which quantifies the difference between the predicted values and the actual target values. The weights and biases of the ANN are updated iteratively using the gradient descent:

$$\theta(t+1) = \theta(t) - \alpha \nabla L(\theta(t))$$

Where α represents the learning rate, θ denotes the set of all model parameters (weights and biases), and $\nabla L(\theta(t))$ is the gradient of the loss function with respect to $\theta(t)$.

Performance Evaluation

We assess the performance of the ANN forecasting model using standard metrics, including Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE), which are defined as follows:

$$MAE = \frac{1}{N} \sum_{i=1}^{n} \left| Y_i - \hat{Y}_i \right|$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{i-1}^{n}\left(Y_i - \hat{Y}_i\right)^2}$$

$$MAPE = \left(\frac{100}{N}\right)\sum_{i-1}^{n}\left|\frac{Y_i - \hat{Y}_i}{\hat{Y}_i}\right|$$

Where *N* is the total number of forecasted values, Y_i represents the actual target value, and $\hat{Y}_i$ denotes the corresponding predicted value.

Results and discussions

Situation of food security in the Arab countries

Considering the periodic global economic crises and the price shocks of strategic agricultural commodities (mainly grains) in foreign markets, Arab economies have suffered and are suffering from the direct and indirect effects of these fluctuations, which undermine the efforts and endeavours of the governments of these countries to improve their levels of food security. According to World Bank statistics for the year 2020, Arab economies import approximately 50% of the food calories they consume. Most of the agricultural imports of the economies of the region are grains (wheat, barley, and rice). On the other hand, the cultivation of these strategic crops is considered the main purpose the agricultural sector (especially in terms of the area of agricultural land and the volume of investments) in most Arab countries. However, agricultural productivity is very weak compared with other countries (as a result of water scarcity, climate change, poor use of agricultural fertilizers, and technology).

Therefore, the import bill is also a real indicator of the situation that all the economies of the Arab countries suffer from, without exception. In the World Bank data for the year 2020, the proportion of food imports in total commodity imports in the Arab region amounted to 13.61% (World Bank, 2022). Unfortunately, this situation has been further complicated by the size of the foreign debt of some Arab countries, which could have been exporters rather than importers, producers rather than consumers, and are inactive in the agricultural sector in the region. The hidden effects of foreign debt can undermine every attempt at real economic reform; it puts provides debtor countries with very limited and almost non-existent development options, especially if we also talk about debt services, which in turn deepens the economic crisis of these economies.

Therefore, the challenge is very sharp at the level of the macroeconomics of these countries, and the previous experiences of these economies (Algeria, Egypt, Tunisia...) and even economies outside the region (Mexico, Cuba) are the best evidence that relying on external debt is dangerous at all levels (economic, social, and even political). In a new 2022 report on the food security index, it was indicated that between 2019 and 2022, the affordability score for the index decreased by 4%, from 71.9 to 69. This decline in food security levels is mainly due to global shocks such as the COVID-19 pandemic, rising input costs, and the Russo-Ukraine war are all driving up food costs.

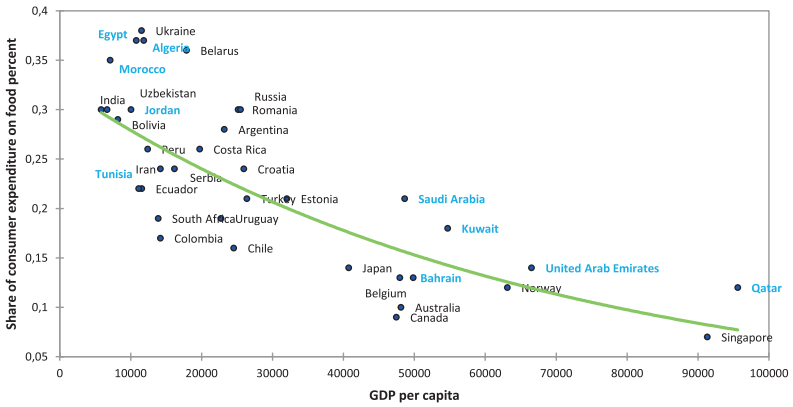

Figure 3. Distribution of economies according to the level of per capita income and the percentage of income allocated to food for the year 2020
Source: Own elaboration based on the World Bank Database, 2020.

Statistics reveal an inverse relationship between the proportion of income allocated to food and the state's progress and economic development. Figure 3 illustrates the correlation between per capita national income levels and food expenditure. Arab Gulf economies exhibit the lowest food expenditure percentages compared with other Arab nations like Algeria, Egypt, and Morocco, estimated at 35 to 38%. Interestingly, these countries also have lower per capita incomes than Gulf economies. Beyond the Arab region, the United States, England, Malaysia, and Canada demonstrate the lowest food expenditure percentages. Addressing price risks, high international prices and increased volatility significantly impact inflation rates. Food price inflation surpasses headline inflation in most Arab countries, particularly affecting the poor who spend 35 to 65 percent of their income on food. The rise in wheat prices escalates staple food costs, potentially heightening poverty rates, especially among households living on the poverty threshold.

Regarding Arab cooperation and integration, the strategy for sustainable Arab agricultural development emphasizes the importance of strengthening agricultural integration among Arab countries and establishing practical mechanisms for cooperation. However, there is a notable weakness in the performance of intra-trade among Arab countries across all commodities. Figure 4 illustrates the value of commodity flows (in dollars) between Arab economies in 2020, revealing a geographic concentration of trade within the Arab Gulf states (e.g., Saudi Arabia, Kuwait, and UAE) and between other countries like Algeria and Tunisia. The volume of these exchanges can be statistically estimated using the foreign trade integration index. The Arab Monetary Fund conducted a detailed study in 2022 that sheds light on the current reality and challenges of intra-Arab trade.

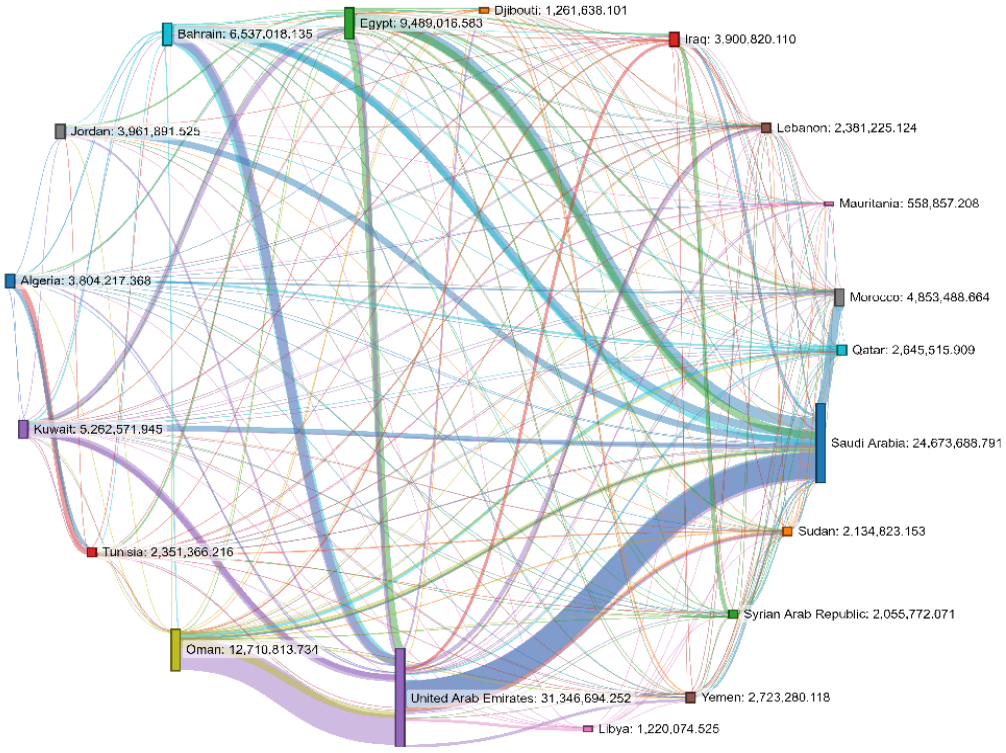

Figure 4. Inter-Arab trade exchanges for the year 2020
Source: Own elaboration using the World Bank Data, 2020.

Our primary focus in examining current intra-Arab trade is closely tied with our next topic: developing a strategy for a regional reserve of strategic commodities. Nations engaged in significant intra-regional trade provide a solid basis for forming agreements to establish a consolidated reserve of critical crops at a regional level. Moreover, Arab economies face the challenge of global security conflicts, as seen in the ongoing Russian-Ukrainian conflict, which has highlighted the importance of key foodstuffs like wheat, barley, and pulses. These geopolitical concerns have disrupted international food markets, emphasizing the need for action. To enhance the Arab region's agricultural sector and ensure food security, creating reserve stockpiles for essential crops is crucial (Fraser et al., 2015).

Stocking levels of strategic crops

Before the onset of the 2008 global crisis that reverberated through agricultural markets, surplus levels in the supply chain for most crops were notably high. Public reserves of agricultural crops were perceived as potential

sources of market distortions, influenced by their impact on production prices. This influence was believed to contribute to domestic surpluses or international releases, thereby affecting prices. However, the landscape shifted post-2008, ushering in an era of structural changes and market shocks. This era brought about increased volatility and instability, differing from the stability preceding the 2008 crisis. Economic studies, such as those by (Mitchell, Levallée, 2005), have examined these changes, stemming from policy shifts in influential players like the USA, EU, and China, resulting in reduced global stock levels. Alternatively, supply and demand shocks linked to biofuels, Asian food demand, climate change, and dynamics within futures markets, as discussed by (Larson et al., 2014), have also contributed. In this context, our goal, aligning with the significance highlighted by (Wright, Cafiero, 2011), is to assess global strategic crop stocks, focusing on wheat and rice across countries, utilizing data up to 2020.

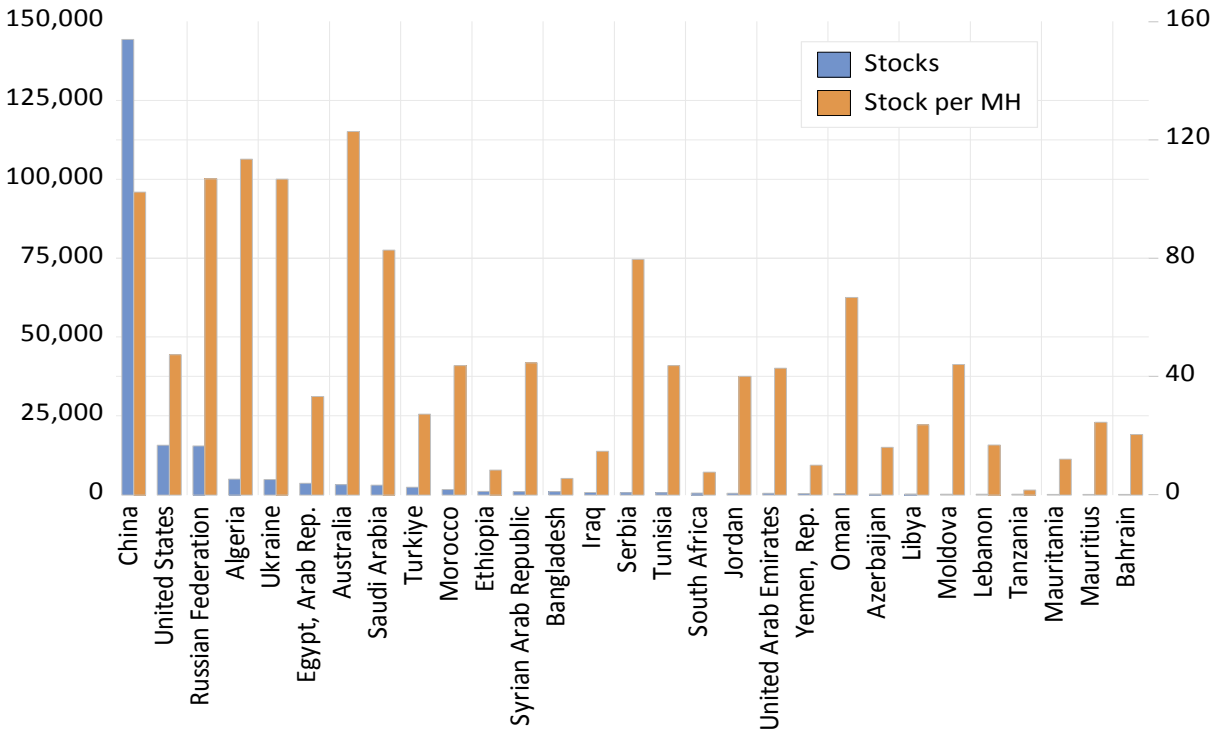

Figure 5. The level of wheat stocks, and the share of stocks per million population across a group of countries for the year 2020
Source: Own elaboration based on the US Department of Agriculture statistics for the year 2020.

Figure 5 presents wheat stock levels across countries, alongside the stocks per million inhabitants. Notably, China, the United States of America, Russia, India, Ukraine, and Canada collectively dominate around 79.1% of global wheat stocks in 2020. Interestingly, when considering stocks relative to population size, the distribution diverges from the absolute stock distribution. For instance, Algeria and Paraguay exhibit stock-to-population ratios surpassing many wheat-producing and exporting nations, akin to India, the United States of America, and Russia. However, this aspect has an underlying implication. Countries like Algeria experience significantly higher cereal consumption within their population's compared with exporting counterparts. This scenario similarly extends to caloric sources, where economies like Algeria and Egypt rely heavily on grain-derived calories. Regarding global wheat consumption, a projected 12% increase is anticipated by 2030, primarily driven by producing countries like China and India. Egypt, within the expected range, is poised to witness a notable 4 million-ton rise in consumption.

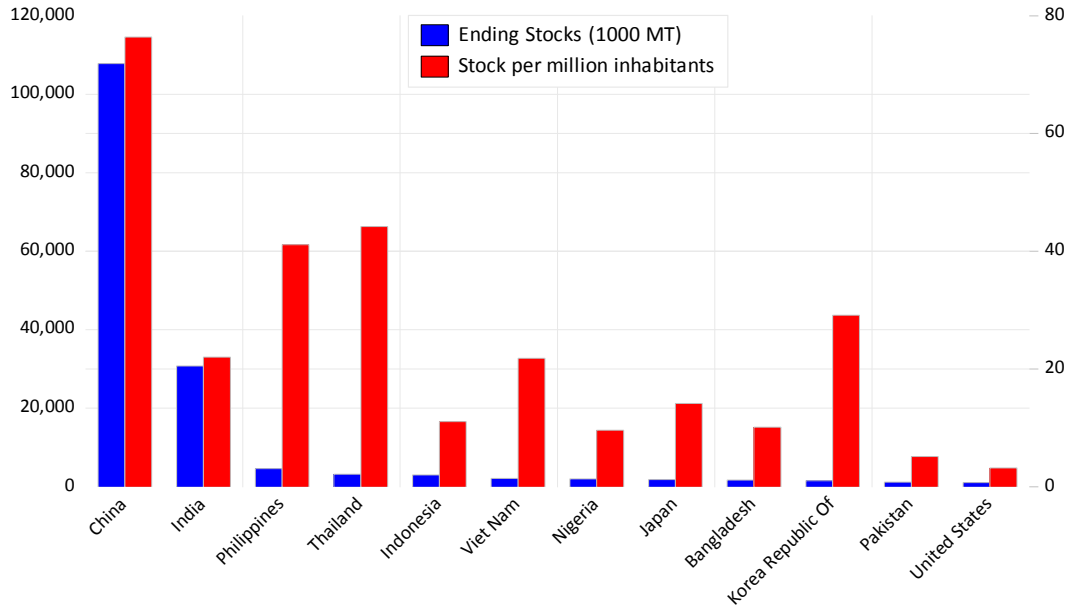

Figure 6. Levels of rice stocks by country for the year 2020
Source: Own elaboration based on the US Department of Agriculture statistics for the year 2020.

Figure 6 shows stock levels of rice in the most important countries, where we see China ranks first in terms of stock, which was in the range of 120 million tons, with an estimated stock level of 76 thousand tons for one million people. In second place, we find India with an estimated stock level of 30 million tons, followed by the Philippines and Thailand. In the forecasts of the World Food Organization, global rice stocks at the close of the 2022/23 marketing seasons are expected to reach 193.4 million tons. This relative abundance mainly reflects the expectation of stock accumulation. In China and India, this could overshadow the expected decline of 8.1 percent in total inventories held by all other countries.

Rice is primarily a food item and continues to be a staple in Asia, Latin America, the Caribbean, and increasingly in Africa. Global rice consumption is expected to increase by 0.9% annually over the next ten years, compared with 1.1% annually in the last decade. Asian countries account for 65% of the projected increase in global rice consumption, and rice intake is expected to lead to significant increases in Africa. In terms of global trade in rice, table (1) shows the development of rice import levels during the period (2019 to 2022), where we note that China, the Philippines, Nigeria, and Saudi Arabia are the four largest importers of this crop with 12.1 million tons. The rest of the Arab countries are included in these statistics, as we note that Iraq's level of imports reached 1.6 million tons, while the United Arab Emirates' levels of imports ranged from 750 to 950 thousand tons during the same period.

Table 1. Evolution of the level of global rice consumption across a group of countries (in thousands of tons)

Country	2019/20	2020/21	2021/22	2022/23 Dec
China	3 200	4 921	6 200	5 200
Philippines	2 450	2 950	3 500	3 400
Nigeria	1 800	2 100	2 400	2 200
Saudi Arabia	1 613	1 200	1 300	1 300
Malaysia	1 220	1 160	1 200	1 200
Iran	1 125	875	1 200	1 200
Cote d'Ivoire	1 100	1 450	1 600	1 500
Senegal	1 050	1 250	1 500	1 100
South Africa	1,000	1,000	1,000	1 025
Nepal	980	1 260	900	1 100
Iraq	970	1 280	1 900	1 600
Brazil	876	685	850	850
Ghana	850	1 050	700	950
United Arab Emirates	850	750	900	950
Mexico	843	759	775	800
Ethiopia	700	850	950	950
Guinea	670	940	800	800
Kenya	600	620	650	650
Indonesia	550	650	750	750
World Total	**45 360**	**51 837**	**55930**	**53 760**

Source: Own elaboration using the USDA data (2022).

In general, Arab countries will remain major consumers of grains in general and wheat and rice in particular with high levels of per capita consumption, (further details in the joint report of (OECD-FAO, 2021)). There is an important factor motivating this trend of consumption, and it is mainly related to the population increase in the countries of the Arab region. This also doubles the demand for food commodities and makes the storage strategy more complex and expensive. Here, the consumption pattern of the population of the Arab region and the problem of diversifying the diet in the region also overlap. With regard to the demographic factor, we note the increase in the size of the population, which was at a rate of 1.95 percent in the Arab countries, and instead of increasing the crop area to three or four times the population increase, but, sadly ironically, the area cultivated with wheat decreased by 8.5 percent in 2020 compared with the area cultivated in 2019.

Furthermore, even countries producing and exporting strategic crops suffer from large fluctuations in production levels (and productivity) mainly as a result of drought and climatic fluctuations (the case of floods in Pakistan in 2022), and this will undoubtedly lead to lower levels of global supply and thus greater pressure on countries. This can be seen from two perspectives, on the one hand, high prices, and on the other, the lack of production supplied in the market (i.e., cannot buy the quantity you want). In the case of India as the world's largest wheat supplier, the level of wheat stocks was already at its lowest level since 2008, as the COVID-19 pandemic disrupted domestic and global supply chains (Lassa et al., 2019).

Recent reports from 2022 show a global surge in food storage. A noteworthy example is a report by The Telegraph magazine (Wallen, Farmer, 2022), which delineates this emerging trend. It reveals that all countries, particularly those engaged in strategic crop production, have actively embraced the age of stockpiling. This shift stands as a departure from the past perspective, where these countries were considered key contributors to inflation spikes and supply disruptions. However, even these producing nations are propelled by genuine motives, driven by the imperative of sustaining acceptable levels of food security. A case in point is India, the world's second-largest wheat producer, which has curtailed its agricultural exports to prioritize reserves. This approach has exacerbated inflation and is poised to deepen food crises in importing countries, including those within the Arab region. Central to our analysis is the inquiry into the implications of this stockpiling for Arab nations.

Forecasting of strategic stocks and price index for agricultural crops

Using the data of the United States Department of Agriculture (USDA) from 1960 to 2021 and the World Food Organization, we created a statistical model based on neural networks. For the training process, 80% of the available dataset was allocated to the training subset, while the remaining 20% was held out for performance evaluation and testing purposes. The forecasting results indicate that the levels of global stocks of wheat will not change significantly and will be within the range of 270 to 280 million tons during the next two years (2023 and 2024).

Table 2. Performance Evaluation Metrics for Forecasting Models

Metric	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
FAO Price Index	-0.00195	2.10899	1.42511	-0.04733	1.58389	0.14518	-0.00602
Global Stock of Wheat	-0.01462	16.0657	13.2610	-1.64387	9.59516	0.85991	0.00510

Source: Own elaboration.

Table 2 presents a comprehensive set of performance evaluation metrics for assessing the accuracy and reliability of time series forecasting models applied to the FAO price index and Global stock of wheat. Together, these measures provide insights into systematic biases, overall magnitudes of errors, relative accuracy, and serial correlation in residuals, enabling a thorough evaluation of the models' predictive capabilities and informing decisions regarding their deployment and potential refinements.

The baseline projections of the primary tenure index correspond to projected baseline supply and demand conditions over the next decade, which considers income growth and population growth along with prevailing consumer preferences on the demand side, and sustained productivity increases on the supply side. In the medium term, it is further assumed that, at the global level, natural resource mobilization will continue to be possible under low real prices and the expansion and intensification of productive capacity will not be permanently constrained from reaching the limits of expected demand.

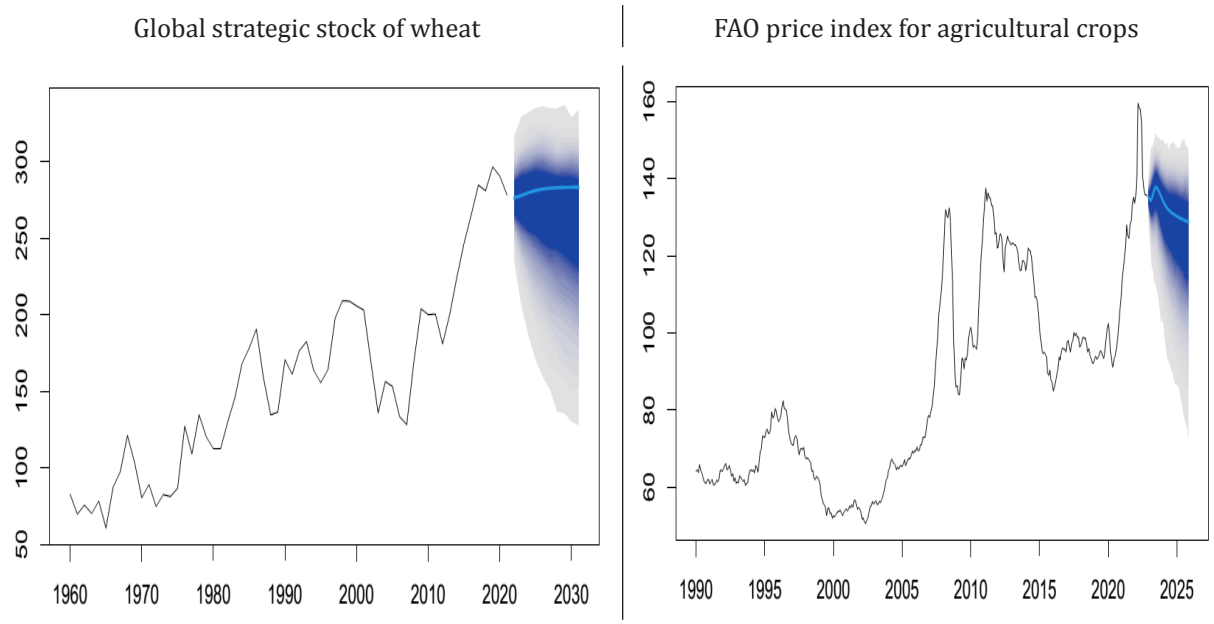

Figure 7. Evolution and prediction of global stock levels of wheat and food price index
Source: Own elaboration.

The results of modelling and forecasting of the artificial neural network model were very close to those published by the US Department of Agriculture. In a recent forecast by the US Department of Agriculture issued for December 2022, we strongly expect a decrease in the levels of global reserves for the wheat crop in the two most important countries, China and India, and the same trend is also expected for the rest of the countries. With

global consumption once again exceeding production, global wheat stocks are expected to decline further in 2022/23. The combined inventories of the eight largest global exporters are expected to decline from 2021/22. Inventories are expected to decline in Russia as demand for export of Black Sea wheat remains strong. Equities in the European Union are also expected to decline with lower yields and increased export demand from neighbouring markets (USDA, 2022).

The relationship between the levels of global stocks and global prices

Food reserves are an old idea, responding to the inherent characteristics of agriculture, particularly the presence of relatively constant and inelastic demand combined with a more volatile short-term supply. Unregulated agricultural markets tend to create a pattern and a certain dynamic – and a relatively long period of intermittent price declines due to short and sharp upward surges in these prices. These sharp price increases cause negative effects on consumers (individuals and governments) and help farmers who have only a crop to sell when prices are high. An invisible loop characterizes such markets, but food reserves can alter this pattern and thereby mitigate the undesirable effects of unstable agricultural markets, see World Bank report (Gadhok, Avesani, 2021).

Low global stocks-to-consumption ratios – and policy measures in the form of export restrictions imposed by major grain exporters – are leading to increased market instability. Cereal prices are more likely to rise when global stock-to-consumption ratios fall (Wright, Cafiero 2009). When low stock ratios are combined with more frequent supply shocks caused by climate change, the global cereal market becomes more vulnerable to disruption. In the event of instability in international markets, exporters can impose export restrictions to ensure sufficient domestic supply and prevent any increases in domestic prices. The use of such trade measures can contribute to the rapid rise in world market prices.

Figure 8 depicts the temporal dynamics between global wheat stock variations and fluctuations in the FAO agricultural commodity price index over the period 1991-2019. The y-axis represents the annual percentage changes in two key variables: “dstock (%)” denotes the year-over-year percentage change in global wheat stock levels, while “dindex (%)” denotes the year-over-year percentage change in the FAO agricultural commodity price index.

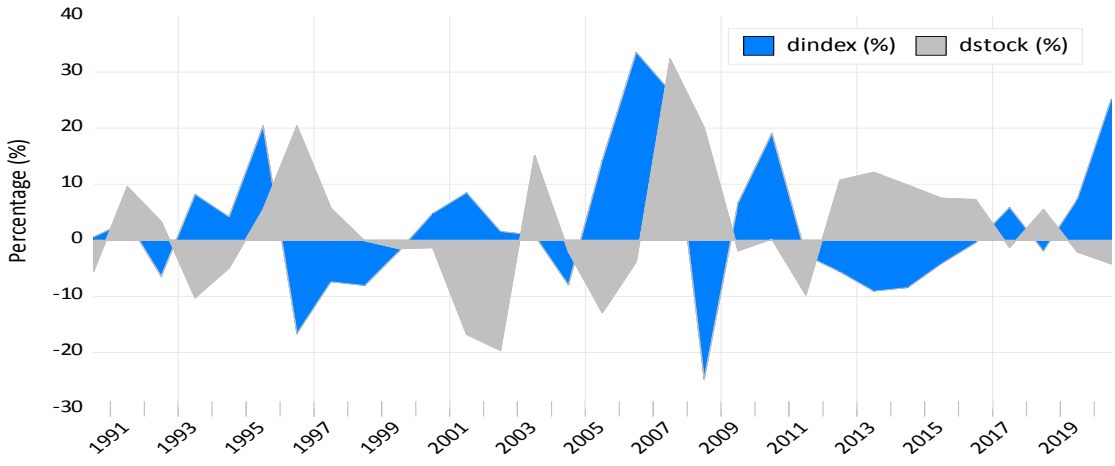

Figure 8. The relationship between the levels of global stocks of wheat and wheat prices during the period 1990-2021
Source: Own elaboration.

This visual representation enables the exploration of potential inverse relationships between global wheat supply, as shown by stock variations, and overall agricultural commodity price movements. Economic theory suggests that an increase in wheat stocks should exert downward pressure on prices and conversely, a contraction in stocks should contribute to upward price pressures. However, the interplay between these two variables may be influenced by a multitude of factors, including demand dynamics, trade policies, and broader market conditions, which could lead to deviations from the expected inverse relationship in specific years or periods.

The hypothesis linking global stock size of strategic crops to price levels received statistical confirmation, visually demonstrated in Figure 8. A significant inverse relationship between global grain stock changes and the

FAO's agricultural commodity price index during 1990-2021 has emerged. Additionally, we examined the link between energy price fluctuations and global food indices, see Figures 9 and 10. The findings revealed a consistent and statistically significant direct relationship between variables. In practice, oil price trends could offer insights into forthcoming agricultural price dynamics. These expectations find support in the ongoing Russia-Ukraine conflict, anticipated to persist, impacting food and energy markets. This situation could spark another wave of inflation in agricultural commodity prices. Therefore, swift establishment of a substantial agricultural stockpile, while ensuring prudent consumption, has become imperative to address these projections.

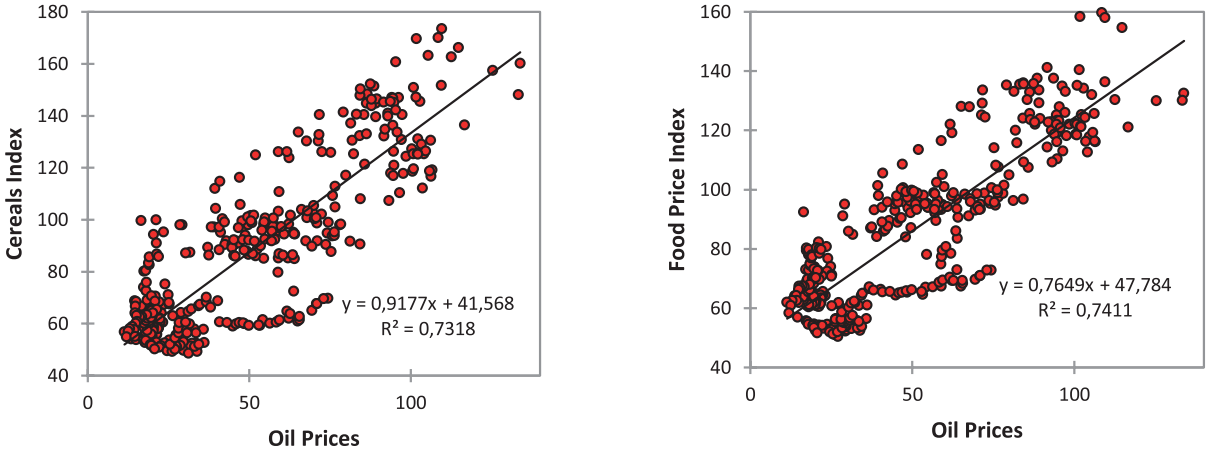

Figure 9. Relationship between agricultural commodity indices and energy prices during the period 1990-2021
Source: Own elaboration.

Food security stocks are used to ensure stability in food availability and prices (Gardner, 1979), (von Braun, Torero 2009) and (Dorosh, 2009). Governments usually use such stocks to control domestic supplies and prices of food. The theoretical basis for such stocks is that governments buy food from farmers and/or markets cheaply and release stocks when market prices move above levels considered acceptable in terms of affordability (Gardner, 1979). The same conclusion was reached by (Mason, Myers, 2013) in their study of the impact of strategic stocks on maize prices in Zambia. On the other hand, a study conducted by (Ahmed et al., 2012) on the real effects of food stocks on prices and indicators of food security in Sudan was not clear due to the financial and organizational obstacles of government agencies responsible for these stocks.

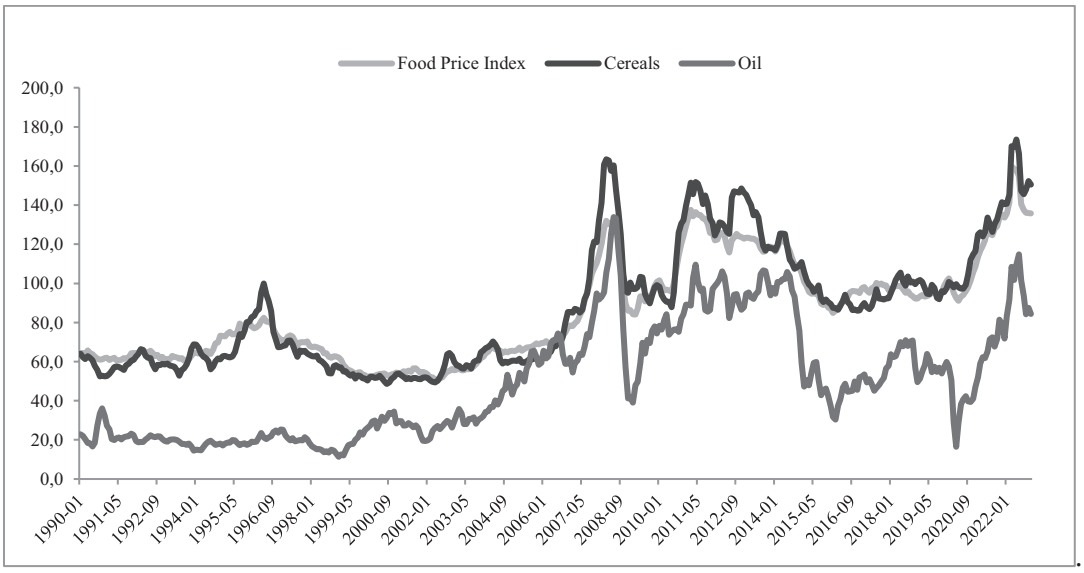

Figure 10. Evolution of the agricultural commodity price index, grain prices and oil prices during the period 1990-2021
Source: Own elaboration.

These strategic food reserves primarily serve as a critical means to secure food access for vulnerable populations during times of emergencies. The activation of these reserves is contingent upon government assessments, strategically positioning public stocks as a vital contingency buffer. Research by (Wright, Cafiero, 2011) focusing on North Africa and the Middle East (MENA), as well as the exploration conducted by (Larson et al., 2014), underscore the pivotal role these reserves play in reinforcing regional food security. While their primary objective is not centred on maintaining price stability, judiciously timed releases have demonstrated the potential to contribute to market stability. This stands in contrast with conventional stockpile schemes typically managed by non-governmental organizations, which are oriented toward stabilizing prices, often releasing stocks during periods of elevated prices to safeguard consumers.

We encountered several challenges in conducting this study, with a key issue being the intricacy of separating the research subject (strategic stocks of agricultural crops) from broader agricultural sector performance and the structure of Arab economies. Strategic stock management is inherently interwoven within each country's national economic framework. Additionally, the scarcity of accurate and up-to-date statistics on government-held strategic crop stocks in the Arab region posed a significant obstacle. Consequently, we propose enhancing and modernizing the agricultural information systems in these countries. Another ongoing challenge relates to measuring and estimating global (local-regional) stock levels. Even with country-specific estimates, obtained through surveys or residual approaches, calculating the overall state of global stocks remains complex due to distinct national definitions of reserve criteria.

Conclusions

The prevalence of price fluctuations and disruptions in supply chains has underscored the inadequacies of relying solely on the market mechanism as the optimal approach to counter the escalating uncertainties and price oscillations, particularly within agricultural markets. In light of these circumstances, a rigorous re-evaluation of formulating a sustainable strategy for establishing food reserves has become imperative. This imperative is further magnified by the escalating and consecutive challenges tied to climate change, water scarcity, conflicts, and natural calamities. In this context, the integration of the strategic stock into the global value chains of agricultural products, specifically strategic crops, has become relevant. Additionally, heightened risks to the global supply of strategic crops, primarily arising from the ongoing Russia-Ukraine conflict, have heightened concerns. Foreseen production reductions, especially in Ukraine, are projected to result in a scarcity of global strategic crop supply. Coupled with anticipated production decreases in other countries, this situation is poised to disrupt the supply chain and trigger anticipated price hikes of these crops in the global markets.

Many Arab countries are working to expand storage capacity, particularly for wheat reserves, as a safeguard against import risks. Some have established regulations for managing strategic commodity reserves. These countries could form emergency reserves for key crops, supervised by a technical committee, ensuring collective preparedness. This regional effort could be guided by a binding agreement mandating crop reserves, primarily for wheat, rice, and barley. The emphasis is on support during crises. Arab nations should prioritize production enhancement, recognizing that reserves alone won't suffice to solve the issue; a focus on bolstering production is imperative.

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