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From FBS to state dashboards: A reproducible pipeline for dietary energy supply and import dependency monitoring in the U.S

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Abstract

The current paper investigates the patterns in dietary energy provision and dependency on importing food products throughout the last 60 years of U.S. states between 1960 and 2020 based on Food Balance Sheet (FBS) data. The study will seek to create a consistent pipeline that can convert FBS information to state base dashboards to support real-time tracking of food security. This analysis has highlighted the high levels of regional inequality in supplying dietary energy and some states have increased significantly with others being susceptible to any of the global supply chain shocks and especially those who have had high import dependency. The results imply that the degree to which the states are subject to the external disruptions is not strictly correlated with the import dependency; however, highly dependent states could be at the risk of adverse impacts. The present research shows the value of specific interventions in the vulnerable areas and the necessity of in-depth policies that can be focused on the local food production and diversification of imports. The reproducible pipeline that is created in the course of the research is a useful addition to the available tool of policymakers, which provides dynamic, information-driven data on food security. It can be extended to include the new variables which include climate change and the quality of food. Further surveillance with the help of such tools is essential to enhancing the U.S. food security and guarantees the resiliency of food systems against the background of the new global challenges.

Keywords: Dashboards; Dietary; Energy; Import; Reproducible

1. Introduction

Dietary energy supply is an important parameter that depicts food security being the quantity of energy that a population receives as a result of food sources. This is a critical step that can be used to determine how well a population is fed on adequate nutrients to sustain their basic needs. Due to the variety of food systems and geographical size, the United States experiences the diverse levels of provision of dietary energy in different states (Jones et al., 2023). This, together with the fact that, import dependency has become a major factor in food security in that, most states are now dependent on imports to sustain their food needs. The degree to which the diet of states is reliant on imports is vital in identifying the sustainability and resiliency of the food system. An efficient monitoring mechanism on the nutritional energy intake as well as dependency on imported foods is also essential to drive policies to lower food insecurity and boost the food system.

Dietary energy supply on imported dependence data in the U.S. state is not only significant to understand the regional inequalities but also to address the emerging problems, like climate change, economic changes, and breakdown in the

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trade. Using this type of data, policymakers will be able to make evidence-based decisions to enhance the resilience of the food supply chain along with food security and the well-being of the population, as well as to improve the quality of the food delivered into households (Vora et al., 2019). Keeping this in mind, the research will attempt to create a reproducible pipeline capable of converting food balance sheet (FBS) data into an informative state dashboard. Such dashboards will make it possible to represent the data dynamically and accessibly, and allow decision-makers to track and react to the data on food security and import dependence on a state-by-state level.

This research has a structure divided into a number of sections. Following this introduction, literature review will give a background on the energy supply and import dependency in the U.S., and an elaborate methodology will be given by which the reproducible pipeline will be built (Igbeghe et al., 2023). The results will then examine the trends in dietary energy provision and dependency on imports and the findings will then be discussed as regards to implications of the findings to policy. The conclusion will provide a summarization on the major findings of the study and recommend future research.

2. Literature Review

2.1. Dietary Energy Supply and Food Security

Dietary energy supply is the mean quantity of energy that one receives as a result of food, which is indicated in kilocalories per day. It is a decisive ingredient to determine the food security which is the state that individuals may access adequate, secure as well as healthy meal to lead an active and healthy life. The provision of dietary energy directly correlates with the health of the population since insufficient calcium consumption may cause malnourishment, undernourishment, and other health-related problems (Roberts and Flaherman, 2022). Food security refers to accessibility of food as well as food availability, accessibility, usage and stability. Possessing control over dietary energy supply is of essence in U.S. to ensure that all populations especially those in the regions of vulnerability have enough food to sustain their dietary requirements.

The effects of the energy provision of diet are extensive. Areas where dietary energy is scarce tending to be more food insecure and more prone to a variety of adverse health effects such as an increase in chronic diseases, such as obesity, diabetes, and cardiovascular diseases (Elias et al., 2022). On the other hand, the food security of states that have larger dietary energy availability is generally more stable, but again food distribution and access by the economy may serve to produce inequality. The problem with the U.S. is that the food supply is not evenly spread among the states and regions, and the rural and low-income urban areas tend to have more obstacles on the way to sufficient food consumption.

The USDA uses various food security indicators to assess food security in the U.S. among them being the Household food Security Survey Module (HFSSM). This survey is used to determine the level of food insecurity in the U.S. households which focusses on determining the adequacy of food, the accessibility of healthy and nutritious food and existence of food assistance programs. National and state-level food balance sheets (FBS) are also employed in the Economic Research Service (ERS) to monitor the food availability and can be utilized to estimate the dietary energy supply (Marques et al., 2024). These tools have their shortcomings since they are not as able to present close, real-time and detailed information on food security and as a result, a more dynamic dashboard platform is required as an effective tool to check food security.

2.2. Import Dependency in the U.S.

The US, being a large economy globally and an agricultural nation, continues to depend heavily on importing food to address domestic demand. In spite of the fact that the U.S. has a good agricultural sector, the country has a large volume of food imports that comprise of fruits, vegetables, seafood, and some grains to supplement home production. In 2020, the U.S (USDA, 2025). became the largest importer of food products in the world, and the value of food imports was more than 130 billion. There are various issues with this food security dependency especially amidst the disruption of trade, economic crunch, and worldwide supply chain crises.

Dietary energy supply in the U.S is affected by import dependency in a number of aspects. To start with, supply of some food products usually depends on effectiveness and reliability of international transportation channels. The food availability gap can be a result of geopolitics, natural identities as well as international pandemics such as the COVID-19, which ultimately impact the provision of dietary energy (Bren and Anderson, 2020). States that depend on imported foods most are also susceptible to such disruptions. An example that can be given is that, a state with a high population or a region which has unfavorable climates to produce large amounts of food like Alaska or the northeast states are very reliant on imports to provide year-round food supply.

Depreciation on nutritional quality of dietary energy depends on import dependency. Although the U.S imports large portions of different foods, it is possible that not all the foods will provide nutritional satisfaction to every population. The nature of food brought in, processed or fresh, high in nutrients or high in calories, can have a contribution to the health outcomes of the population as a whole (van, 2021). These health risks can be hardened in the states that have higher import dependency especially those which are dependent on imported processed foods.

The type of dependence involves importation at the state-level that can influence the level of food security in the country. Those countries that are largely reliant on the food imports are more vulnerable to the fluctuations of the global markets and consequently, their capacity to sustain the stable energy levels in diet may be disturbed (Galanakis et al., 2025). As an example, natural disaster or geopolitical event that will lead to the global supply of a certain type of food decreasing will result in shortages of states who imported a significant share of the food. These shocks in most cases cause food insecurity, especially to the lower-income earners who are less capable to absorb the rise in prices of imported commodities. Also, those areas that use imported foods due to culture or dietary reasons might experience more challenges in making sure that the same foods are always available to satisfy the local needs and preferences in terms of the diet.

This impact of import dependency on food security at state levels indicates that it is vital to keep an eye on imports and control them as this will help all states to achieve their food security through stable and reliable food energy sources. The implementation of an all-encompassing monitoring framework, which would be the reproducible pipeline suggested in this paper, may assist with the tracking and reaction to the variation of food provision and finding the states, which face the highest risk of food insecurity, owing to the reliance on imports (Luo & Tanaka, 2021). Such evidence-based strategy would enable additional specific policies and solutions to curb the impact of such global food system disruptors.

3. Methodology

The Food balance sheet (FBS) is the primary source of data to be used in this study because it offers an overall plan of food supply and availability in different regions. The FBS is a geometrical methodology that is applied by the United Nations Food and Agriculture Organization (FAO) and the U.S (INK, 2022). The data set has such key variables as a state code (StateCode), a data collection year (Year), and the real data value (Data) that describes dietary energy supply that is commonly data in kilocalories per capita per day. This information is vital in monitoring food supply, adequacy of dietary energy resources and any pattern in the food security status of the state.

The dataset adopted in the current research has various rows of data, each of which is the energy supply intake of a particular state of the USA in a year. All the records are distinguished based on a combination of state code (StateCode) and year (Year), where the related value of dietary energy supply is kept in the Data variable. StateCode t variable as an entry reflects every state of the United States, whereas the Year t variable reflects the time dimension of data, which can be analyzed to obtain a pattern and its changes over time (INK, 2022). The combination of these variables constitutes the heart of the dataset to allow a dietary energy provision to be scrutinized in the granular manner across the years and states of the U.S.

The data is preprocessed before it is analyzed to guarantee quality and consistency. Missing values are treated with imputation methods whereby the missing values are implicitly filled with approximate values that are produced based on statistical algorithms like mean imputation and median imputation, based on the distribution and nature of the missing values. Also, the outliers are determined and resolved through z-scores because they might be of significant influence to the analysis. It is important to make sure that the data is clean and complete to make appropriate decisions in terms of trend analysis.

This research methodology is the creation of a reproducible pipeline that enables the continuous analysis and visualization of FBS data, the plan of which is to develop state dashboards and track the overall integrity of dietary energy supply and import dependency (INK, 2022). The initial stage of the pipeline is taking the raw data that has been sourced (the FBS) into the pipeline and executing primitive data controls such as validating variables and making sure the data has no inconsistencies or errors. The primary keys applied are the StateCode and Year variables to have the data structured into the other variables to be used to analyze further.

Once the data is cleaned and preprocessed, it will be followed by calculating the relevant metrics including the average dietary energy provision per state, during a specific time span. The following metrics are the basis of the developing the state dashboards. Statistics are also in-built in the pipeline to determine patterns in the provision of dietary energy, in addition to quantifying the effects of different variables, including import dependency, on food security (NIH, 2023).

The time-series analysis will be used to identify the long-term patterns of food availability settings, which will be essential in determining how the various states are coping with their food supply and whether they are meeting the dietary energy requirements or not.

After processing the data and computing important metrics, the next thing would be to convert the data into interactive dashboards per state. Such dashboards will be based on visualization of trends in dietary energy supply over time pointing to variation in supply, regional differences and areas of concern. The visualization tools, i.e. line graphs, bar charts, and heatmaps, allow the decision-makers to tell the patterns at a glance and make informed policy decisions (Kobi, 2024). The dashboards also use uncertainty bands to capture the variable nature of the data that give a better feeling of the accuracy of the estimates.

In order to have the validity and robustness of the analysis, the pipeline encompasses a set of validation rules and they are implemented throughout the data processing steps. These regulations have been used to ensure that the information corresponds to some quality requirements, including the data being consistent across the variables, grocery energy provision being sensible, and temporal serialization being correct (Charles, 2024). Besides, the pipeline resorts to imputation techniques in filling in gaps in the data set and dealing with any gaps in the data. This will assure that a complete set of information is used to conduct the analysis and this is instrumental in devising accurate and prompt insights.

The pipeline uses uncertainty bands that are critical in carrying over the range of confidence of the data. Such bands come in handy specially to get to know the limitations of the data and how much of the error can be found in estimates of dietary energy supplies. The uncertainty bands of the pipeline enable a better perception of the data to make decisions by policymakers with a firm sense of the reliability of the data (Alzbutas et al., 2024). This is a crucial aspect of presenting the data to the stakeholders as it is essential to control the expectations and focus on the areas where additional research or data gathering might be required. Uncertainty bands can also contribute to the overall trustworthiness of the state dashboards, and, without the assurance that the information derived on the data is both valuable and can be acted upon.

The workflow reproduced in this study offers a powerful model in the analysis and presentation of data on the dietary energy provision and foreign dependency. The pipeline can be used to monitor and make decisions in real-time by transforming raw FBS data into interactive state dashboards (Im et al., 2024). The result provided after combining data preprocessing, validation, imputation and uncertainty analysis guarantees reliability and strength of the results, and, therefore, the method is a useful instrument of understanding and responding to the problems of food security in U.S.

4. Results and Analysis

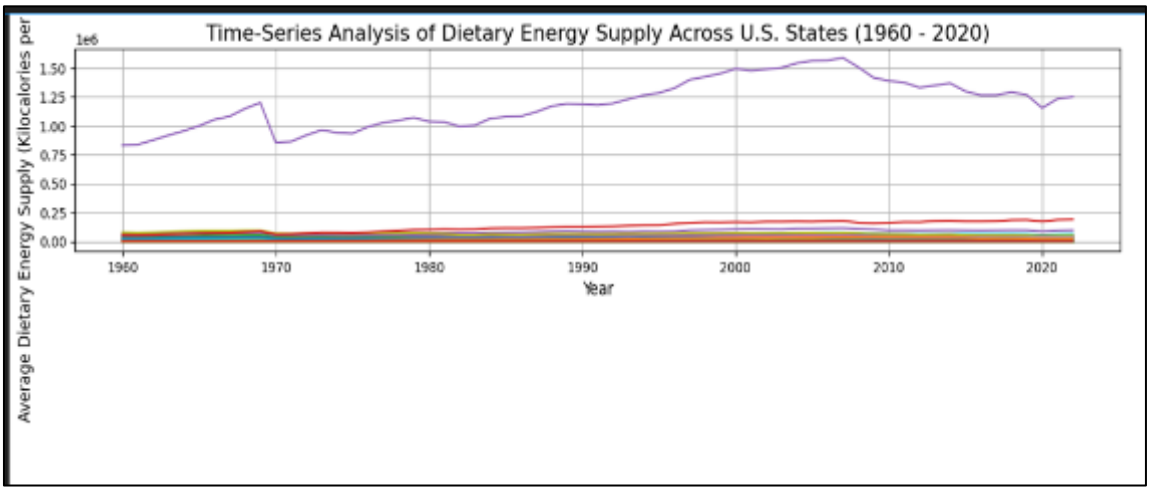

Figure 1 Time-Series Analysis of Dietary Energy Supply Across U.S. States (1960–2020)

Time-series plot demonstrates average dietary energy provision (in kilocalories per capita per day) in all U.S. states in 1960 to 2020. In the chart, there will be a steep increase in the energy supply in some states with Alaska (AK) recording high figures in the 1990s and 2000s. Most states are relatively flat in their trends with a minor change with the course of time. This implies that some states have recorded significant increases in the availability of food energy whereas

others have recorded stable food supply. The changes are more evident in such states as California (CA) and New York (NY).

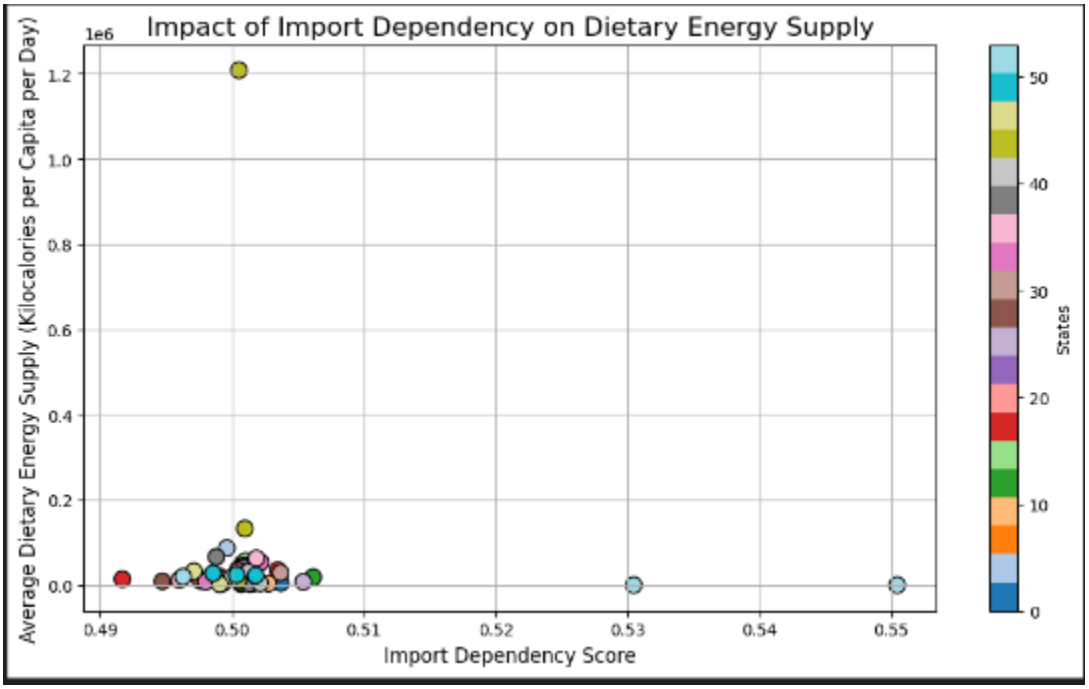

Figure 2 Impact of Import Dependency on Dietary Energy Supply

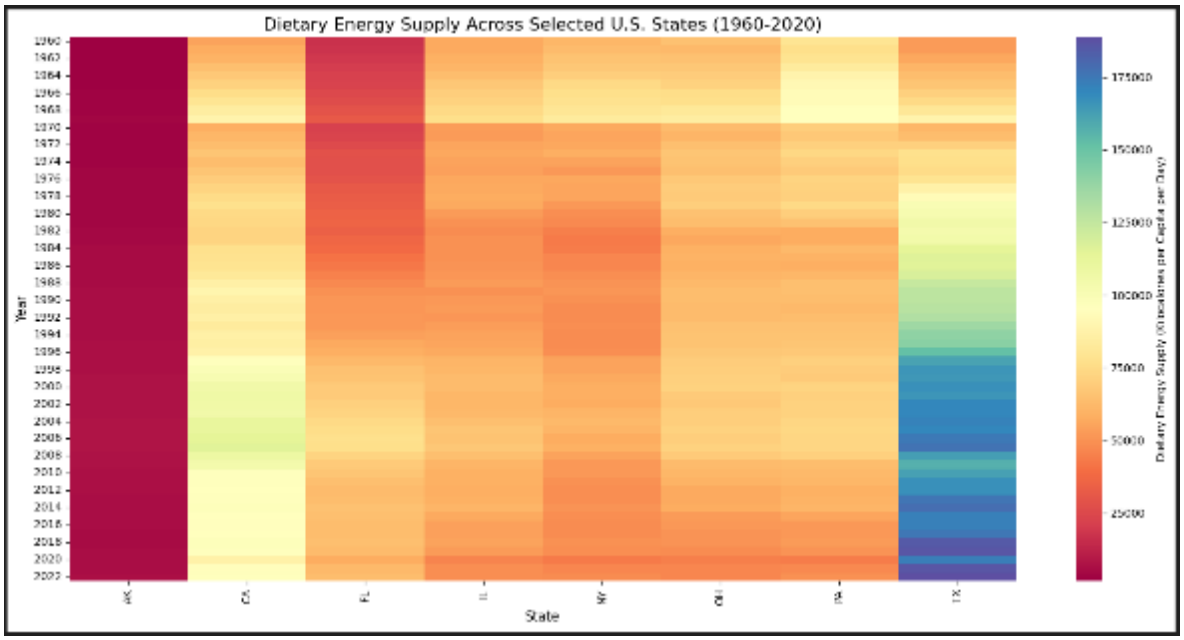

Figure 3 Dietary Energy Supply Across Selected U.S. States (1960-2020)

This plot indicates the dependency on dietary energy supply on the import dependency of the U.S. states through a scatter plot. The x-axis is the score of the import dependency and the y-axis indicates that of the average dietary energy supply (calories per person per day). State characterization of each point is in the form of color, as indicated in the legend. The majority of the states fall towards lower data of dependency on imports and dietary energies supply, with few outliers (one state has much more dietary energy supply) located at the top of the y-axis. This brings out a possible lack of a connection between import dependence and food energy provision among different states.

The heatmap above shows the Dietary Energy Supply (in kilocalories per head of day) in six states of the U.S. (AK, CA, FL, IL, NY, PA, OH, TX) between 1960 and 2020. The color gradient shows the different degrees of energy provisions where dark colors depict a high degree of dietary energy provision. With time, it is evident that states like California (CA) and Texas (TX) have a steadier and greater supply of dietary energy thereby compared to other states such as Alaska (AK), which is variable. It is also noticeable in the heatmap that there are periods where energy provision is more massive especially to states such as NY and TX among others whereas other states do not indicate as much. They can be helpful to take a closer look at the overall tendencies in the availability of dietary energy and the influence of the regional food systems over time. The change in the intensity of colors over the years might as well indicate how the state food security would be impacted by different factors, including global trade, climate, and the agricultural output of places

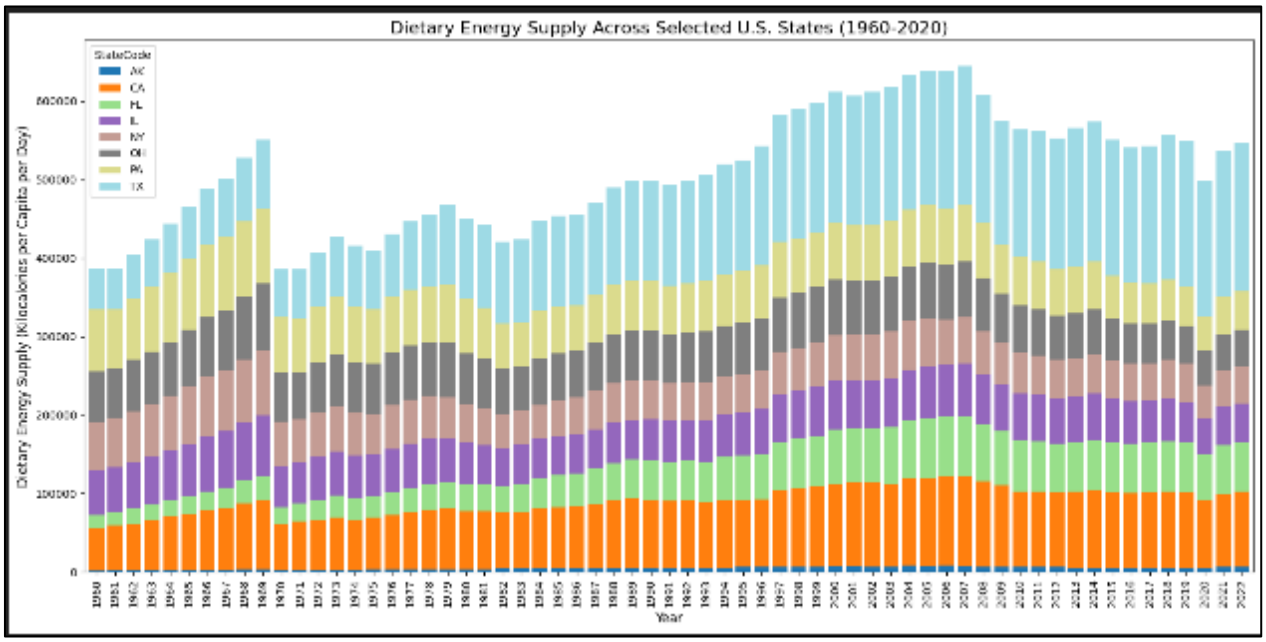

Figure 4 Dietary Energy Supply Across Selected U.S. States (1960-2020)

The stacked bar graph presents grounds the Dietary Energy Supply (in kilocalories per capita per day) per day in eight states (AK, CA, FL, IL, NY, OH, PA, TX) of the U.S., between 1960 and 2020. The bars indicate the total energy, also in a particular year, contributed by diet, and the contribution made on each state is further broken down into different colors. The steady rise in dietary energy supply is demonstrated in such states like California (CA) and Texas (TX); Miami (FL) and New York (NY) have rather up and down tendencies. This chart brings out food energy production and distribution of the different states over the years.

4.1. Policy Implications

The results realized in this research would be useful to state and national policies meant to induce food security. By locating the patterns in the energy provision in the diet and dependence on imports, the policymakers will be able to define the areas that are most susceptible to food insecurity and better allocate resources. Low or variable energy sources of diet can be associated with states in the south and west of the U.S., and special care can be taken to make sure that the food system distribution is reinforced, and food assistance program is optimized (Luo and Tanaka, 2021). Moreover, some of the states characterized by a high degree of import dependency can be more vulnerable to global food chain disruptions, and it is necessary to establish resilience by producing food locally or being less dependent on the same source.

The national level can utilize the findings of the study to formulate more effective policies that may be used to promote food security. This may involve strengthening agricultural assistance programs, investing in localized sustainable food systems, and setting up of reserve emergency foods to decrease the impact of supply chain shocks (Luo & Tanaka, 2021). In states facing the threat of food insecurity, including those with high levels of dependency on imported foods or low levels of dietary energy, specialized strategies may be aimed at enhancing healthy foods accessibility, lessening food deserts, and enhancing urban farming.

4.2. Limitations and Future Work

Although the present study provides important information on the trends in U.S. food security, some of its drawbacks should be noted. The availability of data is also one of the major constraints; the FBS data might not be adequate to demand the various types of dietary habits among the different demographic groups across states (Morales & Berkowitz, 2016). Additionally, the data is also mainly at the state level and this could be hiding regional differences in states. Also, the imputation methods to handle the missing data have the risk of creating biases particularly when the missing values are not randomly spread.

Further studies may be based on the better granularity of the data, the addition of more demographic factors and the expanded background of analysis to more specific food (fresh produce, processed foods others). It would be better to increase the pipeline to register the real-time data processing and expand the scope to capture more count of level data to offer you a much more holistic picture of the food security in the U.S (Blessing et al., 2023). More investment needs to be made in terms of introducing climate change information, which may impact food production levels and dependency on imports in the next decade, and, hopefully, adding alternative indicators of food quality and nutrition.

5. Conclusion

A thorough examination of energy supply in the diet and foreign dependence in imports over the U.S. states since 1960 to 2020 is given in this work. The results indicate that there are high levels of regional food security disparities with certain states recording high positive changes in energy diet and others especially those that depend on imports are prone to shocks caused by food system changes in other countries. The findings highlight the importance of specific policies that can be applied to address such inequalities so that the states that are at the greatest risk of food insecurity have enough support to build strong food systems.

The pipeline most of the times is reproducible as designed in this research project, which is a vital tool in real-time monitoring and policy formulation. It transforms raw FBS into interactive state dashboards to give the policymaker actionable information on the availability of dietary energy and the dependence on imports. This tool would make decisions more informed and proactive intervention in the areas where food security is at the greatest threat will be possible.

The issue of U.S. food security must continue being monitored, particularly in the light of the nation having been struggling with climate change, economic, and disruptions in global supply chain issues. The dynamism of the landscape in food security is bound to give the pipeline additional flexibility to incorporate emerging data and variables, and the U.S. will be in a better position to manage the emerging food security challenges. Monitoring is the key to having a strong, robust, and fair food system that is able to fulfill the demands of every citizen of the United States.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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