Climate Alpha

Whitepaper

Climate Alpha's Economic Momentum Indicator

An overview of Climate Alpha's data engineering, machine learning, and analysis method.

Updated as of 30 August 2023

1. Abstract

The Economic Momentum indicator evaluates a location's economic vigor and potential to respond to climate-related challenges. Integral to resilience measures, it determines how regions can amplify or mitigate climate impacts. Strong economic foundations aid in infrastructure investments, advance climate-resistant R&D, and expedite post-disaster recoveries. Such an indicator becomes a pivotal component of the resilience index. Location intelligence tools, like FEMA's National Risk Indicator, integrate economic, social, and demographic features to understand an area comprehensively. Climate Alpha's indicator further refines this approach by combining employment rates, median income, house prices, and education data, introducing dynamic metrics such as the income-to-house-price ratio to illuminate housing affordability. The tool's correlation with returns from five real estate types offers users a deep insight into location-specific economic trends and their broader ramifications.

2. Introduction

The Economic Momentum indicator highlights the economic strength and potential of a given location. Paired with other resilience measures, it reveals how different areas might exacerbate or lessen the impacts of climate-related hazards. A robust economic status can mitigate the effects of climate hazards by facilitating investments in infrastructure, supporting research and development for climate-resistant technologies, and ensuring a quicker recovery post-disaster through more resources and better financial cushions. Therefore, including economic momentum as one dimension of the resilience index is essential.

Location intelligence platforms often incorporate economic indicators to provide a comprehensive understanding of an area. For instance, the National Risk Indicator developed by the Federal Emergency Management Agency (FEMA) includes a social vulnerability index which integrates social, economic, and demographic attributes of a locale (FEMA, 2023). The Baseline Resilience Indicators for Communities (BRIC) data, which informs FEMA's National Risk Indicator, draws from a range of factors such as homeownership rates, employment statistics, racial and gender income disparities, dependence on key economic sectors, and the presence of large regional or national retailers, among others, to formulate its economic and financial variables (University of North Carolina, 2020).

In a vein akin to the NRI, Climate Alpha's Economic Momentum indicator amalgamates pivotal metrics like employment rates, median income, housing price medians, and educational milestones. Additionally, the tool introduces dynamic metrics such as the income-to-house-price ratio, shedding light on housing affordability vis-à-vis a market's purchasing prowess. The year-on-year evolution in median income provides a lens into the shifting economic dynamism of locations. This indicator's validity has been subjected to correlation tests against the returns of five distinct real estate categories, equipping users with nuanced perspectives on interpreting location-specific cues and discerning potential implications.

3. Results

The Economic Momentum Value serves as an indicator of the economic stability or vigor of a given location. This metric is derived from the equally weighted average of several factors, including the employment ratio, educational attainment, ratio of income to house price, median income, and the growth rate of median income. Due to the extensive nature of census tract level data, we utilize county-level data to showcase the findings. Below is the equation used to derive the economic momentum score. All the indicators are scaled,

Economic Momentum Value = Average [Employment Ratio + Median Income + Education Bachelors Ratio + Education Doctorate Ratio + Income to House Price + Median Income Growth]

Figure 1 presents the nationwide distribution of Economic Momentum Values for the year 2021. Notable counties leading in performance include Los Alamos County (New Mexico), Falls Church City County (Virginia), Arlington County (Virginia), Loudoun County (Virginia), and Howard County (Maryland). In contrast, counties that rank the lowest are Issaquena County (Mississippi), Loving County (Texas), Wolfe County (Kentucky), Quitman County (Georgia), and Kenedy County (Texas).

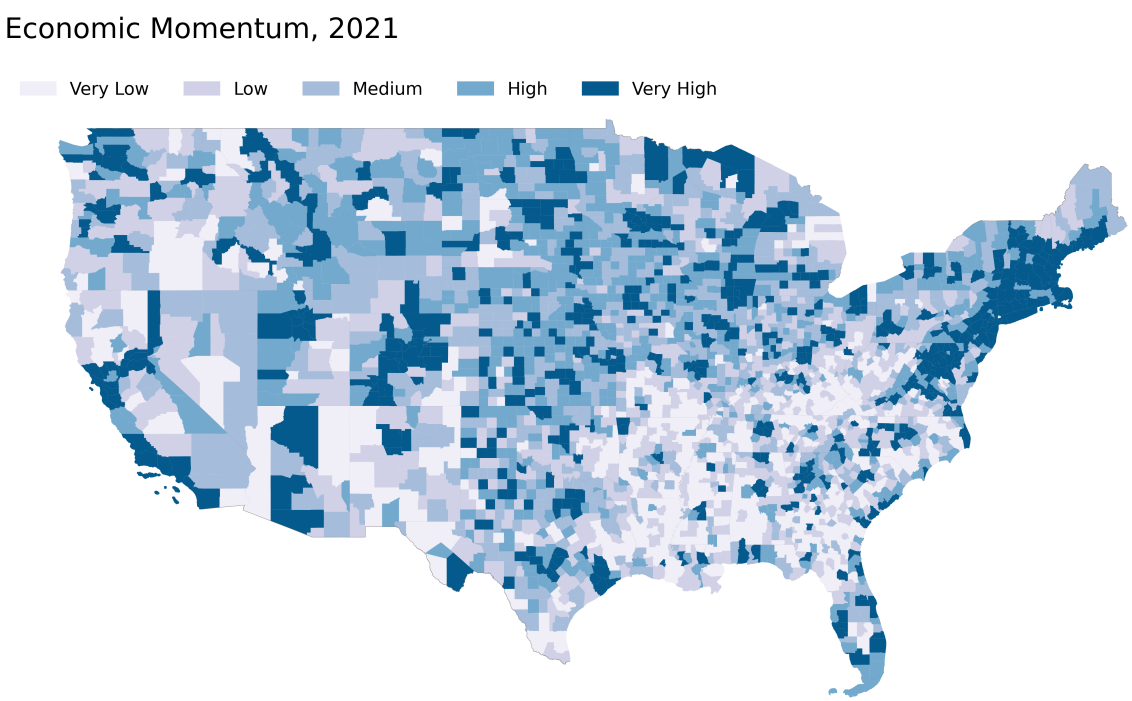

Figure 1: Economic momentum 2021

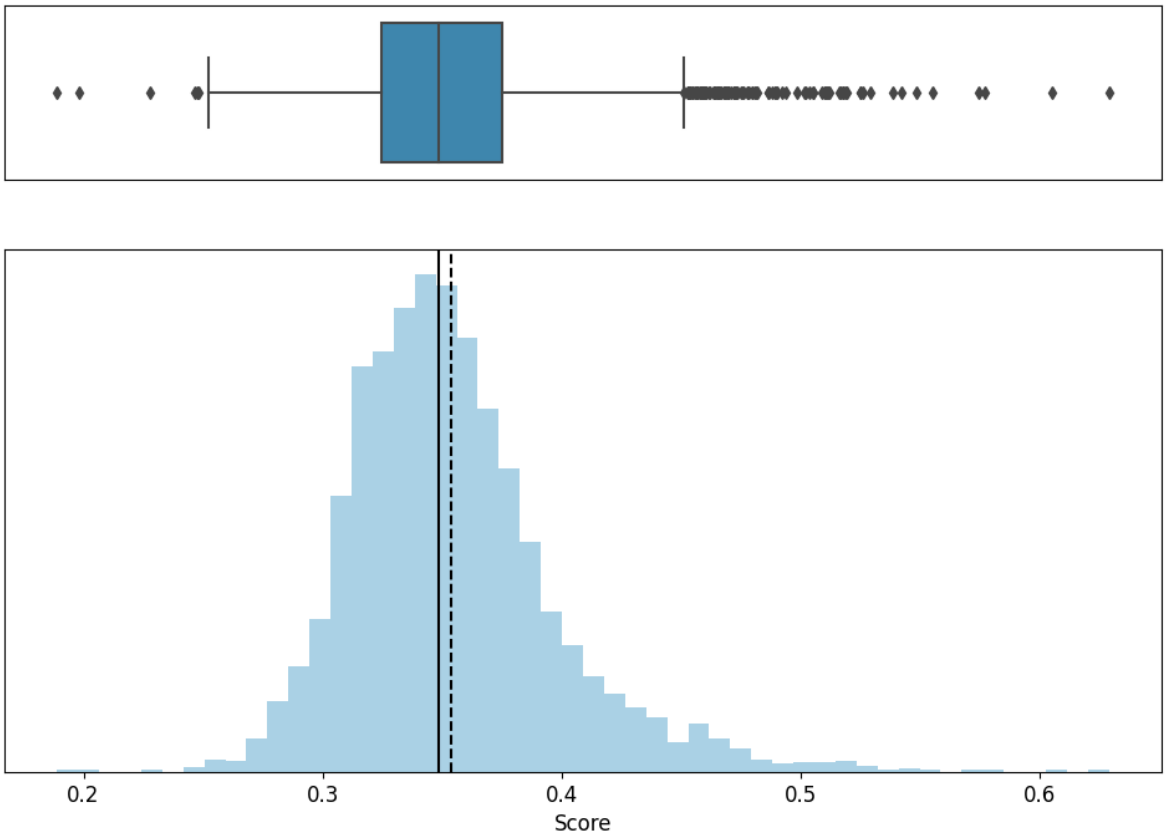

Figure 2: Distribution of the economic momentum score

From a spatial perspective, there isn't a distinctly discernible pattern. Yet, the southeast states generally display lighter shades compared to northeast states like Maryland, New Jersey, and Massachusetts. This suggests that the counties in the southeast may have lower scores in one or several factors contributing to the aggregate value.

On the west coast, counties such as Santa Clara, San Mateo, and Marin demonstrate strong economic indicators. For instance, while Santa Clara County's bachelor's and master's degree ratios hover around the national average, its employment rate and median income surpass national norms, placing it high on the overall ranking.

Considering the data spanning from 2012 to 2021, the counties depicted in Figure 3 have the highest economic momentum values.

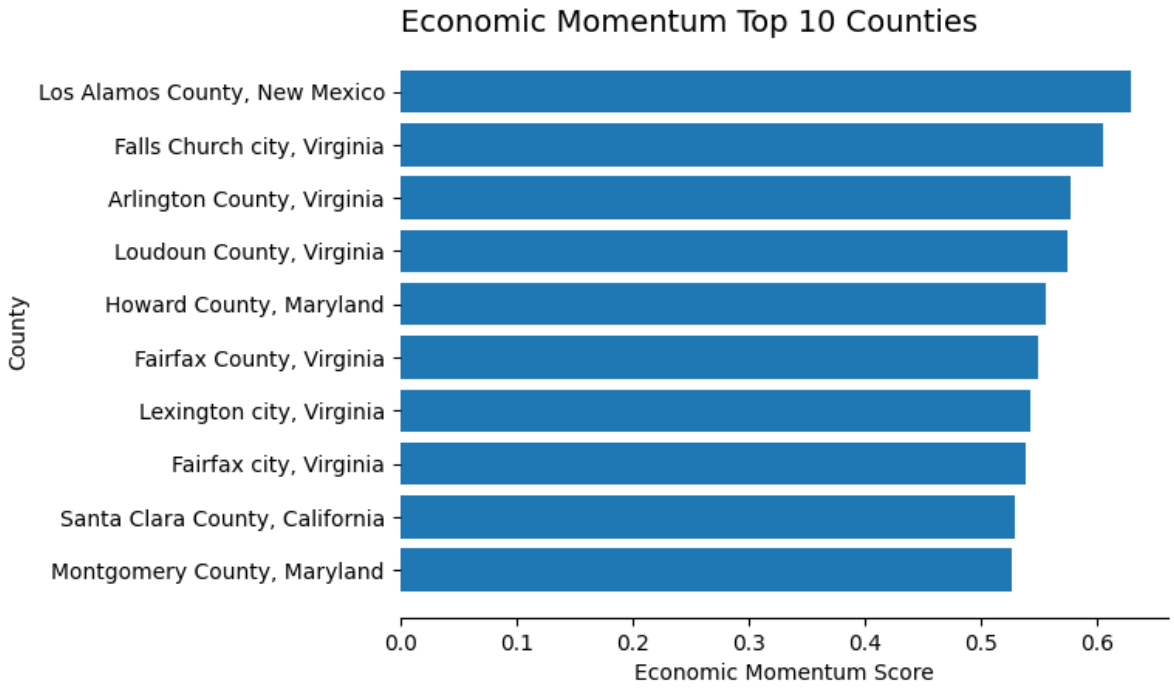

Figure 3: Top 10 counties for economic momentum

4. Discussion

In our analysis, we investigated a range of features against diverse real estate returns encompassing single-family houses, apartments, industrial spaces, offices, and retail properties. While the single-family house price index data is available at the county level, data for the other property types is confined to the CBSA (Core Based Statistical Area) level. Consequently, to maintain consistency, all single-family house values and census features were aggregated to the CBSA level.

The correlation matrix (Figure 5) offers insights into how various socioeconomic indicators relate to returns on different real estate types. For single-family houses, there's a clear positive linkage with the overall economic momentum and higher educational attainment, particularly at the doctorate and bachelor levels. Such areas with robust economic momentum typically yield higher returns for single-family residences. Conversely, apartment returns exhibit a negative relationship with areas of high employment and median incomes, suggesting that robust economic regions might offer lower yields for apartment investments.

When considering commercial real estate sectors like office and retail spaces, there is a stark negative correlation with most of the socioeconomic indicators, including the overarching '***economic_momentum_value***.' This suggests that while thriving economic regions might seem ideal, they don't necessarily translate to high returns for these property types. On the other hand, the industrial sector appears to benefit from areas with solid economic momentum. Overall, the correlations reveal that the relationship between socioeconomic factors and real estate returns is multifaceted, varying considerably across property categories. This nuanced understanding is crucial for investors and policymakers alike, guiding decisions in diverse economic landscapes.

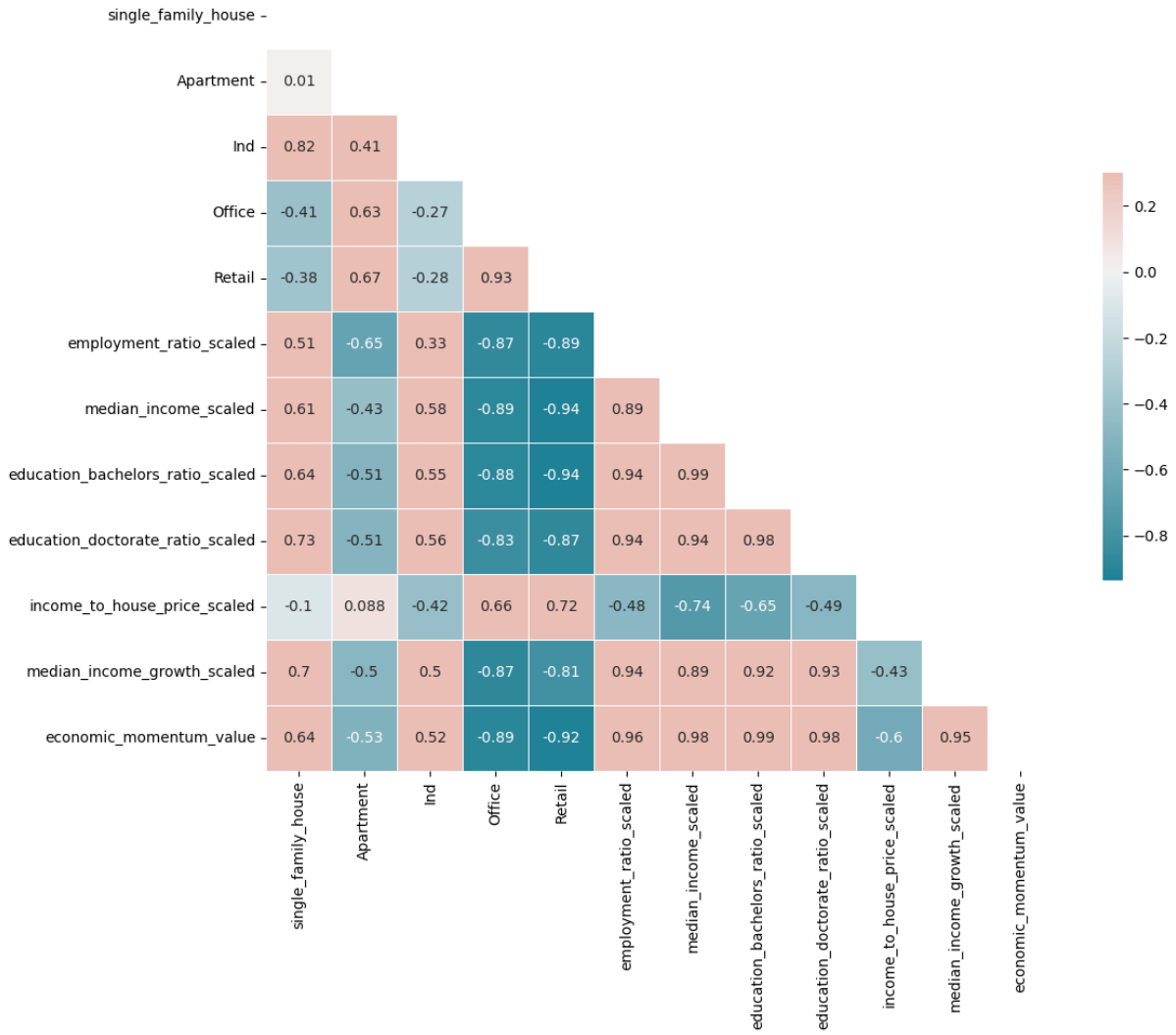

Figure 3: Correlation Matrix of the National Average, 2012-2021

We've noted varied patterns across different geographical areas. Table 1 presents the correlation coefficients between the 'education_doctorate_ratio' and the return on real estate prices. While this ratio demonstrates a consistent correlation with the year-over-year changes in the single-family house price index across various CBSAs, it displays varied results for other property types. This implies that if we intend to create models to forecast real estate price fluctuations using economic momentum indicators, a distinct model tailored to each CBSA might be necessary to capture the unique dynamics of its respective market.

CBSA Name	Single Family House	Apartment	Industrial	Office	Retail
Atlanta-Sandy Springs-Roswell, GA	0.723	0.0198	0.809	0.032	-0.584
Austin-Round Rock, TX	0.583	-0.339	0.379	-0.487	-0.660

Baltimore-Columbia-Towson, MD	0.807	-0.601	0.366	-0.253	-0.908
Boston-Cambridge-Newton, MA-NH	0.853	-0.547	0.635	0.441	-0.794
Charlotte-Concord-Gastonia, NC-SC	0.306	-0.018	0.180	0.0097	-0.118
Chicago-Naperville-Elgin, IL-IN-WI	0.886	-0.864	0.341	-0.733	-0.871
Cincinnati, OH-KY-IN	0.825	nan	0.616	nan	nan
Dallas-Fort Worth-Arlington, TX	0.723	-0.479	0.510	-0.75	-0.732
Denver-Aurora-Lakewood, CO	0.435	-0.279	0.016	-0.541	-0.711
Harrisburg-Carlisle, PA	0.856	nan	0.245	nan	nan
Houston-The Woodlands-Sugar Land, TX	0.769	-0.337	-0.146	-0.544	-0.689
Indianapolis-Carmel-Anderson, IN	0.301	nan	0.329	nan	nan
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Table 1: Correlation Coefficients between education_doctorate_ratio and Real Estate Prices

5. Methods:

The following section outlines the methodology employed by CA to construct the Economic Momentum signal. After the feature selection, min/max scaler was employed and an average Economic Momentum score was computed in the end. To corroborate our results, we cross-referenced them with literature reviews and conducted a correlation analysis, comparing our economic momentum values with the Housing Price Index (HPI) from the Federal Housing Finance Agency (FHFA) and the NCREIF Property Index.

6. Datasets

1. Economic Momentum Indicator:

- Source: Data for this indicator is derived from the 5-year American Community Survey.
- Content: Variables related to employment, educational attainment, median income, and median house price were fetched.
- Tool & Timeframe: The 'tidycensus' package in R was utilized for data extraction, spanning the years 2012-2021.
- Geographical Granularity: The data is segmented at the census tract level.

2. House Price Index:

- Source: Data was procured from FHFA.
- Content: The index provides the price of single-family houses at the county level.
- Timeframe: The dataset starts in 1986, with this year serving as the base for an HPI of 100. For alignment with the census data, we considered data from 2012 onward.
- Measures: We used the 'Annual Change (%)' metric, which calculates the year-over-year change since 1986. This metric was employed to analyze correlations between the HPI and both the raw census variables and the engineered features.

3. NCREIF Property Index (NPI):

- Source: The NCREIF offers insights into returns from institutional-grade real estate maintained in a fiduciary environment within the US.
- Content: It covers a variety of property types, including apartments, industrial spaces, retail areas, and offices.
- Timeframe & Granularity: The dataset furnishes quarterly trailing returns per property type, beginning in 2002. However, the geographical granularity is at the CBSA level.
- Data Manipulation: To make it compatible with the census data, values were spatially joined to CBSAs. When multiple census tracts intersected with a single CBSA, values were averaged to derive a singular value for that CBSA.

7. *Indicator Construction*

Following are the key steps in constructing the aggregate value, percentile score, and rating using python language:

Step 1: Load and Process Data

- Load Census Data:
  - Load the census variable extracted using 'tidycensus' in R.
  - Pivot the census table and reset the index.
  - Adjust column names and fill in missing values.
  - Set default values for ***res*** and ***scenario*** columns.

Step 2: Feature Engineering

- Education Ratios:
  - For each education level (e.g., bachelors, doctorate, etc.), calculate the ratio of individuals with that level of education to the total population over 25 years of age.
- Employment Ratios:
  - Calculate the ratio of employed to the civilian labor force.
  - Compute the ratio of unemployed to the civilian labor force.
- Income to House Price Ratio:
  - Compute the ratio of median income to median house price.
- Population Ratio:
  - Calculate the ratio of 'population_over_25' to 'population'.
- Growth Rates:

- Calculate the growth rate based on current and previous year values.
- Compute interaction features, such as the interaction between median income and employment ratio.

Step 3: Data Scaling

- Feature Scaling:
  - Use MinMaxScaler to scale selected features, like employment ratio, median income, education ratios, etc.
- Aggregate to Form Economic Momentum Value:
  - Compute the '***economic_momentum_value'*** as the mean of scaled features for each record.
  - Calculate the 'mean_economic_momentum_value' for each CBSA across all years and merge this back into the original dataframe.

Step 4: Percentile Score Calculation

- Percentile Score:
  - Rank each county based on their mean economic momentum value and derive a percentile rank.
  - Convert the percentile rank into a score ranging from 0 to 100.

Step 5: Economic Momentum Rating

- Rating Determination:
  - Define bins to categorize the economic momentum.
  - Label each bin, such as 'Very Low', 'Low', 'Medium', 'High', 'Very High'
  - Use the defined bins and labels to categorize each county based on their economic momentum percentile score.

8. Validation of Results

To validate both raw and engineered features, we conducted correlation tests with returns from five real estate categories: single-family houses, apartments, industrial properties, retail spaces, and offices. As elaborated in the "Validation" section, these selected socioeconomic features exhibited varied correlations depending on the property type and CBSA. This indicates that while the Economic Momentum indicator might signal the economic vitality or robustness of specific locations, it doesn't necessarily translate to a direct increase in real estate prices.

9. References

BRIC - College of Arts and Sciences | University of South Carolina. (n.d.). Retrieved August 10, 2023, from https://www.sc.edu/study/colleges_schools/artsandsciences/centers_and_institutes/hvri/data_and_resources/bric/index.php

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NCREIF | National Council of Real Estate Investment Fiduciaries | Home. (n.d.). Retrieved August 9, 2023, from https://www.ncreif.org/