**1. Literature and news search to decide on the variables**

*(i) Find academic articles that investigate the relation between some of the given*

*variables. These academic articles should be focusing on relationships be-*

*tween climate/economic variables.*

*(ii) Decide on a research question that you want to investigate in this assign-*

*ment. Note that the research question should involve at least one climate*

*variable and one economic variable and at least three variables in total. It*

*is important to understand that this assignment requires you to have a clear*

*intuition/model in mind because you are going to investigate the existence*

*of possible long run relationships between the variables you choose.*

<https://www.frontiersin.org/articles/10.3389/fsufs.2021.665025/full>

**2. Graphical analysis of the data**

*Now it is time to work with the data. Start with a graphical analysis of the time series. By graphical analysis we mean plotting the data (levels, logs, first differences). Using these graphics, you should already be able to address, at least partly, issues such as*

*(i) Do you see any evidence in favor or against the assumption of covariance stationarity? Do you suspect them to* be *I(2), I(1), I(0)?*

*(ii) Do you see any evidence in favor or against for the presence of deterministic components such as a constant or a linear trend?*

*(iii) Decide whether you want to use logarithms of any of the variables. Please write your detailed comments and interpretations of the results you obtain.*

Mean temperature  
Looks like the time series shows a linear trend. Expected to be stationary after time series is detrended. Time series has a constant. The time series looks like its stationary after taking first differences. Therefore, time series could be I(1). However, taking first differences instead of detrending could result in loss of information.

Deterministic components: constant, linear trend

Mean rainfall  
Looks like time series has a constant mean and variance. Therefore time series is expected to be already stationary and I(0).

Deterministic components: constant

CO2  
In the first half of the sample the time series seems to be upward trending, while thereafter it is downward trending. Therefore, a structural break seems to be present. Moreover, after taking first differences, the time series appears to be moving around a constant mean of zero and a constant variance. Therefore, we expect the time series to be I(1).

Deterministic components: constant, linear trend, structural break

Crop production  
Looks like the time series shows a linear trend. Expected to be stationary after time series is detrended. Time series has a constant. The time series looks like its stationary after taking first differences. Therefore, time series could be I(1). However, taking first differences instead of detrending could result in loss of information.

Deterministic components: constant, linear trend

**3. Analysis of the order of integration**

*Consider now the issue of testing formally for the presence of unit roots in your series. Try to carefully apply and design a sequence of tests that enables you coherently address the issue of I(2) vs I(1) vs I(0). You may start with simple Dickey Fuller tests but there is no need to limit yourself to DF tests. On the contrary, you should look for some other tests.*

*(i) Discuss carefully your choice of the deterministic components.*Testing whether the levels data has a unit root or not, we first look at the graphs to determine which deterministic components to incorporate. See Part 2.

*(ii) Discuss the possible evidence of serial correlation in the residuals of your Dickey Fuller regression.*

*(iii) Taking into account the presence of possible serial correlation, consider various extensions such as Augmented Dickey Fuller test, Phillips-Perron tests.*

When performing Durbin-Watson tests, no strong evidence emerges of serial correlation between the residuals. Moreover, the autocorrelation graphs emphasize this hypothesis, showing that there only might be some negative serial correlation in the first lag of the residuals of mean\_temperature and crop\_production. However, analyzing the order of integration of the time series we correct for possible serial autocorrelation in the residuals by using the Augmented Dickey-Fuller test, Phillips Perron test, and KPSS test.

*(iv) Use some other tests that are robust to, for example, structural breaks. You need to find the test from the literature yourself.*

*(v) Present the results of the various tests and compare these results.*

Level-data:

Crop production  
The crop production time series exhibits multiple deterministic components, namely, a constant and a trend. When adjusting for these deterministic components in conducting the unit root tests, most test results indicate that the time series is already stationary I(0). Examining the p-values of the Dickey-Fuller, Augmented Dickey-Fuller, and the Phillips Perron tests, these reject the null hypothesis of the presence of a unit root in the time series. Moreover, the KPSS test fails to reject the null hypothesis of a stationary time series and also suggests the time series is stationary I(0). If no compensation is made for deterministic components, it can be inferred from Table X that most tests indicate the presence of a unit root, and the time series is likely I(1). This underscores the importance of correcting for deterministic components in testing for a unit root in the time series. The Zivot-Andrews test can be used to test for a unit root in a univariate process in the presence of serial correlation and a single structural break. Since the crop\_production time series does not show a structural break, we omit an elaboration on these test results.

Mean temperature  
The mean temperature time series has a constant and a trend as deterministic components. When adjusting for these deterministic components in conducting the unit root tests, all test results indicate that the time series is already stationary I(0). Examining the p-values of the Dickey-Fuller, Augmented Dickey-Fuller, and the Phillips Perron tests, these reject the null hypothesis of the presence of a unit root in the time series. Moreover, the KPSS test fails to reject the null hypothesis of a stationary time series and suggests the time series is stationary I(0). If no compensation is made for deterministic components, it can be inferred from Table X that most tests indicate the presence of a unit root, and the time series is likely I(1). This underscores the importance of correcting for deterministic components in testing for a unit root in the time series. The Zivot-Andrews test can be used to test for a unit root in a univariate process in the presence of serial correlation and a single structural break. Since the mean\_temperature time series does not show a structural break, we omit an elaboration on these test results.

Mean rainfall   
The mean rainfall time series has a constant as deterministic component. When adjusting for this deterministic component in conducting the unit root tests, all test results indicate that the time series is already stationary I(0). Examining the p-values of the Dickey-Fuller, Augmented Dickey-Fuller, and the Phillips Perron tests, these reject the null hypothesis of the presence of a unit root in the time series. Moreover, the KPSS test fails to reject the null hypothesis of a stationary time series and suggests the time series is stationary I(0). We consider these findings plausible when examining the time series graph of mean rainfall.

CO2  
In the first half of the sample the time series seems to be upward trending, while thereafter it is downward trending. Therefore, a structural break seems to be present. The Zivot-Andrews test can be used to test for a unit root in a univariate process in the presence of a single structural break. Under the null-hypohesis, the time series has a unit root with a single structural break. Looking at the p-values of the Zivot-Andrews tests for CO2, it does not reject the the null hypothesis, indicating the timeseries to be I(0) and have a unit root with a structural break.

First differences:  
Looking at Table X, we can see that by taking first differences all time series seem to be transformed to a stationary process. Therefore, the time series level data do not appear to have I(2) processes. However, based on the above paragraph, in the ultimate scenario, there could be I(1) processes instead.





