Assignment
Melting Economies Under Global Warming
Multivariate Econometrics
VU Econometrics
Fall 2020

"Once extra CO2 gets into the atmosphere, it stays there for a long time. Most of the carbon dioxide that we emit today will still be there centuries from now. Even if we stopped burning fossil fuels right now, it would take the better part of a millennium for photosynthesis and other carbon-consuming processes to remove all our excess CO2 from the atmosphere. For all practical purposes, the effects of climate change are permanent, and the more CO2 we add to the atmosphere, the more severe those effects will be. It is true that the earth's climate could return to normal after a few thousand years, but most of us don't have a few thousand years to wait for things to get back to normal."

Climate Institute

From the crash course "Climate 101"

VU UNIVERSITY AMSTERDAM

"Growing evidence demonstrates that climatic conditions can have a profound impact on the functioning of modern human societies, but effects on economic activity appear inconsistent. Fundamental productive elements of modern economies, such as workers and crops, exhibit highly non-linear responses to local temperature even in wealthy countries. In contrast, aggregate macroeconomic productivity of entire wealthy countries is reported not to respond to temperature5, while poor countries respond only linearly. Resolving this conflict between micro and macro observations is critical to understanding the role of wealth in coupled human–natural systems and to anticipating the global impact of climate change."

Burke et. al. (2015)[1]

According to the findings of Burke et. al. (2015), if the economic systems behave in a way that they have been behaving until now, unmitigated warming is expected to reshape the global economy by reducing average global incomes roughly 23% by 2100 and widening global income inequality, relative to scenarios without climate change. In this assignment you will use econometric methods to improve our understanding of the relation between climate change and economic production. You will use novel modelling approaches to uncover empirical evidence on the nature and co-evolution of climate/economic variables.

Your task is to investigate time series properties of temperatures, precipitation, radiation, GDP and other related variables; the relationships between them; whether policies, agreements, important technological developments have any effect on climate change and on the relation between climate and economic variables.

[1]Burke, M., Hsiang, S.M. and Miguel, E., 2015. Global non-linear effect of temperature on economic production. Nature, 527(7577), pp.235-239.

Detailed instructions

* This assignment is mandatory and to be solved by groups of (at least) three or (at most) four students.

* **The deadline is 3rd of December 2020, 23:59.**

* You are free to use one of R, Python, Matlab. If there are existing packages to use, you are allowed to use them. But in that case, you need to add comments to the code to clarify the function of each operation in the code.

* The assignment should be **maximum 20 pages**, including tables, figures, references.

* Please make sure that you do not just hand in computer outputs. You should explain how the results are obtained, why a specific choice (model, variables, long-run relationships, . . .) is made and give an interpretation of the results.

* A pdf file must be uploaded in pdf format to Canvas before the deadline mentioned above. You must upload also all the R/Python/Matlab codes used to obtain the answers. The code should be clear and well commented.

* The pdf document must have the names and student numbers of each member of the group.

* You must include a short report explaining the contribution of each group member to the writing process of the assignment.

The Data

This assignment comes with a dataset that you need to analyse. The data set is uploaded on Canvas. The data set is a time-series ranging between 1991 - 2019. There is data on four countries Norway, Thailand, Netherlands, South Africa. Here are the details of the variables that the data set contains:

mean_pre: Mean precipitation

mean_rad: Mean radiation

mean_tmp: Average yearly temperature

NY.GDP.MKTP.KD: GDP (constant 2010 US$)

NY.GDP.PCAP.KD: GDP per capita (constant 2010 US$)

SP.POP.TOTL: Population, total

AG.LND.AGRI.K2: Agricultural land (sq. km)

AG.PRD.CROP.XD: Crop production index

In your analysis, you will use some or all these variables.

The Assignment

The assignment consists of three parts: In Part (1) you need to use graphical means to analyse your data and you need to decide which initial transformation of the data you need to apply. In Part (2) you need to investigate the non-stationarity properties of your data series (See Davidson 2000, Chapter 14, lecture notes and relevant literature). Part (3) should be devoted to cointegration analysis and the estimation of the models (See Davidson 2000, Chapters 15-16, lecture slides and relevant literature). It is important to understand that this assignment requires you to have a clear intuition/model in mind in the sense that you are going to investigate the existence of possible long run relationships in your data set.

You need to choose at least two countries. There are four countries in the data set. The reasons that these countries are there:

- Norway: Because it is one of the countries with lowest average temperatures.
- Thailand: Because it is one of the countries with highest average temperatures.
- Netherlands: Because we live/study here.
- South Africa: Because it is the country with highest agricultural production.

Below you will find a rough guideline to complete each part of the assignment. You should address at least all the items that are presented throughout the guideline. Discussions on issues/topics other than the ones mentioned in the items below for each part are also welcomed.

1. **Graphical analysis of the data**

   Start with a clear and detailed graphical analysis of the time series. By graphical analysis we mean plotting the data (levels, logs, first differences,...), looking at the correlogram of these series (in levels, log levels, 1^{st} difference, 1^{st} difference of

logs, demeaned, detrended, . . .). Using these graphics, you should already be able to address, at least partly, issues such as

(i) Explain why you transform your data before conducting your analysis?

(ii) Do you see any evidence in favor or against the assumption of covariance stationarity? Can you use these graphics to determine the order d? Do you suspect them to be I(2), I(1), I(0)?

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

(iv) Is there any evidence of extreme observations?

(v) Compare the findings on different countries you have chosen.

Please write your detailed comments and interpretations of the results you obtain.

2. 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 shortly, the literature findings about the unit root properties of the variables.

(ii) Discuss carefully your choice of the deterministic components.

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

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

(v) Does the number of lags you use influence the findings?

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

(vii) Compare the findings on different countries you have chosen.

Please write your detailed comments and interpretations of the results you obtain.

3. Cointegration analysis

Once the integration of the order of the data has been determined, you need to carry out a cointegration analysis. Search in the climate science literature, and in the economics of climate literature for any scienfitic/intiutive reason to investigate long-run relations between the variables you have chosen to analyze.

(i) First briefly discuss the type of cointegrating relationship(s) you might expect by using some previous literature findings.

(ii) Assuming that your series are I(1), test for (no)-cointegration using some of the techniques discussed during the course, in Davidson 2000 and in the related literature. Compute and compare the outcomes of various tests for no-cointegration. You may use

- The standard residual based cointegration tests using a static regression. (Engle and Granger approach, ADF type tests, Phillips-Ouliaris' test);
- The Maximum Likelihood based tests (Johansen Trace and Maximum Eigenvalue tests);
- Some other tests from the related literature.

Remember that the first test assumes a single cointegrating vector.

(iii) Is there evidence in favor or against cointegration? Is there any evidence in favor of more than one cointegrating vector? If yes, what identification scheme one should adopt and why?

(iv) Assuming there is a single cointegrating vector, estimate the cointegrating regression by using various approaches discussed in the lectures and in Davidson 2000, such as static least squares, DOLS, FMOLS and ECM. Report your

estimation and inference results (coefficient estimates, test statistics, hypothesis tests, test results etc.) Discuss the similarities and differences between your results of different methods. Discuss the differences between the assumptions of these methods.

(v) Adopt a systems approach and use Johansen's analysis (Chapter 16 of Davidson 2000) to estimate the cointegrated system. Report your estimation and inference results (coefficient estimates, test statistics, hypothesis tests, test results etc.) Discuss the similarities and differences between the results of Johansen's systems approach and the results of the single equation approach (. Discuss the differences between the assumptions of these methods.

(vi) Do the results obtained with different approaches differ? Can you test the hypothesis of weak exogeneity (discuss at least informally, for example, using the point estimates of the loadings obtained with Johansen's maximum likelihood technique.

(vii) Are the results in accordance with your prior expectations? How should we interpret these results?

(viii) Are the long run relations you discover apparently constant through time? If not, do you think whether the interventions of policy makers affect these relations?

(ix) Compare the findings on different countries you have chosen.

Please write your detailed comments and interpretations of the results you obtain.

Scoring Guide:

1. The assignment consists of three parts. (i) visual analysis of the data set, (ii) analysis of the order of integration, (iii) cointegration analysis. In the descriptions of the assignment you will find many bullet points. These are provided to you as a guideline that you can use to construct a whole satisfactory report. You are allowed to deviate from these bullet points. The main purpose of this assignment is to provide gain some understanding and the ability to analyse time series data with a focus on (i) - (iii). Doing this correctly and satisfactorily will give you 60/100 from this assignment. The division of these 60 points among the parts of the assignment is as follows:

- **(i)** visual analysis of the data set is 10 points.
- **(ii)** analysis of the order of integration is 20 points.
- **(iii)** cointegration analysis is 30 points.

2. The second aim of this assignment is to provide you an opportunity to gain more experience in writing well structured reports. The third aim of this assignment is to give you a chance to work within teams and to develop your communications skills. The structure and the quality of the report that is produced by an effective division of labor will be evaluated separately. This is worth 20/100.

3. You are free and encouraged to use econometrics methods that are not discussed during the lectures of this course. This will give you the opportunity to develop your self learning skills. This is worth 20/100.