Monetary Policy Analysis - Final Project

Co-integration Analysis of GDP and the Role of Distance and Oil Rents

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Abstract

We analyze whether GDP per capita between 1960-2019 of different countries are co-integrated and examine variables that potentially explain the co-integration status. We use data from 40 countries to run 1560 pairwise co-integration tests, in 150 of which co-integration is revealed. Further, we estimate a logistic regression model using two different weighting schemes to reveal the effect of the geographical distance and the absolute difference in the oil rent shares of GDP between two countries on the probability of having co-integrated GDP per capita. We find that the distance between two countries does not significantly affect the likelihood of being co-integrated, while the absolute difference in their average oil rent shares does. In particular, we find a significantly negative corresponding effect. It is furthermore analyzed whether some variables exhibit weak exogeneity to found co-integration relationships. The findings support the expectation that the GDP per capita series of large economies often exhibits weak exogeneity to co-integration relationships with that of smaller countries.

Contents

1 Introduction

In an increasingly globalized world, goods and services are not only produced for the domestic market and thus may cross multiple borders before they reach their final consumers. But how much influence does the foreign demand have on the development of domestic GDP? Which role plays the physical distance between two trading countries? How important is the occurrence of natural resources like crude oil? In order to answer these questions, this paper aims to analyze to which extent output per capita of different countries are co-integrated, i.e., whether they are driven by a common trend or whether they move independently of each other.

Using the Engle-Granger two-step method, a test for co-integration between two unit root processes of order 1, we are able to detect country pairings whose GDP per capita are driven by a common trend. The results show that out of 780 investigated pairs, 84 are found to be co-integrated. Among these, 66 pairs are co-integrated in both directions (i.e. regardless of which country's GDP per capita is chosen as the dependent variable in the first step of the Engle-Granger test), while 18 are only co-integrated in one direction. In a next step, we set up a logistic regression model. It estimates the probability of co-integration between two countries given the smallest physical distance between them and the absolute difference in their average oil rents as a percentage of GDP. While the distance between two countries does not have a statistically significant effect on the probability of being co-integrated, the coefficient for the absolute difference in average oil rent shares (ORS) is negative and significant on the 1% level. For three out of the four biggest per capita oil producers, namely Oman, Qatar and Saudi Arabia, we also find co-integration between their GDP per capita (in current US$) and the nominal oil price. Lastly, we test for weak exogeneity among all co-integrated pairings using an Error Correction Model (ECM). This shows that in 13 out of 14 cases in which a G7-member is co-integrated with a country outside the G7, the G7-member exhibits weak exogeneity. Furthermore, the nominal oil price appears to be weakly exogenous to three out of four relationships for which it was found to be co-integrated with an oil intense country's GDP per capita.

The remainder of this paper is structured as follows. Section 2 presents a literature review of recent research dealing with co-integration analysis. Section 3 provides the theoretical background of co-integration analysis. Section 4 introduces the data used, depicts all relevant steps undertaken to clean and preprocess the dataset and provides an exploratory data analysis. Section 5 links our data with the theoretical considerations by explaining how we set up our models. Section 6 presents the corresponding results. Section 7 concludes and discusses some potential directions of future research.

2 Literature Review

With increasing capital mobility and financial integration, changes in GDP can be closely linked between countries. Theoretical models as proposed by Fleming (1962) and Mundell (1963) show that shocks to GDP have spillover effects to other countries and are the basis for a branch of economic research. If country specific shocks have effects on other countries, one would expect that GDP of different countries move together. There are multiple ways in which that can happen. Falvey et al. (2004) analyze how knowledge spillovers affect economic growth. They show that knowledge can spill over to other countries through trade and therefore enhance growth. Especially imports are an important factor in growth-enhancing spillovers.

But spillovers are not the only channel through which trade affects economic development. Many authors have studied possible causal relations between trade and growth. Zestos and Tao (2002) examine causal relationships between growth of output, exports and imports in the United States and Canada using Granger causality tests. The results support strong causality between the three variables in all directions for Canada. The causality in the case of the United States is weaker. The authors argue that because of the size of the national market and the status of its currency, the US was able to import goods irrespective of the level of exports. For countries without that special feature, imports are paid for with foreign exchange provided by exports. So, for most countries, imports and exports are closely related. If a country experiences a positive income shock, it increases its overall demand. As the demand for imports also increases, and imports are mainly paid by exports, the income shock also affects the country's trading partners. Although capital mobility has steadily increased over time, there still seems to exist a strong negative effect of distance on bilateral trade, known as the distance puzzle. Disdier and Head (2008) find that around 1950, the negative impact of distance on trade increased and has remained persistently high since then. The distance puzzle therefore implies that bilateral trade should be strongest for countries close to each other. If one assumes that GDP of countries which trade a lot are more closely related to each other, distance should weaken this relationship.

Another factor, which is related to both GDP and trade, is oil. Many studies have examined the relationship between oil and GDP. Naser (2017) shows that oil consumption as well as oil prices and GDP are co-integrated. A paper by Lardic and Mignon (2006) also analyzes co-integration between GDP and oil prices. Although the results reject standard co-integration, the evidence supports asymmetric co-integration. Therefore, oil resources and oil prices are closely related to GDP in many countries. The effects of oil prices in turn also have an impact on many countries through trade. Korhonen and Ledyaeva (2010) analyze the macroeconomic effects of oil price shocks. They show that a positive oil price shock increases GDP for oil producers and has ambiguous effects on GDP for oil consumers. There is a direct negative effect because of the higher oil price, but also an indirect positive effect. The mechanism mentioned above applies here, namely that the oil producers increase their overall demand because of the oil price shock. Oil consumers can benefit from that, as they can export more to oil producers. This implies that oil price shocks affect GDP not only in countries with relatively high oil resources, but also their trade partners.

3 Theoretical Background

Many economic time series show a tendency to grow over time. Contrary to non-trending stationary processes, which move around a constant mean with only temporary deviations from it, *trending* economic time series are not compatible with stationarity. The reason is that their mean is no longer constant. These growing economic time series only become stationary after differentiation. The number of times that one has to differentiate the process to achieve stationarity is called the *order of integration.* If d times differentiation is necessary, the process (captured e.g. by variable X) is called integrated of order d and is denoted by X $\sim$ I(d). When working with economic variables, it is usually sufficient to differentiate the time series only once, i.e. $d = 1$. Integrated processes with $d > 0$ are also called *unit-root processes.* A regression of an integrated variable X_t on its lagged values X_{t-1}, or a regression of one integrated variable X_t on another integrated variable Y_t, tends to show a relationship between the variables with no informative value. This phenomenon is called *spurious correlation.* In order to test whether there is an economically meaningful correlation between different time series in the long run, the concept of *co-integration* can be useful (Neusser, 2016).

The concept of co-integration was first introduced by Nobel laureates Robert Engle and Clive Granger in 1987 (Engle and Granger, 1987). According to their general definition of co-integration, the components of the vector x_t are said to be co-integrated of order *d, b*, denoted $x_t \sim CI(d, b)$, if the following two conditions are fulfilled:

i) all components of x_t are $I(d)$;

ii) there exists a vector $\alpha \neq 0$ so that $z_t = \alpha' x_t \sim I(d-b), b > 0$, i.e. the difference is a stationary process which removes the common stochastic trend from the variables. This vector α is called the co-integrating vector.

In the case of only two variables, one speaks of *bivariate* co-integration. Two series are said to be co-integrated if they move together over time, and the distance between them is stable. Hence, co-integration reflects the presence of a long-run equilibrium towards which the economic system converges over time. More formally: two non-stationary series are co-integrated if there is a stationary linear combination of the series. For the bivariate case, Neusser (2016) provides a more comprehensive definition. Two stochastic processes X_t and Y_t are called co-integrated, if the following two conditions are fulfilled:

i) X_t and Y_t are both integrated processes of order one, i.e. $X_t, Y_t \sim I(1)$;

ii) there exists a constant $\beta \neq 0$ such that $Y_t - \beta X_t$ is a stationary process, i.e. $Y_t - \beta X_t \sim I(0)$.

More intuitively this means that we have two non-stationary variables X_t and Y_t and we want to test whether there exists an economically meaningful relationship between them. As a regression of integrated variables leads to unreliable results, we need a different method to discover a common trend that drives the variables. The idea of the Engle-Granger test is to find the co-integrating constant β, which, multiplied with X_t, leads to a constant difference between βX_t and Y_t in the long-run. If there exists no such β, i.e. if $\beta = 0$, the two non-stationary variables are not co-integrated. This means that there exists no economic trend that drives the variables and any correlation between them just happens by coincidence.

Because we do not know the co-integrating constant β, the Engle-Granger two-step method starts by estimating a co-integrating regression by Ordinary Least Squares (OLS).

$$Y_t = \beta_0 + \beta_1 X_t + \epsilon_t \tag{3.1}$$

Then, the method tests the residuals for the presence of unit roots, i.e. for co-integration. If the variables X_t and Y_t are $I(1)$ and co-integrated, the linear combination of these variables yields stationary residuals, i.e. $\epsilon_t \sim I(0)$.

$$\epsilon_t = Y_t - \beta_0 - \beta_1 X_t \sim I(0) \tag{3.2}$$

This can be tested by performing the Augmented Dickey-Fuller (ADF) test. It tests the null hypothesis that a unit root is present in an auto-regressive model. The alternative hypothesis is usually stationarity. As the residuals have been obtained from a preceding regression, we are faced with the so-called "generated regressor problem". This implies that we have to use the critical values provided by MacKinnon (1991) instead of the usual Dickey-Fuller tables. The critical value K for the t-statistic of the estimated coefficient ρ depends on

i) the specification of the OLS-co-integration equation (with constant or with constant and trend);

ii) the number of variables involved and the number of observations.

4 Data

In the first part of this section we discuss the data gathering and cleaning process. Thereafter, we provide some preliminary insights into the data through a short exploratory data analysis. As such, we analyze the time series graphically and provide some summary statistics.

4.1 Data Gathering & Prepossessing

In order to analyze the extent to which GDP per capita of different countries are co-integrated (i.e. whether the GDP per capita are driven by a common trend or whether they move independently of each other), and what role the geographical distance and the occurrence of natural resources (such as crude oil) play, we collect data from several different resources. First, we retrieve a customized dataset from the World Development Indicators database, accessible through the World Bank[1] (2020). This dataset contains annual data on GDP per capita in current US dollars as well as oil rents in percentage points of GDP (hereinafter referred to as oil rent shares or ORS). The data includes 217 countries for the period 1960 to 2019. As data on crude oil occurrence appears to be not as readily available as the country specific ORS, we use the latter as a proxy for the former in the subsequent analysis.

We then check for completeness of the data for each country individually before collecting further data. Doing so reveals that for many countries the data on at least one of the variables of interest (i.e. GDP per capita and ORS) are missing for multiple years during the observational period. To ensure that for each country in our analysis enough data is available, we exclude all countries for which either more than 15 values of GDP per capita or more than 20 values for ORS are missing (or both). This approach leaves us with a total of 89 countries for which the data appears to have acceptable coverage in both variables collected so far.

As a next step, we take a dataset from Triff (2017)[2], which contains the closest distances in kilometers between each possible pair from 253 countries. After ensuring that the labeling of all countries coincides in both datasets, we find that in the dataset from Triff (2017) the data for one of the 89 countries identified above (i.e. Hong Kong) is missing. Hence, we drop it from our dataset and are left with 88 countries, for which the required data are available to an acceptable extent.

Then, as a last step of the data gathering process, we retrieve data on the nominal and inflation adjusted annual average crude oil price per barrel in US dollars from 1960 to 2019 from InflationData[3] (2020). Since this completes the set of variables required for the analysis, we then move on to do some final data cleaning steps. As such, we skim through the collected data and look for any striking anomalies or gaps in the contained time series, which could cause issues in the subsequent analysis. Doing so reveals the following: First, GDP per capita of Kuwait appears to be missing for the years 1992 to 1994. Secondly, the ORS of Kuwait and Qatar are missing in the year 1979. To prevent problems these gaps could cause later, we impute these missing values by linear interpolation based on the adjacent entries of each gap.

Thereafter, we move on to the selection of a reasonable subset of the remaining 88 counties in our dataset to consider in the analysis. We make this choice based on several different aspects. First, we want to include countries that make a comparatively large contribution to

[1] `https://databank.worldbank.org/indicator/NY.GDP.PCAP.CD/1ff4a498/Popular-Indicators`

[2] `https://gist.githubusercontent.com/mtriff/185e15be85b44547ed110e412a1771bf/raw/1bb4d287f79ca07f63d4c56110099c26e7c6ee7d/countries_distances.csv`

[3] `https://inflationdata.com/articles/inflation-adjusted-prices/historical-crude-oil-prices-table/`

the gross world product (e.g. G7 countries) and are therefore generally considered as economically important. Secondly, to ensure generalizable results, we intend to include countries from all continents of the world (except Antarctica). Third, as our analysis also deals with differences of oil occurrence among countries, we also include countries that exhibit a comparatively high ORS within the observational period. The selection we make based on these considerations leads to a subset of 41 countries - in particular, we include 17 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom), 5 African countries (Arab Republic Egypt, Morocco, Nigeria, South Africa, Tunisia), 3 North American countries (Canada, Mexico, United States), 5 South American countries (Brazil, Colombia, Ecuador, Paraguay, Peru), 9 Asian countries (China, India, Japan, Kuwait, Oman, Qatar, Saudi Arabia, Turkey, United Arab Emirates) and 2 Australian countries (Australia, New Zealand). A detailed description of how we group these countries as well as an overview of some country specific summary statistics are provided in the next section.

4.2 Exploratory Data Analysis

For the purpose of the analysis, the time series are required to constitute unit root processes. Nelson and Plosser (1982) explain that in the context of GDP series, this appears to be the case only after transforming the data by the natural logarithm. Hence, to enable our data to exhibit the desired properties, we log-transform GDP per capita of all countries in our dataset prior to the subsequent analysis.

Since our dataset consists of 41 countries, we form several groups to enable a convenient interpretation and representation of figures and tables. Generally, countries are grouped according to their continents. However, we also form subgroups for the European Union (EU) and the Group of Seven (G7), as it might be interesting to investigate these important groups separately. The affiliation of each country to these groups and subgroups is shown in Table 1[4]. In addition, Table 1 depicts several descriptive statistics for each country in our dataset, such as the minimum and maximum values of log-GDP per capita, the average ORS in percentage points, as well as the number of missing observations (NAs) in both of these variables. These statistics are chosen by the following rationale: GDP per capita on the one hand is usually growing over time, and its range is therefore of greater interest than its average. For the ORS on the other hand the opposite argument holds, as we expect it to be more or less stable within the observational period.

The log-GDP per capita series of all countries under consideration are displayed in Figure 1 (grouped by Continents, EU and G7 Countries) and Figure 2 (grouped by entire Europe and entire America). We observe that the GDP per capita of the United States (US) follows a somewhat smoother curve than the series of most of the other countries. This might be due to the fact that the US is the only country in our dataset that uses the US $ as its local

[4] Unless explicitly stated otherwise, all tables shown in this paper are produced by means of the R-package *kableExtra* by Zhu (2020).

Country	Continent	Subgroup	Min Log-GDP pc	Max Log-GDP pc	NAs in GDP pc	Avg ORS in %	NAs in ORS
Austria	Europe	EU	6.841	10.854	0	0.074	11
Belgium	Europe	EU	7.15	10.781	0	0	12
Denmark	Europe	EU	7.819	11.072	6	0.522	12
Finland	Europe	EU	7.073	10.888	0	0	12
France	Europe	G7, EU	7.196	10.722	0	0.012	11
Germany	Europe	G7, EU	7.923	10.778	10	0.023	11
Greece	Europe	EU	6.254	10.373	0	0.034	12
Ireland	Europe	EU	6.53	11.273	0	0	12
Italy	Europe	G7, EU	6.69	10.616	0	0.04	11
Netherlands	Europe	EU	6.974	10.962	0	0.056	11
Portugal	Europe	EU	5.887	10.121	0	0	12
Spain	Europe	EU	5.982	10.474	0	0.023	11
Sweden	Europe	EU	7.656	11.021	0	0	12
Iceland	Europe	-	7.255	11.198	0	0	12
Norway	Europe	-	7.274	11.542	0	4.699	12
Switzerland	Europe	-	7.488	11.39	0	0	12
United Kingdom	Europe	G7	7.243	10.831	0	0.695	11
Canada	North America	G7	7.714	10.872	0	1.586	11
Mexico	North America	-	5.844	9.299	0	4.277	11
United States	North America	G7	8.009	11.087	0	0.683	11
Brazil	South America	-	5.323	9.491	0	1.01	11
Colombia	South America	-	5.526	9.014	0	3.359	11
Ecuador	South America	-	5.755	8.76	0	8.376	11
Paraguay	South America	-	5.319	8.717	5	0	12
Peru	South America	-	5.534	8.85	0	2.087	11
Egypt, Arab Rep.	Africa	-	5.091	8.178	5	10.362	11
Morocco	Africa	-	5.068	8.078	0	0.017	11
Nigeria	Africa	-	4.532	8.039	0	12.511	11
South Africa	Africa	-	6.094	8.988	0	0.04	12
Tunisia	Africa	-	5.384	8.368	5	5.38	11
China	Asia	-	4.261	9.236	0	2.788	11
India	Asia	-	4.409	7.65	0	0.937	11
Japan	Asia	G7	6.172	10.791	0	0.011	11
Kuwait	Asia	-	8.259	10.924	5	45.193	11
Oman	Asia	-	4.618	10.005	5	40.76	11
Qatar	Asia	-	7.921	11.351	10	37.518	11
Saudi Arabia	Asia	-	6.656	10.136	8	39.897	11
Turkey	Asia	-	5.648	9.443	0	0.148	12
United Arab Emirates	Asia	-	10.012	10.714	15	24.102	16
Australia	Australia	-	7.5	11.129	0	0.919	11
New Zealand	Australia	-	7.542	10.704	0	0.342	11

Table 1 – Table of Summary Statistics

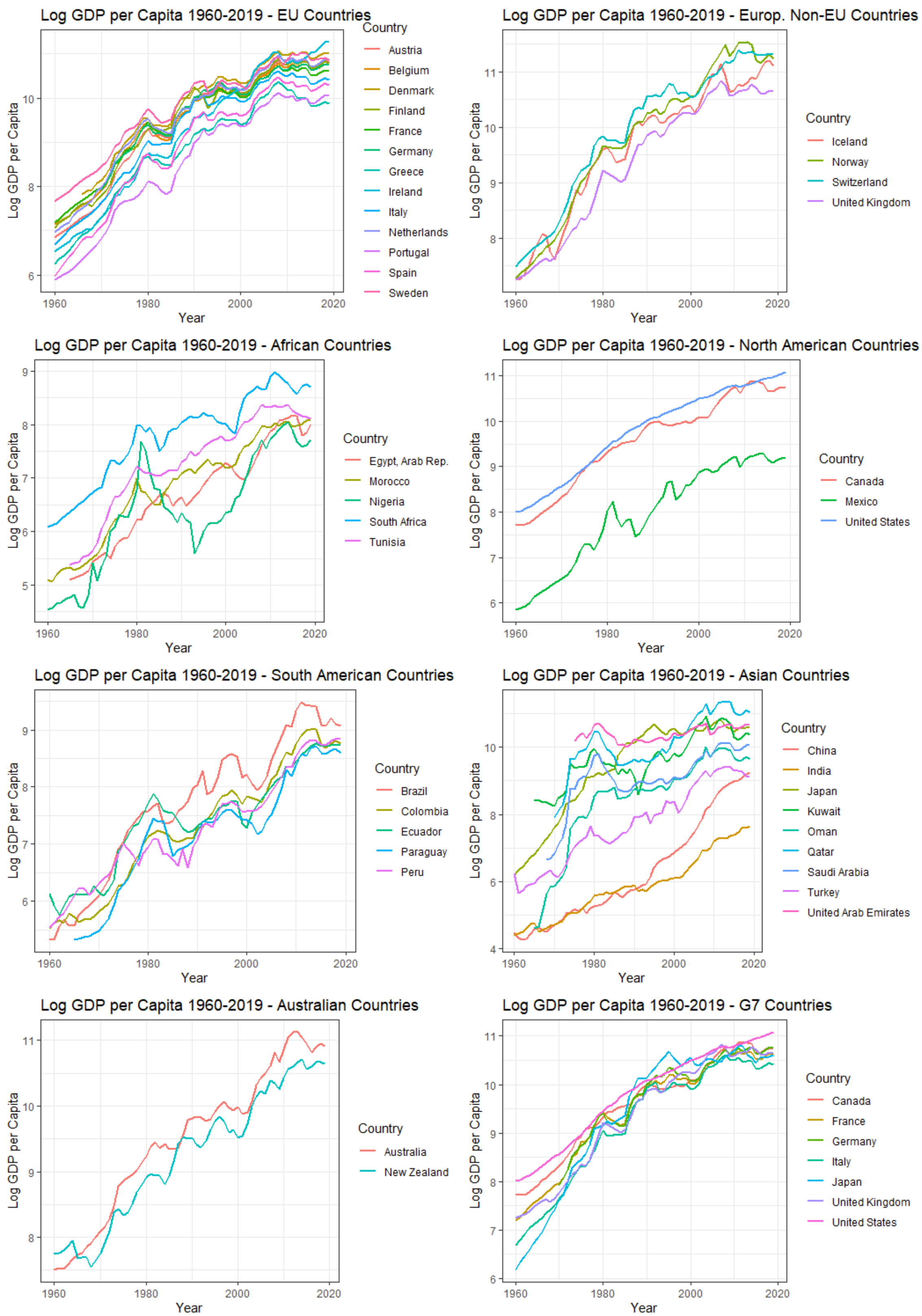

Figure 1 – Log-GDPs per Capita 1960-2019 - Grouped by Continents, EU & G7 Countries

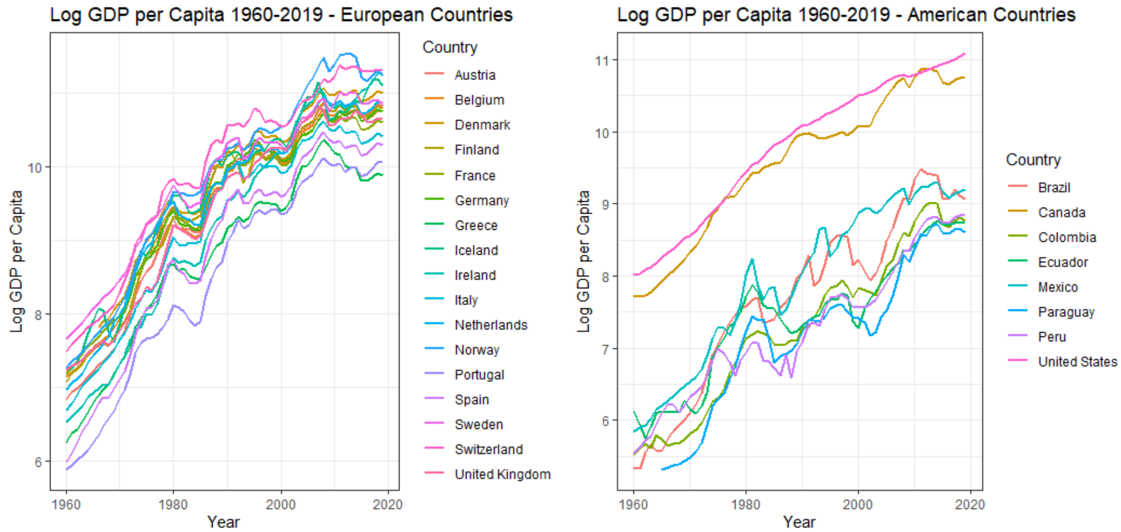

Figure 2 – Log-GDPs per Capita 1960-2019 - Entire Europe and Entire America

currency. GDP per capita of all other countries is therefore confronted with changes in the exchange rate. Furthermore, Figure 3 visualizes the development of the inflation adjusted and the nominal oil price within our observational period[5].

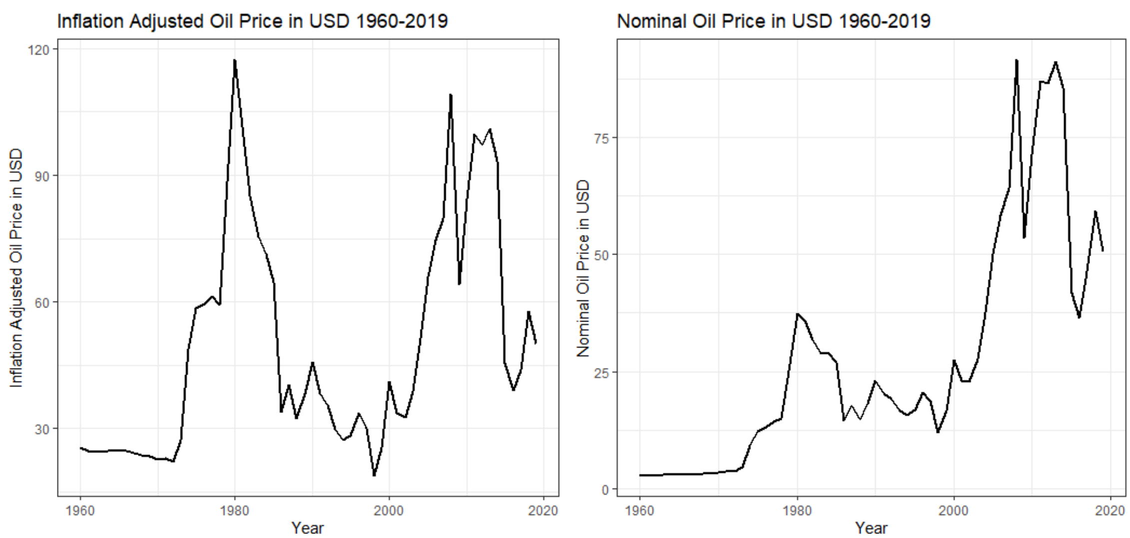

Figure 3 – Inflation Adjusted and Nominal Oil Prices 1960-2019

[5]Figures 1, 2 and 3 are created using the R-package *ggplot2* by Wickham (2016).

5 Methodology

As stated in Section 3, regressing integrated time series on each other leads to the problem of spurious correlation and hence to unreliable results. The log-transformed GDP per capita is typically a growing non-stationary economic time series and thus not applicable for standard regression procedures as can be seen in Figure 1 and Figure 2. In order to analyze whether the log-transformed GDP per capita of different countries are co-integrated, i.e. whether they are driven by a common stochastic trend, we perform pairwise Engle-Granger tests. More precisely, we take the GDP per capita of all remaining countries in our dataset (which are listed in Table 1), and perform pairwise Engle-Granger tests on each pairing for which this is applicable. This analysis as well as the subsequent steps are performed by means of the statistical software R (R Core Team, 2013).

The prerequisite for the Engle-Granger test is that the analyzed time series are both integrated processes of order 1, i.e. they are difference stationary and thus become stationary after differentiating them once (Neusser, 2016). This can be tested by the Augmented Dickey Fuller (ADF) test. In R, this test can be performed using functions provided by the *aTSA* package (Qiu, 2015). Furthermore, we want to find the optimal lag structure for each country's log-transformed GDP per capita series in first differences. Thus, we test down from 4 lags in the variable and choose the number of lags that appears to be most appropriate according to the Akaike Information Criterion (AIC). This means that we choose the number of lags that leads to the smallest value for the AIC. We use the AIC since for small samples, such as the present one consisting of a maximum of only 60 observations per country, it appears to be superior to other information criteria according to Liew (2004). The ADF test is only performed with a drift but without trend, since unit root processes require the series to be stationary after d differentiations instead of being "just" trend stationary (Neusser, 2016). The results of the ADF tests for stationarity and the optimal number of lags are depicted in Table 6. Countries for which we fail to reject the null hypothesis of the ADF test on the 95% level (i.e. time series that are non-stationary in first differences) are excluded from further analyses as they are not applicable for the Engle-Granger test. We calculate the Engle-Granger test statistic for each possible pair of the remaining countries using their log-transformed GDP per capita in levels. Note that for each pair we perform two tests, such that each country's log-transformed GDP per capita serves for both the dependent variable and the explanatory variable in the first step of the Engle-Granger method. Again, the *aTSA* package is used to perform the test in R (Qiu, 2015). Importantly, the applied function automatically uses the correct critical values provided by MacKinnon (1991). By means of our test results, we then create a dummy variable which indicates 1 if co-integration is revealed for a country pair on a 95% significance level and 0 otherwise. Table 7, Table 8 and Table 9 show the corresponding results. This indicator variable is used later as the dependent variable in the logistic regression.

There might be country pairings for which the Engle-Granger test shows a different co-integration status depending on which country's log-transformed GDP per capita serves as the dependent variable in the co-integration test. If this is the case, we include one observation for each possibility, while introducing a weight of 0.5 in the logistic regression model for such observations. This ensures that they will not be overweighted compared to the other observations. Furthermore, we might observe that the resulting dataset is rather unbalanced in the sense that observations (i.e. country pairs) of one co-integration status appear to be clearly predominant. If this is found to be the case, we will account for this by additionally introducing a balanced weighting vector. This vector weights each observation according to the inverse of its share of occurrence of the respective co-integration status in the entire dataset. This procedure ensures that observations of both co-integration status are overall evenly weighted in the logistic regression. Thus, we perform the logistic regression twice - once with the baseline weights consisting of 1 and 0.5, and once with the balanced weights.

Then we proceed by estimating the logistic regression model. With this model, we analyze the effect of the geographical distance, as proposed by e.g. De Benedictis and Taglioni (2011) and Disdier and Head (2008), and the effect of the absolute difference in the average ORS (Naser, 2017) between two countries on their probability of being co-integrated. For each datapoint j (i.e. the j^{th} country pair), the logistic regression model assigns a probability of being co-integrated according to the so called Sigmoid function. This function is denoted $\sigma(\cdot)$ and is given by (Bishop, 2006):

$$\begin{aligned}\mathbf{Pr}(\text{co-integration}_j = 1) &= \sigma\Big(\beta_0 + \beta_1 \text{distance}_j + \beta_2 |\text{dORS}_j|\Big) \\ &= \frac{\exp\Big(\beta_0 + \beta_1 \text{distance}_j + \beta_2 |\text{dORS}_j|\Big)}{1 + \exp\Big(\beta_0 + \beta_1 \text{distance}_j + \beta_2 |\text{dORS}_j|\Big)} \\ &= \frac{1}{1 + \exp\Big(-\big(\beta_0 + \beta_1 \text{distance}_j + \beta_2 |\text{dORS}_j|\big)\Big)}\end{aligned} \tag{5.1}$$

However, fitting the β_k coefficients of a logistic regression model relies on a likelihood maximization approach. Namely, it maximizes the following objective function, which is also referred to as the weighted log-likelihood function:

$$\max_{\beta_0,\beta_1,\beta_2} LL = \sum_{i=1}^{n} w_i * \Bigg(y_i * \log\Big(\sigma\big(x_i\big)\Big) + \big(1 - y_i\big) * \log\Big(1 - \sigma\big(x_i\big)\Big)\Bigg)$$

$$\begin{aligned}\text{where: } & x_i = \beta_0 + \beta_1 \text{distance}_i + \beta_2 |\text{dORS}_i| \\ & y_i : \text{co-integration indicator for country pair } i \\ & w_i : \text{weight assigned to datapoint } i \\ & n : \text{number of observations}\end{aligned} \tag{5.2}$$

Table 2 presents the results of the logistic regression[6]. As mentioned above, the regression is estimated for both the baseline and the balanced weights.

As a next step, we investigate the role of the ORS. First, we define countries with an average ORS $> 4\%$ as oil intense countries. This threshold is chosen to ensure that Norway, which is the most oil intense country from Europe, counts as oil intense in our analysis. Again, we perform an Engle-Granger test in order to test whether GDP per capita of oil intense countries is co-integrated with the nominal oil price. We use the nominal oil price instead of the inflation adjusted oil price for reasons of comparability, because our dataset contains GDP per capita in current US$. Before we can perform the Engle-Granger test, we need to check whether the nominal oil price is also an integrated process of order 1. If this is the case, we can proceed with the Engle-Granger test. It uses the log-transformed GDP per capita of oil intense countries as the dependent variable and the nominal oil price as the explanatory variable in the OLS regression performed in the first step. Table 4 displays the results for the eleven oil intense countries.

Lastly, we want to test for weak exogeneity among the series that were found to be co-integrated by using an error correction model (ECM). This model uses the deviations of the difference of two co-integrated variables from its long-run average - the so called errors. The optimal lag structure used in the ECMs corresponds to the one applied in the ADF tests on the first differences of the respective variables. The ECM estimates the effect of past errors on changes in the co-integrated variables. If this effect is not statistically significant, the variable exhibits weak exogeneity. This indicates that it does not adjust to changes in the other co-integrated variable (relative to its own changes) but is driven by factors outside the relationship. The results from this analysis can be seen in Tables 10-13.

6 Results

In a first step, we determine whether the time series under study (i.e. log-GDP per capita) is stationary in first differences. This is a requirement for the further analysis we want to conduct, as outlined in section 5. The results are reported in Table 6. A value of 1 in the column "Stationarity" means that the series is first-difference stationary at the 95% significance level. P-values below 0.01 were rounded to 0.01. The time-series for the US is the only one that is not found to be first-difference stationary. It is therefore omitted from any further analysis. The results show that the optimal number of lags was determined to be 1 in the majority of cases.

Tables 7, 8 and 9 report the results of an Engle-Granger co-integration test for each pair of countries in our sample. The results are reported in the form of an indicator variable,

[6]Table 2 is created using the R-package *stargazer* by Hlavac (2018).

which takes the value 1 if the pair is found to be co-integrated at the 95% significance level, and 0 otherwise. As stated in section 5, we conduct two tests for each possible pairing of countries in our sample. A country's log-transformed GDP per capita is used as the dependent variable in one test and as an explanatory variable in a second test. As there are 780 pairs in our sample, we conduct 1560 tests. 66 pairs exhibit co-integration in both tests. For another 18 pairs, one test reveals co-integration whereas the second test shows no co-integration. In total, 150 of the 1560 conducted tests reveal co-integration, which equals a rate of 9.6%. Looking at the results within regions, it does not seem to be more likely that GDP per capita of countries within the same continental region exhibit co-integration. Among EU-countries, the share of co-integrated series is 10.3%. However, if European countries outside the EU are included, this share decreases to 8.8%. This is lower than the share in the complete sample. We find similarly low rates of co-integration within Asia and Africa and no instances of co-integration within the group of North- and South-American countries. In fact, among pairs of countries from different regions we find a higher share of co-integrated series (10.2%) than among pairs within the same region (7.2%). These results are however strongly affected by outliers in the sample. Mexico and Turkey alone are represented in 79 of the 150 tests which found co-integration. In addition, in most cases where only one test reveals co-integration either Oman or Turkey are involved. The time series of Mexico and Turkey are relatively close to the averages across series regarding mean and variance. The series of Oman on the other hand is one of the most volatile in the sample. However, we do not observe the same behaviour for characteristically similar time series. These observations are therefore unlikely to explain the extraordinary results we find for these three countries.

The results from the logistic regressions of the co-integration indicator variable on distance and the absolute difference in average ORS are reported in Table 2. Based on the Gravity Model introduced by the first Nobel laureate for economic sciences, Jan Tinbergen, we expect that the distance between two countries negatively affects the probability of being co-integrated (De Benedictis and Taglioni, 2011). However, our results show no significant estimates for the effect of distance on the co-integration probability, neither for the baseline nor for the rebalanced regression. Our second consideration is the absolute difference in ORS and its influence on the probability of being co-integrated. As Naser (2017) points out, oil consumption is a major factor for economic growth and has a predictive power for GDP. Two countries with a high absolute difference in ORS are hence less likely to be co-integrated, i.e. being driven by a common stochastic trend, than two countries with similar levels of ORS. Thus, we expect again a negative sign of the estimate. As shown in Table 2, the coefficient on the absolute difference in average ORS is indeed negative and significant. This holds for both regressions, the one with baseline weights and the one with balances weights, although the coefficient in the latter is less strongly negative. This fits our prediction that the economic development of oil-producing countries differs from other countries regarding the trends or factors that influence it. As the regressions control for the distance between countries, it is also unlikely that this result is driven by the geographical concentration of oil-producing countries in our sample around North Africa and the Arabian Peninsula.

	Dependent variable:	
	Co-integration Indicator	
	Logistic Regression w/ Baseline Weights	Logistic Regression w/ Balanced Weights
Distance	0.00002	0.00001
	(0.00003)	(0.00003)
	p = 0.587	p = 0.830
Abs. Difference of avg. ORS	-0.049^{***}	-0.028^{***}
	(0.014)	(0.010)
	p = 0.001	p = 0.007
Constant	-1.989^{***}	-1.937^{***}
	(0.211)	(0.200)
	p = 0.000	p = 0.000
Observations	798	798
Note:		*p<0.1; **p<0.05; ***p<0.01

Table 2 – Logistic Regression Results

As we want to examine the nominal oil price for possible co-integration with the time series in our sample, we need to determine whether it is also first-difference stationary. As reported in Table 3, the nominal oil price is first-difference stationary at the 95% significance level with an optimal lag length of one. We can therefore conduct co-integration tests involving it.

	Optimal number of Lags	P-Value	Stationarity
First Differences of Nominal Oil Price	1	0.01	1

Table 3 – Results of Augmented Dickey Fuller Test on Nominal Oil Price in First Differences

In order to further examine the effect of oil price changes, we test for co-integration between the nominal oil price and the log-GDP per capita from each of the eleven countries with an average ORS above 4%. The results are shown in Table 4. The indicator variable again takes on the value 1 if we find co-integration. P-values above 0.1 and below 0.01 are displayed as 0.1 and 0.01 respectively. In four instances we find the log-GDP per capita to be co-integrated with the nominal oil price. Generally, we do not find co-integration for countries with a comparatively low average ORS. Among the four countries with an average ORS above 30%, three exhibited co-integration at the 95% significance level, namely Oman, Qatar and Saudi-Arabia. The null hypothesis of no co-integration was only narrowly not rejected in the case of Kuwait, the most oil-intense economy in our sample.

	Co-integrated with Nominal Oil Price	P-Value	Avg. ORS in %
Norway	0	0.100	4.699
Mexico	0	0.100	4.277
Ecuador	0	0.100	8.376
Egypt, Arab Rep.	0	0.100	10.362
Nigeria	1	0.039	12.511
Tunisia	0	0.100	5.380
Kuwait	0	0.057	45.193
Oman	1	0.046	40.760
Qatar	1	0.010	37.518
Saudi Arabia	1	0.039	39.897
United Arab Emirates	0	0.100	24.102

Table 4 – Nominal Oil Price: Results of Engle-Granger Tests with Log-GDPs per Capita of Oil Intense Countries

Country D (dep. variable)	Nominal Oil Price (exp. variable)	Coefficient on D	Coefficient on E	P-Value D	P-Value E	Weak Exogeneity Code	Avg Oil rent share in %
Nigeria	Nominal Oil Price	-0.093	4.749	0.143	0.097	DE	12.511
Oman	Nominal Oil Price	-0.074	2.376	0.037	0.197	E	40.760
Qatar	Nominal Oil Price	-0.062	10.086	0.447	0.023	D	37.518
Saudi Arabia	Nominal Oil Price	-0.108	4.366	0.049	0.173	E	39.897

Table 5 – Error Correction Model: Results of Weak Exogeneity Tests for Co-integration between Oil Intense Countries and Nominal Oil Price

Considering weak exogeneity, we expect that for a pair of co-integrated time series, the larger economy should be less affected by developments in the smaller economy than vice versa. Additionally, the larger economy should be more affected by factors outside the common stochastic trend such as changes in economies outside the pairing. We would therefore expect log-GDP per capita of the larger economy to be more likely to exhibit weak exogeneity. The results of the tests for weak exogeneity are reported in Tables 10-13. The letters D and E in the column "Weak Exogeneity Code" of these tables correspond to weak exogeneity of the dependent and explanatory variable respectively. Furthermore, the combination of them (i.e. DE) indicates that both variables are weakly exogenous, while the letter N corresponds to the case where neither variable exhibits weak exogeneity. In our sample, we find 14 instances of co-integration between a G7-member and a country outside the G7. In 13 of these cases, the G7-member exhibits weak exogeneity at the 95% significance level. The only exception is found in the pairing France-Austria. This general trend also holds for other large economies such as China or Spain. Hence, these results fit the theoretical predictions outlined above. We also test for weak exogeneity in the four cases where the nominal oil price was found to be co-integrated with an oil-producing country's log-GDP per capita. The results are displayed in Table 5. Here, Nigeria and Qatar exhibit weak exogeneity while Oman and Saudi-Arabia do not. The nominal oil price does not show weak exogeneity in the case of Qatar, but it does in the other three cases.

7 Conclusion

This paper analyzes whether GDP per capita of different countries are co-integrated and which variables explain the co-integration status. The results show that distance between two countries does not significantly affect the likelihood of being co-integrated. Hence the predictions based on Gravity models as the one by De Benedictis and Taglioni (2011) are not supported by the evidence. It is also examined whether oil rent shares affect the likelihood of being co-integrated. Unlike it was the case with distance, the results show a significantly negative effect of the difference in average ORS on the probability of being co-integrated. It is furthermore analyzed whether some variables exhibit weak exogeneity. As expected, GDP per capita of large economies often shows weak exogeneity. The results concerning weak exogeneity of the nominal oil price in oil-producing countries are mixed.

A drawback of this study is clearly the sample size. As we have only yearly data and historical data reaching back to 1960, the sample is rather small. Some countries additionally have to be omitted because of missing data. Since such data may appear to be systematically less available for less developed or corrupt countries, this might harm the generalizability of the results. Apart from the small sample size, the results are likely to be consistent. For an omitted variable to cause biased estimates in the logistic regression, the variable would have to be correlated with and causal for both co-integration status and one of the explanatory variables. As the distance between two countries is constant across time, this cannot be the case. The oil rent share of a country is affected by the oil occurrence and the oil price. Oil occurrence again is a variable that does not really change across time. The oil price on the other hand does. However, one can hardly find a variable that is causal for both the co-integration status and the absolute difference in the average ORS between two countries. Reverse causality is also not a problem as the co-integration status cannot cause distance or oil rent shares to change. Therefore, the results of our analysis are expected to be unbiased.

For future research it would be interesting to see whether the results remain consistent when increasing the sample size by using quarterly data. With a higher frequency it would also be possible to look at smaller subsamples. For example, one could look at a subsample that does not include the years of the two major oil crisis in 1973 and 1979. It could be an interesting comparison to look at those results, but with yearly data the sample would be too small. Another extension would be to test for co-integration between more than two time series using a Johannsen-Trace test. If GDP per capita of a group of countries is driven by the same trend, it would become easier to detect what drives this trend. It might also be interesting to look at the strength of co-integration (e.g. by using the resulting p-value from the Engle-Granger test as a proxy) rather than only the co-integration status. If GDP per capita of some countries is more strongly co-integrated than of others, this could provide further evidence on how co-integrated GDP per capita can be explained.

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Appendix

	Optimal number of Lags	P-Value	Stationarity
Austria	1	0.010	1
Belgium	1	0.010	1
Denmark	1	0.010	1
Finland	2	0.010	1
France	1	0.010	1
Germany	1	0.010	1
Greece	1	0.010	1
Ireland	1	0.010	1
Italy	1	0.010	1
Netherlands	1	0.010	1
Portugal	1	0.010	1
Spain	1	0.010	1
Sweden	1	0.010	1
Iceland	4	0.010	1
Norway	1	0.010	1
Switzerland	1	0.010	1
United Kingdom	1	0.010	1
Canada	1	0.010	1
Mexico	2	0.010	1
United States	3	0.498	0
Brazil	1	0.010	1
Colombia	1	0.010	1
Ecuador	1	0.010	1
Paraguay	1	0.010	1
Peru	1	0.010	1
Egypt, Arab Rep.	1	0.010	1
Morocco	1	0.010	1
Nigeria	1	0.010	1
South Africa	4	0.010	1
Tunisia	1	0.036	1
China	1	0.010	1
India	1	0.010	1
Japan	1	0.010	1
Kuwait	1	0.010	1
Oman	1	0.010	1
Qatar	1	0.010	1
Saudi Arabia	1	0.022	1
Turkey	1	0.010	1
United Arab Emirates	2	0.010	1
Australia	1	0.010	1
New Zealand	4	0.010	1

Table 6 – Results of Augmented Dickey Fuller Tests on the Log-GDP per Capita in First Differences

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain	Sweden	Iceland	Norway	Switzerland	UK
Austria	-	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Belgium	0	-	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Denmark	0	0	-	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Finland	0	0	0	-	0	0	0	0	0	0	0	0	0	1	0	0	0
France	1	0	0	0	-	0	0	0	0	0	0	1	1	1	0	0	0
Germany	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0
Greece	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
Italy	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	-	0	0	1	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0
Spain	0	0	0	0	1	0	0	0	0	0	0	-	1	0	0	0	0
Sweden	1	1	1	0	1	0	0	0	0	1	0	1	-	0	0	1	0
Iceland	0	0	1	1	1	0	0	0	0	0	0	0	0	-	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	0
Switzerland	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	-	0
UK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
Canada	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
Mexico	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
Brazil	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Colombia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecuador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peru	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egypt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Morocco	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nigeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tunisia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
China	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
India	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kuwait	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oman	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Qatar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saudi Arabia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkey	0	1	0	0	0	0	1	1	0	1	1	1	1	1	1	0	0
U. Arab Emir.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Zealand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7 – Europe: Results of Pairwise Engle-Granger Tests on Log-GDP per Capita

	Canada	Mexico	Brazil	Colombia	Ecuador	Paraguay	Peru
Austria	0	1	0	0	0	0	0
Belgium	0	1	0	0	0	0	0
Denmark	0	1	0	0	0	0	0
Finland	0	1	0	0	0	0	0
France	0	1	0	0	0	0	0
Germany	0	1	0	0	0	0	0
Greece	0	1	0	0	0	0	0
Ireland	0	1	0	0	0	0	0
Italy	0	0	0	0	0	0	0
Netherlands	0	1	0	0	0	0	0
Portugal	0	1	0	0	0	0	0
Spain	0	1	0	0	0	0	0
Sweden	1	1	1	0	0	0	0
Iceland	0	1	0	0	0	0	0
Norway	1	1	0	0	0	0	0
Switzerland	0	1	1	0	0	0	0
United Kingdom	0	1	0	0	0	0	0
Canada	-	0	0	0	0	0	0
Mexico	0	-	0	0	0	0	0
Brazil	0	0	-	0	0	0	0
Colombia	0	0	0	-	0	0	0
Ecuador	0	0	0	0	-	0	0
Paraguay	0	0	0	0	0	-	0
Peru	0	0	0	0	0	0	-
Egypt, Arab Rep.	0	0	0	1	0	0	0
Morocco	1	1	1	0	0	0	0
Nigeria	0	0	0	0	0	0	0
South Africa	1	1	1	0	1	0	0
Tunisia	0	1	0	0	0	0	0
China	0	0	0	0	0	0	1
India	0	0	0	0	0	0	0
Japan	0	0	0	0	0	0	0
Kuwait	0	0	0	0	0	0	0
Oman	0	0	0	1	0	0	0
Qatar	0	0	0	0	0	0	0
Saudi Arabia	0	0	0	0	0	0	0
Turkey	1	1	1	1	0	0	1
United Arab Emirates	0	0	0	0	0	0	0
Australia	0	0	1	0	0	0	0
New Zealand	0	0	0	0	0	0	0

Table 8 – America: Results of Pairwise Engle-Granger Tests on Log-GDP per Capita

	Egypt	Morocco	Nigeria	S. Africa	Tunisia	China	India	Japan	Kuwait	Oman	Qatar	Saudi Arab.	Turkey	U. Arab E.	Australia	N. Zealand
Austria	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greece	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Italy	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Iceland	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Norway	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
Switzerland	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canada	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0
Mexico	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Brazil	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	0
Colombia	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ecuador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peru	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Egypt	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Morocco	0	-	0	1	0	0	0	0	0	0	0	0	1	0	1	1
Nigeria	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0
South Africa	0	1	0	-	0	0	0	0	0	0	0	0	1	0	1	0
Tunisia	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0
China	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0
India	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
Japan	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0
Kuwait	0	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0
Oman	0	1	0	1	1	1	1	0	0	-	0	0	0	0	0	0
Qatar	0	0	1	0	0	0	0	0	0	0	-	0	0	0	0	0
Saudi Arabia	0	0	0	0	0	0	0	0	0	0	0	-	0	0	0	0
Turkey	0	1	0	1	0	0	0	0	0	0	0	0	-	0	1	1
U. Arab E.	0	0	1	0	0	0	0	0	0	0	0	0	0	-	0	0
Australia	0	1	0	1	0	0	0	0	0	0	0	0	1	0	-	1
New Zealand	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	-

Table 9 – Africa, Asia & Australia: Results of Pairwise Engle-Granger Tests on Log-GDP per Capita

Country D (dep. variable)	Country E (exp. variable)	Coefficient on D	Coefficient on E	P-Value D	P-Value E	Weak Exogeneity Code
Austria	France	0.272	0.654	0.396	0.035	D
Austria	Sweden	-0.052	0.282	0.704	0.045	D
Austria	Mexico	-0.060	0.203	0.307	0.009	D
Austria	Turkey	-0.002	0.090	0.968	0.129	DE
Belgium	Sweden	-0.122	0.235	0.446	0.162	DE
Belgium	Mexico	-0.095	0.285	0.161	0.002	D
Belgium	Turkey	-0.016	0.117	0.739	0.104	DE
Denmark	Sweden	0.126	0.531	0.498	0.007	D
Denmark	Iceland	-0.194	0.165	0.151	0.315	DE
Denmark	Mexico	-0.102	0.294	0.144	0.003	D
Finland	Iceland	-0.217	0.270	0.152	0.150	DE
Finland	Mexico	-0.086	0.187	0.146	0.021	D
Finland	Turkey	-0.004	0.100	0.926	0.129	DE
France	Austria	-0.799	-0.347	0.029	0.358	E
France	Spain	-0.330	-0.069	0.129	0.775	DE
France	Sweden	-0.108	0.260	0.565	0.186	DE
France	Iceland	-0.234	0.201	0.071	0.226	DE
France	Mexico	-0.067	0.254	0.340	0.005	D
France	Turkey	-0.014	0.101	0.762	0.148	DE
Germany	Mexico	-0.101	0.256	0.205	0.012	D
Greece	Mexico	-0.125	0.299	0.058	0.002	D
Greece	Turkey	0.004	0.129	0.929	0.058	DE
Ireland	Mexico	-0.061	0.232	0.302	0.006	D
Ireland	Turkey	0.023	0.167	0.588	0.018	D
Italy	Turkey	-0.007	0.084	0.860	0.133	DE
Netherlands	Sweden	0.034	0.318	0.797	0.021	D
Netherlands	Mexico	-0.071	0.265	0.281	0.002	D
Netherlands	Turkey	-0.008	0.116	0.851	0.079	DE
Portugal	Mexico	-0.046	0.277	0.497	0.001	D
Portugal	Turkey	0.009	0.134	0.837	0.038	D
Spain	France	0.035	0.251	0.858	0.155	DE
Spain	Sweden	0.020	0.243	0.893	0.083	DE
Spain	Mexico	-0.079	0.248	0.238	0.002	D
Spain	Turkey	0.000	0.110	0.998	0.063	DE
Sweden	Austria	-0.381	0.040	0.032	0.816	E
Sweden	Belgium	-0.290	0.113	0.126	0.531	DE
Sweden	Denmark	-0.654	-0.187	0.004	0.388	E

Table 10 – Error Correction Model: Results of Weak Exogeneity Tests for Co-integrated Country Pairs 1-37

Country D (dep. variable)	Country E (exp. variable)	Coefficient on D	Coefficient on E	P-Value D	P-Value E	Weak Exogeneity Code
Sweden	France	-0.304	0.088	0.148	0.662	DE
Sweden	Netherlands	-0.402	-0.069	0.014	0.665	E
Sweden	Spain	-0.341	-0.053	0.065	0.784	DE
Sweden	Switzerland	-0.394	0.108	0.024	0.536	E
Sweden	Canada	-0.341	0.003	0.006	0.969	E
Sweden	Mexico	-0.080	0.284	0.275	0.003	D
Sweden	Brazil	-0.004	0.307	0.959	0.012	D
Sweden	Turkey	-0.026	0.127	0.653	0.116	DE
Iceland	Denmark	-0.215	0.134	0.173	0.307	DE
Iceland	Finland	-0.337	0.183	0.084	0.249	DE
Iceland	France	-0.219	0.179	0.153	0.137	DE
Iceland	Mexico	-0.120	0.211	0.217	0.040	D
Iceland	Morocco	-0.099	0.142	0.361	0.077	DE
Iceland	Turkey	-0.035	0.100	0.567	0.162	DE
Norway	Canada	-0.162	0.121	0.253	0.235	DE
Norway	Mexico	-0.067	0.231	0.274	0.013	D
Norway	South Africa	0.041	0.249	0.585	0.006	D
Norway	Turkey	0.006	0.155	0.902	0.043	D
Switzerland	Sweden	-0.114	0.311	0.435	0.034	D
Switzerland	Mexico	-0.057	0.199	0.316	0.010	D
Switzerland	Brazil	0.008	0.260	0.897	0.009	D
Switzerland	Turkey	-0.020	0.088	0.626	0.152	DE
United Kingdom	Mexico	-0.096	0.241	0.142	0.013	D
Canada	Sweden	-0.020	0.329	0.805	0.012	D
Canada	Norway	-0.180	0.193	0.187	0.310	DE
Canada	Morocco	-0.034	0.293	0.616	0.004	D
Canada	South Africa	0.015	0.362	0.827	0.005	D
Canada	Turkey	-0.008	0.183	0.844	0.062	DE
Mexico	Austria	-0.263	0.046	0.005	0.523	E
Mexico	Belgium	-0.333	0.078	0.001	0.294	E
Mexico	Denmark	-0.344	0.067	0.001	0.373	E
Mexico	Finland	-0.240	0.068	0.008	0.312	E
Mexico	France	-0.278	0.039	0.003	0.583	E
Mexico	Germany	-0.274	0.055	0.006	0.490	E
Mexico	Greece	-0.361	0.112	0.001	0.136	E
Mexico	Ireland	-0.347	0.061	0.003	0.448	E
Mexico	Netherlands	-0.319	0.049	0.001	0.520	E
Mexico	Portugal	-0.383	0.029	0.000	0.734	E

Table 11 – Error Correction Model: Results of Weak Exogeneity Tests for Co-integrated Country Pairs 38-75

Country D (dep. variable)	Country E (exp. variable)	Coefficient on D	Coefficient on E	P-Value D	P-Value E	Weak Exogeneity Code
Mexico	Spain	-0.334	0.068	0.001	0.429	E
Mexico	Sweden	-0.294	0.045	0.001	0.515	E
Mexico	Iceland	-0.259	0.086	0.019	0.417	E
Mexico	Norway	-0.304	0.055	0.006	0.460	E
Mexico	Switzerland	-0.246	0.037	0.004	0.560	E
Mexico	United Kingdom	-0.298	0.085	0.005	0.241	E
Mexico	Morocco	-0.233	0.080	0.014	0.265	E
Mexico	South Africa	-0.117	0.098	0.149	0.181	DE
Mexico	Tunisia	-0.270	0.058	0.021	0.416	E
Mexico	Turkey	-0.161	0.086	0.038	0.334	E
Brazil	Sweden	-0.287	-0.021	0.006	0.757	E
Brazil	Switzerland	-0.285	-0.031	0.005	0.625	E
Brazil	Morocco	-0.394	0.011	0.002	0.880	E
Brazil	South Africa	-0.331	0.088	0.009	0.347	E
Brazil	Turkey	-0.174	0.055	0.033	0.479	E
Brazil	Australia	-0.393	-0.003	0.005	0.970	E
Colombia	Egypt, Arab Rep.	-0.010	0.425	0.918	0.000	D
Colombia	Turkey	-0.279	0.031	0.000	0.784	E
Peru	China	-0.231	0.016	0.006	0.786	E
Peru	Turkey	-0.189	0.068	0.027	0.507	E
Egypt, Arab Rep.	Colombia	-0.521	-0.022	0.000	0.839	E
Morocco	Canada	-0.328	0.017	0.002	0.816	E
Morocco	Mexico	-0.111	0.240	0.177	0.030	D
Morocco	Brazil	-0.034	0.469	0.723	0.005	D
Morocco	South Africa	-0.045	0.309	0.717	0.019	D
Morocco	Turkey	-0.121	0.155	0.096	0.196	DE
Morocco	Australia	-0.261	0.270	0.045	0.025	N
Morocco	New Zealand	-0.096	0.250	0.317	0.028	D
South Africa	Norway	-0.443	-0.115	0.002	0.337	E
South Africa	Canada	-0.480	-0.056	0.002	0.497	E
South Africa	Mexico	-0.172	0.126	0.076	0.246	DE
South Africa	Brazil	-0.177	0.430	0.189	0.020	D
South Africa	Ecuador	-0.083	0.172	0.291	0.027	D
South Africa	Morocco	-0.417	0.012	0.006	0.935	E
South Africa	Turkey	-0.140	0.091	0.073	0.408	DE
South Africa	Australia	-0.363	0.064	0.042	0.609	E
Tunisia	Mexico	-0.103	0.274	0.180	0.031	D

Table 12 – Error Correction Model: Results of Weak Exogeneity Tests for Co-integrated Country Pairs 76-112

Country D (dep. variable)	Country E (exp. variable)	Coefficient on D	Coefficient on E	P-Value D	P-Value E	Weak Exogeneity Code
China	Peru	0.004	0.126	0.915	0.014	D
Oman	Denmark	-0.176	0.032	0.013	0.358	E
Oman	Finland	-0.167	0.055	0.035	0.186	E
Oman	Iceland	-0.125	0.072	0.123	0.180	DE
Oman	Colombia	-0.144	0.022	0.018	0.437	E
Oman	Morocco	-0.205	0.019	0.004	0.577	E
Oman	South Africa	-0.085	0.099	0.325	0.076	DE
Oman	Tunisia	-0.265	0.002	0.003	0.963	E
Oman	China	-0.109	0.013	0.004	0.411	E
Oman	India	-0.138	-0.013	0.004	0.445	E
Qatar	Nigeria	0.031	0.266	0.774	0.016	D
Turkey	Belgium	-0.124	-0.008	0.084	0.871	DE
Turkey	Greece	-0.138	-0.033	0.055	0.449	DE
Turkey	Ireland	-0.229	-0.046	0.012	0.405	E
Turkey	Netherlands	-0.129	-0.021	0.065	0.649	DE
Turkey	Portugal	-0.169	-0.036	0.028	0.479	E
Turkey	Spain	-0.132	-0.029	0.058	0.566	DE
Turkey	Sweden	-0.120	-0.005	0.094	0.915	DE
Turkey	Iceland	-0.108	0.007	0.126	0.908	DE
Turkey	Norway	-0.188	-0.032	0.031	0.546	E
Turkey	Canada	-0.171	-0.010	0.040	0.775	E
Turkey	Mexico	-0.107	0.117	0.196	0.108	DE
Turkey	Brazil	-0.078	0.148	0.330	0.084	DE
Turkey	Colombia	-0.060	0.251	0.574	0.000	D
Turkey	Peru	-0.078	0.131	0.326	0.049	D
Turkey	Morocco	-0.144	0.078	0.136	0.190	DE
Turkey	South Africa	-0.082	0.069	0.283	0.209	DE
Turkey	Australia	-0.170	0.066	0.099	0.319	DE
Turkey	New Zealand	-0.168	0.116	0.077	0.104	DE
United Arab Emirates	Nigeria	-0.195	0.563	0.388	0.219	DE
Australia	Brazil	-0.013	0.404	0.891	0.010	D
Australia	Morocco	-0.248	0.209	0.017	0.065	E
Australia	South Africa	-0.071	0.228	0.451	0.097	DE
Australia	Turkey	-0.088	0.162	0.205	0.140	DE
Australia	New Zealand	-0.129	0.292	0.061	0.003	D
New Zealand	Morocco	-0.217	0.062	0.037	0.483	E
New Zealand	Turkey	-0.133	0.160	0.103	0.143	DE
New Zealand	Australia	-0.298	0.104	0.004	0.153	E

Table 13 – Error Correction Model: Results of Weak Exogeneity Tests for Co-integrated Country Pairs 113-150