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Causality between energy and output in the long run on U.K., Sweden, U.S. and Canada

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SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

Master of Science (MSc) in Energy Building Design

DECEMBER 2018

THESSALONIKI – GREECE

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Abstract

The aim of this study is to investigate the Causal Relationship between Energy Consumption and Gross Domestic Product in the long-run in the case of United Kingdom, Sweden, United States and Canada. Gross Fixed Capital Formation and Labor Force data used in the study as extra variables. Annual data used range from 1960 to 2015 for all countries except from United Kingdom that data range from 1970 to 2015. Johansen Cointegration tests conducted and their result shows one cointegrated equation per country. On the long-run, Granger Causality testing indicates that the only existing causal relationship between energy and output appears on United Kingdom where there is a unidirectional causal relationship from Gross Domestic Product (GDP) to Energy Consumption (EC). On Sweden, United States and Canada there is no evidence for the presence of a causal relationship between Energy and GDP.

I feel grateful for the valuable comments that I acquired from my supervisor that motivated and helped me in order to proceed and complete this paper.

Georgios Papadopoulos

12/2018

Contents

1 Introduction

There is a huge negative impact to the environment that caused because of humanity. There is luck of raw resources and global warming that appeared during last decades. Both of them awaken the society as it concerns environmental protection. Another crucial factor on the society is the economy. In order to create efficient ways of energy consumption for the environment, funds should be spent. At the same time energy price could have positive or negative impacts on the economy or vice versa. Last decades, many studies conducted in order to examine the causal relationship between energy and output which results can affect policies.

The results of studies conducted in order to test for Causal Relationship between Energy Consumption and Gross Domestic Product or Economic Growth varies. They are depended from the range of data, the variables and the methodologies that researchers were using. Moreover, many studies conducted with more than two variables. Energy Consumption and Energy Growth although remain the main variables but many researchers tent to use extra variables for more accurate results.

The purpose of this study is to investigate the *Causal Relationship* between *Energy Consumption* and *Gross Domestic Product* on United Kingdom, Sweden, United States and Canada. Gross Fixed Capital Formation and Labor Force are included to the study as extra variables. The study though, is divided into two scenarios. On the second scenario all of the four variables are used into the model. On the first scenario though, the variable of Energy Consumption is excluded from the model. First Scenario is ancillary.

Last but not least, the *1st Section* that includes the *Introduction* is followed by *Section 2* where there is the *Literature Review* that used for this study, by *Section 3* where there is a description the *Data and Methodology* that used to the study, by S*ection 4* where there is a representation of *Empirical Results* that contain Unit Root tests, Cointegration test and Causality test, by *Section 5* with *Conclusions*, by *Section 6* that contains the *Bibliography* and by the *Appendix*.

2 Literature Review

During last four decades, several studies conducted in order to examine the causal relationship between *Energy Consumption* (EC) and *Economic Growth* (GDP). Everything started back on 1978 from Kraft and Kraft [22] who examined that relationship on United States. Many studies were conducted for United States, other single countries and multi-countries studies but the results vary between them. For instance, while Kraft and Kraft [22] concluded to unidirectional causality running from energy consumption to output *(EC→GDP)* on his study on United States, Stern [33] concluded to unidirectional causality from output to energy consumption *(GDP→EC)* on his study on United States too. The existence of mixed results is a common consensus. They are depended on the methodology, the country and the range of the sample.

According to Ozturk [28] there are four possible hypothesis of the causal relationship between energy and output. *Neutrality hypothesis* that refers that there is no causal relationship, *conservation hypothesis* that refers that there is unidirectional causal relationship from output to energy, *growth hypothesis* that refers that there is unidirectional causal relationship from energy to output and *feedback hypothesis* that refers that there is a bidirectional causality between energy and output.

Some of studies that examined the causal relationship between energy and output are for single countries such as Kraft and Kraft [22], Stern [33], Tsani [38], Belaid and Abderrahmani [8], Stern and Enflo [34], Magazzino [25], Ahmed, Riaz, Khan and Bibi [2], Altunbas and Kapusuzoglu [4] and Tang, Tan and Ozturk [36] while for multi-county studies such as Lee [23], Chontanawat et al. [10], Chiou-Wei, Chen and Zhu [], Ozturk et al. [9], Narayan and Popp [26], Coers and Sanders [11], Akkemik and Göksal [3], Apergis and Tang [6], Rezitis and Ahammad [31], Azam et al. [7] and Streimikiene and Kasperowicz [35].

On *tables 1 to 5* there is a summary representing the counties, the period, methodologies, variables and empirical results of studies that mentioned above.

2.1.1 Tables

Table 1: Literature Review of Single Country Studies Testing

Authors	Countries	Period	Method	Variables	Empirical Results
Kraft and Kraft (1978)	USA	1947–1974 (annually)	Granger causality	Energy consumption, Real GDP	Conservation Hypothesis (Unidirectional causality)
David I. Stern (1993)	USA	1947 – 1990 (annually)	Multivariate VAR model	Energy consumption, Real GDP, Capital stock, Employment	Growth Hypothesis (Unidirectional causality)
Stela Z. Tsani (2009)	Greece	1960 – 2006 (annually)	Toda and Yamamoto Causality test	Energy consumption, Real GDP	Growth Hypothesis (Unidirectional causality)
Fateh Belaid, Fares Abderrahmani (2012)	Algeria	1971 – 2010 (annually)	Gregory–Hansen cointegration, Trivariate VECM	Electricity consumption, Brent oil price, Real (GDP)	Feedback Hypothesis (Bidirectional causality)
David I. Stern, Kerstin Enflo (2013)	Sweden	1850 – 2000 (annual data)	Bivariate Toda Yamamoto causality technique, Multivariate VECM	Gross output, GDP, Capital, Labor, Heat content, Divisia volume index of primary energy, Divisia energy price index deflated by the GDP deflator, Oil price deflated by the GDP deflator	Growth Hypothesis (Unidirectional causality) on full sample Conservation Hypothesis (Unidirectional causality) on recent smaller samples.

Table 2: Literature Review of Single Country Studies Testing

Authors	Countries	Period	Method	Variables	Empirical Results
Cosimo Magazzino (2014)	Italy	1970 – 2009 (annually)	Bivariate VAR, Bivariate VECM	Energy consumption, Real GDP	Feedback Hypothesis (Bidirectional causality)
Mumtaz Ahmed, Khalid Riaz, Atif Maqbool Khan, Salma Bibi (2015)	Pakistan	1971 – 2011 (annually)	Bivariate VAR Multivariate VAR	Real GDP, Energy consumption & Real GFCF, Total labor force	Conservation Hypothesis (Unidirectional causality)
Yener Altunbas, Ayhan Kapusuzoglou (2015)	U.K.	1987 – 2007 (annually)	Bivariate VAR	Energy consumption, Real GDP	Neutrality Hypothesis (LR) (No causality) Feedback Hypothesis (SR) (Bidirectional causality)
Chor Foon Tang, Bee Wah Tan, Ilhan Ozturk (2015)	Vietnam	1971 – 2001 (annually)	Multivariate VAR (Johansen cointegration)	Energy consumption, Real GDP, Real DI, Real FDI, Working-age population, GDP deflator	Growth hypothesis (Unidirectional causality)

2.1.2 Tables

Table 3: Literature Review of Multi-Country Studies Testing

Authors	Countries	Period	Method	Variables	Empirical Results
Chien-Chiang Lee (2005)	18 develop-ing	1975 – 2007 (annually)	Bivariate VECM Panel	Energy consumption, Real GDP	Feedback hypothesis (Bidirectional causality)
Jaruwan Chontanawat, Lester C. Hunt, Richard Pierse (2008)	30 OECD countries & 78 non-OECD	1960 – 2000 (annually) & 1971 – 2000 (annually)	Johansen cointegration, Hsiao causality	Energy consumption, Real GDP	The magnitude of causality from energy to GDP is less prevalent on developing world than developed world. Growth hypothesis (Unidirectional causality)
Song Zan Chiou-Wei, Ching-Fu Chen, Zhen Zhu (2008)	U.S.A. and 8 Asian developing	1954 – 2006 (annually)	Non-linear bivariate VAR	Energy consumption, Real GDP	2 countries conservation hypothesis, 4 countries growth hypothesis, 3 countries neutrality hypothesis

Table 4: Literature Review of Multi-Country Studies Testing

Authors	Countries	Period	Method	Variables	Empirical Results
Ilhan Ozturk, Alper Aslan, Huseyin Kalyoncu (2010)	14 low-income, 24 lower middle-income, 13 upper middle-income	1971 – 2005 (annually)	Panel causality (FMOLS and DOLS)	Energy consumption, Real GDP	Long-run conservation hypothesis for low-income countries and feed-back hypothesis for lower middle and upper middle income countries
Paresh Kumar Narayan, Stephan Popp (2012)	93 developing and developed	1980 – 2006 (annually)	Bivariate VECM Panel	Energy consumption, Real GDP	Different results per country. Growth hypothesis, Conservation hypothesis, Feedback hypothesis
K. Ali Akkemik, Koray Göksal (2012)	79 developing and developed	1980 – 2007 (annually)	Bivariate VECM Panel	Energy consumption, Real GDP	10% no causality, 20% unidirectional causality, 70% Bi-directional causality
Robin Coers, Mark Sanders (2012)	A panel of 30 OECD	1960 – 2000 (annually)	Multivariate panel ap-proach based on panel cointegration and error correction	Energy consumption, Real GDP Employment, Gross fixed capital, Human capital	Feedback hypothesis (Bidirectional causality)

Table 5: Literature Review of Multi-Country Studies Testing

Authors	Countries	Period	Method	Variables	Empirical Results
Nicholas Apergis, Chor Foon Tang (2013)	A panel of 85 countries globally	1975 – 2007 (annually)	Bivariate, Trivariate, Multivariate Toda–Yamamoto–Dolado–Lütkepohl (TYDL) causality (VAR)	Energy consumption, Economic Growth. Labor force, Urbanization	Neutrality hypothesis (No causality) Additional variables enhance rejection rate
Anthony N. Rezitis, Shaikh M. Ahammad (2015)	9 South and Southeast Asian	1990 – 2012 (annually)	Multivariate VAR	Real GDP, Energy consumption, Real GFCF, Total labor force	Feedback hypothesis (Bidirectional causality)
Muhammad Azam, Abdul Qayyum Khan, B.Bakhtyar, Chandra Emirullah (2015)	Indonesia, Malaysia, Thailand, Singapore, Philippines	1980 – 2012 (annually)	Johansen Likelihood Ratio, Multivariate VAR	Energy Consumption, Economic Growth, Exports, Infrastructure proxies with GFCF	Feedback hypothesis (Bidirectional causality)
Dalia Streimikiene, Rafał Kasperowicz (2016)	18 EU	1995 – 2012 (annually)	FMOLS and DOLS	Energy consumption, Real GDP, Real GFCF, Total Employment	Feedback hypothesis (Bidirectional causality)

3 Data and Methodology

On this section of the study, there is the representation of the data that got used and the description of the executed methodologies.

3.1 Data presentation

Data that got used as the sample of the study are annual data of *Energy Consumption (EC)*, *Gross Domestic Product (GDP), Gross Fixed Capital Formation (GFCF) and Labor Force (LF)* from 1960 to 2015 on Sweden, United States and Canada while from 1970 to 2015 on United Kingdom. Energy Consumption, Gross Domestic Product and Gross Fixed Capital Formation data were collected from World Bank's database while data for Labor Force collected from OECD-stats database. Energy Consumption is measured in kg of oil equivalent per capita, Real Gross Domestic Product and Gross Fixed Capital Formation are measured in constant 2010 billion US$ and Employment is measured in Civilian employment on thousand people.

3.2 Methodology

The order of the methodology that used in the study is step by step: Descriptive statistics check, Unit root testing methodology (Dickey, Fuller [14] and Phillips, Perron [30]), Johansen's [20] cointegration methodology and Granger's [16] Causality methodology.

3.2.1 Unit Root

This study is conducted in order to examine the causal relationship between energy and output in the long-run on United Kingdom, Sweden, United States and Canada. The methodology that selected to be used is Granger [16] causality test. As causality tests require stationary series of the same order, Augmented Dickey-Fuller [14] (ADF) and Phillips-Perron [30] (PP) unit root tests examined the stationarity of Energy Consumption, Gross Domestic Product, Gross Fixed Capital Formation and Labor force. According to ADF and PP, if all of the variables are not stationary, we need to take first differences and repeat this stage till we succeed the same order of stationarity. As we check for cointegration, the test is valid only when the series that are used are not stationary.

3.2.2 Cointegration and Causality

As unit root tests are completed, a cointegration test, using the methodology of Johansen [20], will examine the relationship among the variables for all of the countries (U.K, Sweden, U.S. and Canada) with the support of *Trace statistic* and *maximum Eigenvalue statistic* values. As we check for cointegration, the test is valid only when the series that are used are not stationary.

Considering the interpretation of the outcome of the results, we run a VECM (Vector Error Correction Model), if cointegration relationships were found, while we run a VAR (Vector Auto regression) model ,if we found absence of at least one (1) cointegration relationship, in order to test the presence of causal relationship between series.

After the creation of a VAR or a VECM system, the existence and the direction of causal relationships can be examined using Granger's Causality [16] methodology. Furthermore, for the validity of the results, diagnostic test such as *Impulse Responses, Variance Decomposition* and *Historical Decomposition* will be checked.

4 Empirical Results

4.1 Descriptive Statistics

On the beginning of the study and before continue with Unit Root testing we test the descriptive statistics of our variables. *Descriptive statistics table presentation* follows for all four countries on *tables 6-9*. From *table 6* we can notice that in United Kingdom, EC in not normally distributed while GDP, GFCF and LF are normally distributed. EC has a long-left tail (negative skewness) and it is leptokurtic (4.129 > 3) while GDP, GFCF and LF have normal skewness and they are platykurtic (kurtosis < 3). Normal Distribution is also indicated from Jarque-Bera statistics (only on EC we can reject the null hypothesis).

From *table 7* we can understand that in Sweden, EC in not normally distributed while GDP, GFCF and LF are normally distributed. EC has a long-left tail (negative skewness) and it is leptokurtic (4.129 > 3) while GDP, GFCF and LF have normal skewness and they are platykurtic (kurtosis < 3). Normal Distribution is also indicated from Jarque-Bera statistics (only on EC we can reject the null hypothesis).

From *table 8* we can see that in United States, EC in not normally distributed while GDP, GFCF and LF are normally distributed. EC has a long-left tail (negative skewness) and it is leptokurtic (4.129 > 3), GDP and GFCF have skewness close to zero "0" and they are platykurtic (kurtosis < 3). LF has also skewness close to zero "0" but it is negative and it is also platykurtic. Normal Distribution is also indicated from Jarque-Bera statistics (only on EC we can reject the null hypothesis).

From *table 9* we can notice that in Canada, EC in not normally distributed while GDP, GFCF and LF are normally distributed. EC has a long-left tail (negative skewness) and it is leptokurtic (4.129 > 3), GDP and GFCF have skewness close to zero "0" and they are platykurtic (kurtosis < 3). LF has also skewness close to zero "0" but it is negative and it is also platykurtic. Normal Distribution is also indicated from Jarque-Bera statistics (only on EC we can reject the null hypothesis).

Table 6: Descriptive Statistics of United Kingdom

United Kingdom	*EC*	*GDP*	*GFCF*	*LF*
Mean	3551.375	1773.296	297.9585	26413.76
Median	3659.221	1657.226	302.6369	25717.50
Maximum	3880.650	2705.252	444.1817	31193.22
Minimum	2763.980	998.2754	177.4957	23304.00
Std. Dev	280.3918	542.0031	87.74662	2170.529
Skewness	-1.383546	0.208469	0.038810	0.538407
Kurtosis	4.129419	1.609849	1.528873	2.015421
Jarques-Bera	17.12041	4.037184	4.159623	4.080436
Probability	0.000192	0.132842	0.124954	0.130000
Sum	163363.2	81571.61	13706.09	1215033
Sum Sq. Dev.	3537879	13219530	346476.1	2.12E+08
Observations	46	46	46	46

Table 7: Descriptive Statistics of Sweden

Sweden	*EC*	*GDP*	*GFCF*	*LF*
Mean	4969.013	315.8018	71.94449	4152.740
Median	5222.938	304.9541	63.80610	4194.500
Maximum	5878.801	542.8265	130.0237	4836.850
Minimum	2698.792	135.7935	32.60553	3644.000
Std. Dev	864.2065	113.8247	25.31743	319.8296
Skewness	-1.269772	0.363989	0.664482	0.098426
Kurtosis	3.668276	2.030098	2.366453	2.159894
Jarques-Bera	16.09037	3.431547	5.057558	1.737233
Probability	0.000321	0.179825	0.079756	0.419532
Sum	278264.7	17684.90	4028.892	232553.5
Sum Sq. Dev.	41076912	712583	35253.48	5626005
Observations	56	56	56	56

Table 8: Descriptive Statistics of United States

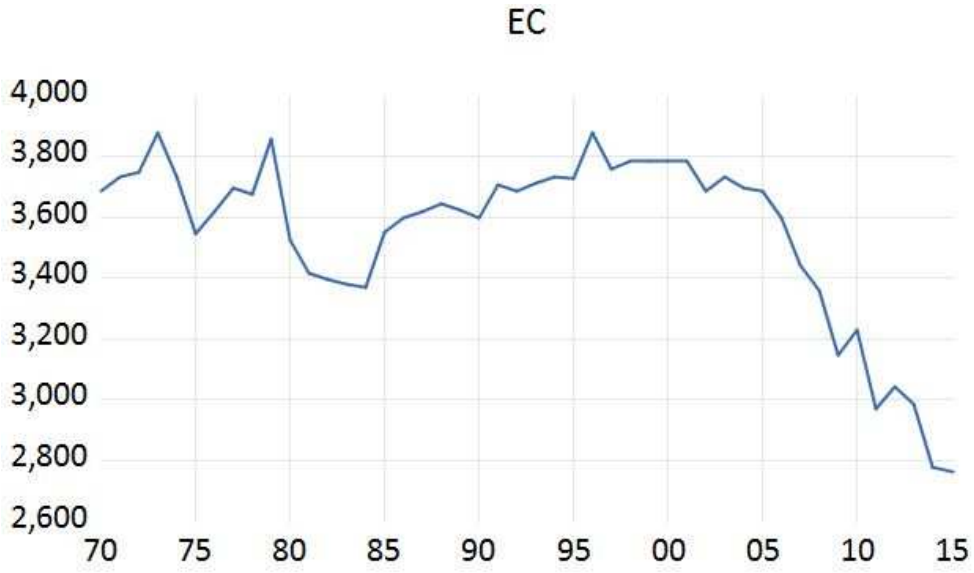
United States	*EC*	*GDP*	*GFCF*	*LF*
Mean	7420.813	9054.832	1731.698	109950.4
Median	7651.901	8404.961	1578.660	113704.4
Maximum	8438.403	16672.69	3315.861	148833.4
Minimum	5612.080	3078.071	447.3170	65745.41
Std. Dev	669.1063	4211.494	935.3972	27032.07
Skewness	-1.171592	0.299591	0.305706	-0.182618
Kurtosis	3.808273	1.727849	1.669382	1.638932
Jarques-Bera	14.33558	4.613904	5.003529	4.633733
Probability	0.000771	0.099564	0.081940	0.098580
Sum	415565.5	507070.6	96975.08	615722
Sum Sq. Dev.	24623675	9.76E+08	48123241	4.02E+10
Observations	56	56	56	56

Table 9: Descriptive Statistics of Canada

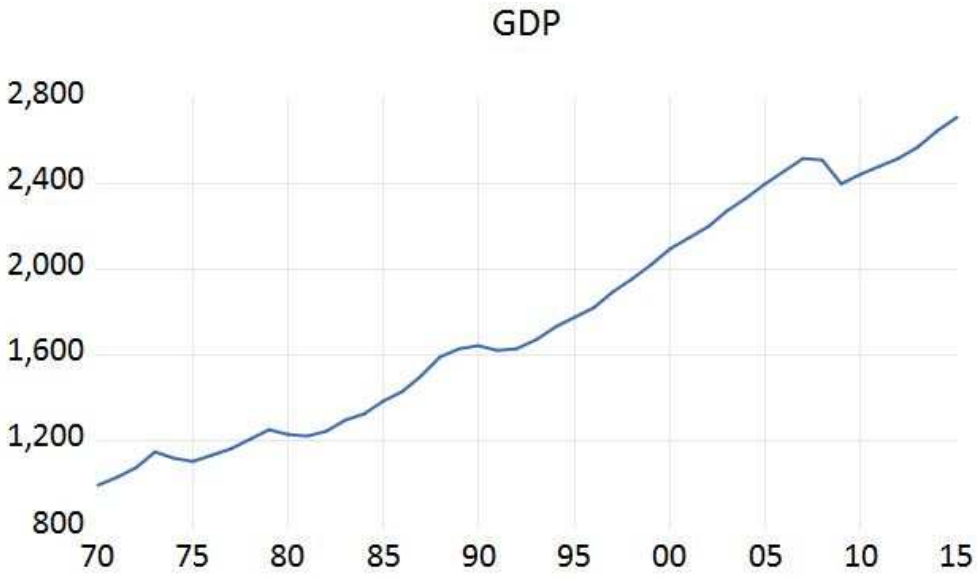
Canada	*EC*	*GDP*	*GFCF*	*LF*
Mean	7215.126	990.5786	202.5696	12063.50
Median	7603.207	968.5291	182.6733	12521.31
Maximum	8441.185	1802.513	431.7809	17946.61
Minimum	4251.436	316.3484	56.29177	5965.167
Std. Dev	1126.936	444.0771	111.7333	3642.184
Skewness	-1.403950	0.248269	0.638804	-0.052661
Kurtosis	3.854934	1.870540	2.239364	1.846454
Jarques-Bera	20.10217	3.551869	5.158643	3.130774
Probability	0.000043	0.169325	0.075825	0.209007
Sum	404047.1	55472.40	11343.89	675556.1
Sum Sq. Dev.	69849123	10846246	686638.6	7.30E+08
Observations	56	56	56	56

4.2 Unit Root Test

Before committing causality test, in order to test for stationarity, *unit root tests* are obligatory. Focusing on *Graphs 1-16* (raw data as collected-price of each variable over time), it seems that all the time series are non-stationary. Although, unit root tests were made.

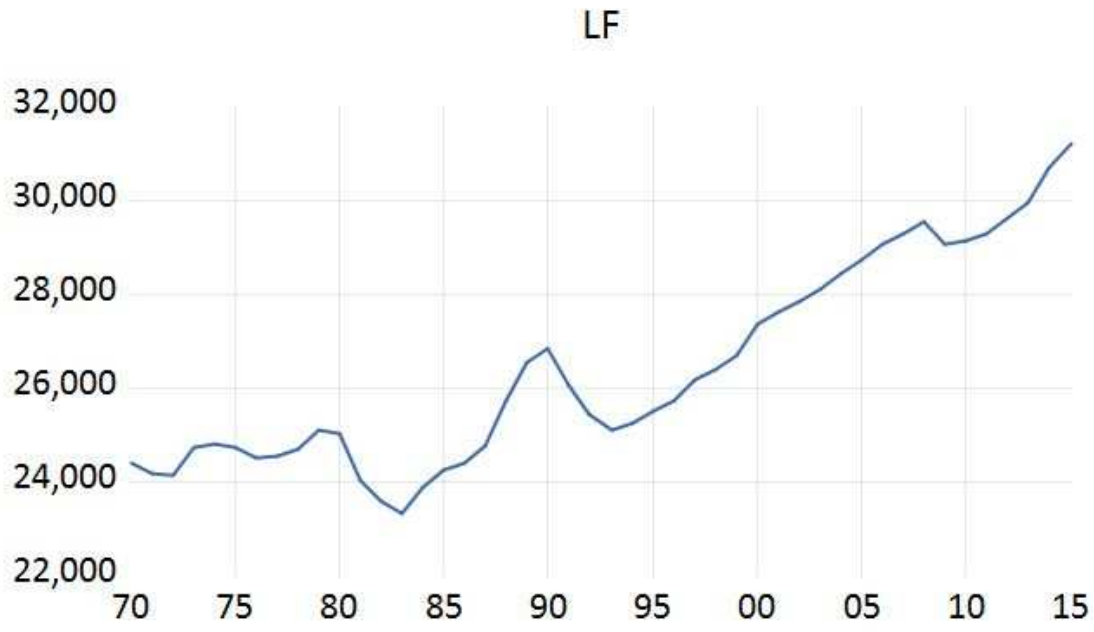


Graph 1: EC graph in U.K.

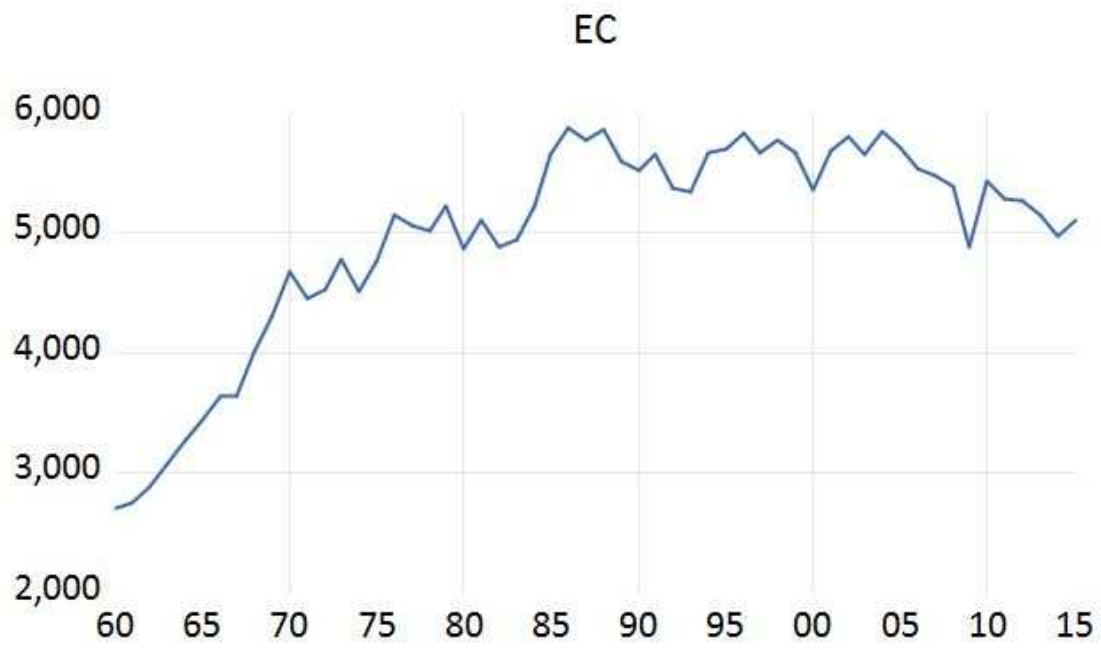


Graph 2: GDP graph in U.K.

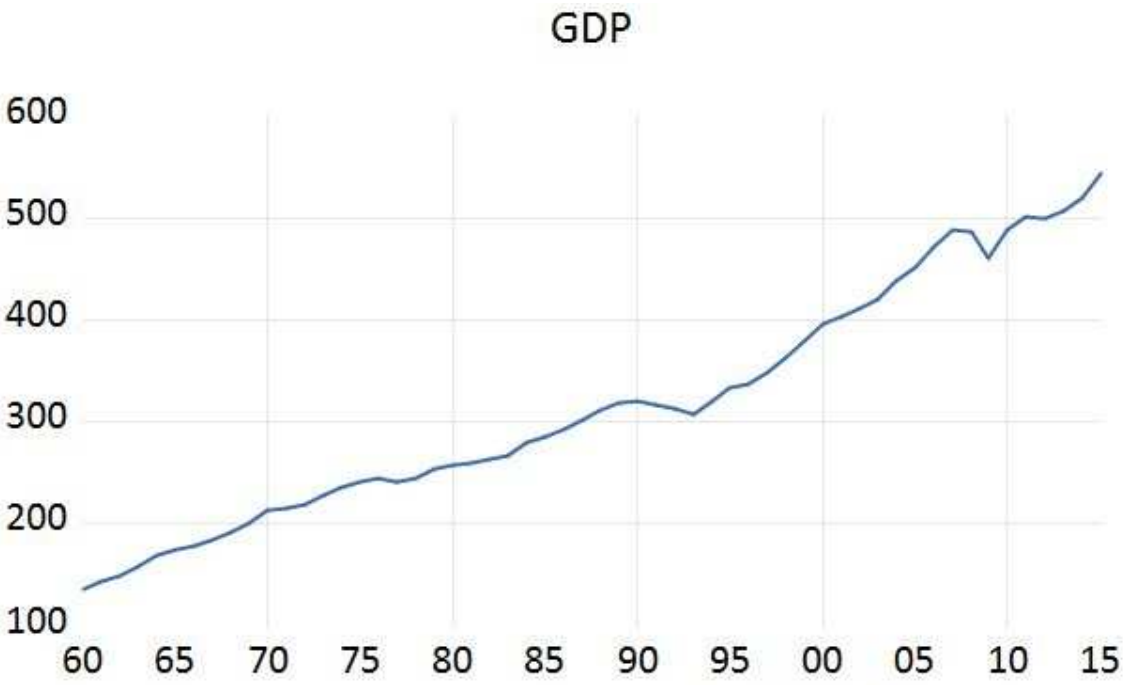
Graph 3: GFCF graph in U.K.



Graph 4: LF graph in U.K.

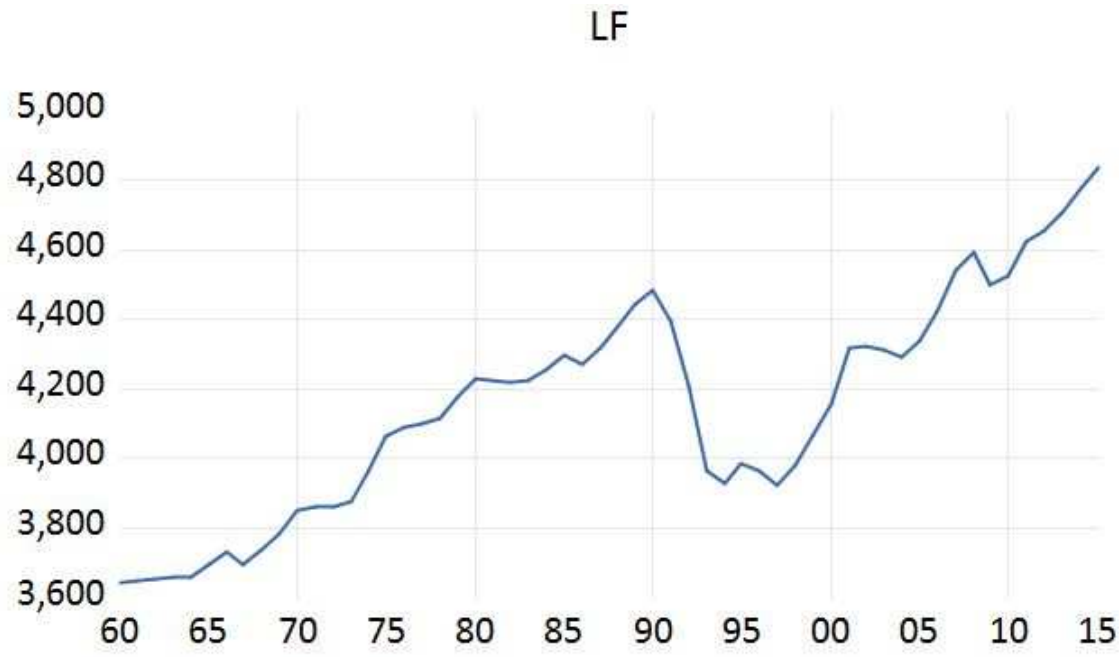


Graph 5: EC graph in Sweden

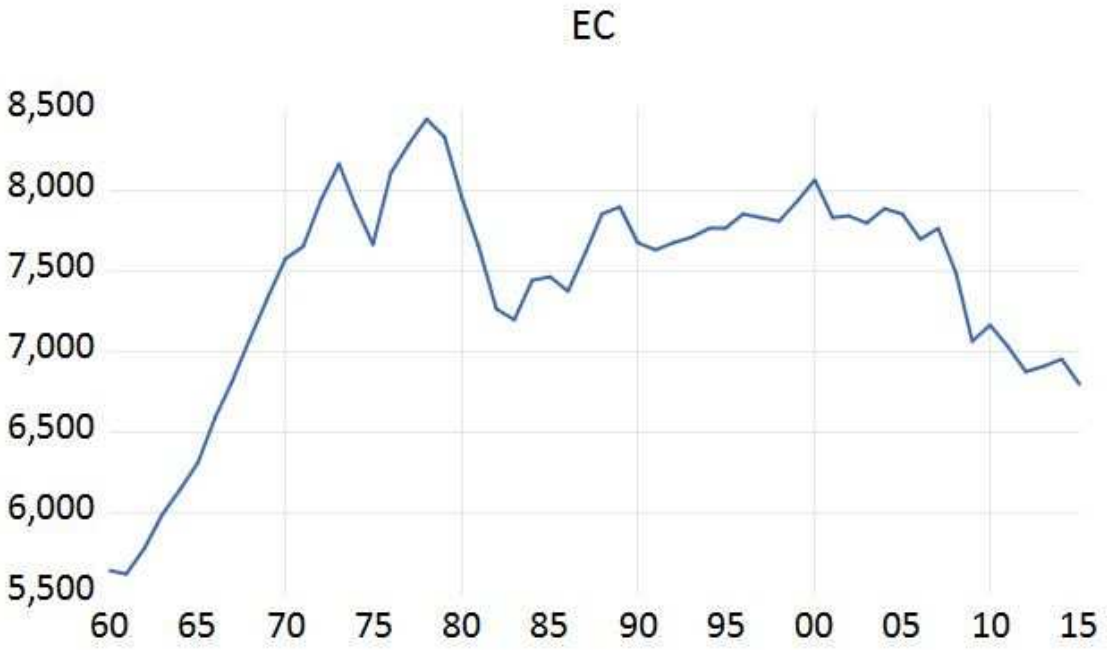


Graph 6: GDP graph in Sweden

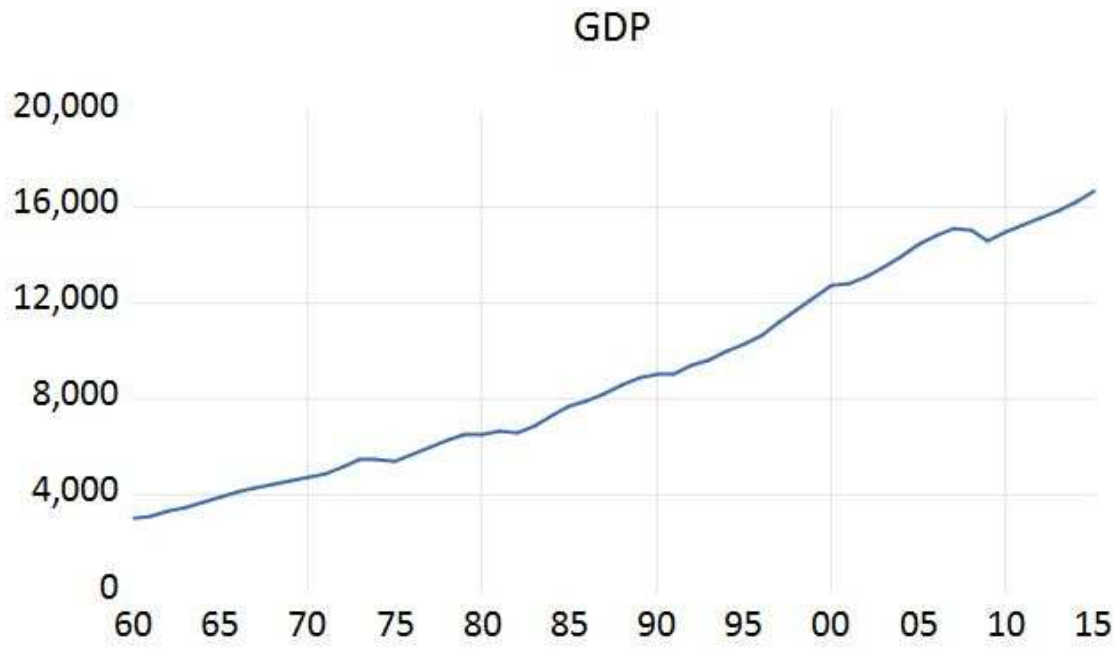
Graph 7: GFCF graph in Sweden



Graph 8: LF graph in Sweden

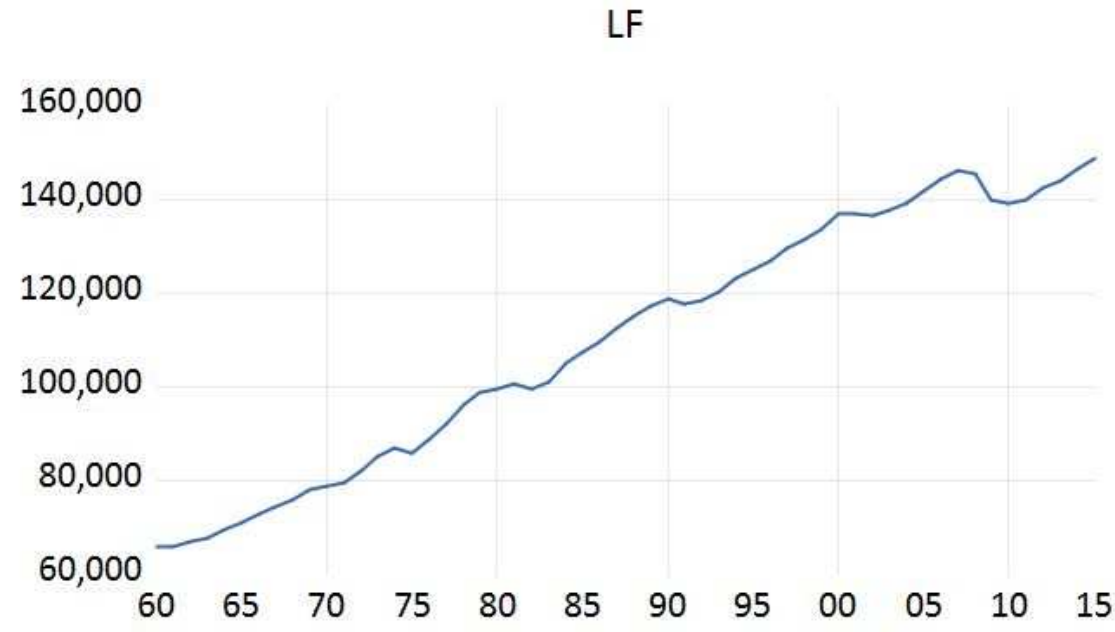


Graph 9: EC graph in U.S.

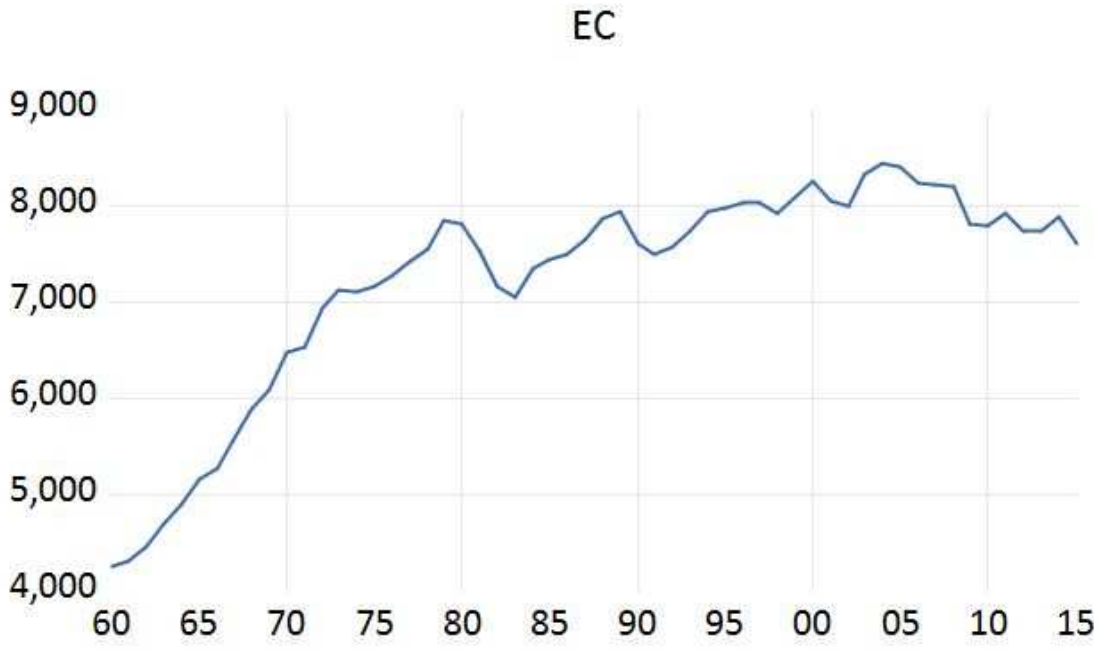


Graph 10: GDP graph in U.S.

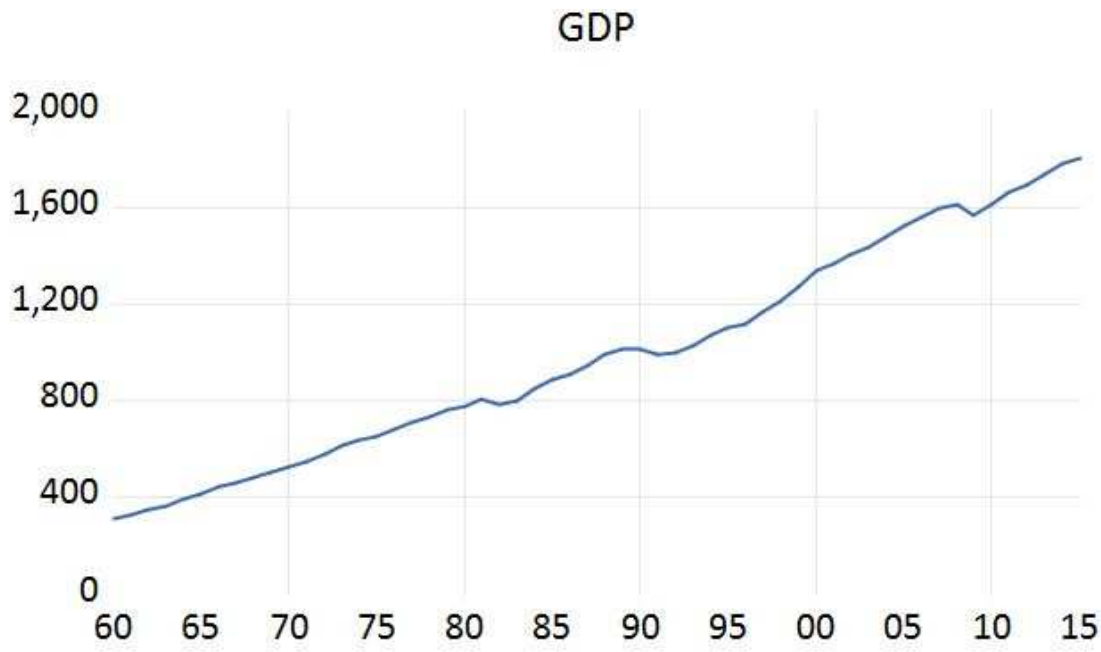
Graph 11: GFCF graph in U.S.



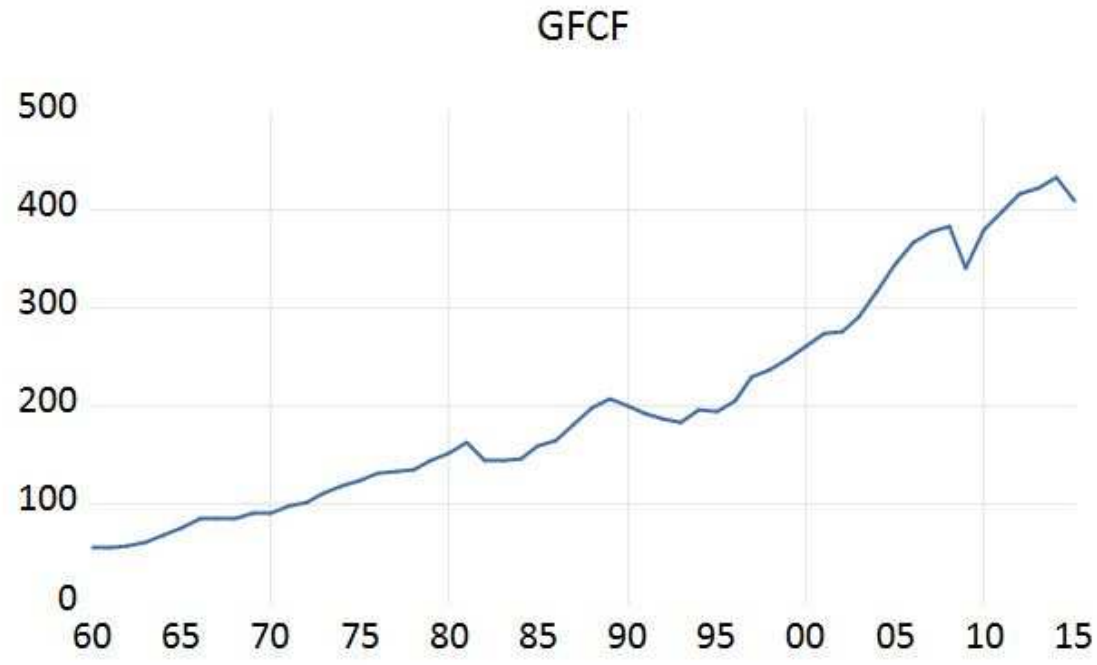
Graph 12: LF graph in U.S.



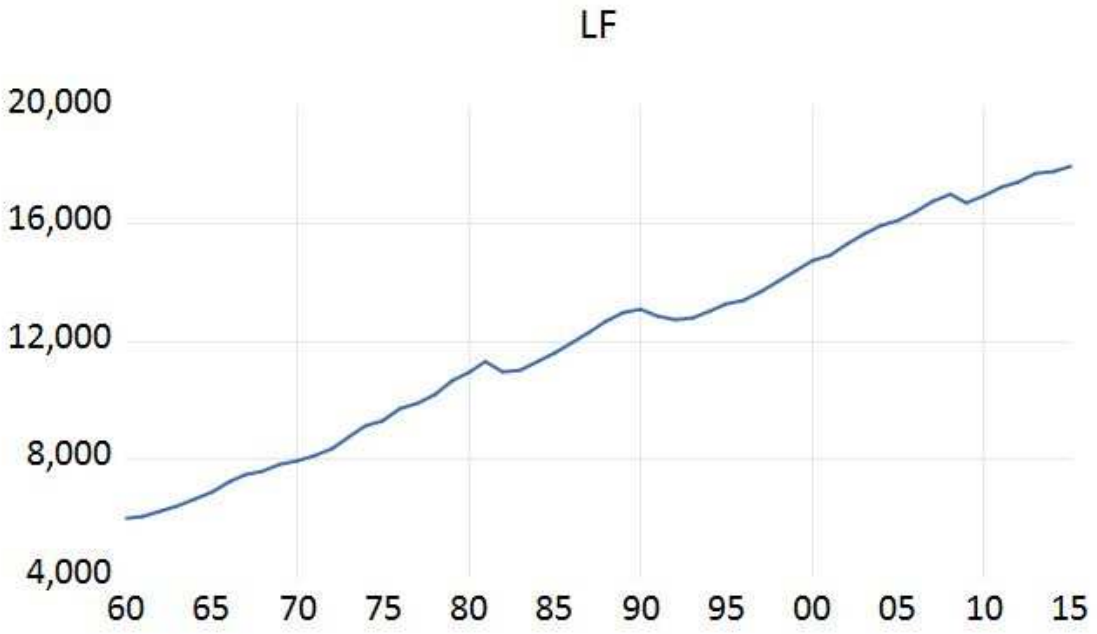
Graph 13: EC graph in Canada



Graph 14: GDP graph in Canada



Graph 15: GFCF graph in Canada



Graph 16: LF graph in Canada

Augmented Dickey-Fuller [14] (ADF) (*table 10*) and Phillip-Perron [30] (PP) (*table 11*) tests executed for every country , for each variable of the country (EC, GDP, GFCF, LF) at level using Schwarz Information Criterion and Bartlett kernel estimation methodology respectively. On the test equation series were tested with intercept, trend and intercept and none of them. Trend was found on GDP, GFCF and LF series for United Kingdom, on EC, GDP, GFCF and LF series for Sweden, United Stated and Canada at level All other series had only Intercept. After taking first differences we can notice that the null Hypothesis was rejected at 5% level of significance on all of the variables (t*able 12, table 13*), so all variables are stationary. While testing on first differences, all testing variables had only intercept.

Table 10: AFD tests, level

U.K.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	0.190356	-2.618801	-3.1301191	-2.493321
p-value	0.9690	0.2743	0.1122	0.3298
Sweden	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-1.711391	-0.871185	-2.162864	-2.431709
p-value	0.7329	0.9518	0.4999	0.3598
U.S.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-2.400625	1.720448	-3.098961	-2.263991
p-value	0.3758	0.7285	0.1170	0.4457
Canada	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-1.406271	-1.412200	-1.649309	-2.970588
p-value	0.8483	0.8465	0.7600	0.1499

There is no rejection of the null hypothesis at 10%, 5%, and 1% level of significance.

Table 11: PP tests, level

U.K.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	0.415287	-1.825813	-2.582279	-1.850686
p-value	0.9815	0.6755	0.2899	0.6631
Sweden	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-1.594425	-0.900696	-1.691204	-1.533332
p-value	0.7825	0.9484	0.7419	0.8058
U.S.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-1.728285	-1.575491	-1.899399	-1.541040
p-value	0.7252	0.7899	0.6414	0.8030
Canada	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-1.393242	-1.412200	-1.696793	-2.021072
p-value	0.8521	0.8465	0.7394	0.5770

There is no rejection of the null hypothesis at 10%, 5%, and 1% level of significance.

Table 12: ADF tests, first differences

U.K.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-7.464849***	-4.172079***	-5.047846***	-4.342610***
p-value	0.0000	0.0020	0.0001	0.0012
Sweden	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-8.239970***	-5.803993***	-5.127728***	-4.967885***
p-value	0.0000	0.0000	0.0001	0.0001
U.S.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-4.714958***	-4.750326***	-4.277553***	-4.677943***
p-value	0.0003	0.0003	0.0012	0.0003
Canada	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-4.751845***	-5.602263***	-6.467079***	-5.345798***
p-value	0.0003	0.0000	0.0000	0.0000

A single star, a double star and a triple star denotes that the null hypothesis is rejected at 10%, 5%, and 1% level of significance respectively.

Table 13: PP tests, first differences

U.K.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-7.439828***	-4.122035***	-4.872318***	-3.044215**
p-value	0.000	0.0023	0.0002	0.0385
Sweden	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-8.197134***	-5.688364***	-4.717893***	-3.631247***
p-value	0.0000	0.0000	0.0003	0.0082
U.S.	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-4.655940***	-4.638058***	-3.843135***	-4.273344***
p-value	0.0004	0.0004	0.0045	0.0012
Canada	**EC**	**GDP**	**GFCF**	**LF**
t-statistic	-4.810516***	-5.543915***	-6.400218***	-5.184763***
p-value	0.0002	0.0000	0.0000	0.0001

A single star, a double star and a triple star denotes that the null hypothesis is rejected at 10%, 5%, and 1% level of significance respectively.

4.3 Cointegration Test

As it is known from unit root tests that were made series are non-stationary, but after taking first differences series are stationary (null hypothesis rejected at 5% level of significance), so we can test for cointegration. Before committing Johansen's [20] cointegration methodology in a multivariate analysis we need to specify the deterministic trend assumption. On United, Kingdom, Sweden and Canada the test made without deterministic trend with restricted constant, while on United States the test made with linear deterministic trend. Trace statistic and the Maximum Eigen value Tests were used in order to reveal us the presence of cointegrating equations in the model.

4.3.1 Scenario 1

On the first scenario, energy consumption excluded from the test. Variables that got used are GDP, GFCF and LF. Both Trace statistic and Maximum Eigen Statistic values indicated that there was one (1) cointegrating equation among the variables on all four countries. Results are represented on *tables 14, 15, 16* and *17* for U.K, Sweden, U.S. and Canada respectively. As there is at least one (1) cointegrating equation per country,

a VECM (Vector Error Correction Model) created for each one of the four countries in order to check the direction of causal relationship.

Table 14: U.K. cointegration tests (1st Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.415379	35.60055	35.19275	0.0452*	23.61881	22.29962	0.0325*
At most 1	0.201344	11.98174	20.26184	0.4504	9.892280	15.89210	0.3443
At most 2	0.046378	2.089464	9.164546	0.7599	2.089464	9.164546	0.7599

*denotes rejection of the hypothesis at 5% level of significance

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Table 15: Sweden cointegration tests (1st Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.430275	48.48811	35.19275	0.0011*	30.38043	22.29962	0.0030*
At most 1	0.190282	18.10768	20.26184	0.0963	11.39776	15.89210	0.2237
At most 2	0.116848	6.709916	9.164546	0.1426	6.709916	9.164546	0.1426

*denotes rejection of the hypothesis at 5% level of significance

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Table 16: U.S. cointegration tests (1st Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.545341	50.55173	29.79707	0.0001*	42.56319	21.13162	0.0000*
At most 1	0.121673	7.988542	15.49471	0.4666	7.005755	14.26460	0.4885
At most 2	0.018035	0.982787	3.841466	0.3215	0.982787	3.841466	0.3215

*denotes rejection of the hypothesis at 5% level of significance

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Table 17: Canada cointegration tests (1st Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.430275	48.48811	35.19275	0.0011*	30.38043	22.29962	0.0030*
At most 1	0.190282	18.10768	20.26184	0.0963	11.39776	15.89210	0.2237
At most 2	0.116848	6.709916	9.164546	0.1426	6.709916	9.164546	0.1426

*denotes rejection of the hypothesis at 5% level of significance

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4.3.2 Scenario 2

On the second scenario all of the variables are included. Except from GDC, GFCF and LF, EC is also included in the model. On this scenario, Trace statistic values indicated that there was one (1) cointegrating equation among the variables on U.K., Sweden and U.S. and two (2) cointegrating equations among the variable on Canada while Maximum Eigen statistic values indicated that there was one (1) cointegrating equations among the variables on all four countries. Results are represented on *tables 18, 19, 20 and 21* for U.K, Sweden, U.S. and Canada respectively. As our results are similar to first scenario's results and there is at least one (1) cointegrating equation per country, a VECM (Vector Error Correction Model) created for each of the four countries in order to check the direction of causal relationship.

Table 18: U.K. cointegration tests (2nd Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.531579	61.26882	54.07904	0.0100*	33.36906	22.58808	0.0113*
At most 1	0.310275	27.89976	35.19275	0.2458	16.34436	22.29962	0.2745
At most 2	0.171846	11.55540	20.26184	0.4895	8.296470	15.89210	0.5127
At most 3	0.071390	3.258926	9.164546	0.5334	3.258926	9.164546	0.5334

*denotes rejection of the hypothesis at 5% level of significance

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Table 19: Sweden cointegration tests (2nd Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.495728	67.35136	54.07904	0.0021*	36.97057	28.58808	0.0034*
At most 1	0.274121	30.38078	35.19275	0.1507	17.30007	22.29962	0.2157
At most 2	0.167696	13.08071	20.26184	0.3574	9.912110	15.89210	0.3424
At most 3	0.056989	3.168603	9.164546	0.5497	3.168603	9.164546	0.5497

*denotes rejection of the hypothesis at 5% level of significance

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Table 20: U.S. cointegration tests (2nd Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.648078	79.29641	47.85613	0.0000*	56.39471	27.58434	0.0000*
At most 1	0.269644	22.90170	29.79707	0.2509	16.96808	21.13162	0.1735
At most 2	0.085517	5.933613	15.49471	0.7034	4.827406	14.26460	0.7635
At most 3	0.020277	1.106208	3.841466	0.2929	1.106208	3.841466	0.2929

*denotes rejection of the hypothesis at 5% level of significance

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Table 21: Canada cointegration tests (2nd Scenario)

Hypothesized No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*0.05 Crit. Value*	*Prob.***	*Max-Eigen Statistic*	*0.05 Crit. Value*	*Prob.***
None	0.459141	70.79134	54.07904	0.0008*	33.18821	28.58808	0.0120*
At most 1	0.277230	37.60313	35.19275	0.0270*	17.53189	22.29962	0.2030
At most 2	0.194980	20.07124	20.26184	0.0531	11.7119	15.89210	0.2033
At most 3	0.143414	8.359249	9.164546	0.0709	8.359249	9.164546	0.0709

*denotes rejection of the hypothesis at 5% level of significance

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4.4 Causality Test

The *Causal Relationship* between *Energy Consumption* and *Gross Domestic Product* investigated for all of the countries (United Kingdom, Sweden, United States and Canada) using Granger's [16] causality methodology. The Causal Relationship among the other variables examined at the same way. Tests were made for both scenarios. For the first scenario (without the variable of energy consumption), testing was ancillary.

Furthermore, in order to check the reliability of the result, some diagnostic tests were executed. Diagnostic tests included were Impulse Responses, Variance Decomposition and Historical Decomposition. Their results are represented on the *Appendix*.

4.4.1 Scenario 1

On this scenario of the study, the variables that are included are only Gross Domestic Product, Gross Fixed Capital Formation and Labor Force. As we can notice on *table 22* that shows the results of Granger's [16] Causality methodology testing on United Kingdom, there is one (1) bidirectional causal relationship between Gross Domestic Product and Labor Force. Furthermore, there are two (2) unidirectional causal relationships from Gross Domestic Product to Gross Fixed Capital Formation and from Labor Force to Gross Fixed Capital Formation.

The report that appears on *table 23* reveals to us the results of Granger's [16] Causality methodology testing on Sweden that indicates that there is no causal relationship between Gross Domestic Product and Gross Fixed Capital Formation, Gross Domestic Product and Labor Force and Gross Fixed Capital Formation and Labor Force.

Results that appear on t*able 24* refer to the results of Granger's [16] Causality methodology testing on United States and denote that there are two (2) unidirectional causal relationships from Labor Force to Gross Domestic Product and from Labor Force to Gross Fixed Capital Formation.

In the case of Canada, Granger's [16] Causality methodology testing is shown on *table 25*. On Canada there is only one (1) causal relationship. A unidirectional causal relationship from Labor Force to Gross Domestic Product was found.

Table 22: Granger Causality/Block Exogeneity Wald Tests on U.K. (1st Scenario)

Null Hypothesis	***Chi-sq***	***Probability***	***Causal Relationship***
GFCF does not Granger cause GDP	0.000603	0.9804	No Causal relationship
LF does not Granger cause GDP	4.797565	0.0285*	*LF causes GDP*
GDP does not Granger cause GFCF	6.704813	0.0096*	*GDP causes GFCF*
LF does not Granger cause GFCF	3.886961	0.0487*	*LF causes GFCF*
GDP does not Granger cause LF	6.948623	0.0084*	*GDP causes LF*
GFCF does not Granger cause LF	0.021578	0.8832	No Causal relationship

*denotes rejection of the hypothesis at 5% level of significance

Table 23: Granger Causality/Block Exogeneity Wald Tests on Sweden (1st Scenario)

Null Hypothesis	***Chi-sq***	***Probability***	***Causal Relationship***
GFCF does not Granger cause GDP	0.452435	0.5012	No Causal relationship
LF does not Granger cause GDP	0.368836	0.5436	No Causal relationship
GDP does not Granger cause GFCF	2.514539	0.1128	No Causal relationship
LF does not Granger cause GFCF	0.732031	0.3922	No Causal relationship
GDP does not Granger cause LF	3.234106	0.0721	No Causal relationship
GFCF does not Granger cause LF	0.164757	0.6848	No Causal relationship

*denotes rejection of the hypothesis at 5% level of significance

Table 24: Granger Causality/Block Exogeneity Wald Tests on U.S. (1st Scenario)

Null Hypothesis	***Chi-sq***	***Probability***	***Causal Relationship***
GFCF does not Granger cause GDP	3.730798	0.0534	No Causal relationship
LF does not Granger cause GDP	13.98265	0.0002*	*LF causes GDP*
GDP does not Granger cause GFCF	3.192487	0.0740	No Causal relationship
LF does not Granger cause GFCF	16.39531	0.0001*	*LF causes GFCF*
GDP does not Granger cause LF	3.255496	0.0712	No Causal relationship
GFCF does not Granger cause LF	1.401584	0.2365	No Causal relationship

*denotes rejection of the hypothesis at 5% level of significance

Table 25: Granger Causality/Block Exogeneity Wald Tests on Canada (1st Scenario)

Null Hypothesis	*Chi-sq*	*Probability*	*Causal Relationship*
GFCF does not Granger cause GDP	0.574841	0.4483	No Causal relationship
LF does not Granger cause GDP	4.424166	0.0354*	*LF causes GDP*
GDP does not Granger cause GFCF	0.226465	0.6342	No Causal relationship
LF does not Granger cause GFCF	0.035260	0.8511	No Causal relationship
GDP does not Granger cause LF	0.023955	0.8770	No Causal relationship
GFCF does not Granger cause LF	0.173618	0.6769	No Causal relationship

*denotes rejection of the hypothesis at 5% level of significance

4.4.2 Scenario 2

On the second scenario all of the variables are included into the test, including Energy Consumption as the fourth variable. We focus on this scenario because the basic purpose of the study is to examine the causal relationship between Energy Consumption and Gross Domestic Product, although, as on the first scenario, all of the variables are included on tests for all of the countries.

From *table26* we can notice that on United Kingdom there are three (3) *unidirectional Causal Relationships* from Labor Force to Gross Domestic Product, from Labor Force to Gross Fixed Capital Formation and finally *from Gross Domestic Product to Energy Consumption*.

As it concerns the results of the Granger's [16] Causality methodology testing among the variable on Sweden, we can notice from *table 27* that the only Causal Relationship is a (1) unidirectional relationship from Gross Domestic Product to Labor Force.

On United States four (4) unidirectional Causal Relationships were found, from Gross Fixed Capital Formation to Gross Domestic Product, from Labor Force to Gross Domestic Product, from Labor Force to Gross Fixed Capital Formations and from Labor Force to Energy Consumption. Results are representing on *table 28*.

Finally, on *table 29* are represented the results concerning the Causal Relationship among all the variables on Canada. On Canada there are two (2) unidirectional Causal Relationships, from Labor Force to Gross Domestic Product and from Energy Consumption to Labor Force.

Table 26: Granger Causality/Block Exogeneity Wald Tests on U.K. (2nd Scenario)

Null Hypothesis	***Chi-sq***	***Probability***	***Causal Relationship***
GFCF does not Granger cause GDP	0.148720	0.6998	No Causal relationship
LF does not Granger cause GDP	5.455322	0.0195*	*LF causes GDP*
EC does not Granger cause GDP	1.061683	0.3028	No Causal relationship
GDP does not Granger cause GFCF	3.407073	0.0649	No Causal relationship
LF does not Granger cause GFCF	4.045941	0.0443*	*LF causes GFCF*
EC does not Granger cause GFCF	0.437393	0.5084	No Causal relationship
GDP does not Granger cause LF	3.552003	0.0595	No Causal relationship
GFCF does not Granger cause LF	0.028048	0.8670	No Causal relationship
EC does not Granger cause LF	4.79e-06	0.9983	No Causal relationship
GDP does not Granger cause EC	6.580921	0.0103*	*GDP causes EC*
GFCF does not Granger cause EC	3.452051	0.0632	No Causal relationship
LF does not Granger cause EC	0.710566	0.3993	No Causal relationship

*denotes rejection of the hypothesis at 5% level of significance

Table 27: Granger Causality/Block Exogeneity Wald Tests on Sweden (2nd Scenario)

Null Hypothesis	***Chi-sq***	***Probability***	***Causal Relationship***
GFCF does not Granger cause GDP	0.829640	0.3624	No Causal relationship
LF does not Granger cause GDP	0.386367	0.5342	No Causal relationship
EC does not Granger cause GDP	0.630855	0.4270	No Causal relationship
GDP does not Granger cause GFCF	3.799010	0.0513	No Causal relationship
LF does not Granger cause GFCF	0.690104	0.4061	No Causal relationship
EC does not Granger cause GFCF	0.754722	0.3850	No Causal relationship
GDP does not Granger cause LF	4.830791	0.0280*	*GDP causes LF*
GFCF does not Granger cause LF	0.380737	0.5372	No Causal relationship
EC does not Granger cause LF	1.415806	0.2341	No Causal relationship
GDP does not Granger cause EC	0.001492	0.9692	No Causal relationship
GFCF does not Granger cause EC	0.359491	0.5488	No Causal relationship
LF does not Granger cause EC	0.003520	0.9527	No Causal relationship

*denotes rejection of the hypothesis at 5% level of significance

Table 28: Granger Causality/Block Exogeneity Wald Tests on U.S. (2nd Scenario)

Null Hypothesis	***Chi-sq***	***Probability***	***Causal Relationship***
GFCF does not Granger cause GDP	4.498482	0.0339*	*GFCF causes GDP*
LF does not Granger cause GDP	12.30433	0.0005*	*LF causes GDP*
EC does not Granger cause GDP	0.464271	0.4956	No Causal relationship
GDP does not Granger cause GFCF	2.257243	0.1330	No Causal relationship
LF does not Granger cause GFCF	16.00482	0.0001*	*LF causes GFCF*
EC does not Granger cause GFCF	0.073348	0.7865	No Causal relationship
GDP does not Granger cause LF	2.476800	0.1155	No Causal relationship
GFCF does not Granger cause LF	1.198440	0.2736	No Causal relationship
EC does not Granger cause LF	0.000430	0.9835	No Causal relationship
GDP does not Granger cause EC	0.044595	0.8328	No Causal relationship
GFCF does not Granger cause EC	0.714242	0.3980	No Causal relationship
LF does not Granger cause EC	4.765404	0.0290*	*LF causes EC*

*denotes rejection of the hypothesis at 5% level of significance

Table 29: Granger Causality/Block Exogeneity Wald Tests on Canada (2nd Scenario)

Null Hypothesis	***Chi-sq***	***Probability***	***Causal Relationship***
GFCF does not Granger cause GDP	0.090871	0.7631	No Causal relationship
LF does not Granger cause GDP	4.073785	0.0436*	*LF causes GDP*
EC does not Granger cause GDP	1.926458	0.1654	No Causal relationship
GDP does not Granger cause GFCF	0.392897	0.5308	No Causal relationship
LF does not Granger cause GFCF	0.057732	0.8101	No Causal relationship
EC does not Granger cause GFCF	0.857591	0.3544	No Causal relationship
GDP does not Granger cause LF	0.028304	0.8664	No Causal relationship
GFCF does not Granger cause LF	0.045514	0.8311	No Causal relationship
EC does not Granger cause LF	5.045951	0.0247*	*EC causes LF*
GDP does not Granger cause EC	0.008314	0.9273	No Causal relationship
GFCF does not Granger cause EC	2.201444	0.1379	No Causal relationship
LF does not Granger cause EC	0.124779	0.7239	No Causal relationship

*denotes rejection of the hypothesis at 5% level of significance

5 Conclusions

The topic of causal relationship between energy and output is a topic that had been investigated many times for different countries. This study though, investigates that relationship on four countries (Unites Kingdom, Sweden, United States and Canada) using Energy Consumption and Gross Domestic Product variables but also, Gross Fixed Capital Formation and Labor Force as extra variables. Collected annual data cover a range of fifty-five (55) years (from 1960 to 2015) for Sweden, United States and Canada while for United Kingdom the covering range equals to forty-five (45) years (from 1970 to 2015). Using unit root test on all of the variables (ADF and PP), empirical results certify our forecasting from viewing the graphs that all the variables are not stationary.

Two different scenarios were made before the test execution of Johansen's [20] cointegration methodology. On the first scenario, the Energy Consumption (EC) variable excluded from the model. As the study conducted in order to find the causal relationship between energy and output and the first scenario was ancillary, the results that help us answer to the topic are the results of the second scenario. The existence of one (1) cointegrating equation on all of the countries reveals the existence of causal relationship(s) between the variables but it doesn't reveal which variables have causal relationship and which is the direction. The creation of a Vector Error Correction Model (VECM) for each country allow us to check the direction of the Causal Relationship of the Variable by committing Granger's [16] Causality methodology.

Contrary to the results of Altunbas and Kapusuzoglou's [4] study, as they found that there is no existence of a Causal Relationship (Neutrality Hypothesis) between Energy Consumption and Gross Domestic Product for United Kingdom, our findings reveals the existence of Growth hypothesis that states that Gross Domestic Product causes Energy Consumption *(GDP→EC)*

Our results on Sweden are contrary to the results of Stern and Enflo's [34] study. They were led to Growth Hypothesis while the results of this study found no existence of Causal Relationship (Neutrality Hypothesis) between energy and output.

Furthermore, our results of the Causal Relationship between Energy Consumption and Gross Domestic Product on United States and Canada are the same as on Sweden. Results reveal the Neutrality Hypothesis. Kraft and Kraft [] and Stern [] on their studies on United States were led to Conservation Hypothesis (Energy Consumption causes Gross Domestic Product) and Growth Hypothesis (Gross Domestic Product causes Energy Consumption) respectively.

Summarizing, *the only Causal Relationship* we found on the 4 countries that got included to the study is the *Causal Relationship from Gross Domestic Product to Energy Consumption (GDP→EC)*. We can notice that the results of similar studies for a country are different. That can be caused because of different variables, range of data and methodologies that researches are using.

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Appendix

This section provides the *Unrestricted Cointegrating Coefficients* and *Unrestricted Adjustment Coefficients* from Johansen's [20] Cointegration methodology and diagnostic diagrams of *Impulse Responses*, *Variance Decomposition* and *Historical Decomposition* for both Scenarios of all of the countries from Granger's [16] Causality.

Unrestricted Coefficients

United Kingdom (Scenario 1)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP	GFCF	LF	C
-0.004307	0.029612	-1.98E-05	1.032964
-0.011804	0.040709	0.001304	-26.22491
0.001647	-0.033527	0.000577	-8.041734

Unrestricted Adjustment Coefficients (alpha):

D(GDP)	9.549478	-13.75041	0.579789
D(GFCF)	-2.232659	-5.736682	0.984832
D(LF)	-66.45984	-105.3434	-32.16073

United Kingdom (Scenario 2)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP	GFCF	LF	EC	C
-0.005593	0.035543	-0.000522	-0.003743	24.72616
0.012748	-0.076340	0.000127	0.002704	-13.60568
0.004740	0.008894	-0.001758	-0.002807	46.08440
0.007296	-0.051704	-4.14E-05	0.003457	-8.557363

Unrestricted Adjustment Coefficients (alpha):

D(GDP)	-7.291296	0.374319	12.57114	2.288359
D(GFCF)	0.700431	4.456205	4.035118	1.580053
D(LF)	32.80272	82.87025	92.20679	-31.90212
D(EC)	54.76923	-26.37908	25.77561	4.628992

Sweden (Scenario 1)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP	GFCF	LF	C
0.006950	-0.002186	-0.001929	7.619969
-0.049553	0.200123	0.001951	-6.981123
-0.005770	0.094434	-0.006417	21.56483

Unrestricted Adjustment Coefficients (alpha):

D(GDP)	3.833452	-2.239054	0.235898
D(GFCF)	0.222021	-1.457758	0.080401
D(LF)	-3.242249	-12.31907	9.513055

Sweden (Scenario 2)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP	GFCF	LF	EC	C
0.002957	0.015883	-0.002147	0.000182	7.594887
-0.031072	0.156294	-0.000953	0.001304	-4.171119
0.051613	-0.199763	0.000264	-0.000627	0.276536
0.000518	-0.073132	0.007201	-0.000393	-22.75815

Unrestricted Adjustment Coefficients (alpha):

D(GDP)	3.409390	-1.765528	2.203064	-0.460037
D(GFCF)	-0.003891	-1.018126	1.425351	-0.213843
D(LF)	-5.928774	-9.553167	8.824906	-10.50070
D(EC)	28.73239	-114.0124	-17.19042	-0.749642

United States (Scenario 1)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP	GFCF	LF
-0.001137	0.005271	3.45E-05
0.000785	-0.006153	0.000111
-0.001538	0.002137	0.000145

Unrestricted Adjustment Coefficients (alpha):

D(GDP)	-8.294127	25.24588	16.55196
D(GFCF)	-29.05432	18.50835	5.886552
D(LF)	-535.8705	27.85339	145.4174

United States (Scenario 2)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP	GFCF	LF	EC
0.001793	-0.005960	-0.000139	0.001050
-0.001031	0.005058	-3.65E-05	-0.001066
0.000520	0.003040	-0.000200	0.001761
-0.001418	0.002685	0.000108	0.000588

Unrestricted Adjustment Coefficients (alpha):

D(GDP)	-8.923813	-21.56668	-27.19009	14.19997
D(GFCF)	21.06022	-18.10961	-16.41955	4.478898
D(LF)	403.7116	-104.6509	-107.8823	151.5805
D(EC)	22.55285	46.61232	-32.24302	11.06390

Canada (Scenario 1)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

GDP	GFCF	LF	C
0.014255	-0.026282	-0.000940	4.605403
0.033326	-0.064720	-0.001969	3.837355
-0.016041	0.020278	0.001598	-7.394524

Unrestricted Adjustment Coefficients (alpha):

D(GDP)	13.46085	2.871571	-0.137354
D(GFCF)	4.422759	4.585021	-0.122028
D(LF)	85.97333	19.58118	-33.61614

Canada (Scenario 2)

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

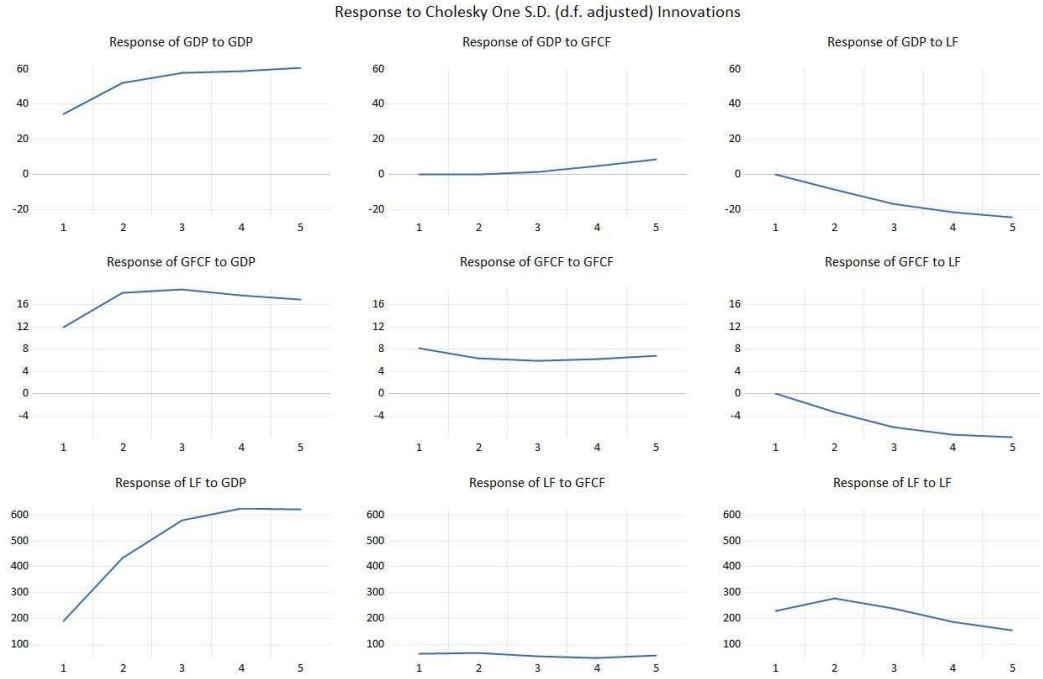
GDP	GFCF	LF	EC	C
0.010842	-0.015947	-0.000838	0.000423	1.691767
-0.013218	0.025757	0.000987	0.000641	-8.911198
-0.030034	0.071692	0.001164	0.000842	-4.824955
-0.022927	-0.000765	0.003497	-0.002450	-1.805348

Unrestricted Adjustment Coefficients (alpha):

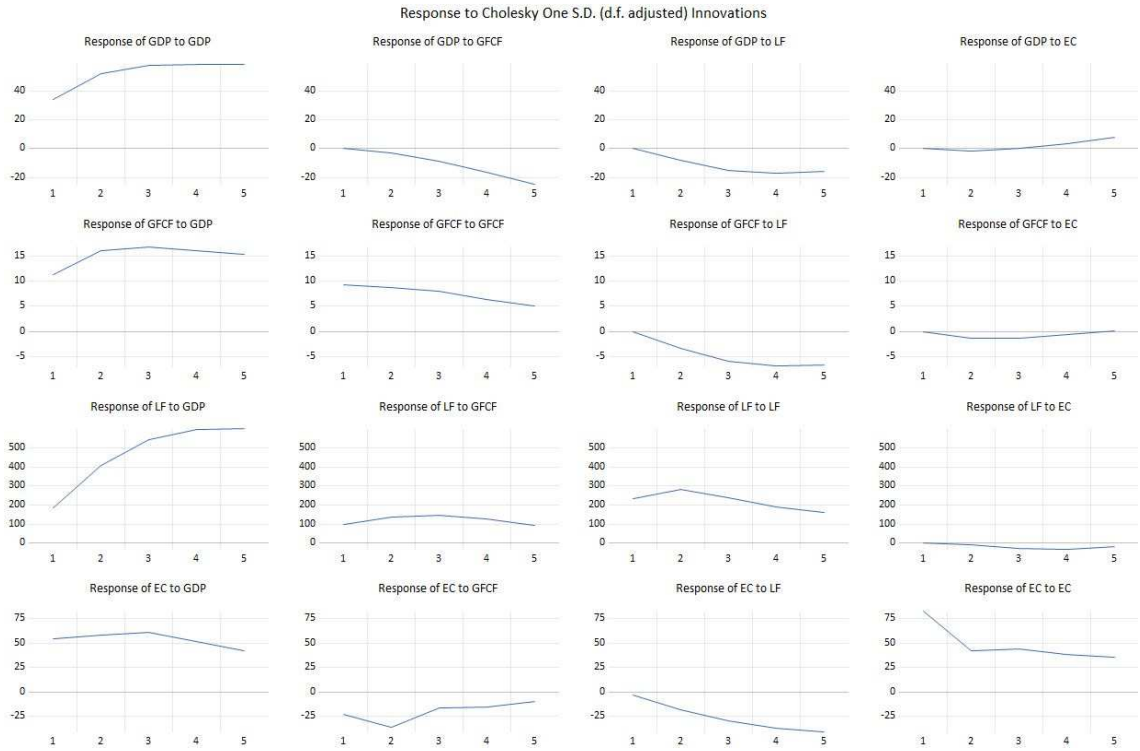
D(GDP)	12.94849	-3.475388	-3.263396	0.175866
D(GFCF)	4.461067	-0.457396	-4.603046	-0.688025
D(LF)	84.70589	-35.39053	-15.01363	-32.10515
D(EC)	16.83416	-83.71597	-21.27910	11.88986

Impulse Responses

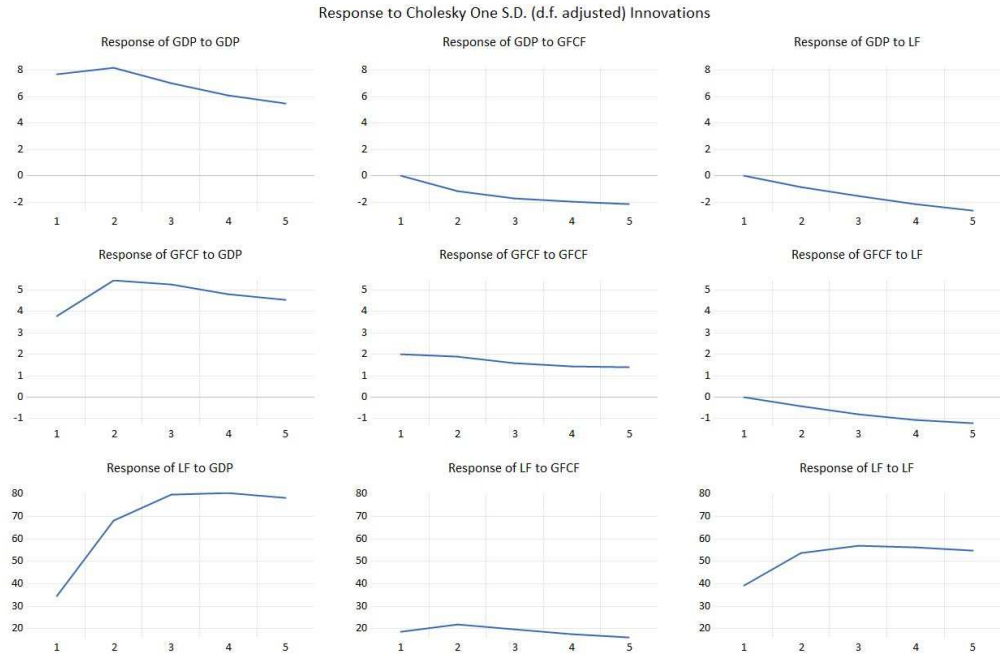
United Kingdom (Scenario 1)



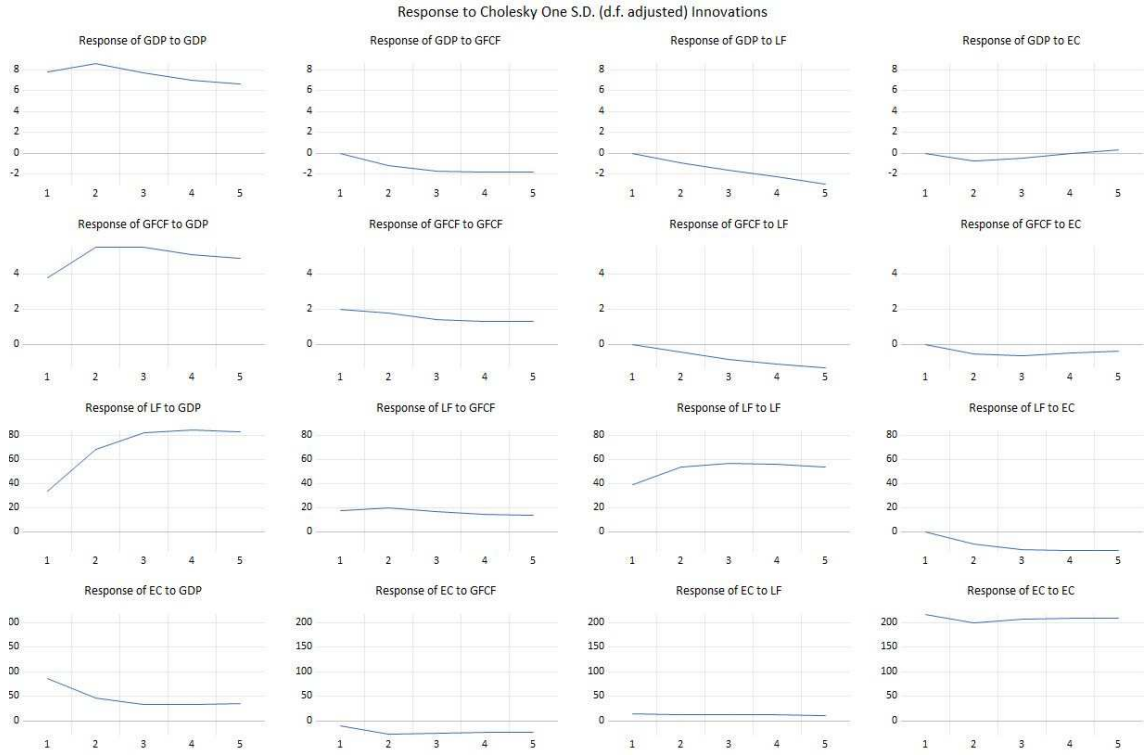
United Kingdom (Scenario 2)



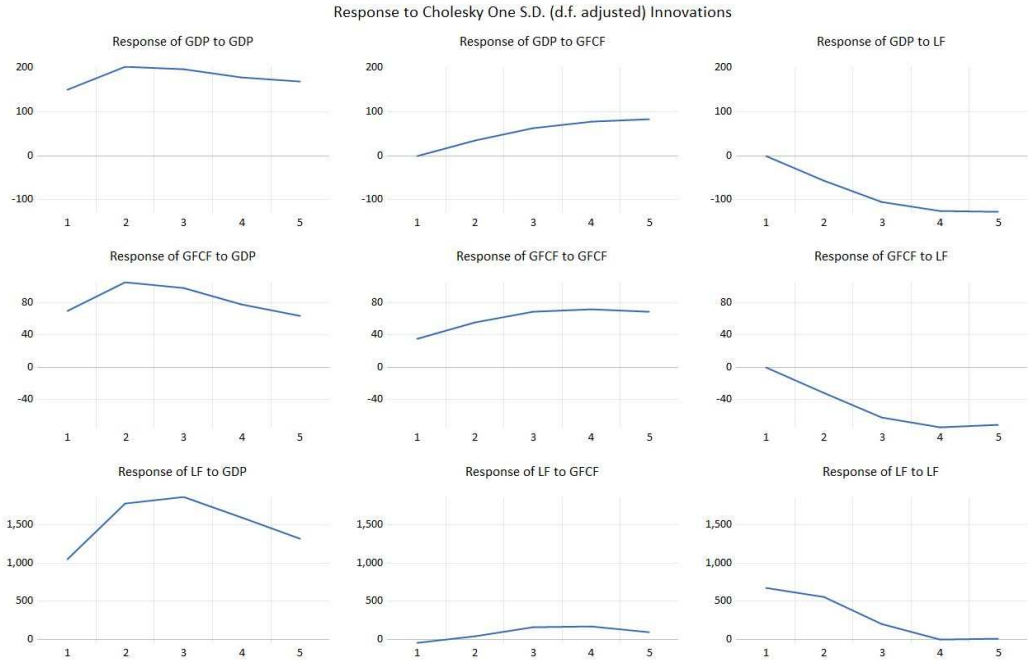
Sweden (Scenario 1)



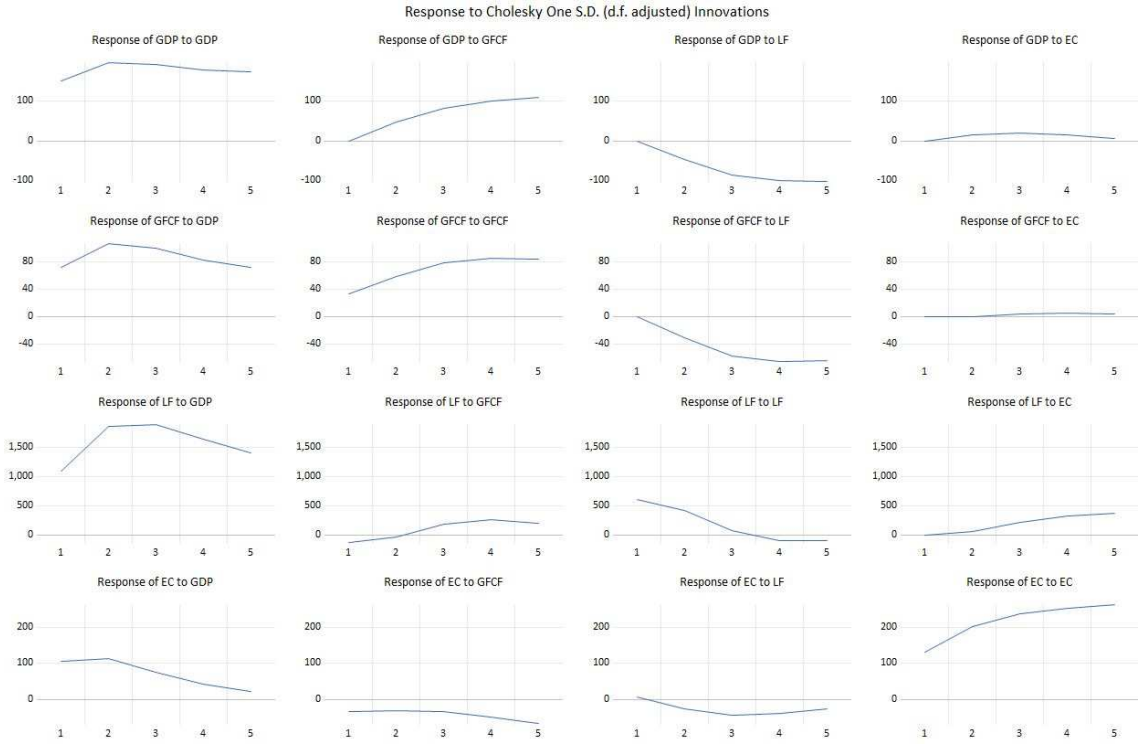
Sweden (Scenario 2)



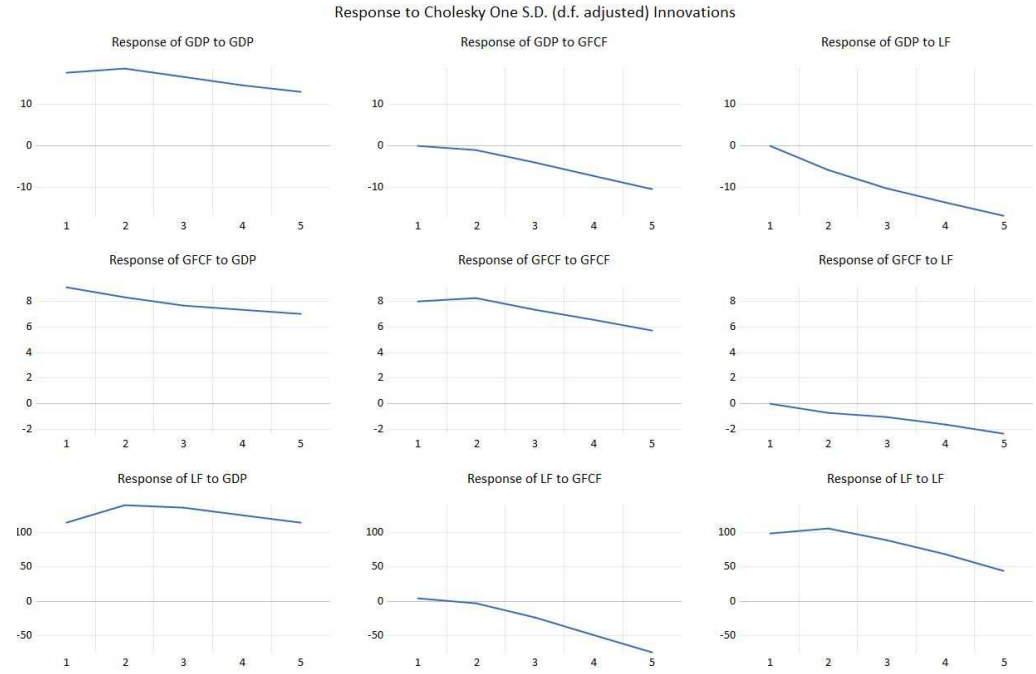
United States (Scenario 1)



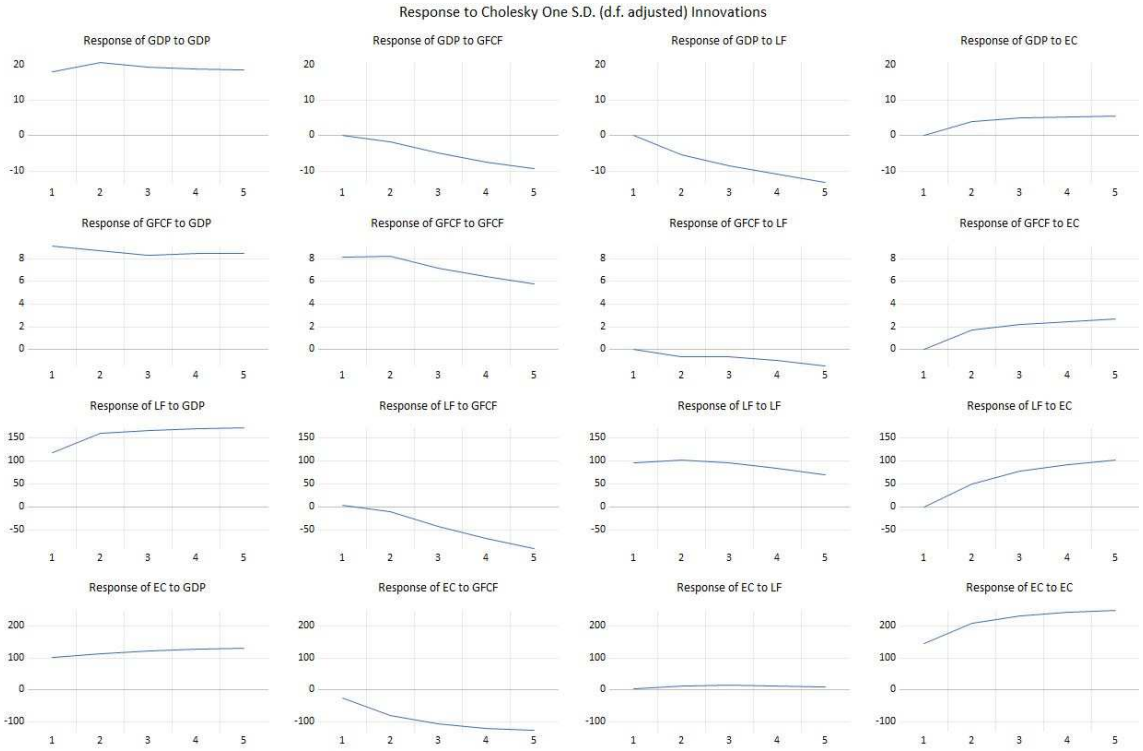
United States (Scenario 2)



Canada (Scenario 1)

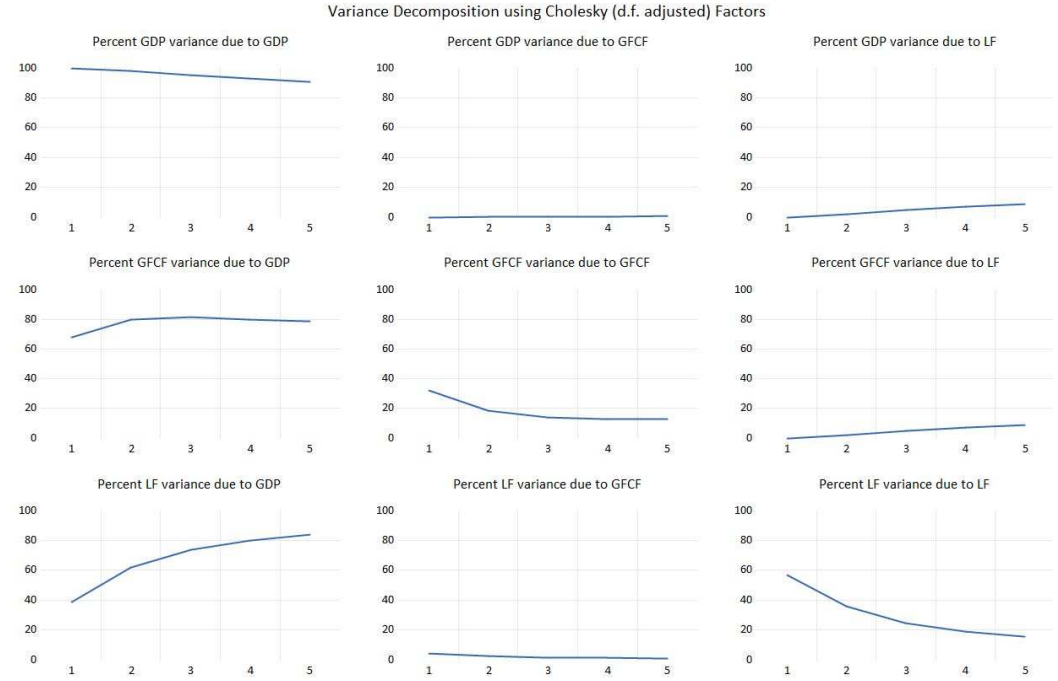


Canada (Scenario 2)

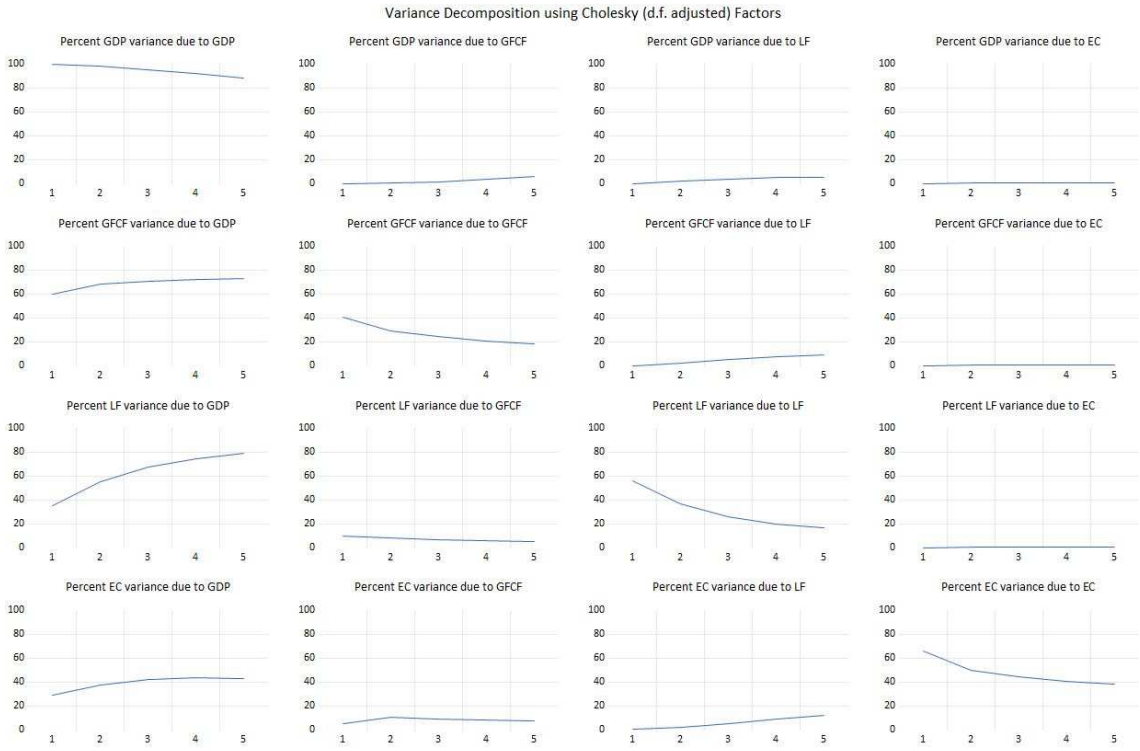


Variance Decomposition

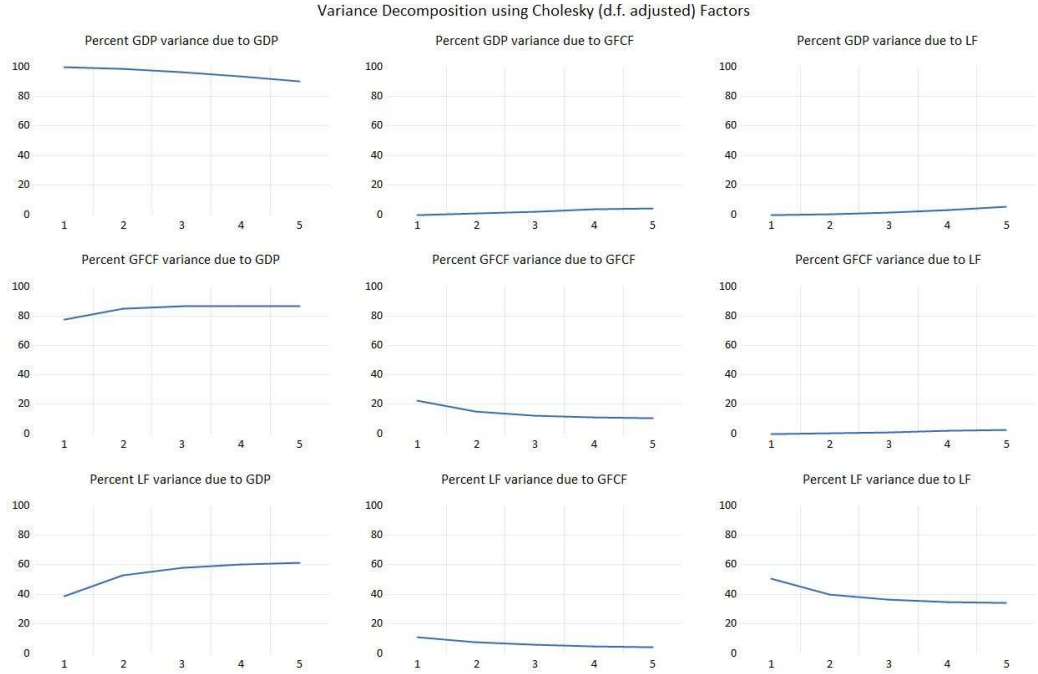
United Kingdom (Scenario 1)



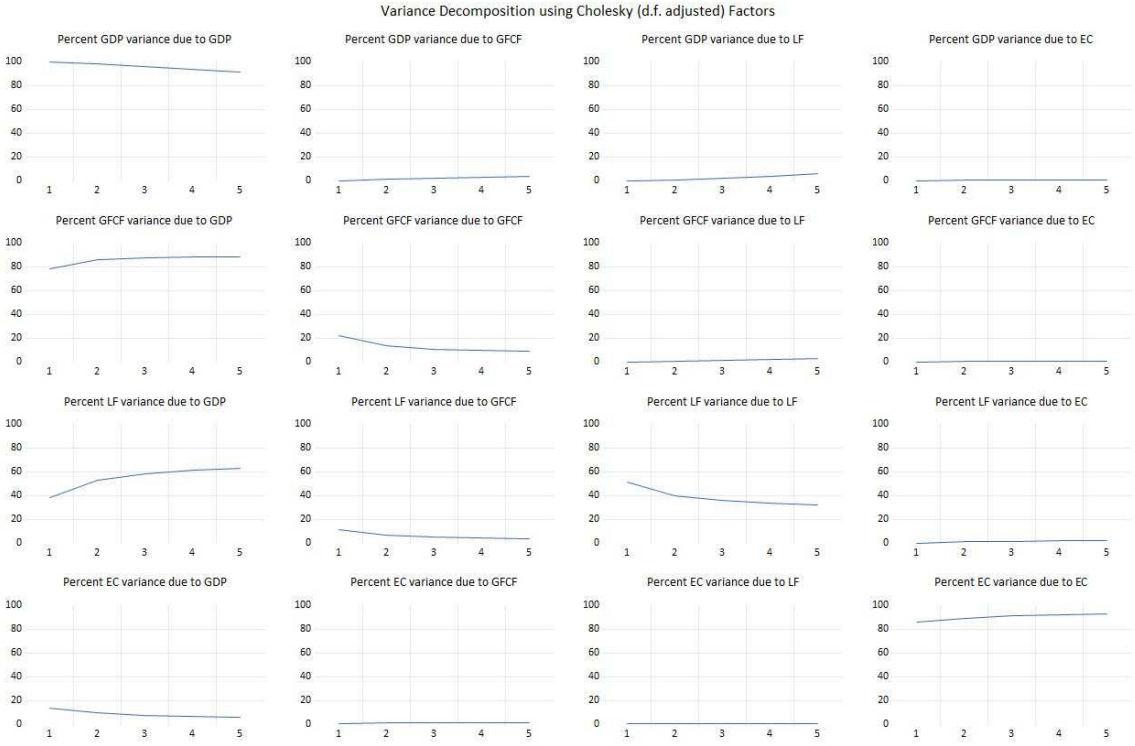
United Kingdom (Scenario 2)



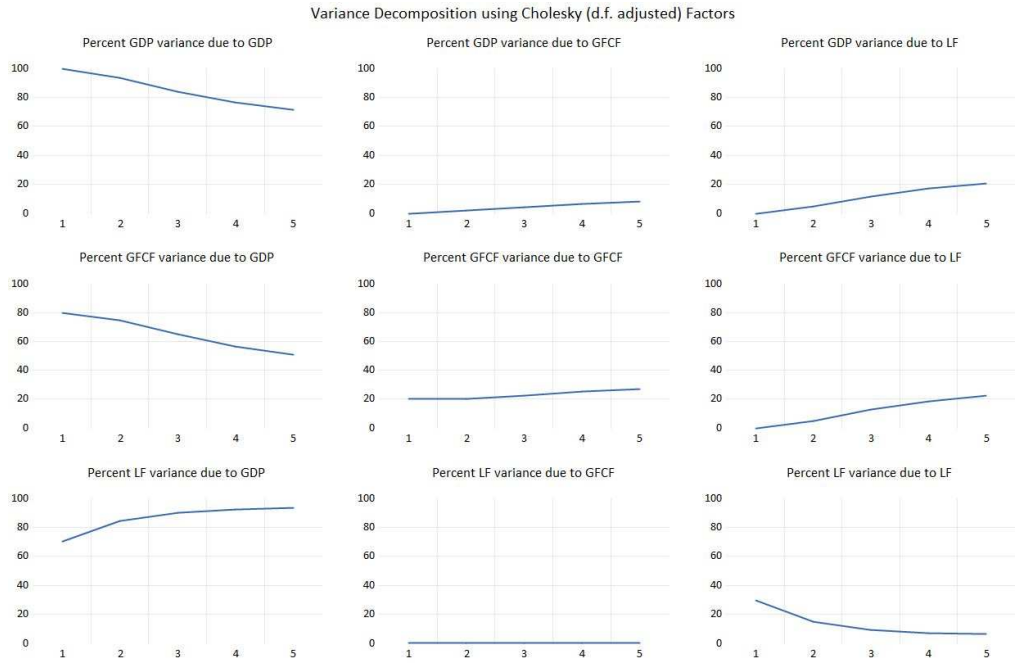
Sweden (Scenario 1)



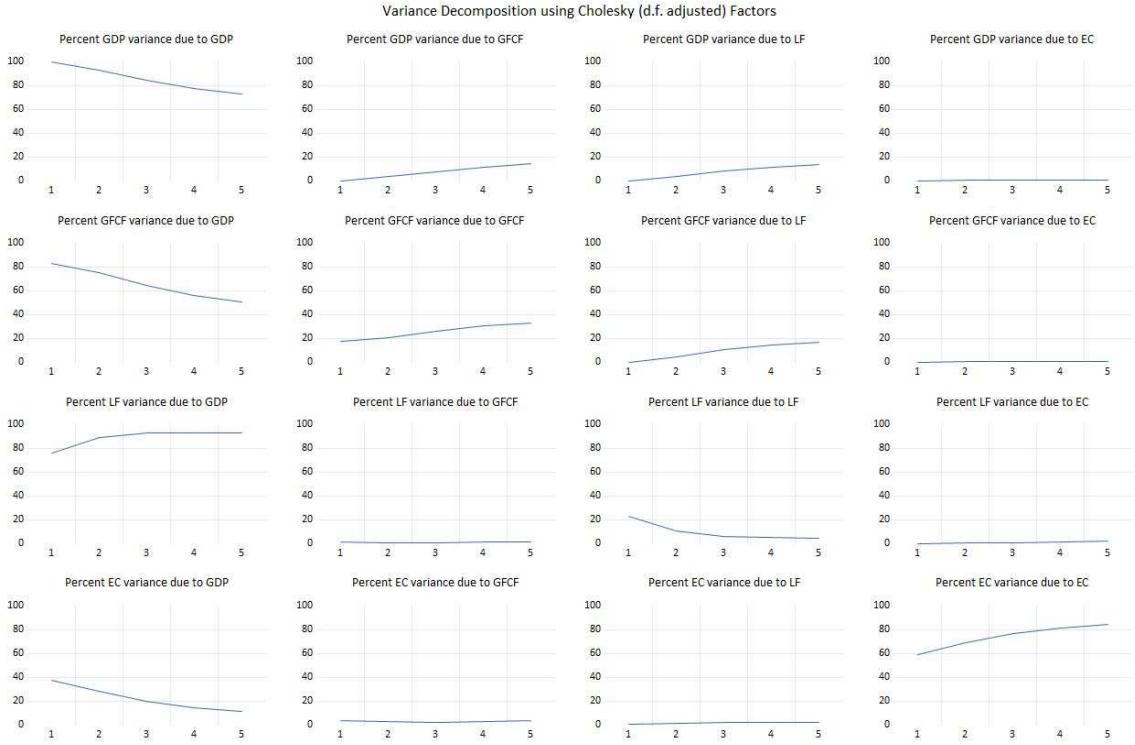
Sweden (Scenario 2)



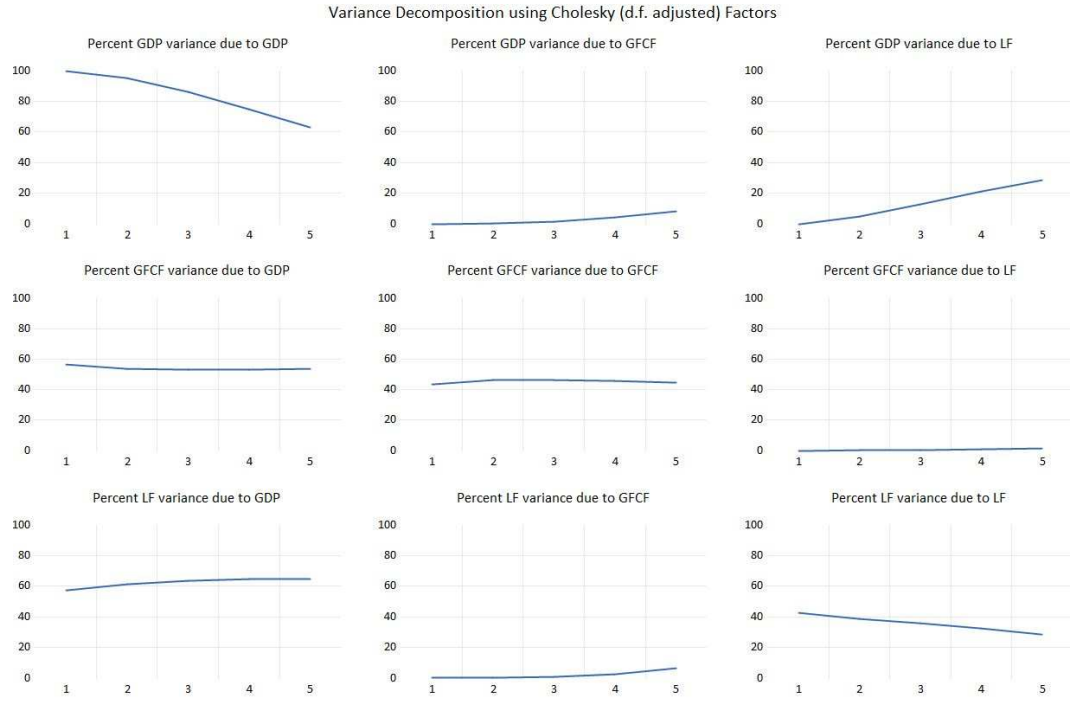
United States (Scenario 1)



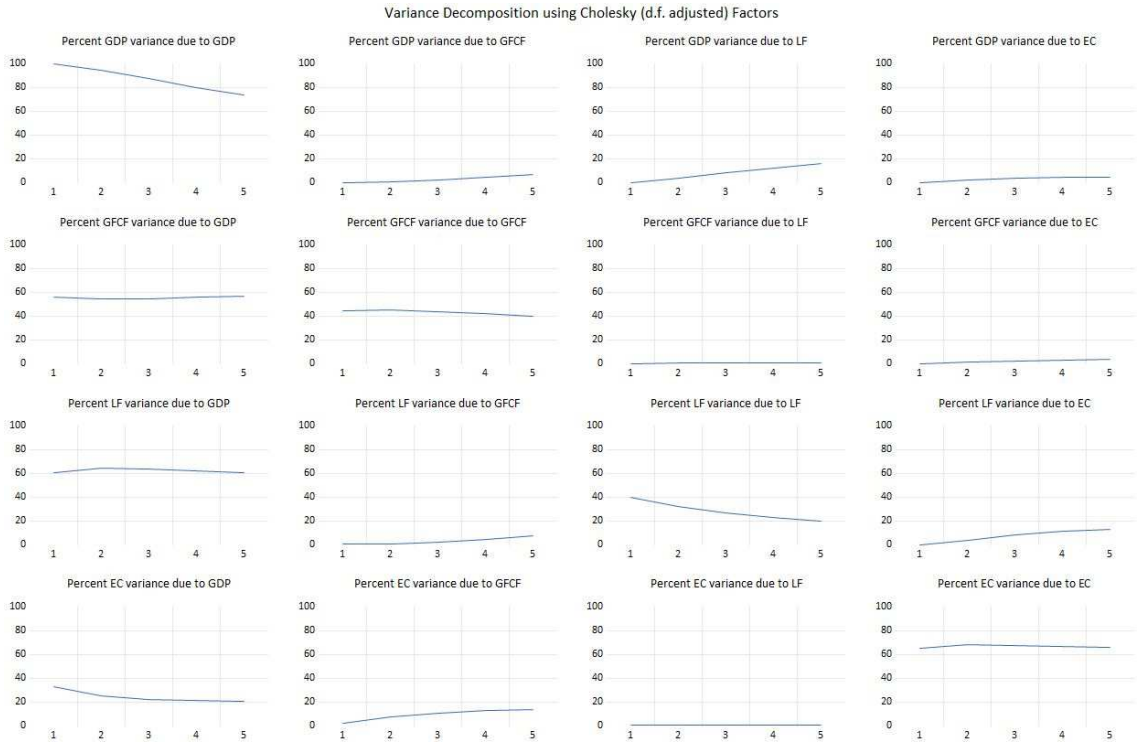
United States (Scenario 2)



Canada (Scenario 1)

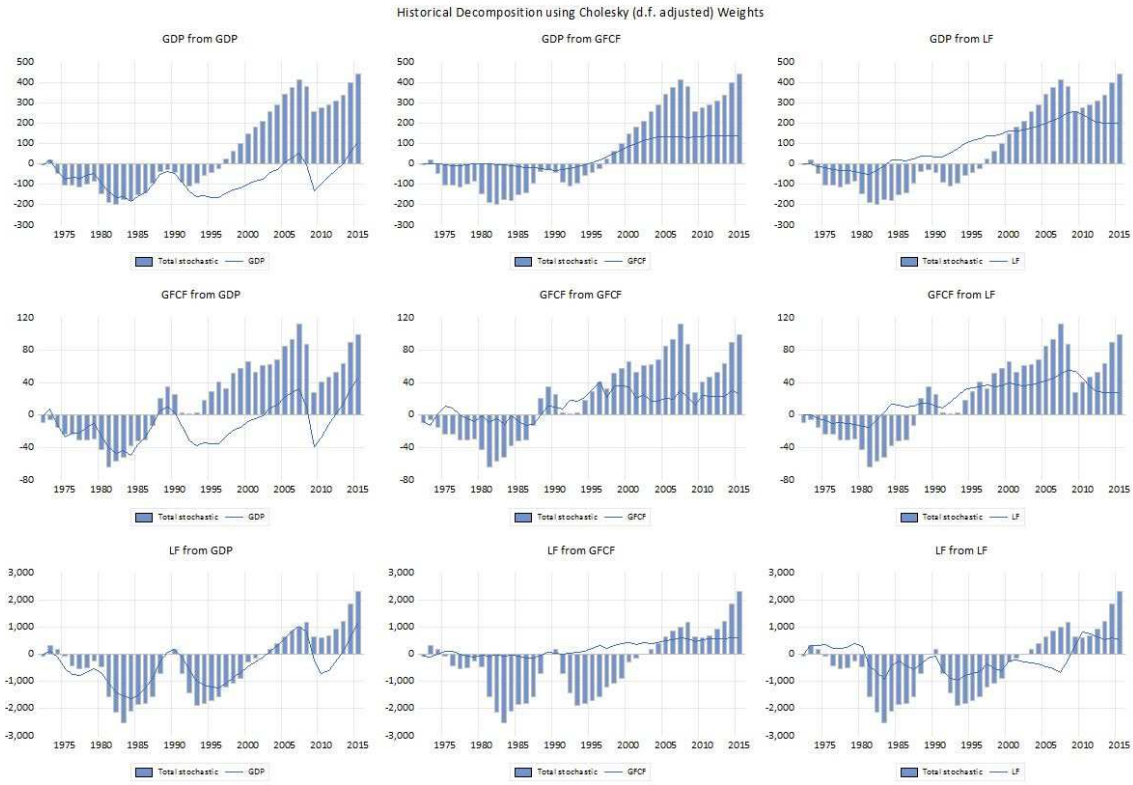


Canada (Scenario 2)

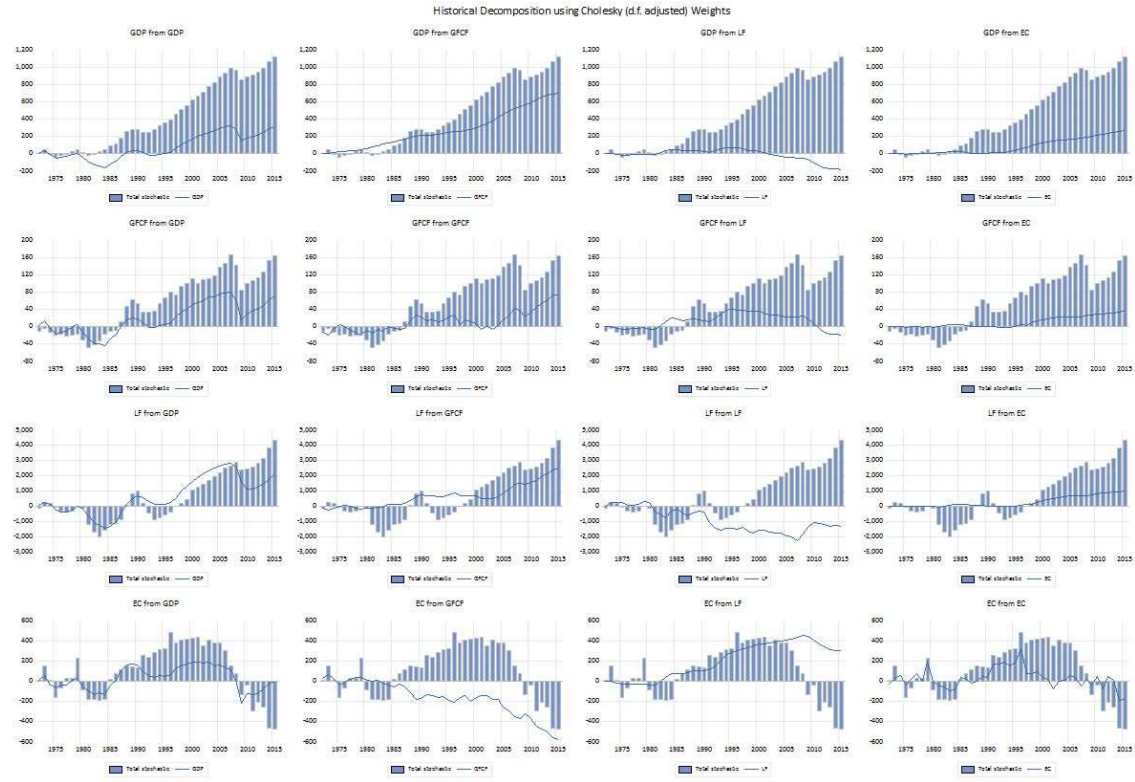


Historical Decomposition

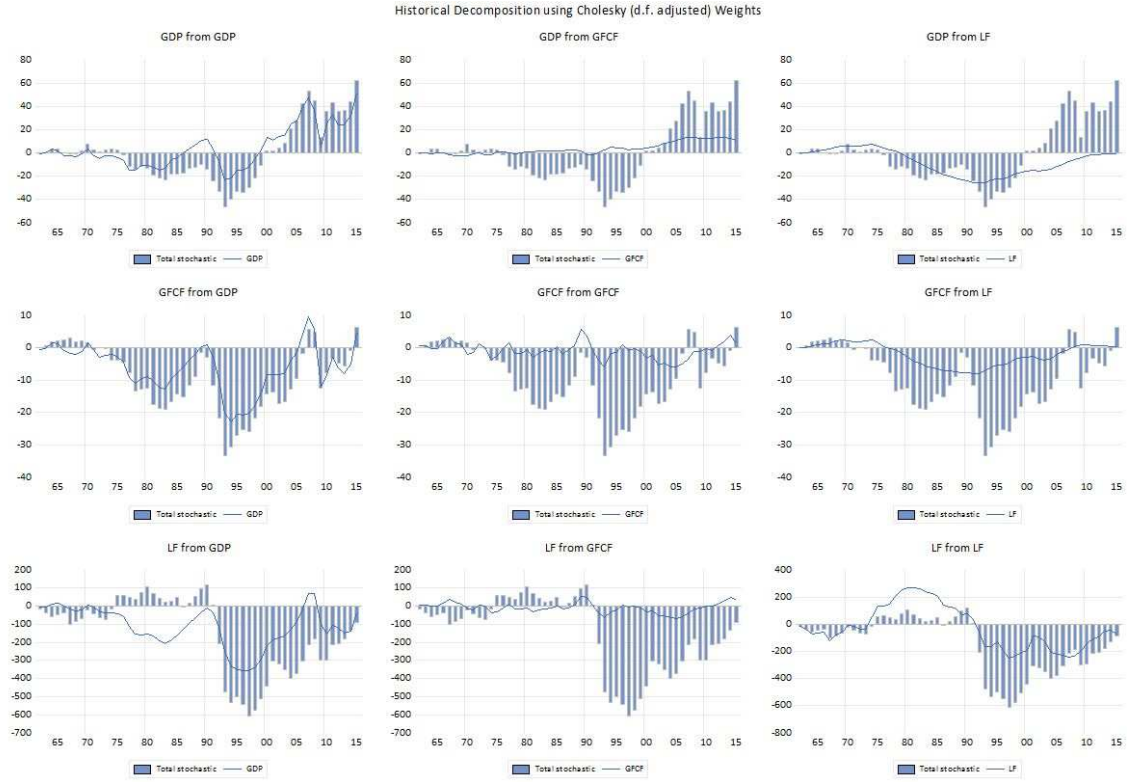
United Kingdom (Scenario 1)



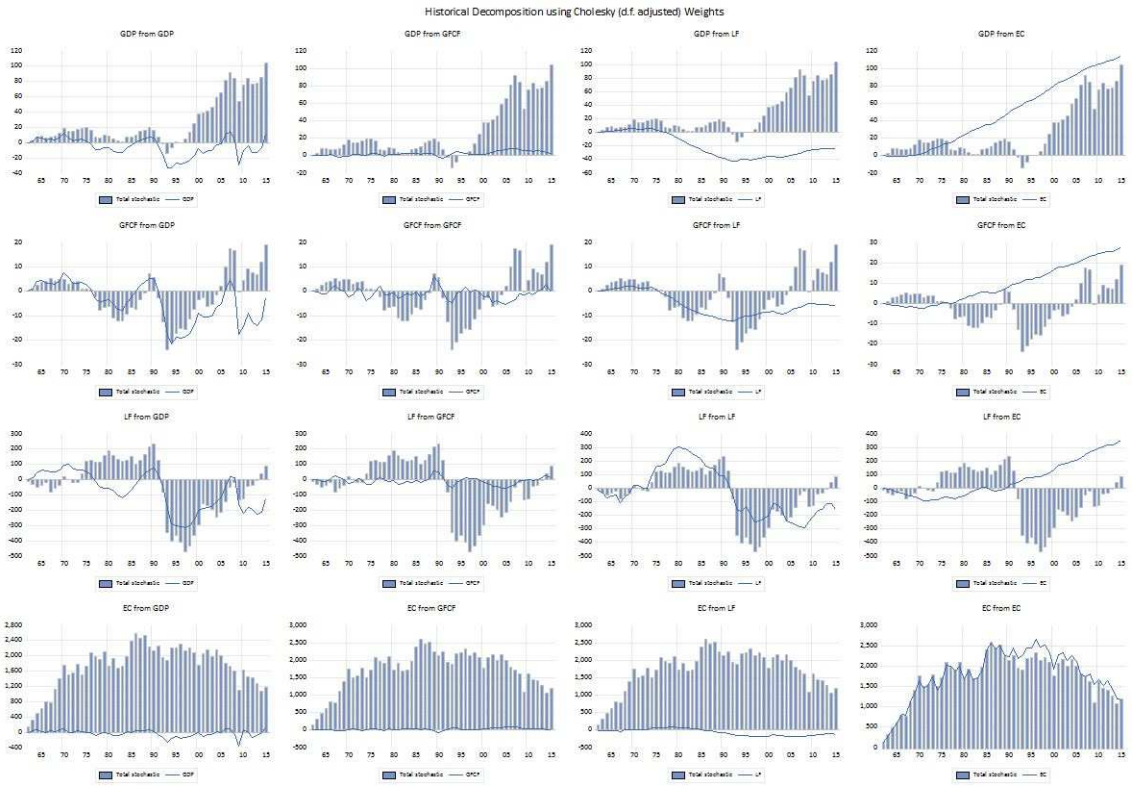
United Kingdom (Scenario 2)



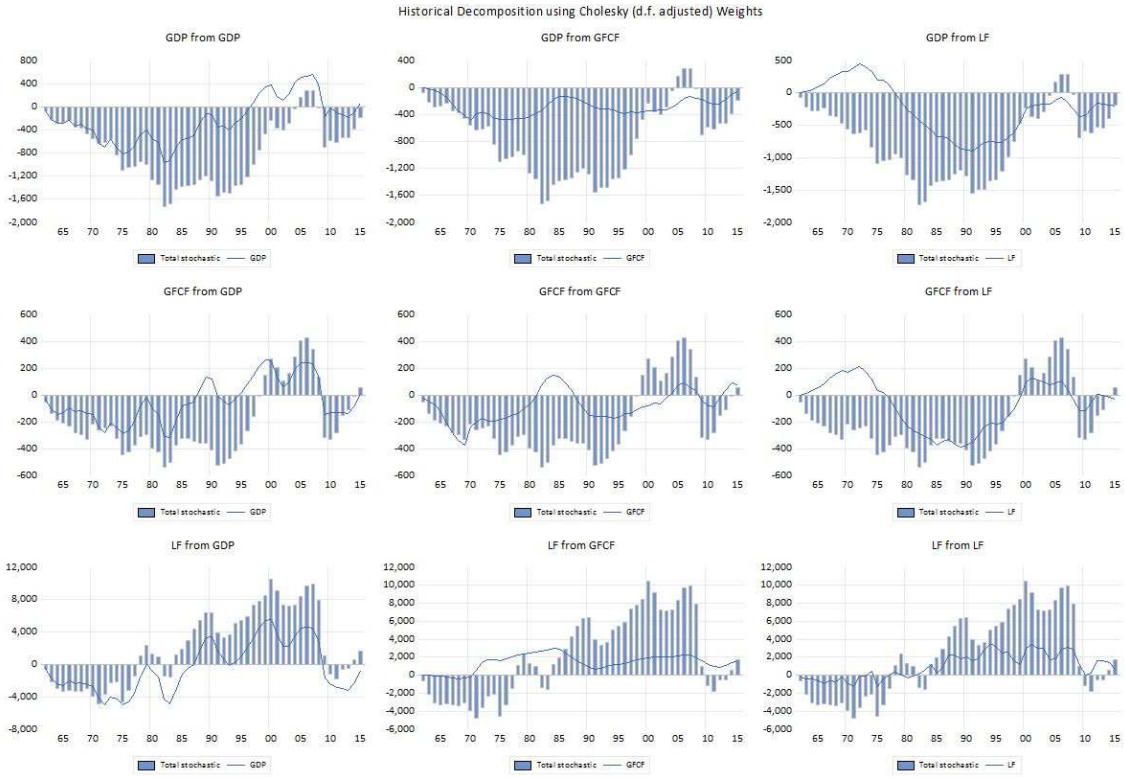
Sweden (Scenario 1)



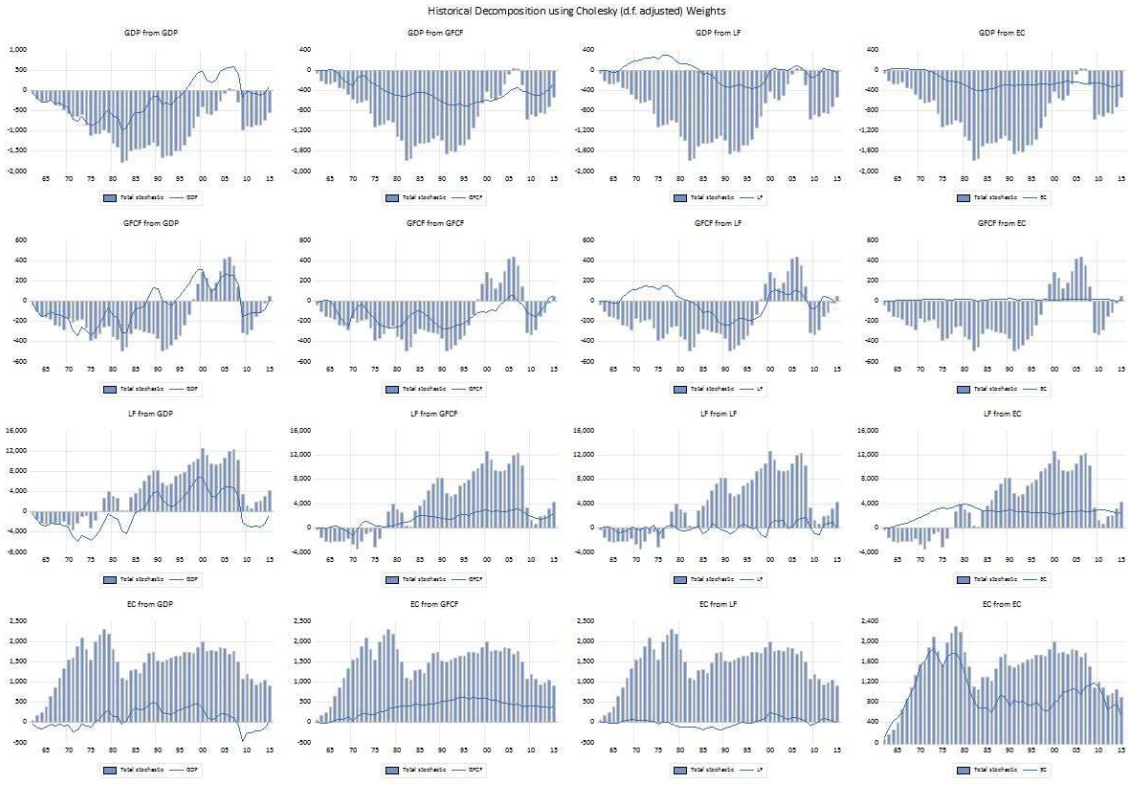
Sweden (Scenario 2)



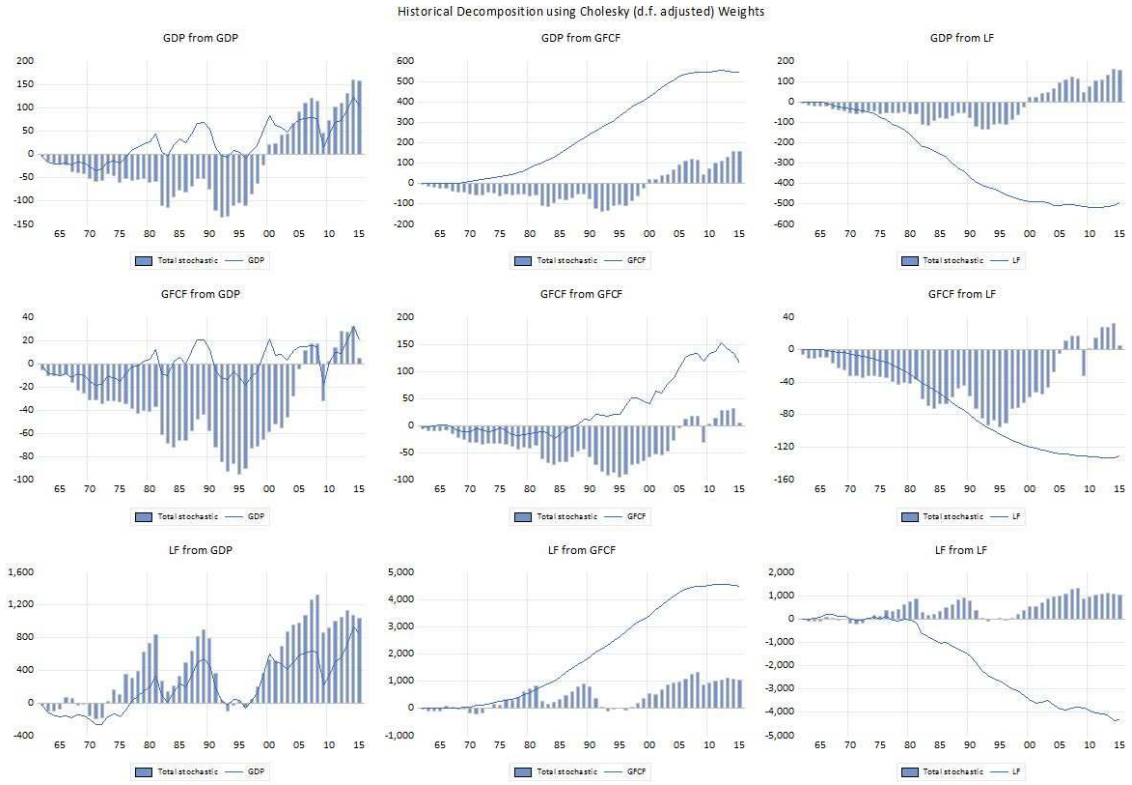
United States (Scenario 1)



United States (Scenario 2)



Canada (Scenario 1)



Canada (Scenario 2)