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THE VOLATILITY OF 10-YEAR GOVERNMENT BONDS IN THE PERIOD OF INCREASED ECONOMIC UNCERTAINTY

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Abstract: Within the scope of this paper is to investigate the dynamic correlation and the volatility of 10-year sovereign bond yields in the G7 countries from January 4, 2010 to December 30, 2022. The following analyses were performed by dividing the said period into two sub-periods taking August 2, 2019 as a breaking point. Conclusions were made based on built VAR models. Conducted research indicates the USA as having the most significant influence on the rest of countries. European countries are perceived as more vulnerable to the external impact in shaping their bond yields. There are noticeable changes taking place in Italy between analyzed two periods – quotes become more dependent on other countries over time.

Keywords: government bond yields, VAR models, variance decomposition

JEL classification: C10, C58, E44

INTRODUCTION

The existence of the G7 group has been formally initialized in 1975 during their first meeting in France, at first as an answer for global economic problems, which had their origins in collapse of the Bretton Woods system and oil crisis. The group consists of seven countries placed all over the world: the United States of America, Canada, Germany, Italy, France, the United Kingdom and Japan, which are perceived as global economic powerhouses. Their undoubted authority in the international arena is coterminous with the influence on the other countries.

The key indicators of the functioning of the internal market are sovereign bond yields. The bond trading constitutes a one of the form of financing government spending and, at the same time, they are the safest way for depositing funds of traders. The dependence on government, identified with security, and high level of

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availability for every investor reflect the factual economic situation of the domestic market evaluated from various perspectives (both from the perspective of the government and investors).

This paper aims at investigating intra-group impact on individual members of the G7 group in the context of changes that came into being with the appearance of COVID-19 pandemic. Above-mentioned influence is measured with examination of the state of the domestic economies, here represented by 10-year government bond yields. However, the period recognized as the beginning of the pandemic is generally defined as a moment with increased investor uncertainty – it is not only COVID-19, but historically high levels of inflation noted in most countries or political and military conflicts affecting decisions in the international arena as well.

LITERATURE REVIEW

The scientific research on intra-group impact in the G7 group in general is a frequent issue for the consideration of scholars from all over the world. This results in giving numerous approaches to the problem considering their financial markets, oil markets, stock markets and others. Studies have also been conducted in a view of significant economic transitions that the world underwent after turning points such as COVID-19 or crises (for example: crash of 2008).

Abakah EJA et al. [2021] aim at investigating the 10-year sovereign bond yields for entities from G7 group, Australia and Eurozone based on the data from January 1970 to February 2019. The analyses were carried out by ARMA-GARCH based pair copula models. The bond markets in Europe are found to have relatively low intrinsic interdependence. In their research, the authors cited previous publications that yielded similar results within the context of interconnectivity of German and the USA sovereign bond yields (weak effect). Finally, the paper also points out the implications for the investors value of this analysis such as strategic diversification of investments or understanding the determinants of macroeconomic policies.

Nasir M. A. et al. [2023] examine the independence of 10-year government bond yields noted in the G7 and the E7 countries. The data, they are analyzing in their research, includes daily quotes noted between December 31, 2019 and August 7, 2020. The authors use the TVP-VAR (time-varying-parameter-vector autoregression) model to study the static and dynamic connectedness. The results highlight the United States leadership in connectedness among the group and strong interdependence between all of the G7 countries. This paper concludes on the advantage of the dynamic approach over the static one in modeling the volatility of bond yields.

Lee H. et al. [2018] investigate the connectedness in G7 countries in house market volatility. The results are built considering VAR models and indicate rather low interdependence. They reveal the USA (especially during the GFC) and Italy

(particularly during the European debt crisis) as having the highest net connectedness to other countries. This paper points out the relationship between Italy and France and strong general interdependence between European countries (from G7 group).

The main objective of this paper is an attempt to investigate the volatility of 10-year government bond yields in G7 countries over the period of increased economic uncertainty. Unlike most recently conducted research, this one focuses not only on changes caused by COVID-19 but examines a longer period following 2020. Thus allow to evaluate following changes in the long run thereby excluding short-term market jitters.

DATA AND METHODOLOGY

Methodology

In order to examine the intra-group influences in the G7 countries on 10-year sovereign bond yields there were VAR models built. The next steps were to analyze the variance decomposition and compare it with previously calculated values of correlation to finally build the impulse responses graphs.

VAR models (Vector Autoregressive Models) were firstly presented in 1980 by Sims as an answer for the high level of complication of the large-scale simultaneous equations structural models (Brooks, 2008). Thus appears basic assumption of such models – their ease-of-use and the simplicity to adjustment the model in line with to the various problems. The basic VAR model with the one lag and two variables ($y_1$and y_2) has a form of equations:

$$y_{1t} = \beta_{10} + \beta_{11} y_{1t-1} + \alpha_{11} y_{2t-1} + u_{1t} \quad (1)$$

$$y_{2t} = \beta_{20} + \beta_{21} y_{2t-1} + \alpha_{21} y_{1t-1} + u_{2t} \quad (2)$$

where β_{10} and β_{20} stand for the constants in the equations and u_{1t}, u_{2t} for error terms. One of the most important stage of building the VAR models, determining the further conclusions, is the correct choice of the number of lags in equations. Thus in this article in order to build such models information criteria has been used. The main limitation of the VAR models, determining further results of statistical tests, is the stationarity of time series. Mentioned stationarity is examined by such statistical tests as KPSS (Kwiatkowski–Phillips–Schmidt–Shin) (Kwiatkowski D. et al., 1992) or ADF (augmented Dickey–Fuller test) which is an augmented version of Dickey-Fuller test (Dickey D. et al., 1979).

Variance decomposition allows to identify the relation of movements caused by internal changes to the ones caused by external movements. This constitutes a tool for getting extra analysis on the basis of built VAR models. Unlike the correlation matrix, this analyzes consider time-series not only as a stochastic data, but their relationship over time.

Impulse responses, on the other hand, indicates to what extend the internal market reacts to the shocks appearing on the rest of the markets. This analysis is

based on the approach of the VMA models (vector moving average) being an expression of built VAR models.

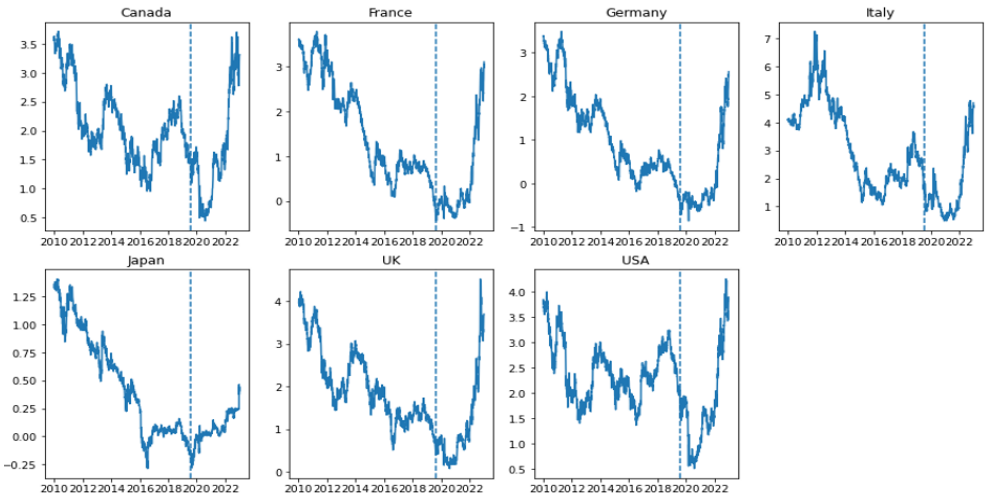
Data

The analysis concerns the data based on daily records of the 10-year bond quotes noted for the G7 countries (the USA, Canada, Germany, Italy, France, the UK and Japan). The data covers up the quotes recorded between January 4, 2010 and December 30, 2022 and consists of 2,971 records. All of the records were provided by https://stooq.pl/ and are expressed in percentages.

RESULTS

Within the scope of finding the breaking point the Bai-Perron test was carried out. Having slightly different results depending on the country, the date obtained for the USA was adopted as a global breaking point. The indicated date, determined as August 2, 2019, has been marked as dotted line in the figure below.

Figure 1. 10-year bond yields in G7 countries



Source: own calculations using Python 3.7

Hence, in the further analysis the separation for two sub-periods was made (the first one: January 4, 2010 to August 2, 2019, the second one: August 3, 2019 to December 30, 2022).

Table 1. Summary statistics, normality and stationarity tests for the first period (columns marked as 1) and the second period (columns marked as 2)

	Canada		France		Germany		Italy		Japan		UK		USA	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Mean	2.12	2.12	1.68	1.68	1.21	1.21	3.28	3.28	0.51	0.51	2.05	2.05	2.43	2.43
Median	2.02	2.02	1.31	1.31	0.95	0.95	2.95	2.95	0.51	0.51	1.86	1.86	2.38	2.38
Variance	0.41	0.41	1.19	1.19	1.00	1.00	2.16	2.16	0.21	0.21	0.74	0.74	0.30	0.30
Stand Dev	0.64	0.64	1.09	1.09	1.00	1.00	1.47	1.47	0.46	0.46	0.86	0.86	0.55	0.55
Coefficient of variation	0.20	0.20	0.88	0.88	1.10	1.10	0.76	0.76	0.53	0.53	0.41	0.41	0.13	0.13
Asymmetry	0.57	0.57	0.32	0.32	0.58	0.58	0.41	0.41	0.21	0.21	0.63	0.63	0.46	0.46
Kurtosis	-0.35	-0.35	-1.31	-1.31	-0.77	-0.77	-0.88	-0.88	-1.25	-1.25	-0.50	-0.50	-0.32	-0.32
Jarque_Bera	130.99	130.99	195.66	195.66	178.27	178.27	132.67	132.67	159.92	159.92	169.31	169.31	89.14	89.14
	Canada		France		Germany		Italy		Japan		UK		USA	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Jarque_Bera_p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KPSS	3.40	3.40	6.67	6.67	6.43	6.43	4.93	4.93	7.04	7.04	5.33	5.33	1.02	1.02
KPSS_p	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ADF	-2.36	-2.36	-2.43	-2.43	-2.45	-2.45	-1.86	-1.86	-2.79	-2.79	-2.62	-2.62	-2.53	-2.53
ADF_p	0.40	0.40	0.36	0.36	0.36	0.36	0.68	0.68	0.20	0.20	0.27	0.27	0.31	0.31
KPSS_diff	0.11	0.11	0.05	0.05	0.07	0.07	0.10	0.10	0.04	0.04	0.07	0.07	0.14	0.14
KPSS_diff_p	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

Source: own calculations using Python 3.7

The above calculations indicate similar distributions for all time-series (all countries in both periods). All data is characterized by other than normal distribution according to the Jarque-Bera test, although it should be noted that the Jarque-Bera test is sensitive to a large number of observation and there are 2,971 of them. The KPSS test indicates that all considered time-series are stationary at first differences.

Table 2. Correlation between 10-year bond yields for the first and the second periods

First period							
	Canada	France	Germany	Italy	Japan	UK	USA
Canada	1	0.776	0.856	0.533	0.750	0.871	0.857
France	0.776	1	0.974	0.856	0.965	0.868	0.422
Germany	0.856	0.974	1	0.748	0.960	0.936	0.545
Italy	0.533	0.856	0.748	1	0.797	0.545	0.144
Japan	0.750	0.965	0.960	0.797	1	0.890	0.394
UK	0.871	0.868	0.936	0.545	0.890	1	0.657
USA	0.857	0.422	0.545	0.144	0.394	0.657	1
Second period							
	Canada	France	Germany	Italy	Japan	UK	USA
Canada	1	0.921	0.923	0.854	0.731	0.934	0.978
France	0.921	1	0.997	0.965	0.808	0.975	0.932
Germany	0.923	0.997	1	0.954	0.805	0.979	0.940
Italy	0.854	0.965	0.954	1	0.703	0.921	0.874
Japan	0.731	0.808	0.805	0.703	1	0.763	0.681
UK	0.934	0.975	0.979	0.921	0.763	1	0.959
USA	0.978	0.932	0.940	0.874	0.681	0.959	1

Source: own calculations using Python 3.7

The above matrixes of correlation between 10-year bond yields show generally high values between stochastic data. But importantly, there is an overall increase in values in the second period compared to the first one which suggests an increase in intra-group influence.

In order to build VAR models, length of lags for both time periods were selected by using information criteria (Akaike, Schwartz-Bayesian, Hannan-Quinn Criteria). The obtained results for the first period indicate VAR(2) with two lags and for the second period as well VAR(2) as the ones with the lowest values of information criteria.

In order to build a VAR models, it is required for the time series to be stationary. Thus, the data was transformed into the first differences, which the KPSS test indicated as stationary.

Table 3. Model fit measures for VAR(2) for the first and the second periods

First period							
Parameters	Canada	France	Germany	Italy	Japan	UK	USA
R-squared	0.068	0.046	0.057	0.053	0.129	0.057	0.057
Adj. R-squared	0.057	0.029	0.040	0.036	0.114	0.041	0.041
sum sq. Resids	2.433	2.362	2.146	5.493	0.156	3.760	3.045
S.E. equation	0.057	0.056	0.054	0.086	0.014	0.071	0.064
Mean dependent	0.003	0.004	0.004	0.004	0.001	0.004	0.003
S.D. dependent	0.059	0.057	0.055	0.087	0.015	0.072	0.065
Second period							
Parameters	Canada	France	Germany	Italy	Japan	UK	USA
R-squared	0.068	0.046	0.057	0.053	0.129	0.057	0.057
Adj. R-squared	0.057	0.029	0.040	0.036	0.114	0.041	0.041
sum sq. Resids	2.433	2.362	2.146	5.493	0.156	3.768	3.045
S.E. equation	0.057	0.056	0.054	0.086	0.014	0.071	0.064
Mean dependent	0.003	0.004	0.004	0.004	0.001	0.004	0.003
S.D. dependent	0.059	0.056	0.055	0.087	0.015	0.072	0.065

Source: own calculations using Gretl

Building two separate VAR models for each period on the first differenced data resulted in slight differences while considering the above fit measures.

In order to examine the dynamic variance there was variance decomposition conducted and results were presented in Table 4. The order of countries used in the

variance decomposition matrix was chosen based on the importance of their position in the G7 group. It has a significant meaning as the result of variance decomposition may differ depending on the adopted order of the variables.

Table 4. Variance decomposition for VAR(2) for the first period (columns tagged as 1) and the second period (columns tagged as 2)

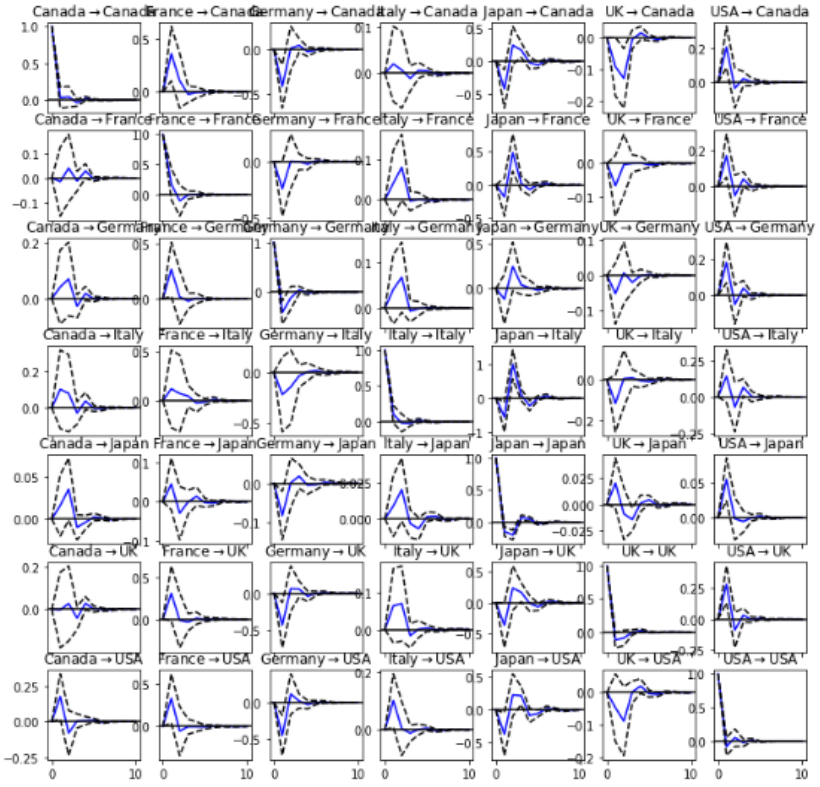
		Explained by:													
	Days	USA		UK		Japan		Italy		Germany		France		Canada	
PERIOD		1	2	1	2	1	2	1	2	1	2	1	2	1	2
USA	1	100.00	100.00	0	0	0	0	0	0	0	0	0	0	0	0
	2	99.62	95.42	0.16	0.01	0	0.38	0.03	2.58	0.06	0.37	0.03	0.67	0.10	0.58
	3	99.52	94.65	0.16	0.37	0.02	0.62	0.08	2.56	0.06	0.42	0.05	0.68	0.11	0.70
	5	99.52	94.38	0.16	0.38	0.02	0.87	0.08	2.56	0.06	0.44	0.05	0.67	0.11	0.70
	9	99.52	94.36	0.16	0.38	0.02	0.88	0.08	2.56	0.06	0.44	0.05	0.67	0.11	0.70
	10	99.52	94.36	0.16	0.38	0.02	0.88	0.08	2.56	0.06	0.44	0.05	0.67	0.11	0.70
UK	1	45.52	42.35	54.48	57.65	0	0	0	0	0	0	0	0	0	0
	2	45.52	41.75	54.11	55.91	0.01	0.40	0.06	0.90	0.08	0.60	0.18	0.44	0.04	0
	3	45.40	41.42	53.88	55.29	0.02	0.70	0.09	1.49	0.10	0.66	0.44	0.44	0.07	0.01
	5	45.37	41.35	53.87	55.18	0.02	0.79	0.11	1.52	0.10	0.67	0.45	0.44	0.08	0.05
	9	45.37	41.34	53.87	55.17	0.02	0.81	0.11	1.53	0.10	0.67	0.45	0.44	0.08	0.05
	10	45.37	41.34	53.87	55.17	0.02	0.81	0.11	1.53	0.10	0.67	0.45	0.44	0.08	0.05
Japan	1	3.58	7.87	0.91	0.06	95.52	92.07	0	0	0	0	0	0	0	0
	2	13.69	12.33	0.90	0.34	84.20	86.06	0	0.28	0.97	0.67	0.11	0.23	0.13	0.09
	3	13.56	11.86	1.04	0.34	83.71	85.74	0.07	0.59	0.97	0.67	0.26	0.29	0.38	0.49
	5	13.65	11.90	1.08	0.48	83.56	85.44	0.07	0.61	0.99	0.74	0.27	0.31	0.39	0.52
	9	13.65	11.90	1.08	0.49	83.55	85.42	0.07	0.61	0.99	0.75	0.27	0.31	0.39	0.53
	10	13.65	11.90	1.08	0.49	83.55	85.41	0.07	0.61	0.99	0.75	0.27	0.31	0.39	0.53
Italy	1	0.29	18.18	0	13.52	0.09	0.42	99.62	67.89	0	0	0	0	0	0
	2	0.51	18.24	0.66	13.39	0.14	1.06	98.32	67.06	0.02	0.10	0.33	0.05	0.02	0.11
	3	1.24	17.76	0.65	13.05	0.21	3.49	97.33	65.33	0.03	0.13	0.45	0.07	0.08	0.16
	5	1.25	17.85	0.70	13.00	0.22	3.61	97.26	65.13	0.04	0.13	0.46	0.08	0.08	0.19
	9	1.25	17.85	0.70	13.00	0.22	3.62	97.25	65.12	0.04	0.14	0.46	0.08	0.08	0.19
	10	1.25	17.85	0.70	13.00	0.22	3.62	97.25	65.12	0.04	0.14	0.46	0.08	0.08	0.19
Germany	1	44.47	51.10	21.59	14.80	0.11	0.46	0.03	4.59	33.80	29.05	0	0	0	0
	2	44.49	50.38	21.49	14.53	0.10	0.50	0.31	5.15	33.21	28.80	0.40	0.60	0.00	0.05
	3	44.45	49.67	21.40	14.39	0.11	0.95	0.42	5.68	32.96	28.53	0.65	0.60	0.02	0.17
	5	44.44	49.64	21.39	14.41	0.11	0.96	0.43	5.68	32.95	28.50	0.65	0.60	0.02	0.20
	9	44.44	49.64	21.39	14.41	0.11	0.96	0.43	5.68	32.95	28.50	0.65	0.60	0.02	0.20
	10	44.44	49.64	21.39	14.41	0.11	0.96	0.43	5.68	32.95	28.50	0.65	0.60	0.02	0.20
France	1	22.56	42.16	12.74	16.80	0.42	0.77	11.29	17.47	14.86	15.21	38.13	7.60	0	0
	2	23.13	41.98	13.12	16.70	0.41	0.90	11.40	17.63	14.74	15.12	37.17	7.67	0.03	0.01
	3	23.07	41.14	13.19	16.39	0.42	2.32	11.37	17.66	14.74	14.89	37.11	7.57	0.10	0.04
	5	23.05	41.17	13.22	16.36	0.42	2.35	11.39	17.63	14.73	14.87	37.08	7.56	0.10	0.07
	9	23.05	41.17	13.22	16.36	0.42	2.35	11.39	17.63	14.73	14.87	37.08	7.55	0.10	0.07
	10	23.05	41.17	13.22	16.36	0.42	2.35	11.39	17.63	14.73	14.87	37.08	7.55	0.10	0.07
Canada	1	64.90	69.96	5.21	2.41	0.05	0.16	0.02	0.38	0.54	2.45	0	0.01	29.28	24.63
	2	64.44	67.93	5.20	2.81	0.08	0.95	0.08	1.21	0.60	2.71	0.02	0.97	29.57	23.43
	3	64.40	66.84	5.20	3.09	0.08	1.44	0.08	1.52	0.65	2.97	0.03	1.04	29.55	23.10
	5	64.40	66.68	5.20	3.10	0.08	1.59	0.08	1.54	0.66	2.98	0.03	1.04	29.55	23.08
	9	64.40	66.66	5.20	3.10	0.08	1.61	0.08	1.54	0.66	2.98	0.03	1.04	29.55	23.07
	10	64.40	66.66	5.20	3.10	0.08	1.61	0.08	1.54	0.66	2.98	0.03	1.04	29.55	23.07
		USA		UK		Japan		Italy		Germany		France		Canada	
PERIOD		1	2	1	2	1	2	1	2	1	2	1	2	1	2

Source: own calculations using Gretl

The most independent country for both periods remains the USA and that is the only country that became less dependent on the other countries in the second period. There appeared significant dynamic changes of independence in Italy, which was initially one of the most unrelated to intra-group influences, to finally become dependent on bond yields in the USA and UK. The Japanese economy, taking account of its specific nature, continues to be independent with a small increase of the influence of the USA to its changes over time. In both periods it is possible to indicate the UK as the one modelling its economy on the actions of the USA market as dependence on the USA is nearly as high as the internal. There are strong external influences observed in France, Germany and Canada and each of these countries increased the level of external influences in the second period. The USA increased its influence in other countries over time, even though from the very beginning it was significant.

In order to analyze the impulse responses there were Orthogonal Impulse Responses used.

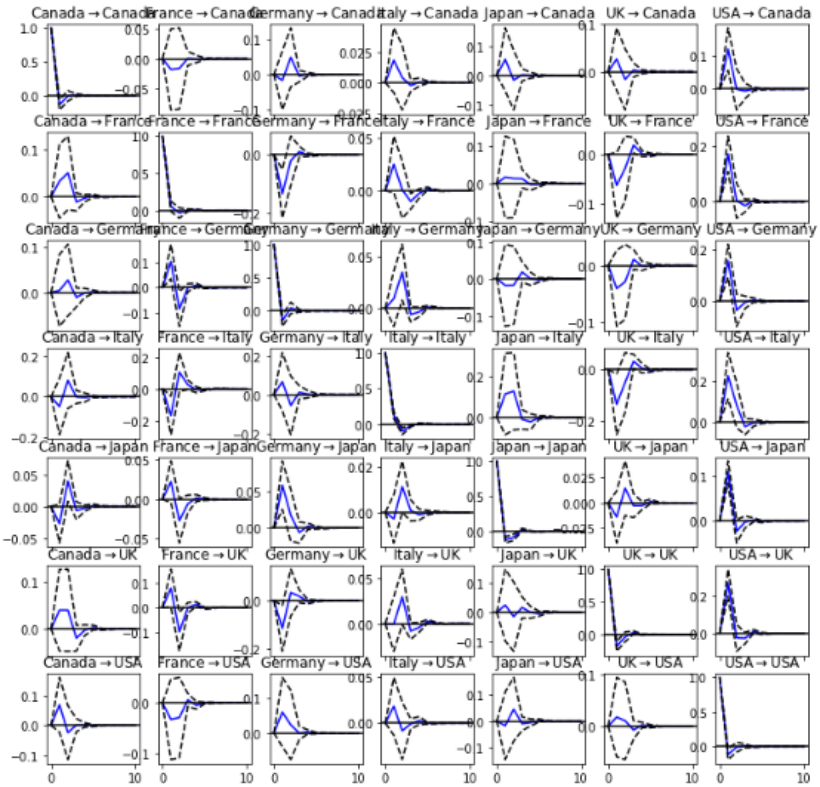
Figure 2. Impulse responses for VAR(2) for the first period



*A → B: shocks in country A causing the impulse responses in country B

Source: own calculations using Python 3.7

Figure 3. Impulse responses for VAR(2) for the second period



*A → B: shocks in country A causing the impulse responses in country B

Source: own calculations using Python 3.7

The structure of responses indicates the similarities in both periods with minor amendments. They are informing about reactions to the shocks in VAR models. Shocks on bond yields in the Germany significantly changed their influence on USA, Italy and Japan in the second period (now there are negative shocks vs. positive in the first one). There are noticeable changes in impulse responses in bond yields in Italy and Canada caused by France. Impulse responses occurring in the UK, Germany and France do not form a tendency to change the trend over time.

CONCLUSIONS

Aforementioned analysis investigates the volatility and dynamic correlation between 10-year sovereign bond yields in the G7 countries and changes taking place in the recent time. Conducted research stresses the fact of occurring interactions between bond markets in considered group. This study indicates USA as the most impacting on the rest of the G7 member economies in both periods. The most

significant shifts are taking place in Italian economy – initially independent of intra-group influences, becomes increasingly dependent on other members (especially on the USA) over time. Japan is recognized as remaining in its strong independence over time with slight movements in the area of being impacted by the USA in the second period. Conducted analysis points out European countries as a group of being strongly impacted by others.

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