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Interactions between financial markets and macroeconomic variables in EU: a nonlinear modelling approach

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Abstract

There is a general acceptance of the fact that a significant direct relationship between financial markets and macroeconomic variables exists, especially by considering the assertion that developed financial markets correspond to high GDP levels. This paper provides an investigation of the correlation between the market capitalization and stock market dynamics on one hand and GDP per capita on the other hand, for two groups of regions in EU (western countries, EU15, and central and eastern countries, EU11). Based on data for a number of EU countries (both western and eastern) and using some special modelling techniques, we provide an analysis of the convergence phenomenon for both the macroeconomic variables and the financial ones. Using a deep time resolution and some spline functions we generated high frequency time series (the so-called virtual monthly GDP) to investigate the correlations with financial markets. In spite of ECB's careful monitoring of the financial integration within the euro zone, a possible financial integration process within the non-euro zone continues to be ignored. It seems that due to the weak development of financial markets, the economies outside of the euro zone are relatively more protected against crisis when compared to those inside the euro zone. Therefore, the so-called contagion effect is weaker in the Central and Eastern region of European Union.

Keywords: macroeconomic variables, financial crisis, convergence, non-linear modelling
JEL Codes: G01, G15, E44, E47, O47

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1. Introduction

According to the well-established (mainstream) paradigm, financial markets should reflect the fundamental variables in the generalized view that they serve mainly as a high frequency accounting, generating values for the economy almost at the twist of any moment (with the exception of non-trading intervals, which is the case for the stock markets). The extent to which the dynamics of macroeconomic variables on one hand and financial market variables on the other hand show sufficient evidence of convergence is investigated in this paper.

The recent nowcasting techniques rely on the high frequency data to generate updates for the macroeconomic fundamental variables (GDP especially), providing powerful evidence that financial markets are strongly correlated with their macroeconomic counterparts (Doz, Giannone and Reichlin (2012) The relatively recent MiDaS methodology allows for the study of these connections taking into account the fact that the two sets of variables have different frequencies. Various uses of this methodology can be found in contributions such as: Ghysels et al (2016), Lupu and Călin (2014), or Călin (2015).

Our approach deals with the use of a non-linear model to study the convergence of these sets of variables. It is well known that the financial assets exhibit special statistical properties

(stylized facts) and one of them relies on the large-numbers effect, i.e. the fact that when we observe the data at low frequencies, they tend to behave more according to the normal distribution and all the stylized facts that are present at the high frequency levels tend to disappear. Therefore, the monthly and quarterly observations tend to converge to the fundamental dynamics, eliminating the general volatile movements that could belong to the general trading behaviour.

In our present analysis we aim at investigating the convergence dynamics of two types of variables from the financial market group – the market capitalizations and the stock market changes – and the convergence in GDP for a large set of European countries. We notice that the convergence tends to be similar for the two groups of variables and also the fact that the results show how much the stock markets reflect the economic activity.

These findings are further presented for the case of the Eastern European countries, which exhibit a level of development of stock markets that is sufficient to motivate the existence of a stock market index. They are generally part of the group of frontier markets¹, i.e. less liquid than the emerging markets and with low probability to be included in the international investors' portfolios. These markets reflect about 10% to 20% of their national economic activities but they have active stock markets that exhibit efforts to develop.

The investigation of the possible linkages between the dynamics of financial markets and macroeconomic fundamentals has become a robust research area despite the inconveniences that derive from the differences in data frequencies. Seminal contributions on this topic can be found in Chen, Roll and Ross (1986), Geske and Roll (1983) or Poon and Taylor (1991).

Pilinkus and Boguslauskas (2009) try to observe which macroeconomic variables have a positive and respectively a negative effect on the stock market prices, using the Lithuanian market as a case study. The authors report that GDP and money supply have a positive influence on stock market prices. On the opposite spectrum, variables such as the unemployment rate, the exchange rate and the interest rate have a negative impact.

Alper and Forni (2011) and Gruber and Kamin (2012) consider fiscal and macroeconomic variables and they report that these elements have an influence on long term yields.

Narayan and Narayan (2012) study the influence of US fundamentals on a series of seven Asian markets focusing on the exchange rate and short term interest rate. They report that for the case of the interest rate the only response is found for Philippines whereas all the markets included in the analysis except China react to the dynamics of exchange rates.

Kumari and Mahakud (2014) isolate a relation between macroeconomic volatility and the volatility of the equity market for the case of India. They use a battery of GARCH models and a VAR approach and demonstrate a connection between the dynamics of the equity market and macroeconomic variables such as bond yield, money supply and inflation.

In a similar approach to the one in this study, Albu, Lupu and Călin (2014) use a simulation model developed for the study of convergence to investigate the evolution of market capitalization and GDP for CEE countries. In their nonlinear setup, the authors offer a convergence based explanation for the dynamics of the two variables.

Yuan, Gupta and Roca (2015) target the possible linkages between the prices of American Depositary Receipts of BRICS states and the macroeconomic fundamentals of their home countries. The authors target both a short run and a long run perspective and incorporate a VAR approach. They observe that besides the case of Russia, there is a long run connection between ADR prices and economic growth. A comparable analysis is conducted by Chittedi (2015) who also targets the BRIC countries. Investigating the nature of the linkages between stock prices fundamentals the authors provides certain evidences both for the short and the long run.

¹ According to various classifications generated by rating agencies, MSCI beign the most cited.

2. Empirical evidences and an optimal trajectory of real convergence

The convergence programme is one of the priorities in EU. Since 2000, the convergence trend among countries in EU was improved in line with the standard economic theory of development. For instance, the average level of GDP per capita for EU11 (expressed in PPS) increased from 44.4% of average EU28 level in 2000 to 65.7% in 2014. In the same period, the average level in case of EU15 decreased from 116.0% to 108.9%, as it is shown in Figure 1.

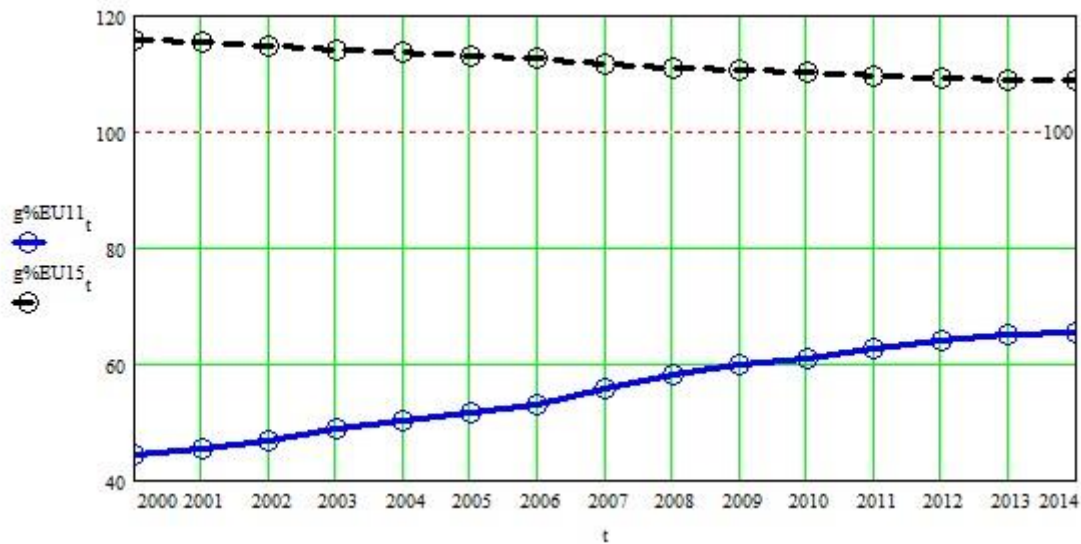


Figure 1

During the considered period, the dynamics of the variation coefficient is demonstrating in the case of EU11 a strong trend of convergence before the crisis and a stagnation in the period 2009-2014. Contrary, in case of EU15 a stagnation process was registered in matter of convergence before the crisis, followed by a divergence in the period 2009-2014, as it is shown in Figure 2.

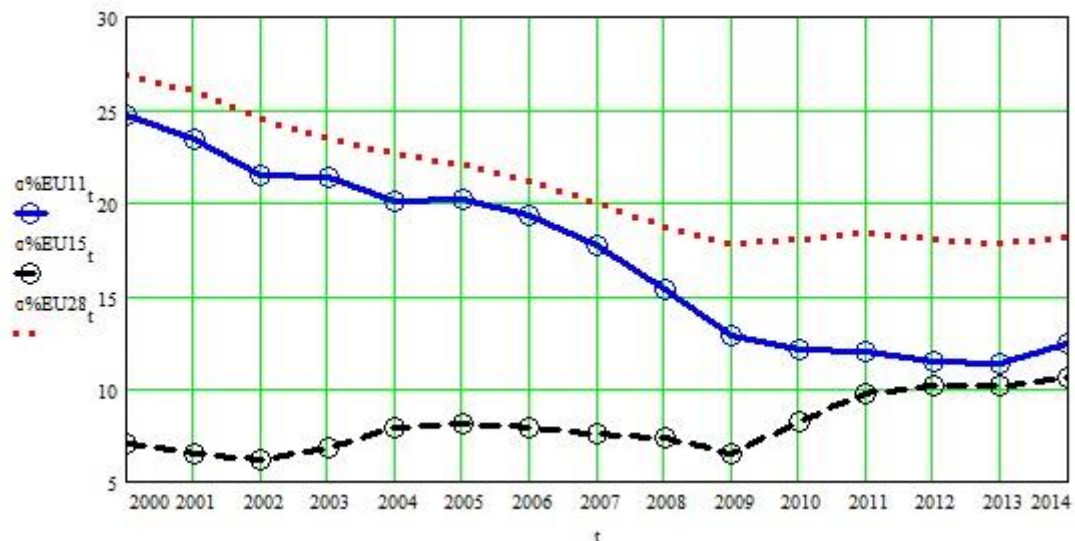


Figure 2

Moreover, since 2007, together with the convergence in relative terms between the two groups of countries in EU (EU11 and EU15), a convergence in absolute terms started. Thus, the difference decreased from the maximum level of 14594 euro GDP per capita in 2006 to 11807 euro per capita in 2014, as it is presented in Figure 3.

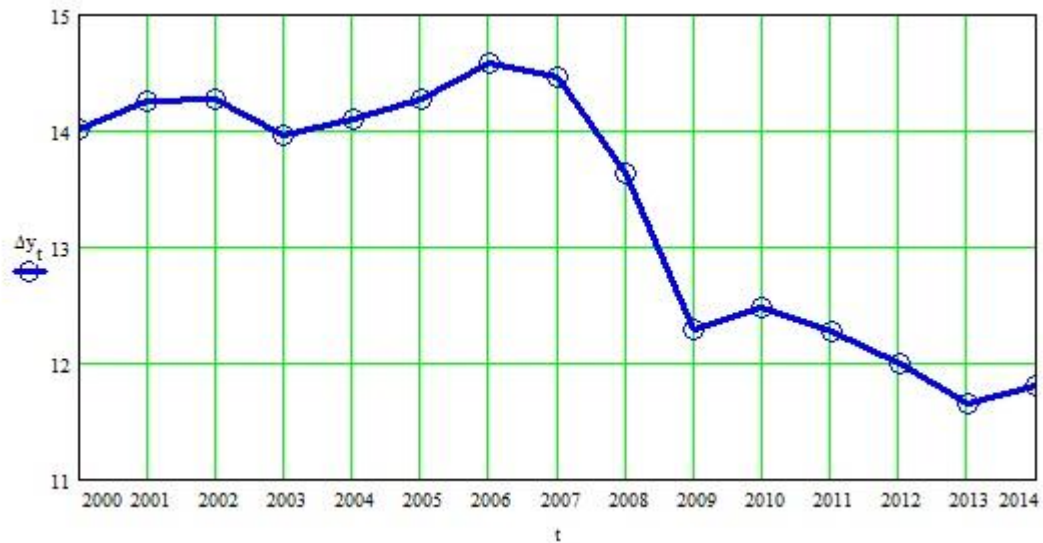


Figure 3

In order to evaluate the convergence within each group of countries in EU, we applied a non-linear model of the moving target type conceived to compare the real trajectory with an optimal trajectory of convergence. The simulation period is 2000-2014. For the simulations we used as optimisation criterion the following condition: the total estimated GDP for the whole period 2000-2014 should be equal to the total real registered GDP in EU for the same period (see Albu et al (2014), for details on the optimisation model and methodological details).

Figure 4 and Figure 5 represent the output of the simulation model showing the two trajectories, real and hypothetical, for EU11 and respectively for EU15.

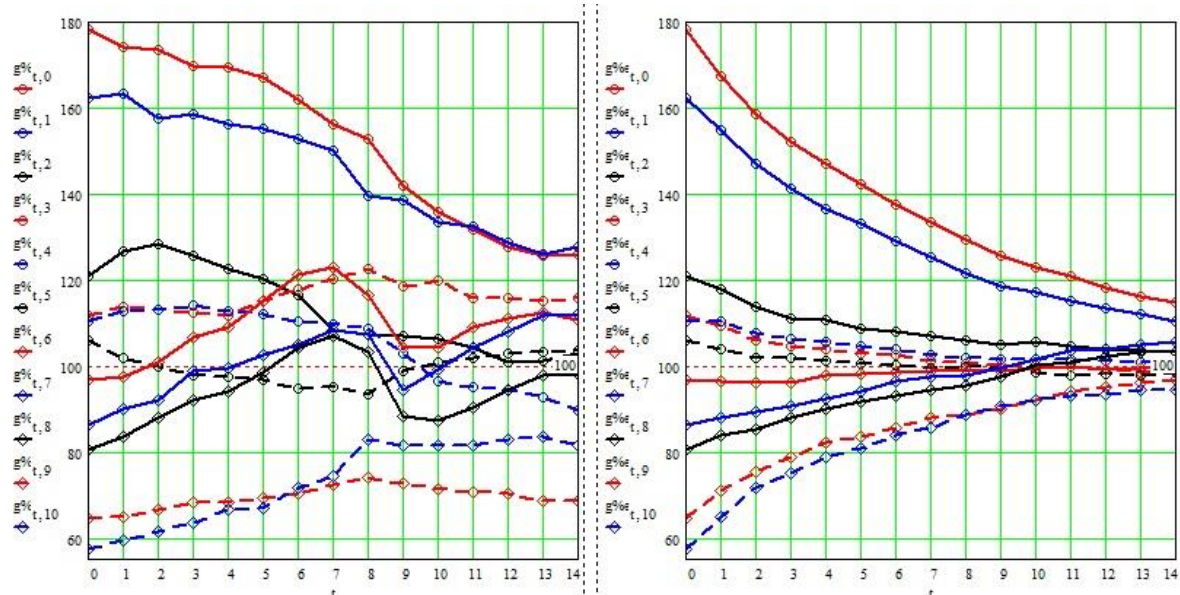


Figure 4

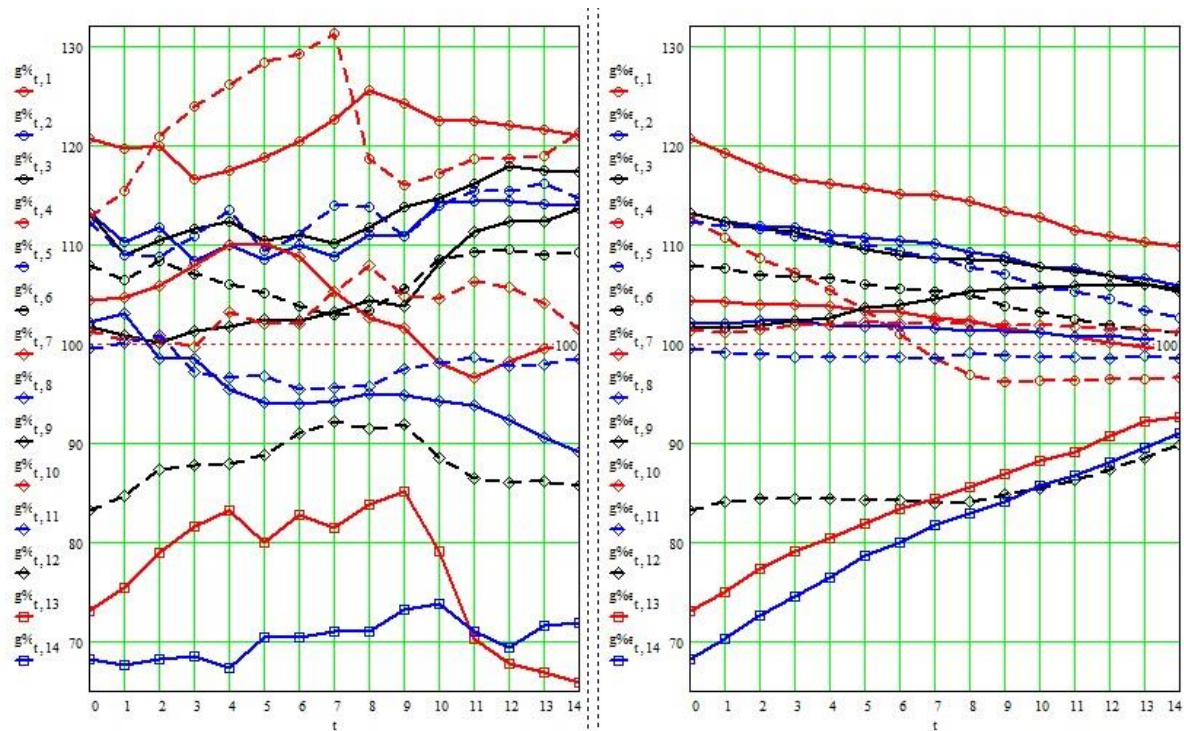


Figure 5

3. Evidences on market capitalisation and correlations

In order to study the relations between the financial market and real convergence we used, as annual data, the published time series for market capitalisation. Such series are available only until 2012. Usually, data on market capitalisation are reported as percentage of GDP. Despite of a general positive dynamics in Eastern countries of EU in the period 2000-2012, a huge difference in matter of market capitalisation between the two group of countries in EU, EU15 and EU11, still persists, as it is shown in Figure 6.



Figure 6

In case of EU15, market capitalisation decreased from 102.1% of GDP in 2000 to 64.9% in 2012. In case of EU11, market capitalisation increased from only 15.4% in 2000 to 22.6%. Thus, in 2012, the degree of market capitalisation in Eastern side of EU, as a measure of financial market development, was about three times smaller than in the group of more developed countries.

Taking into account the average level per capita of market capitalisation (equivalent in euro PPS), in the period 2000-2012 we observe a trend of convergence between EU11 and EU15, but far weaker than in case of GDP, as it is shown in Figure 7 (the average level of market capitalisation per capita in EU11 and in EU15 are expressed as percentages of average EU28 level).

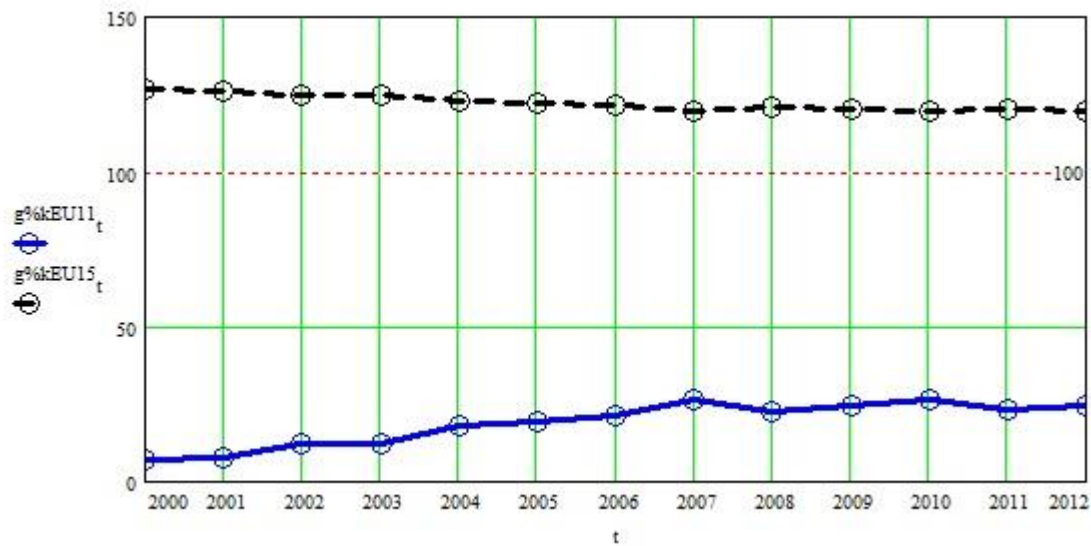


Figure 7

Analysing the data for the period 2000-2012, in the case of both groups of countries in EU, we notice that the dynamics of the variation coefficient is demonstrating a significant trend of convergence before the crisis and a divergence after that, as it is shown in Figure 8.



Figure 8

However, a positive fact is that, together with the convergence in relative terms between the two groups of countries in EU, a convergence in absolute terms was observed, as it is visible in Figure 9. Thus, the difference decreased from a maximum level of 21839 euro per capita market capitalisation in 2000 to 14935 euro in 2012 (with a minimum level of 10163 euro in 2008). Moreover, we can see a higher volatility in case of market capitalisation against GDP (see for comparison Figure 2).

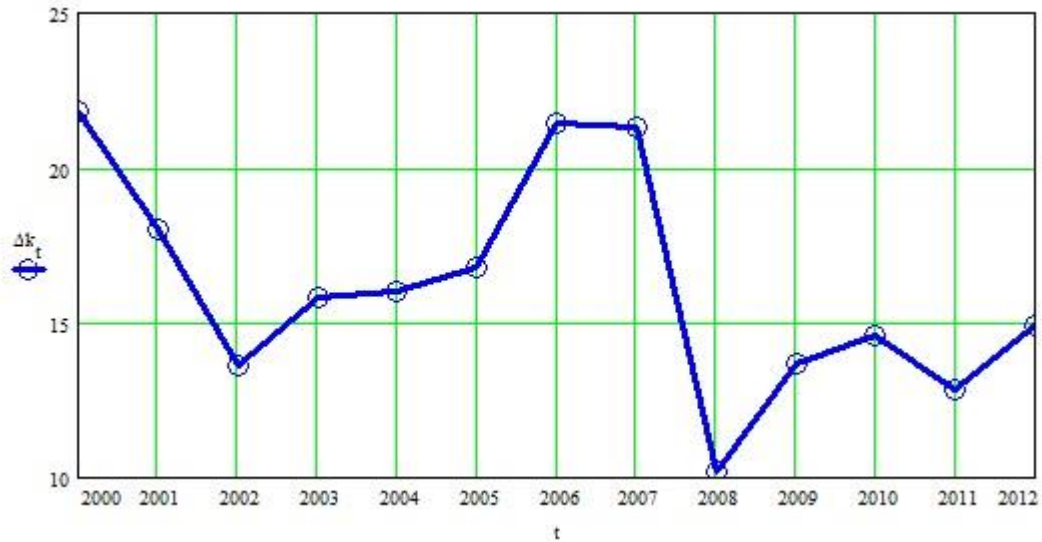


Figure 9

As a measure of the intensity of relation between GDP, Y, and market capitalisation, K, we are using the values of the correlation coefficient between GDP and market capitalisation for the period 2000-2012. Their dynamics for EU28 is presented in Figure 10. We can see in 2007 a major perturbation (sharp decrease) in the correlation coefficient dynamics that could be attributed to crisis.



Figure 10

4. High frequency in financial market and correlations

Usually, the study of financial markets assumes the use of time series with a high frequency, the most recent available information for stock market indices for national financial markets in the EU covering the period 2000Q1 – 2015Q2 (62 quarters). In the case of GDP series (also observed quarterly) the available data cover only the 2002Q1 – 2015Q1 for all countries in EU (53 quarters). In order to be able to conduct a dynamics comparison, we selected a corresponding time frame for the two data sets for all the countries in the EU.

In order to ensure the compatibility of the data series, we isolated data for three groups of countries. Thus, for a group of 16 EU countries the data cover the whole period 2002Q1 – 2015Q1 (1 - France, 2 - UK, 3 - Portugal, 4 - Spain, 5 - Belgium, 6 - Netherlands, 7 - Germany, 8 - Sweden, 9 - Finland, 10 - Denmark, 11 - Poland, 12 - Czech Rep., 13 - Austria, 14 - Italy, 15 - Greece, and 16 - Hungary). For the second group of 21 countries, comprising the first 16 countries plus a number 5 countries (17 - Slovenia, 18 - Croatia, 19 - Romania, 20 - Bulgaria, and 21 - Estonia) the data cover the period 2005Q4 – 2015Q1. Finally, for the third group of 22 countries, comprising the previous group of 21 countries plus one country (22 - Lithuania) the available data corresponds to the period 2008Q3 – 2015Q1.

In order to evaluate the relations among national stock markets, on the one hand, and real economies, on the other hand, in case of each group of countries, in the corresponding period we computed indices both for the dynamics of quarterly stock market and for the quarterly GDP dynamics.

4.1. Quarterly time series for stock index and GDP

4.1.1. EU16 group, 2002Q1 – 2015Q1

The matrix of correlation coefficients for the dynamics of quarterly stock indices, CORR_QIx, for the first group of countries, estimated for the period 2002Q1 – 2015Q1, is presented in Table 1, and for the dynamics of quarterly GDP, CORR_QY, in Table 2.

Table 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.000	0.799	0.679	0.856	0.899	0.907	0.845	0.692	0.828	0.522	0.827	0.638	0.768	0.684	0.567	0.736
2	0.799	1.000	0.224	0.618	0.623	0.860	0.947	0.946	0.410	0.852	0.823	0.587	0.377	0.153	0.033	0.569
3	0.679	0.224	1.000	0.761	0.642	0.371	0.268	0.066	0.820	-0.191	0.596	0.579	0.915	0.898	0.936	0.767
4	0.856	0.618	0.761	1.000	0.671	0.653	0.685	0.558	0.769	0.377	0.846	0.854	0.795	0.653	0.681	0.838
5	0.899	0.623	0.642	0.671	1.000	0.810	0.652	0.508	0.791	0.355	0.654	0.407	0.786	0.779	0.605	0.602
6	0.907	0.860	0.371	0.653	0.810	1.000	0.920	0.793	0.691	0.718	0.678	0.426	0.463	0.415	0.240	0.469
7	0.845	0.947	0.268	0.685	0.652	0.920	1.000	0.922	0.534	0.867	0.788	0.605	0.388	0.208	0.106	0.528
8	0.692	0.946	0.066	0.558	0.508	0.793	0.922	1.000	0.269	0.936	0.767	0.554	0.230	-0.008	-0.125	0.479
9	0.828	0.410	0.820	0.769	0.791	0.691	0.534	0.269	1.000	0.119	0.576	0.500	0.796	0.842	0.798	0.615
10	0.522	0.852	-0.191	0.377	0.355	0.718	0.867	0.936	0.119	1.000	0.573	0.405	-0.009	-0.219	-0.332	0.229
11	0.827	0.823	0.596	0.846	0.654	0.678	0.788	0.767	0.576	0.573	1.000	0.876	0.720	0.440	0.429	0.893
12	0.638	0.587	0.579	0.854	0.407	0.426	0.605	0.554	0.500	0.405	0.876	1.000	0.675	0.367	0.497	0.873
13	0.768	0.377	0.915	0.795	0.786	0.463	0.388	0.230	0.796	-0.009	0.720	0.675	1.000	0.899	0.898	0.851
14	0.684	0.153	0.898	0.653	0.779	0.415	0.208	-0.008	0.842	-0.219	0.440	0.367	0.899	1.000	0.934	0.621
15	0.567	0.033	0.936	0.681	0.605	0.240	0.106	-0.125	0.798	-0.332	0.429	0.497	0.898	0.934	1.000	0.666
16	0.736	0.569	0.767	0.838	0.602	0.469	0.528	0.479	0.615	0.229	0.893	0.873	0.851	0.621	0.666	1.000

At the level of this group of countries, for the whole period, the correlation between dynamics of stock market indices and the dynamics of GDP was significant (the value of correlation coefficient between QIx and QY being equal to 0.593).

Based on those matrices, we can see how strong or how weak are the relations among national stock indices (QIx) and respectively among real economies (QY). For instance, the data in the 15th column show how much Greece is correlated with the other countries in the group, in matter of stock market indices and respectively in matter of GDP indices. Thus, the results point to the fact that for the whole period the dynamics of the Greek stock market index was highly correlated with dynamics of stock market indices in Portugal (0.936), Italy (0.934), Austria (0.898), Finland (0.798), and Spain (0.681), and negatively or weakly correlated with dynamics of stock market indices in Denmark (-0.332), Sweden (-0.125), UK (0.033), Germany (0.106), and Netherlands (0.240).

A relative similar situation was registered for the real economy analysis. Thus, in the same period, the dynamics of GDP in Greece was highly correlated with dynamics of GDP in Portugal (0.732), Spain (0.663), and Italy (0.572), and negatively or weakly correlated with dynamics of stock index in Denmark (-0.332), UK (-0.095), Sweden (-0.001), and Germany (0.086).

Table 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.000	0.535	0.822	0.890	0.989	0.988	0.937	0.917	0.971	0.984	0.966	0.937	0.967	0.856	0.276	0.818
2	0.535	1.000	0.308	0.378	0.513	0.479	0.608	0.606	0.513	0.555	0.496	0.347	0.524	0.400	-0.095	0.462
3	0.822	0.308	1.000	0.963	0.799	0.864	0.696	0.628	0.857	0.859	0.819	0.914	0.811	0.923	0.732	0.910
4	0.890	0.378	0.963	1.000	0.860	0.931	0.727	0.695	0.893	0.900	0.851	0.929	0.839	0.928	0.663	0.888
5	0.989	0.513	0.799	0.860	1.000	0.973	0.939	0.936	0.975	0.978	0.969	0.920	0.973	0.864	0.223	0.817
CORR_QY = 6	0.988	0.479	0.864	0.931	0.973	1.000	0.893	0.864	0.964	0.973	0.960	0.950	0.944	0.881	0.364	0.832
7	0.937	0.608	0.696	0.727	0.939	0.893	1.000	0.932	0.929	0.942	0.942	0.867	0.971	0.731	0.086	0.757
8	0.917	0.606	0.628	0.695	0.936	0.864	0.932	1.000	0.912	0.910	0.899	0.802	0.914	0.749	-0.001	0.720
9	0.971	0.513	0.857	0.893	0.975	0.964	0.929	0.912	1.000	0.984	0.968	0.948	0.976	0.912	0.340	0.896
10	0.984	0.555	0.859	0.900	0.978	0.973	0.942	0.910	0.984	1.000	0.969	0.952	0.979	0.887	0.333	0.872
11	0.966	0.496	0.819	0.851	0.969	0.960	0.942	0.899	0.968	0.969	1.000	0.948	0.974	0.850	0.270	0.852
12	0.937	0.347	0.914	0.929	0.920	0.950	0.867	0.802	0.948	0.952	0.948	1.000	0.939	0.877	0.502	0.880
13	0.967	0.524	0.811	0.839	0.973	0.944	0.971	0.914	0.976	0.979	0.974	0.939	1.000	0.843	0.261	0.854
14	0.856	0.400	0.923	0.928	0.864	0.881	0.731	0.749	0.912	0.887	0.850	0.877	0.843	1.000	0.572	0.932
15	0.276	-0.095	0.732	0.663	0.223	0.364	0.086	-0.001	0.340	0.333	0.270	0.502	0.261	0.572	1.000	0.596
16	0.818	0.462	0.910	0.888	0.817	0.832	0.757	0.720	0.896	0.872	0.852	0.880	0.854	0.932	0.596	1.000

4.1.2. EU21 group, 2005Q4 – 2015Q1

The matrix of correlation coefficients for the dynamics of quarterly stock market indices, QIx, for the second group of countries (21 EU countries) estimated for the period 2005Q4 – 2015Q1, is presented in the Table found in Appendix 1, while the one for the dynamics of quarterly GDP, QY, in present Table of Appendix 2.

For this group of countries, the analysis reports a lack of correlation between the dynamics of stock market indices and the dynamics of GDP (the value of correlation coefficient between QIx and QY is equal to -0.010).

Following the paradigm of the previous section, the results in the 15th column show how much Greece is correlated with the other countries in the group, in matter of stock market index and respectively in matter of GDP index, in this period. Thus, we can observe that, for the whole period 2005-2015, the dynamics of the national stock market index of Greece was

again highly correlated with dynamics of stock market indices of few countries from the southern flank of EU, Portugal (0.955), Italy (0.940), and Spain (0.851), but also in emerging stock markets, like Bulgaria (0.947), Czech Republic. (0.871), Hungary (0.842), Slovenia (0.802), Croatia (0.796) or Austria (0.936). The dynamics of the national stock market index of Greece was negatively or weakly correlated with the dynamics of stock market indices in several Nordic countries such as: Denmark (-0.420), Sweden (-0.185), UK (0.047), Germany (0.167), and Netherlands (0.296). A different situation was observed in the analysis about the real economy side. Thus, in the same period, the dynamics of GDP in Greece was only moderate correlated with the dynamics of GDP in Portugal (0.597), Croatia (0.522), and Spain (0.455), and negatively or weakly correlated with the majority of countries in this group (for twelve countries it was a negative correlation, and for five countries a very weak correlation).

4.1.3. EU22 group, 2008Q3 – 2015Q1

For this period, which includes the crisis and post-crisis period, some authors are taking into account the so-called phenomenon of contagion. Therefore, we can incorporate this logic in the interpretation of the information provided by the results on both the financial market and real economy.

The matrix of correlation coefficients for the dynamics of quarterly stock market indices, QIx, for the third group of countries (22 EU countries), estimated for the period 2008Q3 – 2015Q1, is presented in the Table found in Appendix 3, and for the dynamics of quarterly GDP, QY, in the Table exhibited in Appendix 4.

For this group of countries and for the entire period, there is a moderate correlation between the dynamics of stock indices and the dynamics of GDP (the value of the correlation coefficient between QIx and QY was equal to +0.497).

The results provided in the 15th column explain how much Greece is correlated with the other countries in this group, both in terms of stock market indices and GDP.

Thus, we report that, the dynamics of the stock market index of Greece was highly correlated with dynamics of stock market indices in seven countries, Slovenia (0.881), Portugal (0.803), Czech Rep. (0.722), Bulgaria (0.655), Italy (0.653), Austria (0.598), and Spain (0.534). For three countries there was a moderate correlation (Finland, Hungary, and Croatia), but for eleven countries the results indicate a negative correlation, UK (-0.643), Sweden (-0.638), Denmark (-0.630), Belgium (-0.571), Estonia (-0.581), Lithuania (-0.532), Germany (-0.513), Netherlands (-0.503), Romania (-0.422), Poland (-0.297), and France (-0.255). We can extrapolate and assume that for this last group a countries there was a certain dose of protection against possible contagion originating from the stock market of Greece.

In the same period, the dynamics of GDP in Greece was significantly correlated with the dynamics of GDP only in Portugal (0.704), Croatia (0.685), and Spain (0.549), and moderately or weakly correlated with dynamics of GDP in Slovenia (0.355), Czech Rep. (0.237), Hungary (0.178), Italy (0.124), and Romania (0.068). For the majority of countries (13 countries) we found a negative correlation in terms of GDP: France (-0.803, UK (-0.793), Germany (-0.782), etc. Again, for last group of thirteen countries there was perhaps a sort of reaction against contagion effects coming from the Greek economy.

4.2. Quarterly and monthly time series on stock market

For the case of stock market indices we considered for the quarterly time series a time frame ranging from 2000Q1 to 2015Q2 (62 quarters) and correspondingly for monthly time series the period 2000M3 – 2015M6 (184 months).

The correlation matrix coefficients for the dynamics of quarterly stock indices, denoted this time as Q_{corr} , in case of the first group of countries (16 countries), estimated for the period 2000Q1 – 2015Q2, is presented in Table 3, and the dynamics of monthly stock market indices, M_{corr} , in Table 4.

Based on those matrices, we can determine how strong or how weak are the relations among the evolution of national stock indices within a group of countries, both in the case of using quarterly data (Q) and in the case of using monthly data (M). The results (exhibited in the columns) show how strong is the dynamics of a stock index correlated with the dynamics in all other countries within the group. As expected, there is a large similarity between the two time series. Changes from one matrix to the other are dependent on degree of rezolution.

In a similar way, we estimated the correlation matrices for the second group (21 countries), for the period 2005Q4 – 2015Q2 (39 quarters – Appendix 5) and respectively 2005M11 – 2015M6 (116 months – Appendix 6), and for the last group (22 countries), for the period 2008Q3 – 2015Q2 (28 quarters – Appendix 7) and respectively 2008M7 – 2015M6 (84 months – Appendix 8).

Table 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$Q_{corr} =$	1.000	0.772	0.716	0.746	0.844	0.925	0.857	0.653	0.801	0.314	0.527	0.191	0.478	0.750	0.631	0.376
	0.772	1.000	0.258	0.622	0.639	0.794	0.934	0.925	0.379	0.747	0.717	0.399	0.300	0.218	0.099	0.449
	0.716	0.258	1.000	0.671	0.598	0.469	0.340	0.084	0.739	-0.316	0.370	0.199	0.668	0.913	0.948	0.446
	0.746	0.622	0.671	1.000	0.653	0.544	0.659	0.566	0.434	0.360	0.797	0.709	0.749	0.576	0.618	0.760
	0.844	0.639	0.598	0.653	1.000	0.765	0.664	0.510	0.530	0.320	0.525	0.222	0.664	0.737	0.568	0.442
	0.925	0.794	0.469	0.544	0.765	1.000	0.897	0.701	0.737	0.455	0.347	-0.014	0.186	0.550	0.367	0.117
	0.857	0.934	0.340	0.659	0.664	0.897	1.000	0.898	0.561	0.701	0.612	0.306	0.243	0.324	0.217	0.334
	0.653	0.925	0.084	0.566	0.510	0.701	0.898	1.000	0.296	0.852	0.705	0.417	0.175	0.045	-0.054	0.417
	0.801	0.379	0.739	0.434	0.530	0.737	0.561	0.296	1.000	-0.128	0.118	-0.177	0.177	0.769	0.721	0.020
	0.314	0.747	-0.316	0.360	0.320	0.455	0.701	0.852	-0.128	1.000	0.570	0.444	0.034	-0.307	-0.411	0.295
	0.527	0.717	0.370	0.797	0.525	0.347	0.612	0.705	0.118	0.570	1.000	0.863	0.719	0.227	0.267	0.902
	0.191	0.399	0.199	0.709	0.222	-0.014	0.306	0.417	-0.177	0.444	0.863	1.000	0.687	0.017	0.171	0.892
	0.478	0.300	0.668	0.749	0.664	0.186	0.243	0.175	0.177	0.034	0.719	0.687	1.000	0.629	0.676	0.846
	0.750	0.218	0.913	0.576	0.737	0.550	0.324	0.045	0.769	-0.307	0.227	0.017	0.629	1.000	0.934	0.304
	0.631	0.099	0.948	0.618	0.568	0.367	0.217	-0.054	0.721	-0.411	0.267	0.171	0.676	0.934	1.000	0.400
	0.376	0.449	0.446	0.760	0.442	0.117	0.334	0.417	0.020	0.295	0.902	0.892	0.846	0.304	0.400	1.000

Table 4

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
$M_{corr} =$	1.000	0.758	0.718	0.734	0.847	0.927	0.855	0.644	0.803	0.311	0.505	0.175	0.480	0.749	0.619	0.342
	0.758	1.000	0.239	0.595	0.626	0.789	0.940	0.927	0.359	0.772	0.698	0.380	0.287	0.192	0.060	0.417
	0.718	0.239	1.000	0.688	0.622	0.479	0.344	0.082	0.731	-0.296	0.372	0.212	0.682	0.911	0.941	0.440
	0.734	0.595	0.688	1.000	0.659	0.532	0.644	0.546	0.437	0.353	0.793	0.705	0.763	0.573	0.627	0.746
	0.847	0.626	0.622	0.659	1.000	0.760	0.662	0.491	0.540	0.298	0.518	0.215	0.676	0.747	0.589	0.429
	0.927	0.789	0.479	0.532	0.760	1.000	0.895	0.689	0.739	0.438	0.327	-0.030	0.190	0.556	0.357	0.087
	0.855	0.940	0.344	0.644	0.662	0.895	1.000	0.898	0.553	0.708	0.601	0.296	0.251	0.318	0.194	0.311
	0.644	0.927	0.082	0.546	0.491	0.689	0.898	1.000	0.283	0.859	0.688	0.407	0.167	0.027	-0.079	0.392
	0.803	0.359	0.731	0.437	0.540	0.739	0.553	0.283	1.000	-0.129	0.093	-0.173	0.192	0.771	0.700	-0.004
	0.311	0.772	-0.296	0.353	0.298	0.438	0.708	0.859	-0.129	1.000	0.583	0.447	0.042	-0.316	-0.413	0.299
	0.505	0.698	0.372	0.793	0.518	0.327	0.601	0.688	0.093	0.583	1.000	0.865	0.726	0.201	0.256	0.900
	0.175	0.380	0.212	0.705	0.215	-0.030	0.296	0.407	-0.173	0.447	0.865	1.000	0.687	0.002	0.184	0.895
	0.480	0.287	0.682	0.763	0.676	0.190	0.251	0.167	0.192	0.042	0.726	0.687	1.000	0.626	0.698	0.845
	0.749	0.192	0.911	0.573	0.747	0.556	0.318	0.027	0.771	-0.316	0.201	0.002	0.626	1.000	0.930	0.273
	0.619	0.060	0.941	0.627	0.589	0.357	0.194	-0.079	0.700	-0.413	0.256	0.184	0.698	0.930	1.000	0.395
	0.342	0.417	0.440	0.746	0.429	0.087	0.311	0.392	-0.004	0.299	0.900	0.895	0.845	0.273	0.395	1.000

5. Conclusions

Convergence in Europe has always been a phenomenon that attracted a lot of attention in both politics and academic analysis. The idea of economic integration covers both the intention to have a united European Union (the political will) and the economic process of generating synergies from the interlinkages generated by the business connections among all the countries. This paper provides an investigation of the phenomenon of convergence, which sits at the heart of economic integration by providing a measurement of the whole process. We used data on GDP dynamics and data that characterizes the stochastic changes of stock a few market features – the market capitalization and the stock market indices. The analysis relies on a nonlinear model of convergence used both on the macroeconomic time series and for the financial market series.

We conclude that the stock market dynamics relate to the financial market dynamics both in linear terms via correlations and in non-linear terms by means of the non-linear model used to measure convergence for the European economies.

The Eastern European countries, which are the main focus of this investigation, show lower connections with the rest of the European countries, which could be motivated by the fact that they are less liquid and they account for lower levels of activities than the more developed countries. One of the reasons for this finding is the fact that most of these countries are rated as frontier countries by the most important rating agencies. Given the fact that the connections between financial markets and macroeconomic variables are more powerful in the case of the developed markets, we could consider that a shift to the level of ‘emerging’ could provide a better development of these countries by the inclusion of their stocks in the portfolios of international investors.

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Appendix 1

CORR_Qix =

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.000	0.741	0.704	0.830	0.948	0.900	0.814	0.597	0.899	0.357	0.878	0.576	0.802	0.838	0.656	0.710	0.611	0.676	0.920	0.801	0.844
2	0.741	1.000	0.173	0.347	0.724	0.897	0.901	0.897	0.474	0.748	0.674	0.080	0.306	0.306	0.047	0.304	0.179	0.312	0.727	0.297	0.652
3	0.704	0.173	1.000	0.858	0.621	0.357	0.238	-0.062	0.842	-0.365	0.781	0.862	0.946	0.932	0.955	0.920	0.801	0.883	0.677	0.941	0.723
4	0.830	0.347	0.858	1.000	0.701	0.602	0.505	0.210	0.917	-0.007	0.766	0.824	0.830	0.888	0.851	0.778	0.839	0.777	0.798	0.866	0.595
5	0.948	0.724	0.621	0.701	1.000	0.883	0.762	0.593	0.821	0.365	0.806	0.455	0.776	0.801	0.597	0.615	0.488	0.591	0.853	0.768	0.872
6	0.900	0.897	0.357	0.602	0.883	1.000	0.958	0.857	0.713	0.707	0.734	0.285	0.492	0.539	0.296	0.420	0.396	0.422	0.846	0.511	0.701
7	0.814	0.901	0.238	0.505	0.762	0.958	1.000	0.872	0.630	0.791	0.663	0.238	0.357	0.387	0.167	0.308	0.385	0.344	0.815	0.390	0.589
8	0.597	0.897	-0.062	0.210	0.593	0.857	0.872	1.000	0.305	0.898	0.480	-0.132	0.059	0.098	-0.185	0.075	0.006	0.078	0.541	0.053	0.437
9	0.899	0.474	0.842	0.917	0.821	0.713	0.630	0.305	1.000	0.088	0.835	0.807	0.876	0.904	0.844	0.796	0.842	0.786	0.899	0.922	0.754
10	0.357	0.748	-0.365	-0.007	0.365	0.707	0.791	0.898	0.088	1.000	0.176	-0.289	-0.229	-0.178	-0.420	-0.252	-0.123	-0.191	0.361	-0.196	0.120
11	0.878	0.674	0.781	0.766	0.806	0.734	0.663	0.480	0.835	0.176	1.000	0.691	0.819	0.793	0.656	0.853	0.671	0.843	0.880	0.812	0.876
12	0.576	0.080	0.862	0.824	0.455	0.285	0.238	-0.132	0.807	-0.289	0.691	1.000	0.812	0.790	0.871	0.836	0.898	0.841	0.674	0.857	0.507
13	0.802	0.306	0.946	0.830	0.776	0.492	0.357	0.059	0.876	-0.229	0.819	0.812	1.000	0.975	0.936	0.889	0.724	0.839	0.749	0.977	0.838
14	0.838	0.306	0.932	0.888	0.801	0.539	0.387	0.098	0.904	-0.178	0.793	0.790	0.975	1.000	0.940	0.857	0.712	0.791	0.745	0.965	0.785
15	0.656	0.047	0.955	0.851	0.597	0.296	0.167	-0.185	0.844	-0.420	0.656	0.871	0.936	0.940	1.000	0.842	0.802	0.796	0.620	0.947	0.634
16	0.710	0.304	0.920	0.778	0.615	0.420	0.308	0.075	0.796	-0.252	0.853	0.836	0.889	0.857	0.842	1.000	0.722	0.880	0.692	0.859	0.776
17	0.611	0.179	0.801	0.839	0.488	0.396	0.385	0.006	0.842	-0.123	0.671	0.898	0.724	0.712	0.802	0.722	1.000	0.830	0.756	0.819	0.480
18	0.676	0.312	0.883	0.777	0.591	0.422	0.344	0.078	0.786	-0.191	0.843	0.841	0.839	0.791	0.796	0.880	0.830	1.000	0.757	0.863	0.694
19	0.920	0.727	0.677	0.798	0.853	0.846	0.815	0.541	0.899	0.361	0.880	0.674	0.749	0.745	0.620	0.692	0.756	0.757	1.000	0.796	0.779
20	0.801	0.297	0.941	0.866	0.768	0.511	0.390	0.053	0.922	-0.196	0.812	0.857	0.977	0.965	0.947	0.859	0.819	0.863	0.796	1.000	0.787
21	0.844	0.652	0.723	0.595	0.872	0.701	0.589	0.437	0.754	0.120	0.876	0.507	0.838	0.785	0.634	0.776	0.480	0.694	0.779	0.787	1.000

Appendix 2

CORR_QY =

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.000	0.302	0.198	0.384	0.975	0.952	0.915	0.899	0.919	0.946	0.936	0.730	0.923	0.508	-0.592	0.451	0.571	0.113	0.636	0.737	0.883
2	0.302	1.000	-0.276	-0.229	0.264	0.166	0.463	0.464	0.270	0.352	0.238	-0.178	0.288	0.032	-0.531	0.161	-0.141	-0.314	0.141	0.008	0.507
3	0.198	-0.276	1.000	0.843	0.224	0.348	0.102	0.021	0.410	0.311	0.382	0.616	0.290	0.717	0.597	0.718	0.723	0.658	0.649	0.504	0.182
4	0.384	-0.229	0.843	1.000	0.397	0.591	0.131	0.160	0.555	0.412	0.473	0.645	0.338	0.801	0.455	0.687	0.703	0.495	0.611	0.464	0.328
5	0.975	0.264	0.224	0.397	1.000	0.928	0.881	0.900	0.925	0.944	0.932	0.716	0.931	0.583	-0.578	0.489	0.550	0.086	0.663	0.763	0.847
6	0.952	0.166	0.348	0.591	0.928	1.000	0.783	0.766	0.894	0.884	0.911	0.763	0.838	0.599	-0.409	0.500	0.630	0.165	0.649	0.701	0.803
7	0.915	0.463	0.102	0.131	0.881	0.783	1.000	0.885	0.851	0.926	0.885	0.658	0.945	0.335	-0.657	0.435	0.546	0.190	0.655	0.772	0.910
8	0.899	0.464	0.021	0.160	0.900	0.766	0.885	1.000	0.854	0.894	0.832	0.576	0.858	0.441	-0.694	0.411	0.401	0.012	0.523	0.638	0.858
9	0.919	0.270	0.410	0.555	0.925	0.894	0.851	0.854	1.000	0.954	0.936	0.813	0.933	0.718	-0.355	0.710	0.728	0.341	0.830	0.847	0.915
10	0.946	0.352	0.311	0.412	0.944	0.884	0.926	0.894	0.954	1.000	0.947	0.777	0.956	0.588	-0.491	0.602	0.667	0.267	0.765	0.826	0.912
11	0.936	0.238	0.382	0.473	0.932	0.911	0.885	0.832	0.936	0.947	1.000	0.839	0.946	0.635	-0.405	0.669	0.663	0.301	0.808	0.852	0.847
12	0.730	-0.178	0.616	0.645	0.716	0.763	0.658	0.576	0.813	0.777	0.839	1.000	0.788	0.618	0.004	0.676	0.879	0.680	0.799	0.893	0.644
13	0.923	0.288	0.290	0.338	0.931	0.838	0.945	0.858	0.933	0.956	0.946	0.788	1.000	0.551	-0.486	0.601	0.662	0.324	0.811	0.907	0.900
14	0.508	0.032	0.717	0.801	0.583	0.599	0.335	0.441	0.718	0.588	0.635	0.618	0.551	1.000	0.179	0.834	0.542	0.301	0.750	0.585	0.461
15	-0.592	-0.531	0.597	0.455	-0.578	-0.409	-0.657	-0.694	-0.355	-0.491	-0.405	0.004	-0.486	0.179	1.000	0.236	0.181	0.522	0.041	-0.148	-0.508
16	0.451	0.161	0.718	0.687	0.489	0.500	0.435	0.411	0.710	0.602	0.669	0.676	0.601	0.834	0.236	1.000	0.695	0.597	0.893	0.703	0.579
17	0.571	-0.141	0.723	0.703	0.550	0.630	0.546	0.401	0.728	0.667	0.663	0.879	0.662	0.542	0.181	0.695	1.000	0.817	0.780	0.815	0.636
18	0.113	-0.314	0.658	0.495	0.086	0.165	0.190	0.012	0.341	0.267	0.301	0.680	0.324	0.301	0.522	0.597	0.817	1.000	0.632	0.631	0.285
19	0.636	0.141	0.649	0.611	0.663	0.649	0.655	0.523	0.830	0.765	0.808	0.799	0.811	0.750	0.041	0.893	0.780	0.632	1.000	0.901	0.731
20	0.737	0.008	0.504	0.464	0.763	0.701	0.772	0.638	0.847	0.826	0.852	0.893	0.907	0.585	-0.148	0.703	0.815	0.631	0.901	1.000	0.752
21	0.883	0.507	0.182	0.328	0.847	0.803	0.910	0.858	0.915	0.912	0.847	0.644	0.900	0.461	-0.508	0.579	0.636	0.285	0.731	0.752	1.000

Appendix 3

CORR_Qix =

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1.000	0.840	-0.167	0.560	0.883	0.947	0.946	0.882	0.834	0.868	0.677	-0.125	0.292	0.503	-0.255	0.104	0.082	-0.080	0.932	0.294	0.568	0.802
2	0.840	1.000	-0.409	0.130	0.876	0.899	0.903	0.932	0.475	0.874	0.743	-0.414	0.034	0.036	-0.643	0.031	-0.375	-0.011	0.904	-0.079	0.809	0.927
3	-0.167	-0.409	1.000	0.498	-0.570	-0.432	-0.435	-0.466	0.096	-0.578	0.099	0.730	0.786	0.607	0.803	0.705	0.705	0.620	-0.311	0.631	-0.239	-0.249
4	0.560	0.130	0.498	1.000	0.223	0.354	0.302	0.229	0.793	0.203	0.294	0.524	0.566	0.936	0.534	0.336	0.756	0.191	0.385	0.711	-0.188	0.148
5	0.883	0.876	-0.570	0.223	1.000	0.973	0.962	0.940	0.610	0.977	0.511	-0.436	-0.109	0.119	-0.571	-0.198	-0.239	-0.269	0.886	-0.064	0.610	0.804
6	0.947	0.899	-0.432	0.354	0.973	1.000	0.981	0.966	0.714	0.966	0.613	-0.336	0.024	0.251	-0.503	-0.070	-0.154	-0.157	0.931	0.057	0.626	0.845
7	0.946	0.903	-0.435	0.302	0.962	0.981	1.000	0.949	0.691	0.960	0.618	-0.350	0.058	0.233	-0.513	-0.099	-0.183	-0.180	0.927	0.054	0.648	0.826
8	0.882	0.932	-0.466	0.229	0.940	0.966	0.949	1.000	0.600	0.961	0.670	-0.396	-0.031	0.108	-0.638	-0.047	-0.301	-0.121	0.895	-0.084	0.692	0.875
9	0.834	0.475	0.096	0.793	0.610	0.714	0.691	0.600	1.000	0.600	0.453	0.182	0.436	0.768	0.155	0.145	0.485	0.031	0.722	0.574	0.203	0.483
10	0.868	0.874	-0.578	0.203	0.977	0.966	0.960	0.961	0.600	1.000	0.545	-0.422	-0.137	0.106	-0.630	-0.220	-0.285	-0.268	0.882	-0.084	0.596	0.798
11	0.677	0.743	0.099	0.294	0.511	0.613	0.618	0.670	0.453	0.545	1.000	0.156	0.509	0.309	-0.297	0.557	-0.068	0.536	0.719	0.277	0.715	0.822
12	-0.125	-0.414	0.730	0.524	-0.436	-0.336	-0.350	-0.396	0.182	-0.422	0.156	1.000	0.660	0.665	0.722	0.657	0.716	0.674	-0.202	0.671	-0.412	-0.256
13	0.292	0.034	0.786	0.566	-0.109	0.024	0.058	-0.031	0.436	-0.137	0.509	0.660	1.000	0.717	0.598	0.763	0.658	0.702	0.154	0.765	0.180	0.205
14	0.503	0.036	0.607	0.936	0.119	0.251	0.233	0.108	0.768	0.106	0.309	0.665	0.717	1.000	0.653	0.446	0.828	0.294	0.323	0.821	-0.171	0.113
15	-0.255	-0.643	0.803	0.534	-0.571	-0.503	-0.513	-0.638	0.155	-0.630	-0.297	0.722	0.598	0.653	1.000	0.381	0.881	0.302	-0.422	0.665	-0.581	-0.532
16	0.104	0.031	0.705	0.336	-0.198	-0.070	-0.099	-0.047	0.145	-0.220	0.557	0.657	0.763	0.446	0.381	1.000	0.391	0.856	0.057	0.438	0.241	0.252
17	0.082	-0.375	0.705	0.756	-0.239	-0.154	-0.183	-0.301	0.485	-0.285	-0.068	0.716	0.658	0.828	0.881	0.391	1.000	0.299	-0.079	0.811	-0.444	-0.271
18	-0.080	-0.011	0.620	0.191	-0.269	-0.157	-0.180	-0.121	0.031	-0.268	0.536	0.674	0.702	0.294	0.302	0.856	0.299	1.000	-0.009	0.476	0.231	0.210
19	0.932	0.904	-0.311	0.385	0.886	0.931	0.927	0.895	0.722	0.882	0.719	-0.202	0.154	0.323	-0.422	0.057	-0.079	-0.009	1.000	0.205	0.645	0.845
20	0.294	-0.079	0.631	0.711	-0.064	0.057	0.054	-0.084	0.574	-0.084	0.277	0.671	0.765	0.821	0.665	0.438	0.811	0.476	0.205	1.000	-0.138	0.048
21	0.568	0.809	-0.239	-0.188	0.610	0.626	0.648	0.692	0.203	0.596	0.715	-0.412	0.180	-0.171	-0.581	0.241	-0.444	0.231	0.645	-0.138	1.000	0.871
22	0.802	0.927	-0.249	0.148	0.804	0.845	0.826	0.875	0.483	0.798	0.822	-0.256	0.205	0.113	-0.532	0.252	-0.271	0.210	0.845	0.048	0.871	1.000

Appendix 4

CORR_QY =

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1	0.828	-0.261	-0.016	0.968	0.901	0.885	0.931	0.876	0.93	0.868	0.274	0.871	0.463	-0.803	0.368	0.047	-0.417	0.43	0.447	0.887	0.704
2	0.828	1	-0.342	-0.285	0.727	0.663	0.915	0.755	0.653	0.839	0.731	0.104	0.76	0.103	-0.793	0.248	0.048	-0.323	0.342	0.35	0.84	0.708
3	-0.261	-0.342	1	0.758	-0.121	-0.05	-0.246	-0.288	0.06	-0.04	0.098	0.557	-0.028	0.582	0.704	0.598	0.654	0.621	0.512	0.383	-0.227	-0.064
4	-0.016	-0.285	0.758	1	0.147	0.329	-0.27	-0.139	0.279	0.103	0.205	0.527	0.03	0.785	0.549	0.591	0.525	0.329	0.491	0.316	-0.075	-0.014
5	0.968	0.727	-0.121	0.147	1	0.919	0.811	0.899	0.905	0.917	0.882	0.353	0.882	0.601	-0.692	0.457	0.141	-0.348	0.506	0.531	0.847	0.668
6	0.901	0.663	-0.05	0.329	0.919	1	0.662	0.744	0.838	0.838	0.831	0.295	0.73	0.645	-0.584	0.446	0.096	-0.412	0.478	0.389	0.743	0.556
7	0.885	0.915	-0.246	-0.27	0.811	0.662	1	0.872	0.793	0.906	0.825	0.293	0.912	0.259	-0.782	0.392	0.181	-0.184	0.494	0.563	0.921	0.823
8	0.931	0.755	-0.288	-0.139	0.899	0.744	0.872	1	0.844	0.898	0.824	0.372	0.848	0.385	-0.778	0.349	0.094	-0.284	0.369	0.492	0.853	0.717
9	0.876	0.653	0.06	0.279	0.905	0.838	0.793	0.844	1	0.935	0.904	0.618	0.915	0.712	-0.487	0.687	0.454	0.01	0.736	0.747	0.9	0.851
10	0.93	0.839	-0.04	0.103	0.917	0.838	0.906	0.898	0.935	1	0.926	0.499	0.93	0.551	-0.629	0.586	0.345	-0.106	0.64	0.656	0.926	0.832
11	0.868	0.731	0.098	0.205	0.882	0.831	0.825	0.824	0.904	0.926	1	0.597	0.914	0.68	-0.494	0.733	0.312	-0.041	0.744	0.705	0.834	0.752
12	0.274	0.104	0.557	0.527	0.353	0.295	0.293	0.372	0.618	0.499	0.597	1	0.52	0.762	0.237	0.856	0.728	0.64	0.774	0.796	0.36	0.505
13	0.871	0.76	-0.028	0.03	0.882	0.73	0.912	0.848	0.915	0.93	0.914	0.52	1	0.563	-0.587	0.634	0.351	-0.002	0.729	0.799	0.921	0.853
14	0.463	0.103	0.582	0.785	0.601	0.645	0.259	0.385	0.712	0.551	0.68	0.762	0.563	1	0.124	0.8	0.496	0.229	0.76	0.672	0.373	0.372
15	-0.803	-0.793	0.704	0.549	-0.692	-0.584	-0.782	-0.778	-0.487	-0.629	-0.494	0.237	-0.587	0.124	1	0.178	0.355	0.685	0.068	-0.036	-0.7	-0.474
16	0.368	0.248	0.598	0.591	0.457	0.446	0.392	0.349	0.687	0.586	0.733	0.856	0.634	0.8	0.178	1	0.738	0.567	0.94	0.85	0.504	0.624
17	0.047	0.048	0.654	0.525	0.141	0.096	0.181	0.094	0.454	0.345	0.312	0.728	0.351	0.496	0.355	0.738	1	0.766	0.705	0.719	0.324	0.544
18	-0.417	-0.323	0.621	0.329	-0.348	-0.412	-0.184	-0.284	0.01	-0.106	-0.041	0.64	-0.002	0.229	0.685	0.567	0.766	1	0.533	0.554	-0.088	0.225
19	0.43	0.342	0.512	0.491	0.506	0.478	0.494	0.369	0.736	0.64	0.744	0.774	0.729	0.76	0.068	0.94	0.705	0.533	1	0.908	0.609	0.721
20	0.447	0.35	0.383	0.316	0.531	0.389	0.563	0.492	0.747	0.656	0.705	0.796	0.799	0.672	-0.036	0.85	0.719	0.554	0.908	1	0.651	0.767
21	0.887	0.84	-0.227	-0.075	0.847	0.743	0.921	0.853	0.9	0.926	0.834	0.36	0.921	0.373	-0.7	0.504	0.324	-0.088	0.609	0.651	1	0.937
22	0.704	0.708	-0.064	-0.014	0.668	0.556	0.823	0.717	0.851	0.832	0.752	0.505	0.853	0.372	-0.474	0.624	0.544	0.225	0.721	0.767	0.937	1

Appendix 5

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.000	0.746	0.654	0.824	0.949	0.889	0.816	0.608	0.894	0.384	0.858	0.540	0.771	0.821	0.614	0.686	0.590	0.640	0.921	0.768	0.822
2	0.746	1.000	0.141	0.347	0.731	0.883	0.897	0.887	0.474	0.724	0.659	0.057	0.285	0.296	0.022	0.289	0.165	0.286	0.733	0.276	0.634
3	0.654	0.141	1.000	0.837	0.564	0.265	0.173	-0.119	0.819	-0.407	0.775	0.865	0.944	0.923	0.956	0.915	0.799	0.885	0.628	0.939	0.720
4	0.824	0.347	0.837	1.000	0.693	0.574	0.493	0.206	0.917	0.005	0.763	0.811	0.822	0.886	0.836	0.774	0.834	0.766	0.792	0.858	0.592
5	0.949	0.731	0.564	0.693	1.000	0.878	0.770	0.610	0.814	0.402	0.783	0.415	0.738	0.779	0.550	0.588	0.465	0.551	0.856	0.730	0.844
6	0.889	0.883	0.265	0.574	0.878	1.000	0.959	0.872	0.683	0.746	0.672	0.214	0.422	0.492	0.220	0.367	0.345	0.346	0.838	0.439	0.636
7	0.816	0.897	0.173	0.493	0.770	0.959	1.000	0.882	0.617	0.801	0.624	0.186	0.311	0.361	0.114	0.273	0.349	0.290	0.816	0.342	0.549
8	0.608	0.887	-0.119	0.206	0.610	0.872	0.882	1.000	0.302	0.903	0.439	-0.172	0.020	0.079	-0.225	0.045	-0.019	0.029	0.555	0.014	0.392
9	0.894	0.474	0.819	0.917	0.814	0.683	0.617	0.302	1.000	0.096	0.831	0.792	0.866	0.901	0.826	0.789	0.835	0.773	0.894	0.911	0.749
10	0.384	0.724	-0.407	0.005	0.402	0.746	0.801	0.903	0.096	1.000	0.133	-0.323	-0.253	-0.178	-0.444	-0.261	-0.145	-0.233	0.386	-0.226	0.076
11	0.858	0.659	0.775	0.763	0.783	0.672	0.624	0.439	0.831	0.133	1.000	0.690	0.818	0.793	0.655	0.854	0.672	0.841	0.862	0.811	0.876
12	0.540	0.057	0.865	0.811	0.415	0.214	0.186	-0.172	0.792	-0.323	0.690	1.000	0.815	0.787	0.874	0.836	0.897	0.844	0.636	0.859	0.510
13	0.771	0.285	0.944	0.822	0.738	0.422	0.311	0.020	0.866	-0.253	0.818	0.815	1.000	0.973	0.936	0.889	0.726	0.841	0.719	0.977	0.839
14	0.821	0.296	0.923	0.886	0.779	0.492	0.361	0.079	0.901	-0.178	0.793	0.787	0.973	1.000	0.934	0.857	0.713	0.788	0.729	0.963	0.786
15	0.614	0.022	0.956	0.836	0.550	0.220	0.114	-0.225	0.826	-0.444	0.655	0.874	0.936	0.934	1.000	0.842	0.802	0.800	0.580	0.947	0.635
16	0.686	0.289	0.915	0.774	0.588	0.367	0.273	0.045	0.789	-0.261	0.854	0.836	0.889	0.857	0.842	1.000	0.724	0.880	0.670	0.860	0.777
17	0.590	0.165	0.799	0.834	0.465	0.345	0.349	-0.019	0.835	-0.145	0.672	0.897	0.726	0.713	0.802	0.724	1.000	0.830	0.734	0.820	0.483
18	0.640	0.286	0.885	0.766	0.551	0.346	0.290	0.029	0.773	-0.233	0.841	0.844	0.841	0.788	0.800	0.880	0.830	1.000	0.720	0.865	0.695
19	0.921	0.733	0.628	0.792	0.856	0.838	0.816	0.555	0.894	0.386	0.862	0.636	0.719	0.729	0.580	0.670	0.734	0.720	1.000	0.764	0.759
20	0.768	0.276	0.939	0.858	0.730	0.439	0.342	0.014	0.911	-0.226	0.811	0.859	0.977	0.963	0.947	0.860	0.820	0.865	0.764	1.000	0.787
21	0.822	0.634	0.720	0.592	0.844	0.636	0.549	0.392	0.749	0.076	0.876	0.510	0.839	0.786	0.635	0.777	0.483	0.695	0.759	0.787	1.000

Appendix 6

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.000	0.734	0.662	0.821	0.955	0.894	0.819	0.597	0.885	0.383	0.864	0.535	0.779	0.819	0.612	0.667	0.595	0.638	0.933	0.774	0.815
2	0.734	1.000	0.119	0.329	0.717	0.888	0.913	0.896	0.436	0.762	0.639	0.027	0.263	0.265	-0.014	0.249	0.141	0.260	0.719	0.251	0.605
3	0.662	0.119	1.000	0.848	0.589	0.290	0.192	-0.113	0.833	-0.388	0.783	0.863	0.943	0.924	0.952	0.905	0.821	0.879	0.662	0.945	0.707
4	0.821	0.329	0.848	1.000	0.705	0.577	0.490	0.205	0.917	-0.003	0.775	0.811	0.829	0.883	0.835	0.766	0.839	0.753	0.801	0.858	0.590
5	0.955	0.717	0.589	0.705	1.000	0.879	0.770	0.585	0.817	0.384	0.794	0.427	0.756	0.791	0.567	0.590	0.483	0.561	0.881	0.748	0.841
6	0.894	0.888	0.290	0.577	0.879	1.000	0.960	0.858	0.673	0.737	0.685	0.221	0.443	0.497	0.228	0.362	0.352	0.358	0.842	0.449	0.641
7	0.819	0.913	0.192	0.490	0.770	0.960	1.000	0.882	0.603	0.804	0.631	0.174	0.325	0.361	0.109	0.258	0.339	0.295	0.804	0.343	0.544
8	0.597	0.896	-0.113	0.205	0.585	0.858	0.882	1.000	0.263	0.908	0.434	-0.172	0.013	0.061	-0.237	0.025	-0.030	0.033	0.545	0.004	0.388
9	0.885	0.436	0.833	0.917	0.817	0.673	0.603	0.263	1.000	0.077	0.820	0.792	0.874	0.903	0.830	0.767	0.849	0.763	0.888	0.913	0.711
10	0.383	0.762	-0.388	-0.003	0.384	0.737	0.804	0.908	0.077	1.000	0.137	-0.332	-0.247	-0.188	-0.449	-0.269	-0.152	-0.219	0.368	-0.230	0.082
11	0.864	0.639	0.783	0.775	0.794	0.685	0.631	0.434	0.820	0.137	1.000	0.681	0.823	0.795	0.652	0.853	0.655	0.830	0.878	0.813	0.865
12	0.535	0.027	0.863	0.811	0.427	0.221	0.174	-0.172	0.792	-0.332	0.681	1.000	0.815	0.781	0.870	0.837	0.888	0.824	0.632	0.842	0.465
13	0.779	0.263	0.943	0.829	0.756	0.443	0.325	0.013	0.874	-0.247	0.823	0.815	1.000	0.976	0.938	0.889	0.740	0.830	0.753	0.981	0.818
14	0.819	0.265	0.924	0.883	0.791	0.497	0.361	0.061	0.903	-0.188	0.795	0.781	0.976	1.000	0.936	0.847	0.727	0.781	0.756	0.970	0.777
15	0.612	-0.014	0.952	0.835	0.567	0.228	0.109	-0.237	0.830	-0.449	0.652	0.870	0.938	0.936	1.000	0.831	0.807	0.779	0.599	0.946	0.612
16	0.667	0.249	0.905	0.766	0.590	0.362	0.258	0.025	0.767	-0.269	0.853	0.837	0.889	0.847	0.831	1.000	0.706	0.857	0.681	0.857	0.761
17	0.595	0.141	0.821	0.839	0.483	0.352	0.339	-0.030	0.849	-0.152	0.655	0.888	0.740	0.727	0.807	0.706	1.000	0.818	0.713	0.815	0.446
18	0.638	0.260	0.879	0.753	0.561	0.358	0.295	0.033	0.763	-0.219	0.830	0.824	0.830	0.781	0.779	0.857	0.818	1.000	0.711	0.849	0.669
19	0.933	0.719	0.662	0.801	0.881	0.842	0.804	0.545	0.888	0.368	0.878	0.632	0.753	0.756	0.599	0.681	0.713	0.711	1.000	0.778	0.761
20	0.774	0.251	0.945	0.858	0.748	0.449	0.343	0.004	0.913	-0.230	0.813	0.842	0.981	0.970	0.946	0.857	0.815	0.849	0.778	1.000	0.774
21	0.815	0.605	0.707	0.590	0.841	0.641	0.544	0.388	0.711	0.082	0.865	0.465	0.818	0.777	0.612	0.761	0.446	0.669	0.761	0.774	1.000

Appendix 7

Qcorr =

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1.000	0.836	-0.249	0.577	0.899	0.952	0.952	0.896	0.851	0.885	0.645	-0.172	0.246	0.527	-0.300	0.096	0.066	-0.087	0.941	0.236	0.540	0.801
2	0.836	1.000	-0.436	0.157	0.858	0.875	0.897	0.924	0.500	0.848	0.738	-0.431	0.021	0.067	-0.655	0.030	-0.374	-0.041	0.889	-0.096	0.800	0.929
3	-0.249	-0.436	1.000	0.423	-0.613	-0.493	-0.486	-0.514	0.005	-0.620	0.084	0.736	0.773	0.524	0.810	0.678	0.686	0.634	-0.382	0.632	-0.237	-0.284
4	0.577	0.157	0.423	1.000	0.273	0.390	0.339	0.272	0.797	0.258	0.296	0.481	0.543	0.938	0.484	0.330	0.738	0.157	0.418	0.678	-0.180	0.174
5	0.899	0.858	-0.613	0.273	1.000	0.978	0.963	0.944	0.654	0.981	0.481	-0.457	-0.129	0.182	-0.586	-0.182	-0.230	-0.311	0.904	-0.101	0.566	0.793
6	0.952	0.875	-0.493	0.390	0.978	1.000	0.978	0.965	0.745	0.972	0.569	-0.367	-0.010	0.301	-0.525	-0.064	-0.152	-0.212	0.941	0.006	0.576	0.826
7	0.952	0.897	-0.486	0.339	0.963	0.978	1.000	0.955	0.722	0.958	0.596	-0.378	0.031	0.277	-0.537	-0.095	-0.182	-0.223	0.935	0.016	0.620	0.826
8	0.896	0.924	-0.514	0.272	0.944	0.965	0.955	1.000	0.640	0.959	0.644	-0.421	-0.053	0.160	-0.652	-0.045	-0.294	-0.168	0.907	-0.114	0.661	0.871
9	0.851	0.500	0.005	0.797	0.654	0.745	0.722	0.640	1.000	0.647	0.443	0.123	0.393	0.775	0.089	0.137	0.453	-0.021	0.752	0.513	0.202	0.507
10	0.885	0.848	-0.620	0.258	0.981	0.972	0.958	0.959	0.647	1.000	0.504	-0.443	-0.154	0.175	-0.636	-0.197	-0.268	-0.311	0.900	-0.121	0.545	0.781
11	0.645	0.738	0.084	0.296	0.481	0.569	0.596	0.644	0.443	0.504	1.000	0.147	0.505	0.311	-0.299	0.556	-0.069	0.522	0.677	0.271	0.715	0.816
12	-0.172	-0.431	0.736	0.481	-0.457	-0.367	-0.378	-0.421	0.123	-0.443	0.147	1.000	0.662	0.617	0.730	0.649	0.712	0.683	-0.245	0.676	-0.411	-0.277
13	0.246	0.021	0.773	0.543	-0.129	-0.010	0.031	-0.053	0.393	-0.154	0.505	0.662	1.000	0.690	0.600	0.761	0.658	0.702	0.114	0.767	0.178	0.188
14	0.527	0.067	0.524	0.938	0.182	0.301	0.277	0.160	0.775	0.175	0.311	0.617	0.690	1.000	0.598	0.438	0.808	0.255	0.363	0.784	-0.163	0.142
15	-0.300	-0.655	0.810	0.484	-0.586	-0.525	-0.537	-0.652	0.089	-0.636	-0.299	0.730	0.600	0.598	1.000	0.375	0.871	0.324	-0.454	0.669	-0.576	-0.547
16	0.096	0.030	0.678	0.330	-0.182	-0.064	-0.095	-0.045	0.137	-0.197	0.556	0.649	0.761	0.438	0.375	1.000	0.391	0.845	0.051	0.436	0.241	0.247
17	0.066	-0.374	0.686	0.738	-0.230	-0.152	-0.182	-0.294	0.453	-0.268	-0.069	0.712	0.658	0.808	0.871	0.391	1.000	0.300	-0.084	0.809	-0.444	-0.272
18	-0.087	-0.041	0.634	0.157	-0.311	-0.212	-0.223	-0.168	-0.021	-0.311	0.522	0.683	0.702	0.255	0.324	0.845	0.300	1.000	-0.073	0.484	0.223	0.175
19	0.941	0.889	-0.382	0.418	0.904	0.941	0.935	0.907	0.752	0.900	0.677	-0.245	0.114	0.363	-0.454	0.051	-0.084	-0.073	1.000	0.148	0.605	0.835
20	0.236	-0.096	0.632	0.678	-0.101	0.006	0.016	-0.114	0.513	-0.121	0.271	0.676	0.767	0.784	0.669	0.436	0.809	0.484	0.148	1.000	-0.141	0.029
21	0.540	0.800	-0.237	-0.180	0.566	0.576	0.620	0.661	0.202	0.545	0.715	-0.411	0.178	-0.163	-0.576	0.241	-0.444	0.223	0.605	-0.141	1.000	0.861
22	0.801	0.929	-0.284	0.174	0.793	0.826	0.826	0.871	0.507	0.781	0.816	-0.277	0.188	0.142	-0.547	0.247	-0.272	0.175	0.835	0.029	0.861	1.000

Appendix 8

M corr =

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1.000	0.847	-0.230	0.563	0.913	0.952	0.953	0.886	0.811	0.886	0.660	-0.132	0.270	0.508	-0.289	0.085	0.088	-0.049	0.935	0.242	0.572	0.789
2	0.847	1.000	-0.437	0.155	0.877	0.890	0.917	0.931	0.445	0.875	0.731	-0.401	0.031	0.054	-0.651	0.024	-0.340	-0.043	0.878	-0.065	0.812	0.918
3	-0.230	-0.437	1.000	0.454	-0.566	-0.476	-0.463	-0.502	0.074	-0.605	0.130	0.720	0.708	0.554	0.798	0.684	0.671	0.624	-0.299	0.611	-0.189	-0.272
4	0.563	0.155	0.454	1.000	0.285	0.375	0.326	0.265	0.791	0.237	0.353	0.492	0.547	0.918	0.494	0.350	0.709	0.184	0.445	0.614	-0.103	0.176
5	0.913	0.877	-0.566	0.285	1.000	0.980	0.964	0.935	0.629	0.974	0.505	-0.374	-0.024	0.196	-0.538	-0.161	-0.169	-0.249	0.892	-0.024	0.578	0.792
6	0.952	0.890	-0.476	0.375	0.980	1.000	0.977	0.956	0.682	0.970	0.582	-0.326	0.032	0.276	-0.509	-0.064	-0.135	-0.184	0.916	0.014	0.601	0.817
7	0.953	0.917	-0.463	0.326	0.964	0.977	1.000	0.948	0.668	0.959	0.617	-0.334	0.071	0.258	-0.525	-0.087	-0.156	-0.175	0.922	0.041	0.640	0.822
8	0.886	0.931	-0.502	0.265	0.935	0.956	0.948	1.000	0.537	0.955	0.641	-0.405	-0.075	0.118	-0.647	-0.050	-0.312	-0.176	0.868	-0.138	0.668	0.849
9	0.811	0.445	0.074	0.791	0.629	0.682	0.668	0.537	1.000	0.576	0.440	0.249	0.507	0.815	0.193	0.142	0.551	0.072	0.735	0.598	0.188	0.446
10	0.886	0.875	-0.605	0.237	0.974	0.970	0.959	0.955	0.576	1.000	0.504	-0.425	-0.115	0.140	-0.624	-0.196	-0.262	-0.294	0.874	-0.113	0.560	0.782
11	0.660	0.731	0.130	0.353	0.505	0.582	0.617	0.641	0.440	0.504	1.000	0.180	0.495	0.328	-0.256	0.594	-0.005	0.522	0.720	0.318	0.734	0.787
12	-0.132	-0.401	0.720	0.492	-0.374	-0.326	-0.334	-0.405	0.249	-0.425	0.180	1.000	0.739	0.640	0.759	0.676	0.753	0.688	-0.098	0.741	-0.335	-0.256
13	0.270	0.031	0.708	0.547	-0.024	0.032	0.071	-0.075	0.507	-0.115	0.495	0.739	1.000	0.735	0.622	0.718	0.751	0.718	0.262	0.881	0.177	0.174
14	0.508	0.054	0.554	0.918	0.196	0.276	0.258	0.118	0.815	0.140	0.328	0.640	0.735	1.000	0.633	0.437	0.834	0.315	0.399	0.789	-0.106	0.122
15	-0.289	-0.651	0.798	0.494	-0.538	-0.509	-0.525	-0.647	0.193	-0.624	-0.256	0.759	0.622	0.633	1.000	0.372	0.881	0.355	-0.366	0.677	-0.555	-0.529
16	0.085	0.024	0.684	0.350	-0.161	-0.064	-0.087	-0.050	0.142	-0.196	0.594	0.676	0.718	0.437	0.372	1.000	0.387	0.845	0.120	0.477	0.278	0.231
17	0.088	-0.340	0.671	0.709	-0.169	-0.135	-0.156	-0.312	0.551	-0.262	-0.005	0.753	0.751	0.834	0.881	0.387	1.000	0.372	0.033	0.855	-0.377	-0.239
18	-0.049	-0.043	0.624	0.184	-0.249	-0.184	-0.175	-0.176	0.072	-0.294	0.522	0.688	0.718	0.315	0.355	0.845	0.372	1.000	0.035	0.566	0.246	0.159
19	0.935	0.878	-0.299	0.445	0.892	0.916	0.922	0.868	0.735	0.874	0.720	-0.098	0.262	0.399	-0.366	0.120	0.033	0.035	1.000	0.262	0.613	0.834
20	0.242	-0.065	0.611	0.614	-0.024	0.014	0.041	-0.138	0.598	-0.113	0.318	0.741	0.881	0.789	0.677	0.477	0.855	0.566	0.262	1.000	-0.059	0.053
21	0.572	0.812	-0.189	-0.103	0.578	0.601	0.640	0.668	0.188	0.560	0.734	-0.335	0.177	-0.106	-0.555	0.278	-0.377	0.246	0.613	-0.059	1.000	0.867
22	0.789	0.918	-0.272	0.176	0.792	0.817	0.822	0.849	0.446	0.782	0.787	-0.256	0.174	0.122	-0.529	0.231	-0.239	0.159	0.834	0.053	0.867	1.000