

# REVIEWING WALSH'S DYNAMIC CORRELATIONS

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## ABSTRACT

The main aim of this project is to humbly assess the resilience of Carl E. Walsh study and interpretations about the behaviour of dynamic correlations between GDP and Monetary Aggregates in time, and also between output, prices, and interest rates. In order to do so, we will firstly present his work. As a continuation, we will introduce a study of the monetary aggregates taken from the different countries used to conduct this research. And finally, with data obtained from freely available sources, we will strive to replicate Walsh's figures with different countries and time intervals.

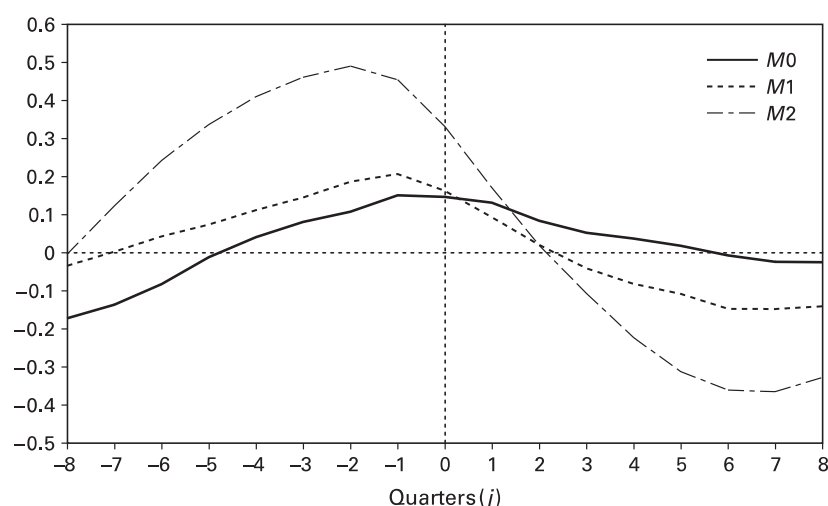
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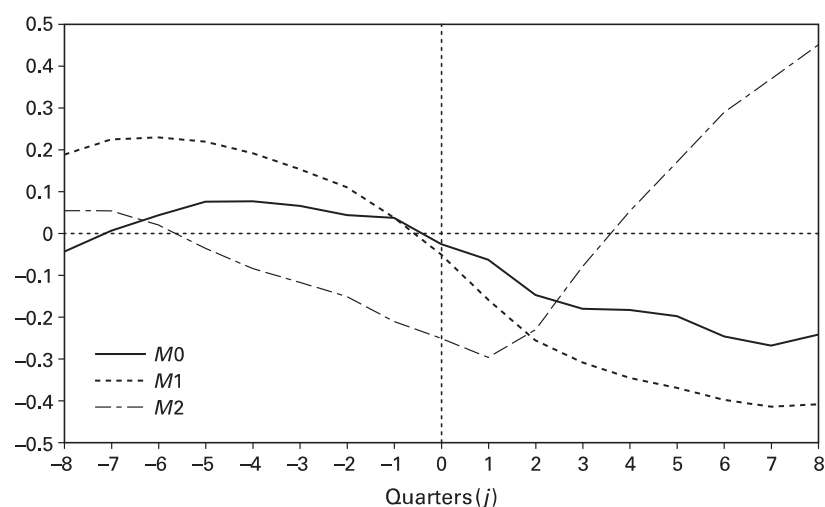
## CARL E. WALSH FIGURES

This section is a mere selection of the most relevant fragments concerning our analysis. Therefore, we will extract part of the first chapter of Walsh's book, entitled *Empirical Evidence on Money, Prices, and Output*.

Some evidence on short-run correlations for the United States are provided in figures 1.1 and 1.2. The figures show correlations between the detrended log of real GDP and three different monetary aggregates, each also in detrended log form. Data are quarterly from 1967:1 to 2008:2, and the figures plot, for the entire sample and for the subperiod 1984:1–2008:2, the correlation between real GDP<sub>t</sub> and M<sub>t</sub>. The three aggregates are the monetary base (sometimes denoted M0), M1, and M2. The post-1984 period is shown separately because 1984 often is identified as the beginning of a period characterized by greater macro-economic stability, at least until the onset of the financial crisis in 2007.



**Figure 1.1**  
Dynamic correlations, GDP<sub>t</sub> and M<sub>t+j</sub>, 1967:1–2008:2.

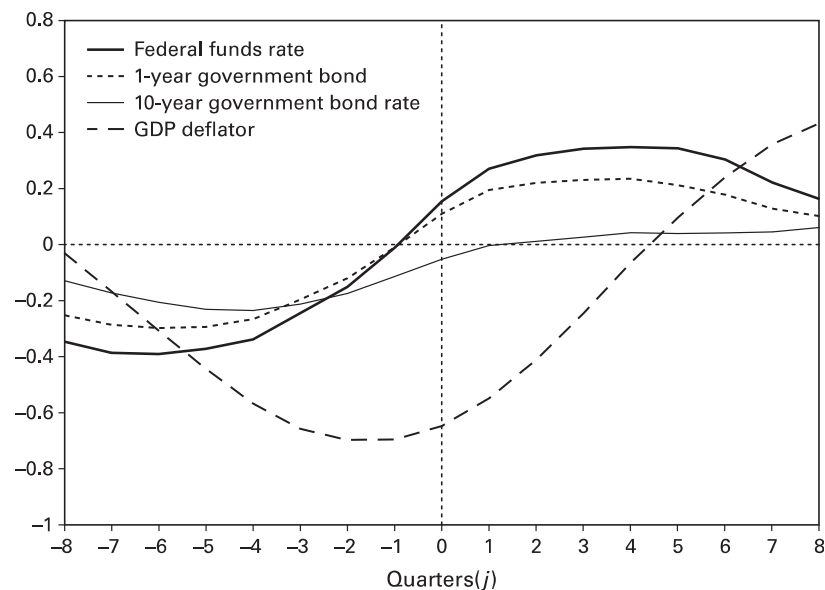


**Figure 1.2**  
Dynamic correlations, GDP<sub>t</sub> and M<sub>t+j</sub>, 1984:1–2008:2.

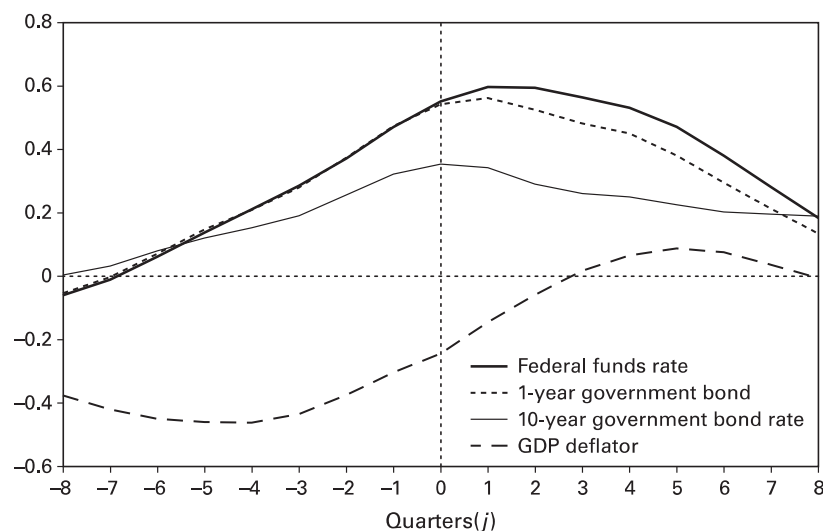
Source: Walls

As figure 1.1 shows, the correlations with real output change substantially as one moves from M0 to M2. M0 is positively correlated with real GDP at both leads and lags over the entire period, but future M0 is negatively correlated with real GDP in the period since 1984. M1 and M2 are positively correlated at lags but negatively correlated at leads over the full sample. In other words, high GDP tends to be preceded by high values of M1 and M2 but followed by low values. The positive correlation between  $GDP_t$  and  $M_t$  indicates that movements in money lead movements in output.

The larger correlations between GDP and M2 arise in part from the endogenous nature of an aggregate such as M2, depending as it does on banking sector behaviour as well as on that of the nonbank private sector. However, these patterns for M2 are reversed in the later period, though M1 still leads GDP.



**Figure 1.3**  
Dynamic correlations, output, prices, and interest rates, 1967:1–2008:2.



**Figure 1.4**  
Dynamic correlations, output, prices, and interest rates, 1984:1–2008:2.

Source: Walls

Figures 1.3 and 1.4 show the cross-correlations between detrended real GDP and several interest rates and between detrended real GDP and the detrended GDP deflator. The interest rates range from the federal funds rate, an overnight interbank rate used by the Federal Reserve to implement monetary policy, to the 1-year and 10-year rates on government bonds. The three interest rate series display similar correlations with real output, although the correlations become smaller for the longer-term rates. For the entire sample period (figure 1.3), low interest rates tend to lead output, and a rise in output tends to be followed by higher interest rates. This pattern is less pronounced in the 1984:1–2008:2 period (figure 1.4), and interest rates appear to rise prior to an increase in detrended GDP.

In contrast, the GDP deflator tends to be below trend when output is above trend, but increases in real output tend to be followed by increases in prices, though this effect is absent in the more recent period. This pattern seems consistent with demand shocks playing an important role in accounting for short-run fluctuations and supply shocks playing a more important role in the long-run behavior of output and prices.

## INDIVIDUAL COUNTRIES' MONETARY AGGREGATES COMPARISON

When striving to conduct such an analysis, we need to accommodate monetary aggregates from different countries to those M0, M1 and M2 used in the original research by Walls. Then, we will be ultimately able to test the behaviour of these variables. As countries use several criteria to organize their monetary aggregates, we will first look into the details of each studied country. Once observed them, we will accommodate their figures to Walls's.

As discussed above, there are various criteria which can be used to define and classify monetary aggregates. We will now summarize them in the following categories:

### 1. Degree of liquidity

Financial assets with high liquidity are included in narrower measures, whereas financial assets with lower liquidity are included in broader measures.

### 2. Size of the denomination or minimum deposits

Financial instruments requiring small denominations or low minimum levels are in narrower measures, on the assumption that these tend to be held by households. Financial instruments requiring large denominations or high minimum levels are in broader measures or not included at all. For example, U.S. small time deposits and retail money market mutual funds (MMMFs) are included in M2, while large time deposits and institutional MMMFs are excluded.

### 3. The original maturity of the deposits

Maturity may not matter at all, as in the United States. However, some countries place deposits with short original maturities in narrower money. The ECB, puts savings redeemable up to three months and time deposits with agreeable maturity up to two years in M2, but excludes savings and time deposits with longer maturities from each of its three monetary aggregates.

### 4. The types of financial institutions

In most cases, deposits with commercial banks are in narrower money than those with non-bank depository institutions, while deposits with other non-depository financial institutions, such as post offices and life insurance companies, are either excluded or included only in broad money. For example, all deposits at post offices are only in money broader than M2 in Japan.

However, individual central banks usually use only some of these criteria to define their monetary aggregates. The similarities and differences among the monetary aggregates for individual countries are summarized below.

- The composition of M1 for all countries is essentially the same. In other words, M1 consists of currency and demand and other checkable deposits held by money holders.
- The composition of monetary aggregates broader than M1 varies substantially. The variations mainly result from emphasis on different criteria for money definitions. The compositions of monetary aggregates classified entirely based on term of maturity are very different from those classified solely according to types of money issuers. Nonetheless, savings deposits and most time deposits are generally included in M2.
- Variations among monetary aggregates also arise from differences in scopes of financial instruments, money issuers, and money holders being included in money. These differences are mostly owing to an inclusion or exclusion of money market mutual funds (MMMFs), foreign currency denominated deposits, central government deposits, deposits at central banks, non-bank deposits at depository institutions and at non-depository institutions, and short-term borrowings.

### **The Monetary Aggregates in the EMU**

The defined monetary aggregates are M1, M2 and M3. Money issuers are monetary financial institutions (MFIs) and central governments (CGs) located in the EMU. MFIs include the Eurosystem, resident credit institutions, all other resident financial institutions, and money market funds. On the counterpart, money holders are private non-MFI residents in the EMU.

Savings deposits and time deposits are classified by terms of maturities with savings redeemable at a period of up to 3 months and time deposits maturing up to 2 years being included in M2. Deposits with ECB, CGs, and deposits denominated in foreign currencies held by money holders are included in each aggregate. MMMFs, repurchase agreements (RPs), and debt securities issued with a maturity of up to 2 years held by money holders and issued by MFIs in the Euro area are included only in M3.

Currency in circulation (issued by MFIs in the EMU) is entirely included in the monetary aggregates, irrespective of whether it is held by residents or non-residents in the EMU. However, holdings by foreign residents of deposits with MFIs in the EMU, MMMFs issued by money market funds in the EMU, and debt securities issued by MFIs located in the EMU are excluded from the EMU monetary aggregates.

## **Composition and Definition of Monetary Aggregates in the EMU**

<b>Components of Major Aggregates</b>	<b>Definition of Each Component</b>
<b>M1 (Narrow Money)</b>	Sum of the following two components.
(1) Currency in Circulation	Notes and coins issued by money issuers held by private non-MFI residents located in and <b>outside</b> the EMU.
(2) Overnight and Similar Deposits	Deposits which can be converted into currency or used for cashless payments.
<b>M2 (Intermediate Money)</b>	M1 plus non-M1 component of M2.
<b>Non-M1 Component of M2</b>	Sum of the following two components.
(1) Short-term Saving Deposits	Deposits redeemable at a period of notice up to 3 months.
(2) Short-term Time Deposits	Deposits with an agreeable maturity of up to 2 years.
<b>M3 (Broad Money)</b>	M2 plus marketable instruments issued by MFIs.
<b>Marketable Instruments Issued by Monetary Financial Institutions (MFIs)</b>	Sum of the following three components.
(1) Money market fund shares and units (MMMFs)	Excluding shares and units held by MFIs, CGs, and non-euro area residents.
(2) Repurchase Agreements (RPs)	RP liabilities of the MFIs with the money-holding sector
(3) Debt securities with an original maturity of up to 2 years	Liabilities of MFIs held by the money-holding sector

**Source:** Yueh-Yun C. O'Brien

### **The Monetary Aggregates in the United States**

The defined monetary aggregates are M1 and M2. Money issuers are depository institutions, Federal Reserve Banks for currency, and U.S. Treasury for coins. On the other hand, money holders consist of private non-depository sector.

Time deposits are classified based on sizes of denominations with denomination less than \$100,000 (called small time deposits) being included in M2. Time deposits with denominations at least \$100,000 (called large time deposits) are excluded from both monetary aggregates.

Money market mutual funds (MMMFs) are classified by holders' characteristics with those held by individuals/households being included in M2. MMMFs held by institutions generally require large minimum balances and they are excluded from both monetary aggregates. Foreign currency denominated deposits, as well as repurchase agreements (RPs) are excluded from M1 and M2.



### **Composition and Definition of U.S. Monetary Aggregates**

<b>Components of Major Aggregates</b>	<b>Definition of Each Component</b>
<b>M1</b>	Sum of the following four components.
(1) Currency Component	Currency outside the U.S. Treasury, Federal Reserve Banks, and the vaults of depository institutions.
(2) Demand Deposit Component	Demand deposits at commercial banks (excluding those amounts held by depository institutions, the U.S. government, and foreign banks and official institutions) less cash items in the process of collection (CIPC) and Federal Reserve float.
(3) Other Checkable Deposits (OCD)	Including negotiable order of withdrawal (NOW) and automatic transfer service (ATS) accounts at depository institutions, credit union share draft accounts, and demand deposits at thrift institutions.
(4) Non-bank Traveler's Checks	Traveler's checks issued by non-depository institutions.
<b>M2</b>	M1 plus non-M1 component of M2.
<b>Non-M1 Component of M2</b>	Sum of the following three components.
(1) Saving Deposits	Including money market deposit accounts (MMDA), but excluding those held by the U.S. government.
(2) Small-denomination Time Deposits	Time deposits in amounts of less than \$100,000, less individual retirement account (IRA) and Keogh balances at depository institutions.
(3) Retail Money Market Mutual Funds (MMMFs)	Excluding those held in IRA and Keogh accounts.
<b>Institutional MMMFs <sup>2</sup></b>	

**Source:** Yueh-Yun C. O'Brien

### **Summary of Japanese Monetary Aggregates**

Defined money stock statistics are M1, M2 and M3. Classifications of money categories are based more on the types of money issuers than on degree of liquidity. There is no distinction for term of maturity for time deposits. The deposit money component of M1 includes savings deposits and deposits at notice with banks, along with highly liquid checking accounts with banks. Foreign currency denominated deposits are excluded from M1, but included in all other broader aggregates.

M2 includes M1 plus quasi-money (time deposits, fixed savings, instalment savings, and non-resident Yen deposits and foreign currency deposits at M2 depository corporations) issued by M2 depository corporations. The non-M2 component of M3 includes checking accounts, savings deposits, time deposits, and non-resident Yen deposits and foreign currency deposits, etc. with M3 depository corporations.

Money issuers of M1 or M2 are Bank of Japan for notes and coins (in practice, coins are issued by central government), domestically licensed banks, foreign banks in Japan, Shinkin banks, Shinkin Central Bank, Norinchukin Bank, and Shoko Chukin Bank. Finally, money issuers of non-M2 component of M3 are Japan post, credit cooperatives, Shinkumi Federation Bank, Labor Credit Associations, Agricultural Cooperatives, Credit Federations of Agricultural Cooperatives, Fishery Cooperatives, Credit Federations of Fishery Cooperatives, and trust accounts of domestically licensed banks.

### **Composition and Definition of Japanese Monetary Aggregates**

<b>Components of Major Aggregates</b>	<b>Definition of Each Component</b>
<b>M1</b>	Sum of the following two components.
(1) Cash Currency in Circulation	Banknotes and coins
(2) Deposit Money	Demand deposits (excluding non-resident yen deposits and foreign currency deposits) minus checks and notes held by M2 depository corporations.
<b>M2</b>	M1 plus the following component.
(1) Quasi Money	Time Deposits + Fixed Savings + Instalment Savings + Non-resident Yen Deposits + Foreign Currency Deposits at banks.
<b>M3</b>	M2 plus the following three components
(1) Deposits of Post-Offices	Ordinary deposits, cumulative deposits, fixed amount deposits, time deposits, and post giro.
(2) Other Savings and Deposits with Money Issuers of M3 Components	Deposit money + regular savings + instalment savings + non-resident yen accounts + foreign currency deposits
(3) Money Trusts	Trust accounts of domestically licensed banks, excluding investment trusts, pension trusts, etc. Trust accounts of foreign banks are excluded.

**Source:** FRED

### **The Monetary Aggregates in the United Kingdom**

The defined monetary aggregates are M1, M2 and M3. Money issuers are monetary financial institutions (MFIs) and the Bank of England (BoE). MFIs include resident credit institutions, all other resident financial institutions, and money market funds. On the counterpart, money holders are private non-MFI residents in the United Kingdom.

M1 includes notes and coin in circulation with the public, private sector non-interest-bearing sterling sight bank deposits, and private sector interest-bearing sterling sight bank deposits.

Savings deposits and time deposits are classified by terms of maturities with savings redeemable at a period of up to 3 months and time deposits maturing up to 2 years being included in M2. Foreign currency deposits of private or public sectors, as well as private sector sterling time bank deposits with a maturity of over two years, are included in M3. MMMFs, RPs, and debt securities area are included only in M3.

### **Composition and Definition of U.K. Monetary Aggregates**

<b>Components of Major Aggregates</b>	<b>Definition of Each Component</b>
<b>M1</b>	Sum of the following two components.
(1) Notes and Coin in Circulation	Banknotes and coins
(2) Sight and Similar Deposits	Private sector interest and non-interest-bearing sterling sight bank deposits.
<b>M2</b>	M1 plus the following component.
(3) Short-Term Saving Deposits	Deposits redeemable at a period of originally up to 3 months.
(4) Short-Term Time Deposits	Deposits with an original agreeable maturity of up to 2 years.
<b>M3</b>	M2 plus the following three components
(5) Foreign Currency Deposits	Foreign currency deposits of private or public sectors.
(6) Long-Term Time Deposits	Private sector sterling time bank deposits with a maturity of over two years.
(7) Repurchase Agreements, Debt Securities and MMMFs	Excluding assets held by non-UK residents and liabilities of the MFIs held by the money-holding sector.

**Source:** Bank of England

After a sharp analysis about the monetary aggregates from our four central banks, we have summarized the main issues in the following graph. We have also inserted Walls' monetary aggregates grouping method, so as to compare with the already mentioned.

### **Monetary Aggregates Containing Components**

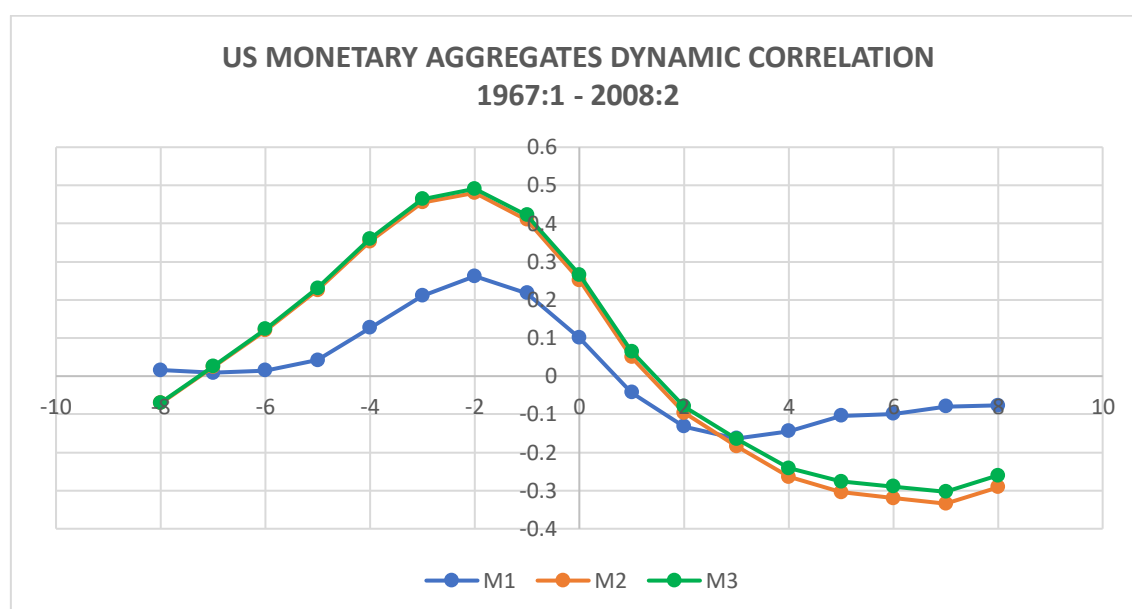
	<b>Currency</b>	<b>Demand Dep.</b>	<b>Savings Dep.</b>	<b>Time Dep.</b>	<b>MMMFs</b>	<b>RP</b>	<b>Debt Securities</b>	<b>Foreign Currency Dep.</b>
<b>EMU (ECB)</b>	M1	M1	M2	M2	M3	M3	M3	M1, M2 & M3
<b>EEUU (Fred)</b>	M1	M1	M2	M2	M2			
<b>Japan (BoJ)</b>	M1	M1	M2	M2				M2, M3
<b>UK (BoE)</b>	M1	M1	M2	M2	M3	M3	M3	M3
<b>Walls</b>	M0	M0	M1	M1	M2	M2	M2	

Conclusively, we can confirm that the main components of the aggregates coincide between the main money stock groups. We observe disparities between the EMU and EEUU in terms of MMMFs, as well as in terms of Foreign Currency Deposits concerning nearly all the studied central banks. Nevertheless, we will omit the above dissimilar factors from our analysis due to the negligible weight which they represent within the whole monetary aggregate group. Thereafter, along the following analysis, we assume that within our chosen countries, M1, M2 and M3, coincide with Walls' M0, M1 and M2 magnitudes.

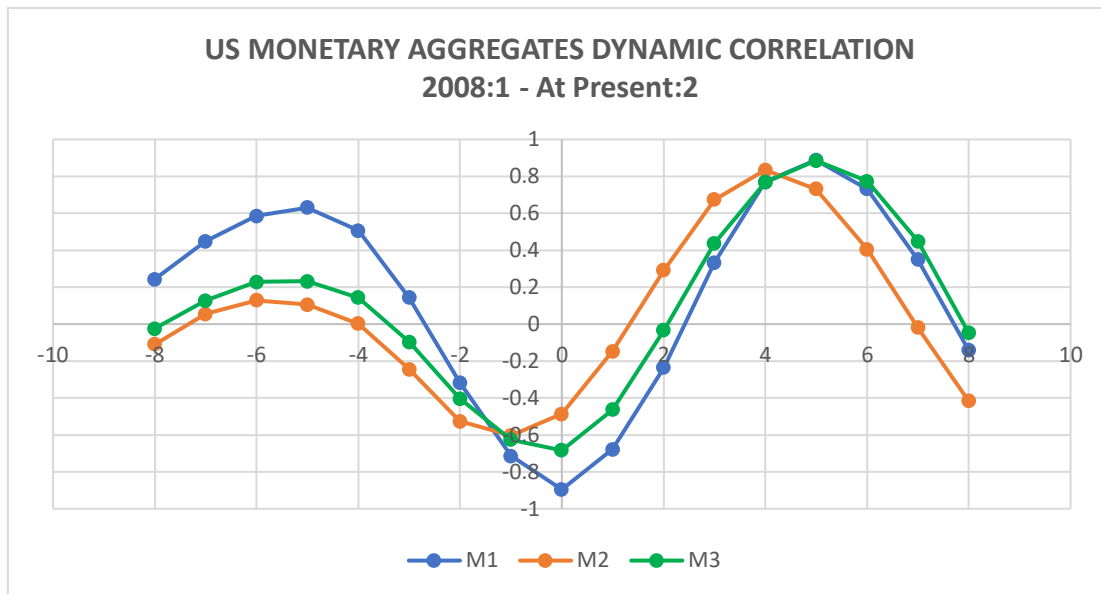
## RECONSTRUCTED FIGURES

Along this section, have built up short-term correlations of GDP to monetary aggregates, GDP deflator, 1-year bonds and 10-year bonds. We employed quarterly data, differentiating the analysis in two stages: before and after the 2008 Great Recession. That is, the first stage extends until the second quarter of 2008 and the second one begins in the first quarter of 2008. Some sample periods are not equal amongst all countries due to lack of data availability, nevertheless, we have adapted the sample periods so that the comparison is possible and consistent.

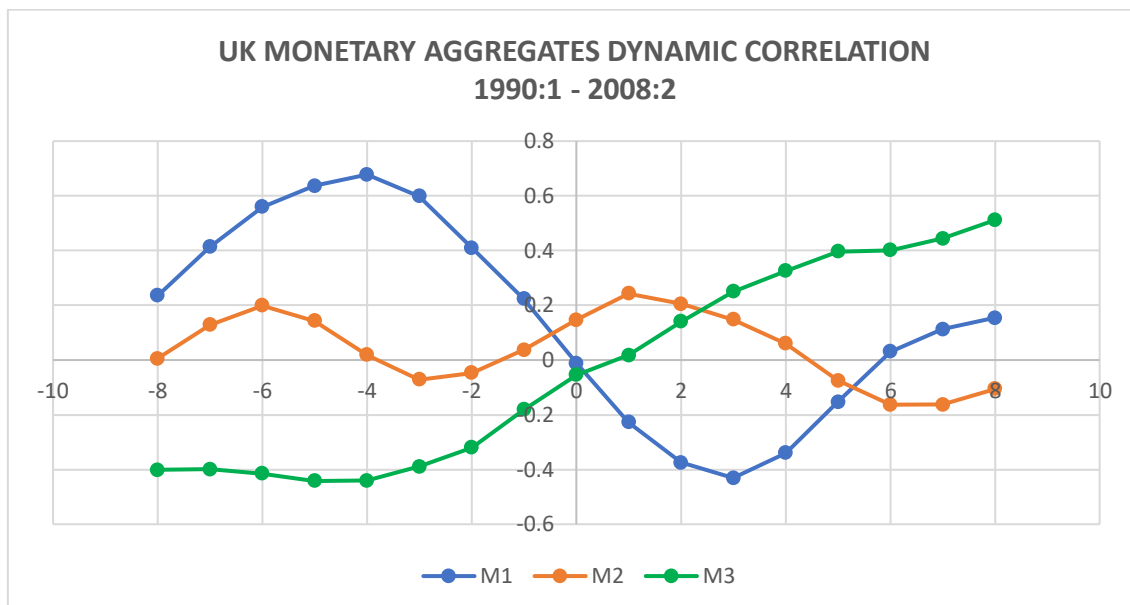
We need to take into account that short-term variations change from one country to another. This is due to the fact that different central banks implement distinct policies over time in every country, since sources of economic disturbances vary. The following graphs provide some evidence on the short-term correlations for the United States, United Kingdom, Japan and the Eurozone.



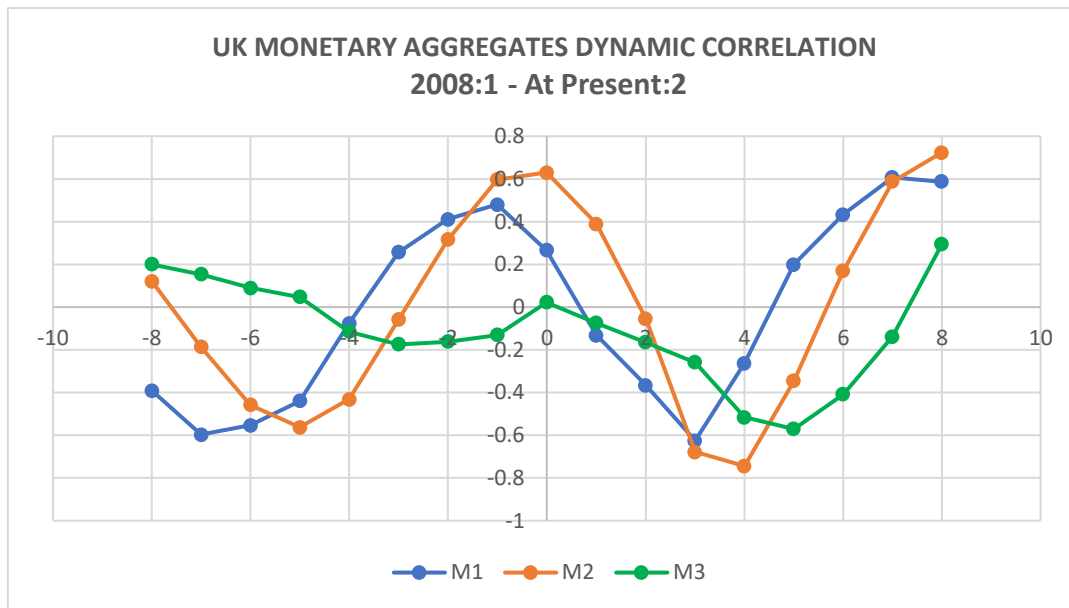
Correlation is very significant in M2 and M3, and less but still significant in M1 along the 6 months prior to the changes experienced by the GDP magnitudes in period 0. On the other hand, what happens to GDP in period 0, affects monetary aggregates M2 and M3 a year and a half later.



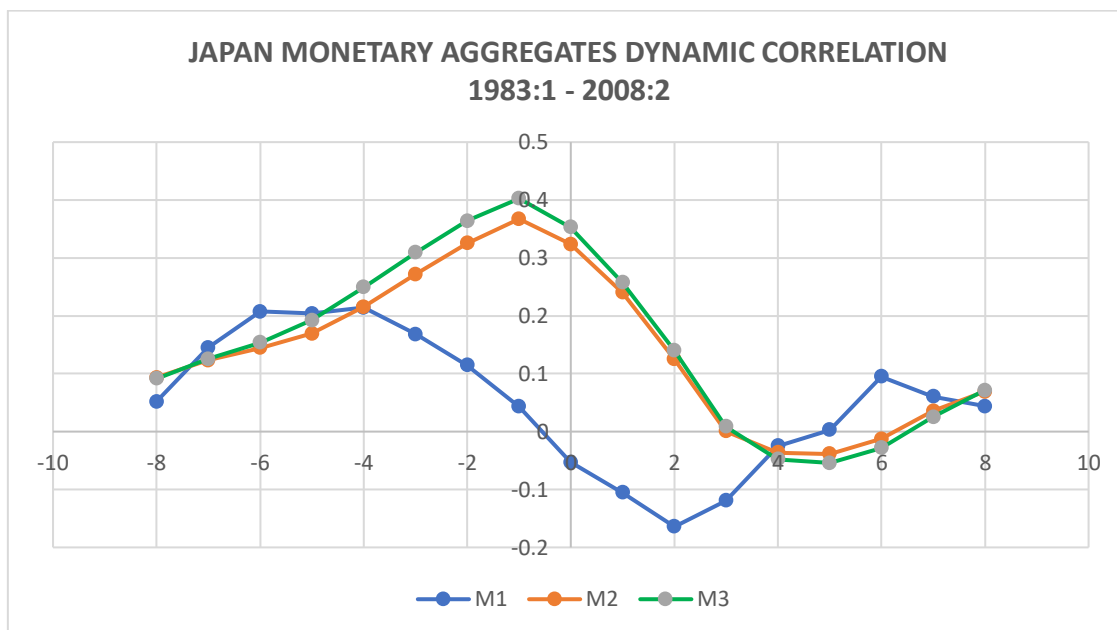
Taking into account the shape of at the figure, we instantly notice that correlations with all three monetary aggregates are very significant, both positively and negatively. Taking the data into account, we cannot conclude if it is the GDP what explains the behaviour of monetary aggregates or vice versa.



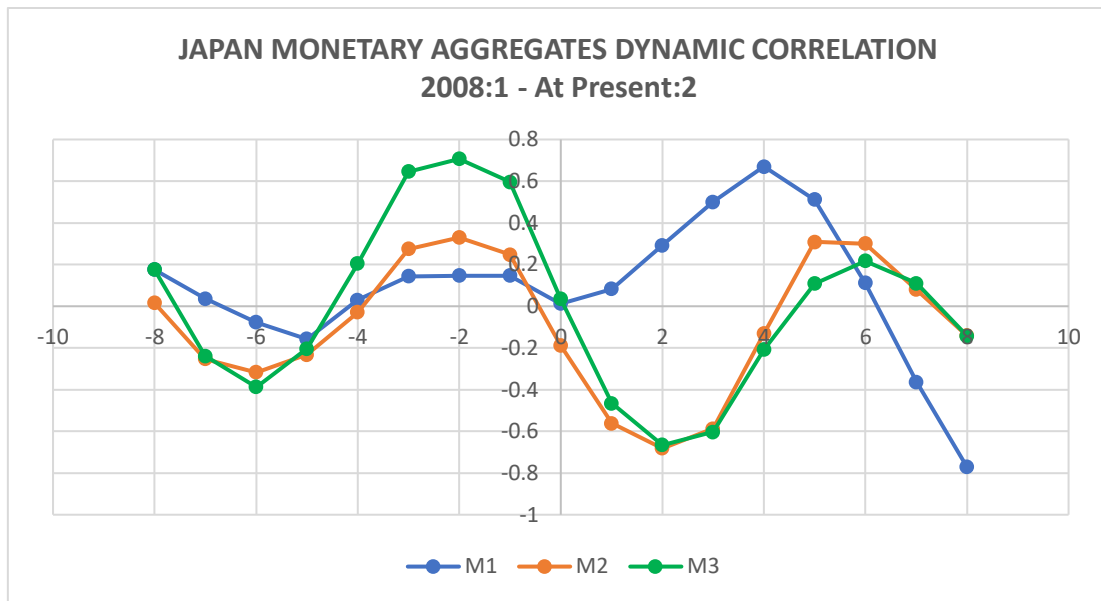
Unlike US, UK's M2 is not significant in any period. This implies that GDP movements nearly do not affect M2. On the other hand, M1 and M3 are both significant. What happens to GDP in period 0, depends highly on how the M1 behaved on the previous year. At the same time, GDP variations in period 0 affect the M3 year and a half later.



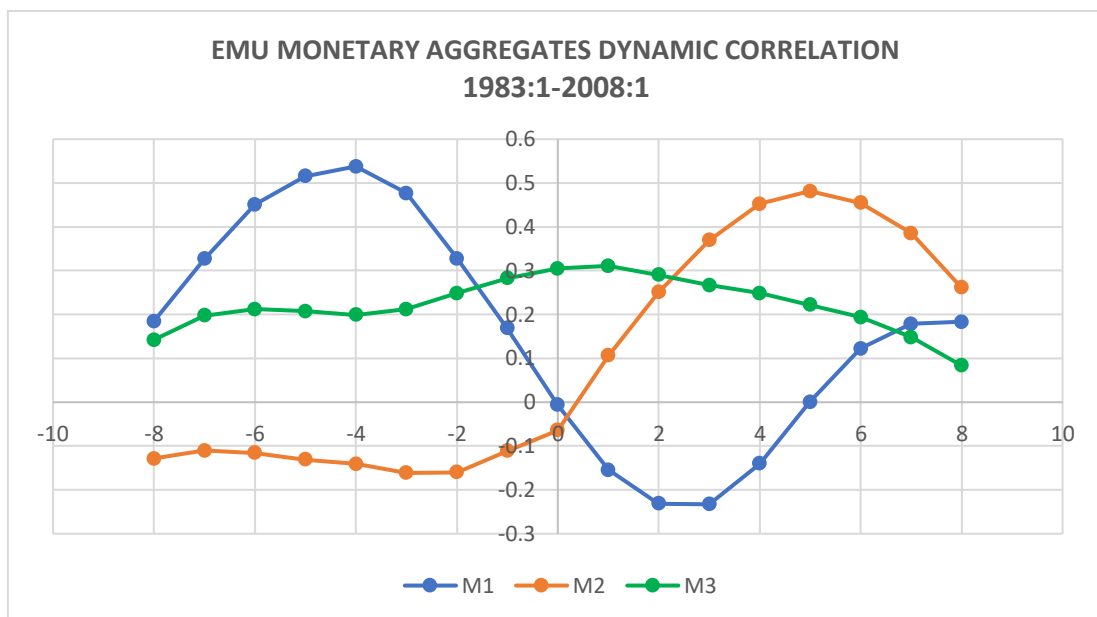
This figure highlights the speed with which monetary aggregates fluctuate. It takes almost a year to reverse their relationship with GDP. Since the changing periods are so short, it is not easy to acknowledge if the money movements lead to movements in production or vice versa.



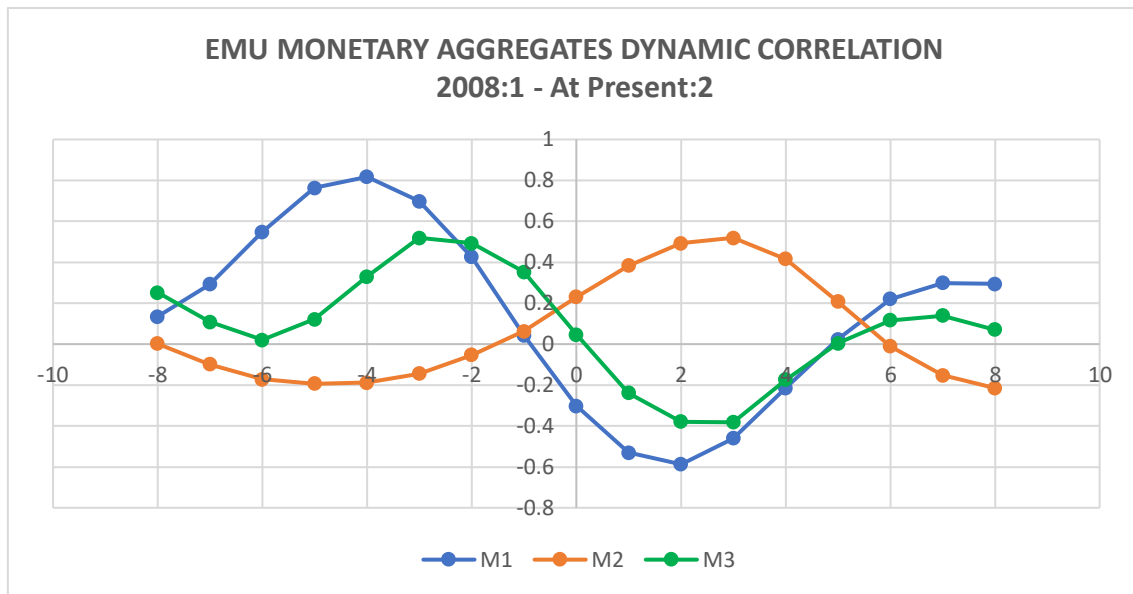
Alterations of Japanese GDP in period 0 depend on the movements of the M2 and M3 taken place three months earlier. In period 8, we observe that the monetary aggregates' movements are negligibly related to what happened previously with the GDP.



Following the dynamics from previous graphs covering the 2008 period onwards, there is no sufficient evidence to make solid conclusive arguments about the relationship between GDP and monetary aggregates. Fluctuations occur in a very short period of time and with very high correlations.

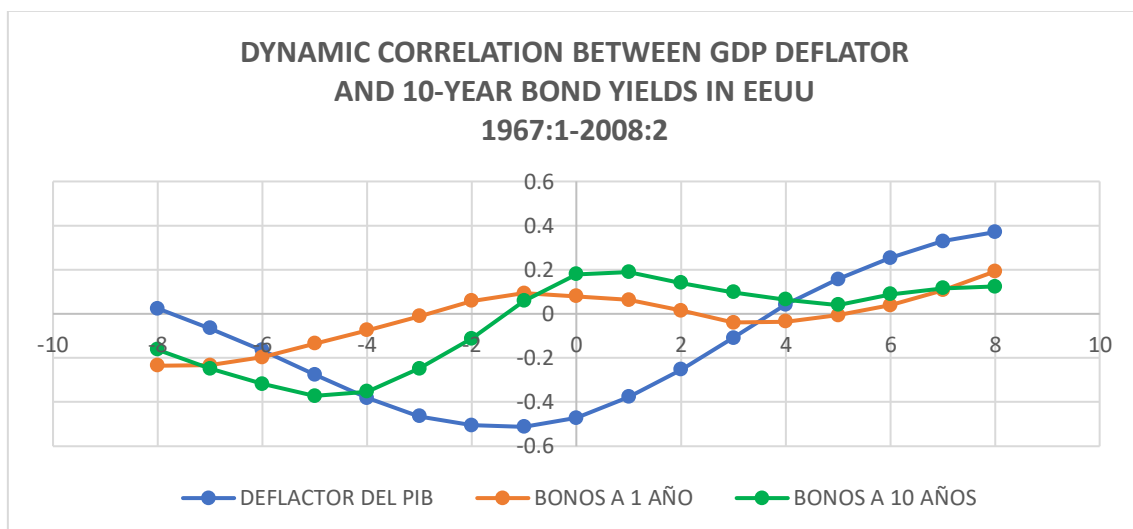


M3 is significantly correlated with GDP in period 0. On the other hand, M2 has no correlation with GDP fluctuations in prior to period 0 periods. Nonetheless, it has indeed in subsequent periods one year later.



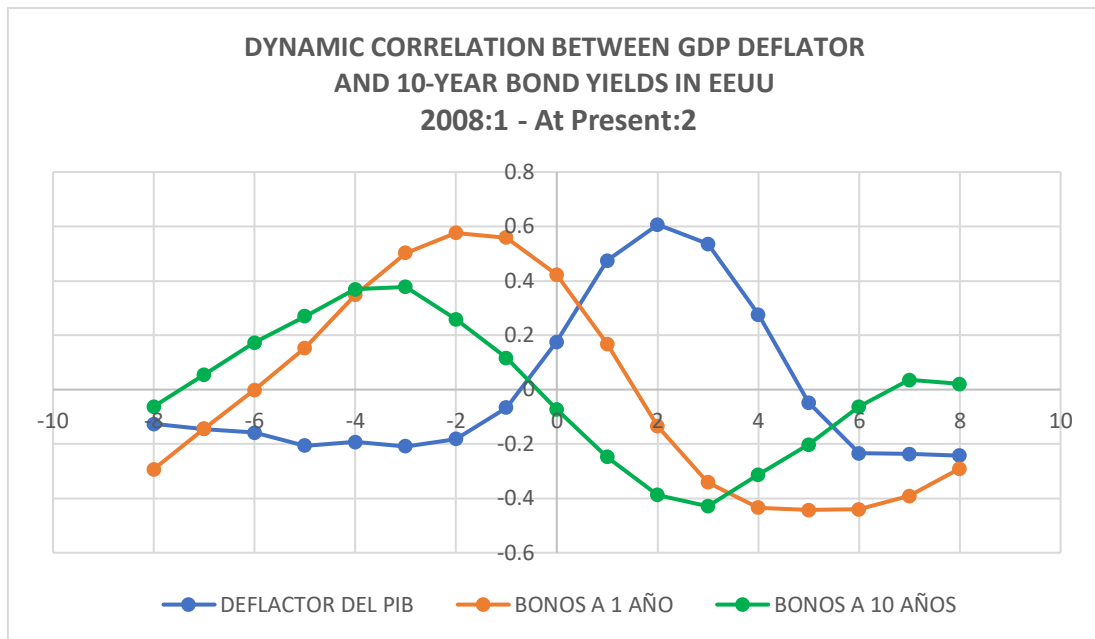
We observe that also in the euro zone, correlations have very high values, hindering the understanding about whether it is the movements of money which explain the movements of production or vice versa.

The following graphs illustrate the short-term correlations in the United States, United Kingdom, Japan and the Eurozone. The figures show correlations between the real GDP trend record and the GDP deflator; and 10-year bonds, each also in the form of a trend record.

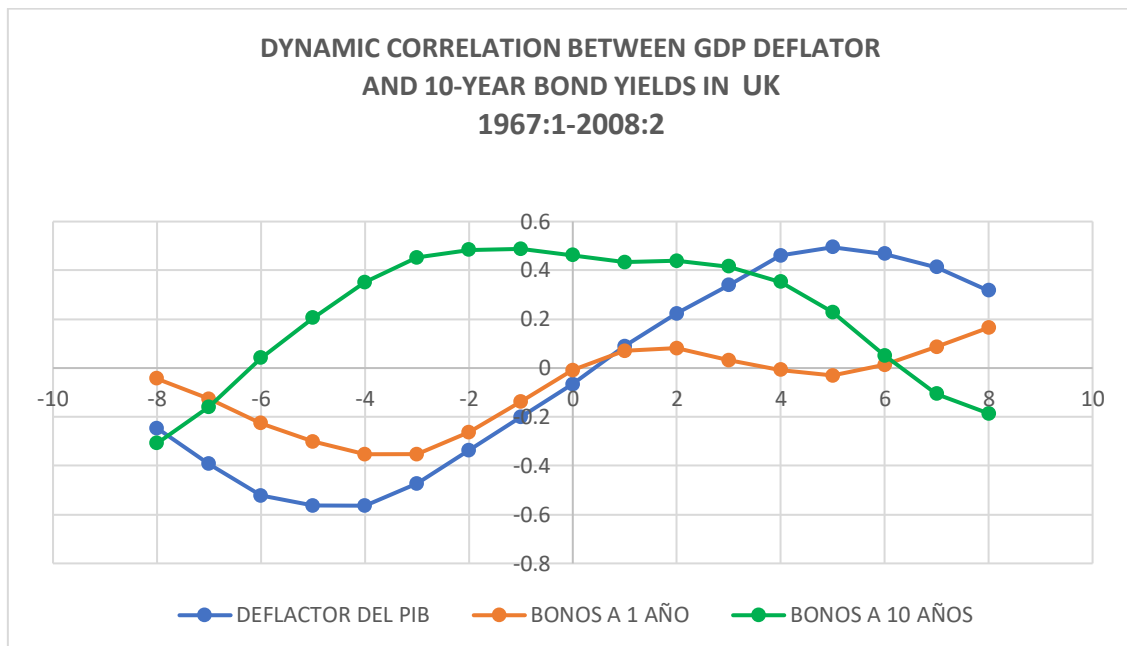


Our GDP deflator follows a countercyclical trend with respect to GDP. Bonds, for its part, follow a similar trend, although longer-term rates depend slightly more negatively on GDP.

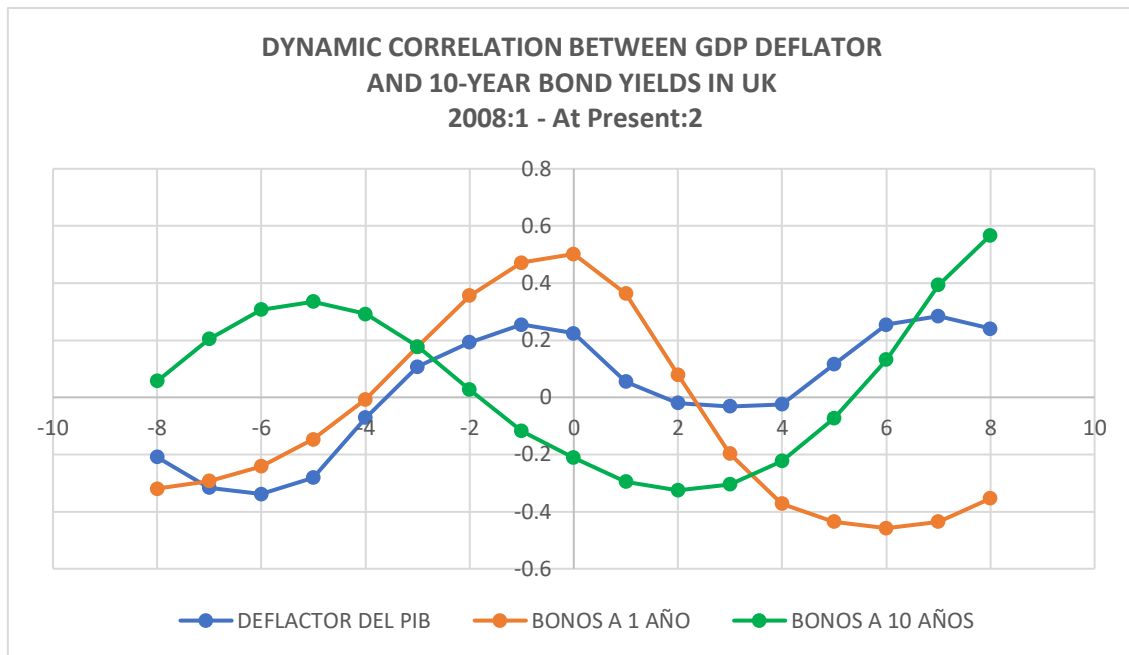




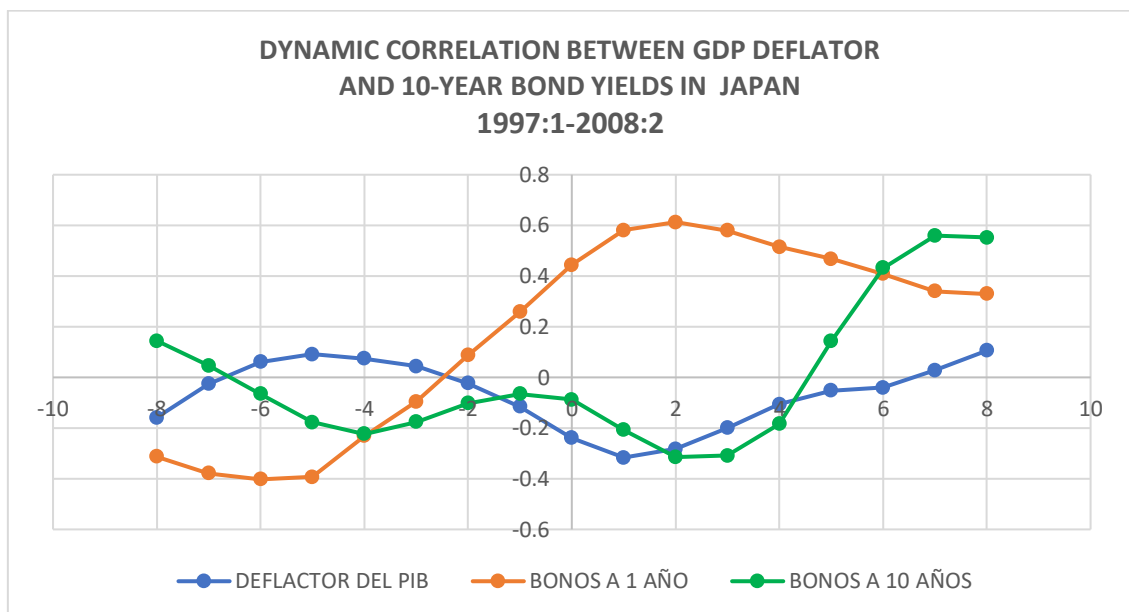
We observe how the correlations of both bonds and deflator reflect quite high positive values, with significant magnitudes in several periods of time both positively and negatively. Therefore, taken this data into account, we can also conclude that it is not clear which one is the causal variable.



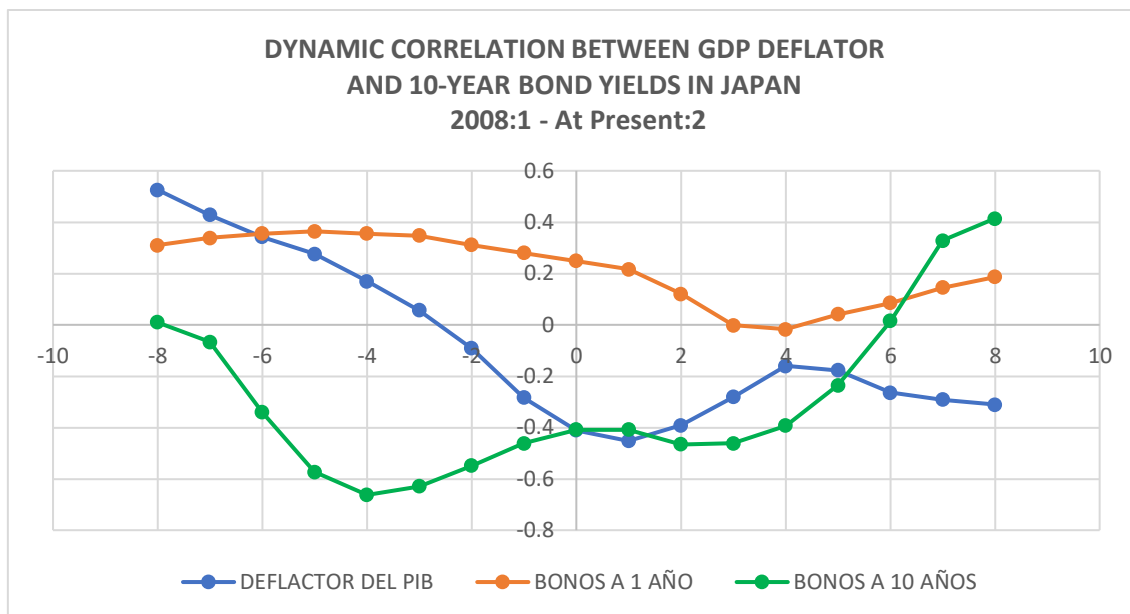
This figure exhibits how one year before period 0 we observe a significant correlation for both the 10-year bonds and the GDP deflator, and a slightly significant correlation for the 1-year bonds. 10-year bonds follow a procyclical trend with respect to GDP, and the 1-year bonds, just as the deflator, follow a countercyclical trend. A year after period 0, we also see how the GDP deflator remains significant with a procyclical trend.



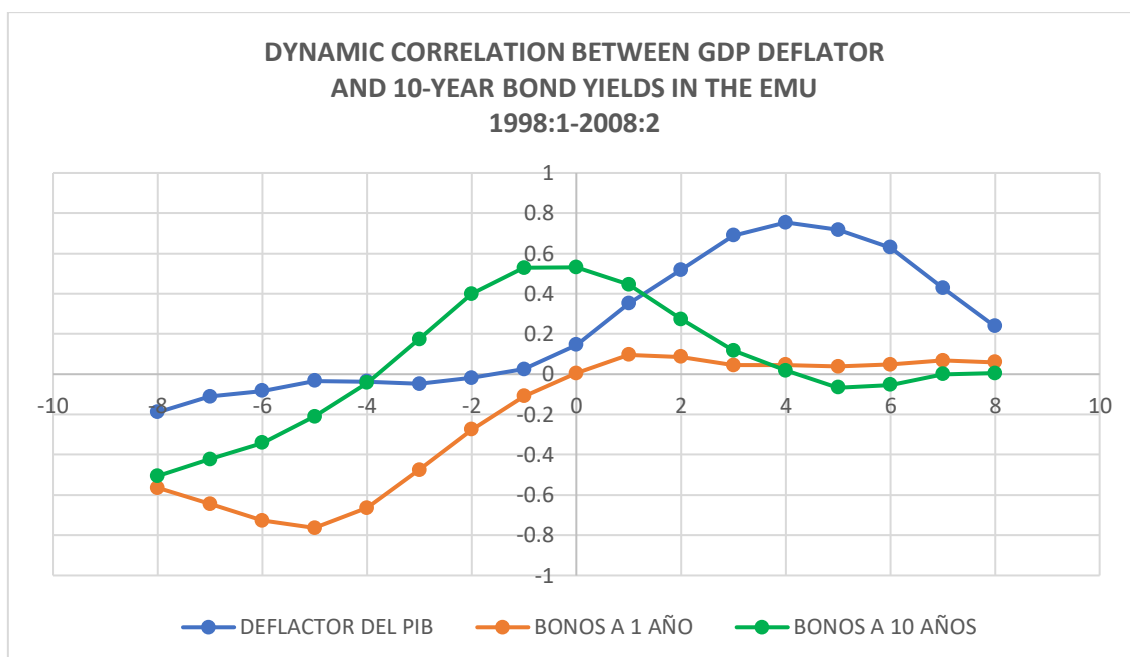
Correlations drawn in this graph do not follow high trends compared to the same period graph for the United States, where no clear causality can be determined. Back in the UK, all correlations collected neither show exactly which movements explain the rest, since the values get reversed very erratically in time.



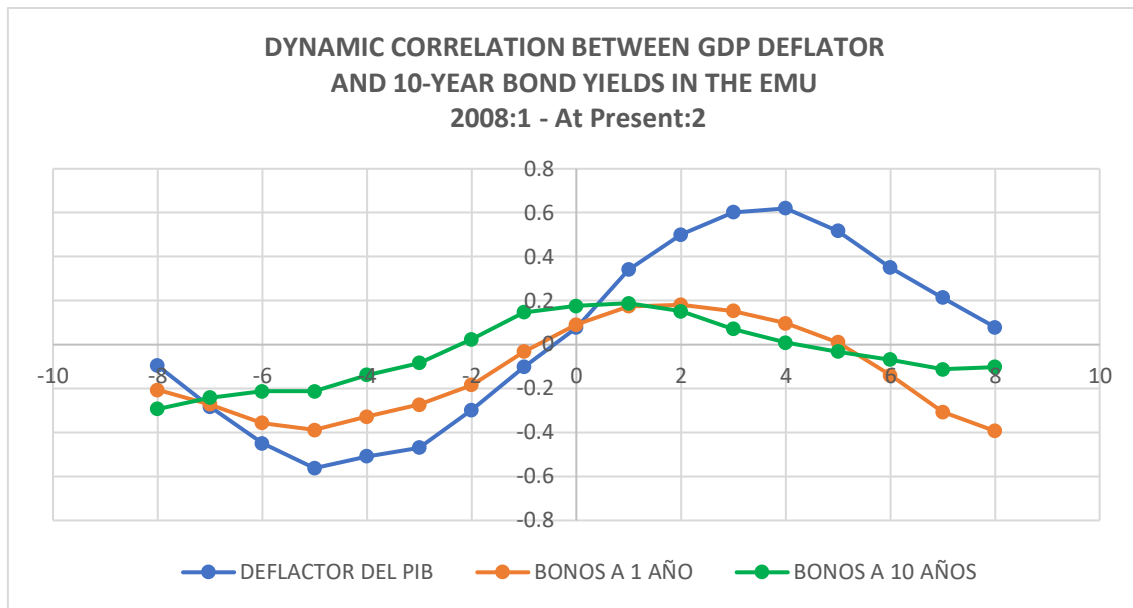
Japan exhibits how, a year and a half before period 0, the only variable achieving a significant correlation is the 1-year bond. This correlation is negative and therefore follows a countercyclical trend. After period 0, all variables reflect a certain significance at some period, highlighting the positive significance of 1-year bonds in period 2.



With regard to the dynamic correlation in Japan, we appreciate how the variables' significance extends over most periods, including quite significant values (although not excessively high). Therefore, we still cannot state solid conclusions about causality.



In this graph, the limited extension of our sample period may partly explain higher than usual values. Nevertheless, we observe that, prior to period 0, the only significant variable are 1-year bonds, which follow a countercyclical trend. After period 0, it is the GDP deflator what picks up a fairly high significance and follows a cyclical trend in period 4.



With this last figure, we observe that in the Eurozone, a year and a half prior to the period 0, we can collect as significant variables 1-year bonds and GDP deflator, where both follow a countercyclical trend. This trend is reversed 2 periods after period 0 where 1-year bonds are not significant but the GDP deflator is.

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