Business Cycles Under Monetary Union: EU and US Business Cycles Compared

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Abstract: In discussions of the likely implications for Europe of EMU, the United States is often cited as an *example* of a monetary union, while the United States' central bank, the Federal Reserve System, is cited as a *model* for how a central bank would function in a monetary union. While the costs and benefits of monetary union in Europe have been subject to a lot of debate, we focus on a potential set of costs and benefits that seem to have received relatively little attention in the existing literature. Specifically, we ask what are the likely benefits to Europe in terms of business cycle stabilization or synchronization from monetary union. We compare the business cycle properties of the fifteen EU countries that are potentially eligible for membership in EMU with the properties of the 12 Federal Reserve districts in the U.S.

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1. Introduction

In discussions of the likely implications for Europe of economic and monetary union (EMU), the US is often cited as an *example* of an enduring monetary union, while the US central bank, the Federal Reserve System, is cited as a *model* for a central bank in a monetary union. While the costs and benefits of monetary union in Europe have been subject to a lot of debate, we focus on a potential set of costs and benefits that seem to have received relatively little attention in the existing literature. Specifically, we ask what are the likely benefits to Europe in terms of business cycle stabilization or synchronization from monetary union. We address this question by comparing the characteristics of the business cycle in the fifteen countries that are (at least technically) eligible for membership in EMU with the characteristics of the business cycle in the 12 Federal Reserve districts in the US.

The practice of looking to the experience of the US to obtain insights into the problems and functioning of a monetary union has a long precedent in the literature on fixed exchange rates in general and in the literature on EMU in particular. For example, in making an argument for fixed exchange rates that builds on the analysis of Wallace (1979), Rolnick and Weber (1994) note that the United States can be viewed as having a system of fixed exchange rates between currencies issued by the twelve regional federal reserve banks. The key point they argue is that the notes issued by the twelve banks are not strictly the same, and that the difference between the notes creates the possibility that the US could have a system of floating exchange rates between the twelve Federal Reserve districts.[2] Rolnick and Weber go on to examine the features of the relationship between the twelve regional Federal Reserve Banks in the US that make a system of fixed exchange rates between them feasible, in the process drawing lessons for how a monetary union among the countries of the European Union (EU) might work. Rolnick, Smith and Weber (1994) examine the factors surrounding the creation of the monetary union in the US. Prior to the adoption of the US Constitution there were a variety of state-issued monies circulating in the US and the exchange rates between these monies fluctuated to varying degrees. The

[2]We might note, however, that many of the physical differences between the notes issued by the twelve regional Federal Reserve Banks are in the process of being eliminated as the currency is redesigned, starting with the $100 bill issued in early 1996. Specifically, the new notes will no longer have the seal of individual Federal Reserve Banks but rather a new universal seal representing the entire Federal Reserve system.

Constitution made the issuing of money the exclusive right of the federal government and created the monetary union between the states that persists (except for a brief period in the nineteenth century) to this day.

The US experience has been drawn on for insights not just by analysts of the proposed monetary union in Europe, but also by the architects of that union. Thus the original plan for monetary union put forward in the Werner Report in 1970, which called for the completion of such a union by 1980, envisaged that monetary policy in the union would be conducted by a European Community system of central banks modeled on the US Federal Reserve System.

> "The constitution of the Community system for the central banks could be based on organisms of the type of the Federal Reserve System operating in the United States. This Community institution will be empowered to take decisions, according to the requirements of the economic situation, in the matter of internal monetary policy as regards liquidity, rates of interest, and the granting of loans to public and private sectors. In the field of external monetary policy, it will be empowered to intervene in the foreign exchange market and the management of the monetary reserves of the Community."(Werner, 1970, 13)

The Delors Report (1989) argued that "...the domestic and international monetary policy-making of the Community should be organized in a federal form, in what might be called a European System of Central Banks (ESCB). This new System...could consist of a central institution (with its own balance sheet) and the national central banks...The national central banks would be entrusted with the implementation of policies in conformity with guidelines established by the Council of the ESCB and in accordance with the instructions of the central institution." (Delors, 1989. 21).

It is worth noting that the US is not the only example of a monetary union from which insights can be had into the likely experience of the EU under EMU. Monetary unions of varying degrees of strength have existed between countries in Europe to a greater or lesser degree in the past. One of the oldest and longest running was that between Great Britain and Ireland which lasted from the Act of Union in 1800 until 1979. Belgium and Luxembourg have a *de facto* monetary union under which Belgian currency is legal tender in Luxembourg. A more recent example is the monetary and political union between West and East Germany which took effect in 1991. Finally the Netherlands and Germany have had a *de facto* monetary union since 1984.

However all of these examples differ in important respects from the proposed arrangement under EMU.

While Great Britain and Ireland did share a common currency from 1800 until 1922, and Ireland did not even have a central bank for the first 20 years of independence, the union between the two did eventually break down in the late 1970's because both countries retained authority over their monetary policies. Likewise there is nothing in the current German-Dutch union that mandates its persistence. The union between East and West Germany is a good model for EMU. The Bundesbank has a similar structure to the United States Federal Reserve System, but the monetary liabilities of the regional banks in Germany are not physically distinguishable.

The analysis in this paper complements a number of earlier analyses. The resurgence in interest in business cycle research over the past decade and a half has inevitably included analyses of international business cycles. Backus and Kehoe (1992) document the business cycle behavior of output, the price level and the money stock in ten countries over a one-hundred year period. Their choice of countries was dictated by data availability and included only five of the current fifteen EU members. Danthine and Donaldson (1993) document some stylized facts about the business cycle during the postwar period in a sample of OECD countries that also includes only five of the current EU members, while Fiorito and Kollintzas (1994) look at the behavior of the business cycle in the G7 countries. To date, the only attempt to examine and document the business cycle regularities in all of the member countries of the EU is Christodoulakis, Dimelis, and Kollintzas (1995). Their analysis is specifically intended to address concerns about the business cycle that might arise from increased integration between the member countries of the EU, and they look at the twelve countries that made up the EU prior to the most recent enlargement. They identify the critical question associated with greater integration as being "...whether the economies involved in the integration process appear to have a similar and synchronous response to shocks, or whether their cycles differ with regards to their intensity, duration and timing."(Christodoulakis, Demis and Kollintzas, 1995, 1). In what follows we will characterize the degree of synchronization between the cycles of the EU member countries and the US Federal Reserve Districts in terms of the extent to which these cycles are correlated with each other and have similar amplitude.

There is also a large literature on regional business cycles in the United States. Recent examples include Sherwood-Call (1988) and Browne (1992).[3] A contribution to the regional business cycle literature that is particularly relevant for the questions to be considered below is Tootell (1990). He examines the costs and benefits of monetary unification using a simple two-region model and draws on his model to obtain insights about exchange rate policy in the EU and the US. As part of his analysis he documents co-movements between real activity at the state level, the "optimal currency region" level and the Federal Reserve district level in the United States.[4] Tootell documents significant differences in the degree of synchronization in the cycle at the different levels of aggregation, emphasizing the importance of differences in the sectoral composition output in accounting for the asynchronicity. Most recently Carlino and Sill (1997) document business cycle patterns across eight Census regions of the United States using quarterly data on real per capita personal income for the postwar period.

In what follows we extend the existing analyses of the business cycle in the US and the EU along a number of dimensions. First, we look at the cycle in all 15 current members of the EU. Second, our measure of the cyclical component is based on the band pass filter proposed by Baxter and King (1995) and shown by them to have superior properties along a number of dimensions to the more widely used Hodrick-Prescott (1996) filter employed by Christodoulakis, Dimelis, and Kollintzas (1995) or the deterministic detrending employed by Tootell (1990).[5] Third, in our analysis of cycles in the US we analyze data at the level of Federal Reserve districts, rather than state or regional level. And fourth, we perform a comparative analysis, drawing out similarities and differences between the US and the EU.

Before proceeding we should note that questions about the nature of the business cycle in the EU are at the very heart of the debate over the feasibility of a monetary union between the member states. The logical point of departure for any discussion of a monetary union is the theory of optimum currency areas. Under one

[3]There is also a relatively comprehensive literature on convergence of income levels across regions of the United States which makes use of the long time series on personal incomes at the level of individual states. See for example Carlino and Mills (1993)

[4]Tootell defines optimal currency regions on the basis of the strength of the pairwise correlations between the cyclical components of activity in the states.

[5] We might also note that Stock and Watson (1997) use a band pass filter to characterize the business cycle properties of the major time series aggregates in the US for the postwar period.

definition a collection of countries or regions are said to constitute an optimal currency area if fixing the nominal exchange rate between the currencies issued by the countries or regions does not impose any real costs on them. This will be the case if either prices and wages are perfectly flexible, or factors are perfectly mobile. The point is that the discussion of the optimality of a currency area is in terms of response to the shocks that produce the fluctuations in economic activity that we refer to as business cycles.

A major feature of the proposed monetary union among the member countries of the EU is a central bank that will determine monetary policy for the participating countries and a common currency (the Euro) that will replace the national currencies of the participating countries. In a sense then the proposed institutional arrangement is not unlike that governing the process whereby monetary policy is made in the United States. The Federal Reserve System was designed in 1913 to diffuse power away from the East Coast and to give the different regions in the country a say in the setting of policy. Thus the system has twelve regional Reserve Banks, the presidents of which participate in monetary policy deliberations at FOMC meetings in Washington. In a sense, then, the United States experience might be taken as a model for what the countries of Europe might expect under complete monetary union. Of course the analogy is not perfect: the countries of Europe are sovereign nations, while the states that make up the twelve Federal Reserve districts are less at liberty to act independently of the Federal government.

2. Isolating the business cycle component of economic activity

To investigate the comparative behavior of business cycles in a monetary union we need an operational definition of the cyclical component of economic activity. Following Lucas (1977) we define the business cycle in terms of fluctuations around trend. This is the definition preferred by modern macroeconomists and is the definition most frequently employed in the empirical literature on business cycles.[6] We operationalize this definition by employing the band-pass (BP) filter proposed by Baxter and King (1995). This filter is shown by

[6]Note, however, that this is not the only way to define a business cycle. The older Burns and Mitchell (1946) inspired NBER definition of a cycle in terms of absolute declines in economic activity was widely used for a long time and still forms the basis for the influential NBER business cycle chronology for the United States. Milton Friedman's (1993) plucking model of the business cycle is based on this alternative view of business fluctuations.

Baxter and King to have all of the desirable characteristics of a filter intended to isolate the business-cycle component of an economic time series without many of the shortcomings of the more widely used Hodrick-Prescott (HP) filter.[7] The primary drawbacks of the HP filter are the unusual behavior of the isolated cyclical components near the end of the sample period and the problem of choosing the smoothing parameter, λ.[8] This parameter penalizes variation in the trend component of the time series and following the original contribution of Hodrick and Prescott is typically set at 1600 for quarterly data. This parameter does not have a very intuitive interpretation, and the difficulties are compounded when we have to work with data that are sampled less frequently than quarterly. Thus Backus and Kehoe (1992) set $\lambda = 100$ in their study of international business cycles using annual data, while Englund, Persson and Svensson (1992) set $\lambda = 400$ to isolate the cyclical component of economic activity in annual Swedish data. Baxter and King show that if the objective is to isolate in annual data fluctuations at the same frequency as those isolated by setting $\lambda = 1600$ in quarterly data, then a setting of $\lambda = 10$ is probably more appropriate.

The BP filter proposed by Baxter and king requires that we set three parameters, which they term "Up", "Down", and "K". The "Up" and "Down" parameters determine the highest and lowest frequencies passed by the filter. For quarterly data, Baxter and King recommend the values suggested by Burns and Mitchell's (1946) definition of the business cycle, specifically "Up"=6 and "Down"=32.[9] For annual data, the corresponding values would be "Up"=2, "Down"=8. Baxter and King show that if we accept the Burns and Mitchell definition of the business cycle, then the value of the λ parameter in the HP filter than comes closest to isolating these components of an annual time series is $\lambda = 10$, somewhat lower than the values used in

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[7]Additionally, the BP filter renders stationary time series that are integrated of order 2.

[8]The Hodrick-Prescott filter defines the cyclical component, y_t^c of a time series, y_t, as $y_t^c = ((\lambda(1-L)^2(1-L^{-1})^2)/(1+\lambda(1-L)^2(1-L^{-1})^2))y_t$ where L denotes the lag operator.

[9]Burns and Mitchell (1946) take as their point of departure the definition of the business cycle first proposed by Mitchell (1927), which stated that "...in duration business cycles vary from more than one year to ten or twelve years in duration..." (Mitchell, 1927, 468) In the course of their study Burns and Mitchell found that business cycles in the United States lasted a minimum of 17 months and a maximum of 101 months when measured peak to peak, or a minimum of 29 months and a maximum of 99 months when measured trough-to-trough (Burns and Mitchell, 1946, 371) This provides the basis for Baxter and King's recommendation for the values of the "Up" and "Down" parameters, specifically "Up"=6 and "Down"= 32 for quarterly data.

existing studies of annual data.[10]

Following Backus and Kehoe (1992) we estimate the correlation coefficients between the cyclical components of the various variables and the associated standard errors using Generalized Methods of Moments (GMM) estimation (see Hansen (1982), Ogaki (1993a,b)). The use of GMM allows us to obtain estimates of the standard errors of the coefficients that are corrected for autocorrelation and heteroskedasticity.

Our characterization of the co-movement of the cyclical components of economic activity in the EU and the US is based on an analysis of three major indicators of aggregate economic activity: total output, total employment and the price level. Our choice of indicators was constrained by the requirement that we be able to obtain comparable series for comparable sample periods for both the EU and the US. This constraint is particularly binding when it comes to data for the states in the US.

3. Business cycles in the EU

Aggregate output: Table 1a presents the pairwise correlations between the business cycle components of real GDP for the 15 EU countries and also for each country with the U.S., along with the percentage standard deviation of output in each country As we have already noted the business cycle component was defined using Baxter and King's band pass filter with Burns and Mitchell parameter settings "Up"=2, "Down"=8, and K=3. The countries are ordered alphabetically by date of joining the EU. Reading across the table we have the original six (Belgium, France, Germany, Italy, Luxembourg, Netherlands), next the three countries (Denmark, Ireland and U.K.) that joined in 1973, followed by the three (Greece, Portugal, and Spain) that joined in the 1980's and finally the most recent members (Austria, Finland and Sweden). The data in the Table is computed using a shorter sample than the maximum to facilitate comparison with the Gross State Product (GSP) data for

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[10]Burns and Mitchell had a very sophisticated view of the problems associated with isolating the cyclical component of a time series as the following quote indicates: "...the isolation of cyclical fluctuations is a highly uncertain operation. Edwin Frickey once diligently assembled 23 trend lines fitted by various investigators to pig iron production in the United States, and found that some of the trend lines yield cycles averaging 3 or 4 years in duration while others yield cycles more than ten times as long. This range of results illustrates vividly the uncertainty that attaches to separations of trends and cycles, though it perhaps exaggerates the difficulties. *If an investigator fits a trend line in a mechanical manner, without specifying in advance his conception of the secular trend or of cyclical fluctuations, he may get 'cycles' of almost any duration.*"(Burns and Mitchell, 1946, 37, emphasis added)

the U.S. The business cycle characteristics of the data are robust to our use of the shorter sample, with one or two minor exceptions.

A number of comments are in order. First note that we are able to reject the hypothesis that there is no pairwise correlation between the business cycle component of output for the original six. Every single one of the pairwise correlation coefficients is statistically significant at the 1% level, with the exception of Italy and Luxembourg. This is consistent with the hypothesis that business cycle co-movement was an important impetus pushing these countries to integrate in the first place, but also with the alternative hypothesis that the cycles in these countries have become more synchronized over time. Other evidence lends more support to the latter interpretation: a comparison of the correlation coefficients calculated using a longer sample which includes data from the 1950's reveals that in almost all cases the correlation coefficients are lower in the longer sample. Also, we will see that there is a much higher degree of synchronization of the business cycle across the twelve Federal Reserve districts in the US.

Second, note that there is a lot less correlation between the cycles of the countries that joined later, although we do see co-movement between countries that are geographically proximate (e.g. Denmark, Germany and the Netherlands, Austria, Germany and Italy, Finland and Sweden). Table 1a also gives the correlations between the cyclical component of aggregate output in the EU countries and the U.S. Output in the larger EU economies (Germany, France and UK) is more highly correlated with output in the US at the business cycle frequencies than is output in the smaller economies. Aggregate output in the UK has the highest correlation with US output, with a pairwise correlation coefficient of 0.67.

Finally, Table 1a reveals notable differences in the volatility of output across the member countries of the EU. The standard deviation of the cyclical components of output in the countries with the most volatility (Luxembourg, Portugal and Finland) is about two and a half times greater than the standard deviation of output in the countries with the lowest volatility (France and Austria). Averaged across the fifteen countries the standard deviation of the cyclical component of output is 1.62.

Employment: The correlations between the cyclical components of aggregate employment in the 15 EU countries are given in Table 1b. What strikes one immediately about this table is that employment is a lot less volatile at the business cycle frequencies in Europe than is output.[11] Whereas the standard deviation of the cyclical component of output averaged 1.62 across the 15 member countries of the EU, the standard deviation of employment averages only 0.89. Note also that there is less correlation between the countries in the cyclical component of employment as compared to output. The high degree of correlation between the cyclical components of output that we found for geographically proximate countries is partially mirrored in employment. Interestingly, whereas there does not appear to be a statistically significant correlation between the cyclical components of output in Ireland and the UK, the same is not true of the cyclical components of employment. Finally as with output, the UK has the highest correlation of the cyclical component of employment with the US.

Prices: Finally, in Table 1c we report the correlation between the cyclical component of prices in the EU. We choose as our measure of the prices the Consumer Price Indexes (CPI) for each country as reported in the IMF's International Financial Statistics (IFS). Note that there is a perhaps surprisingly high degree of correlation in the price levels in the different EU countries: 70 of the 105 pairwise correlations are significant at the 1% level. In terms of volatility of the price level, it ranges from a low of 0.88% in Germany to a high of 2.72% in Greece. Across all 15 EU countries the average standard deviation of the CPI is 1.73. Once again, the cyclical component of the price level in the UK is more highly correlated with that in the US than is the price level of any of the other EU countries.

We also examined the comovement between the cyclical components of inflation in the EU countries. These statistics are reported in Table 1d. In general inflation rates are somewhat less synchronized across the EU countries than are the cyclical components of the different countries price levels': only 58 of the 105 pairwise correlations are statistically significant at the 5% level. However in terms of volatility, we see about the same degree of volatility in the cyclical components of each country's inflation rate as we do in the cyclical

[11]The difference in relative volatility cannot be attributed to differences in the sample period: the samples differ by only three years, and we obtain the same qualitative results if we match sample periods exactly.

component of each country's price level. The average standard deviation of the cyclical component of inflation across the fifteen EU countries is 1.67, versus 1.73 for the price level.

To summarize our key findings about the volatility and co-movement of the major aggregates in the EU: Economic activity in the UK is more highly correlated with economic activity in the US than with any of the other EU countries. This is true whether we look at employment. There is a much greater degree of correlation between economic activity in the original six members or the EU than among any of countries that joined later. There are some exceptions to this for countries that are geographically proximate. The degree of comovement in the cyclical components of the price levels and inflation rates in the EU countries is surprisingly high, although nowhere near what we would expect under monetary union. These relatively high correlations obviously reflect the frequency with which the member countries of the EU have fixed their exchange rates. The correlations are not higher because of the frequency with which these fixed exchange rates have had to be abandoned.

4. Business cycles in the U.S.

To characterize the co-movement in the major aggregates at business cycle frequencies within the US, we could examine data the level of individual states or at the more highly aggregated Census region level.[12] However, we felt it was more in keeping with the spirit of our question of what might happen under monetary union in Europe to look at the US data at an intermediate level of aggregation, that of a Federal Reserve district. But the fact that the Federal Reserve districts do not follow state lines complicates the analysis of cycles in the districts. In view of the fact that the boundary changes have been relatively minor over the eighty plus year history of the system we used the boundary definitions that are currently in place and shown in Figure 2.

The structure of the Federal Reserve System.

[12]The latter is the approach taken by Carlino and Mills (1993) in their study of income convergence across the US.

The Federal Reserve Act of 1913 authorized the designation of between 8 and 12 cities as "Federal reserve cities" and the division of the continental United States into Federal Reserve districts, each containing one Federal Reserve city. The boundaries of each district were to be determined "with due regard to the convenience and customary course of business" and need not necessarily be coterminous with any State or States (see Willis, 1923). As currently constituted the Federal Reserve System consists of the Board of Governors in Washington D.C., and twelve regional Federal Reserve Banks located in Boston, New York, Philadelphia, Cleveland, Richmond, Atlanta, Chicago, St. Louis, Minneapolis, Kansas City, Dallas and San Francisco. The districts served by the twelve regional banks do not follow state lines exactly. Some states are split between two banks. Figure 1 shows the current boundaries of the system: these boundaries have been in place since May 1984. These boundaries are not radically different to those established under the Federal Reserve Act of 1913.[13]

Aggregate output: Table 2a presents the pairwise correlations between the business cycle components of real Gross State Product (GSP) in the 12 Federal Reserve districts in the U.S. As we might expect there is a much higher degree of correlation between the cycles in the twelve Federal Reserve districts in the US than there is between the individual countries of the EU. Figure 3a presents the data that forms the basis of these correlations. Inspection of the Figure reveals that the degree of comovement of economic activity between the

[13]Under the terms of the Act some 14 states (Pennsylvania, West Virginia, Kentucky, Tennessee, Mississippi, Louisiana, Wisconsin, Michigan, Illinois, Indiana, Missouri, Oklahoma, New Mexico and Arizona) were divided between two Federal Reserve districts. Over time there has been some consolidation of the districts. Shortly after the system was established the northern counties of New Jersey were shifted from the Philadelphia district to the New York district, while Fairfield county in Connecticut was shifted from the Boston district to the new York district. Several counties in Oklahoma were shifted from the Dallas district to the Kansas City district at the same time (the remaining counties in Oklahoma were shifted from the Dallas to the Kansas City district in 1984 - see Federal Reserve Bulletin May 1984), as were two counties in West Virginia shifted from the Richmond to the Cleveland district. Several counties in southern Arizona were allocated to the Dallas district from 1913 until 1977. Effective January 1977 all of Arizona was included in the San Francisco district. Missouri is the only state with two Federal Reserve Banks. The last major reallocation of counties in Missouri between the two banks took effect on January 24 1972 when 24 counties were shifted from the St. Louis to the Kansas City district. At present there are still 14 states that are split between Federal Reserve districts: Oklahoma and Arizona are in the 10th and 12th districts respectively, while New Jersey and Connecticut are divided between the 2nd and 3rd and 1st and 2nd districts respectively.

twelve Federal Reserve districts was strongest for the cycle associated with the run up to the first oil price shock. Towards the end of the sample (during the 1980's) there are signs that the cycles in the different districts are becoming less correlated. This pattern is consistent with the notion of regional "rolling recessions" that permeated policy discussions in the U.S. over this period. A second interesting feature of the behavior of output across Federal Reserve districts is how different the Dallas District seems to be to the rest of the nation. The business cycle component of output in the Dallas district tends to be much less highly correlated with output in the other districts. Output in the Dallas district is most highly correlated with output in the Kansas City district. Both of these districts share a number of common characteristics, such as a relatively heavy dependence on oil extraction and related industries.[14] Third, note that there are some striking differences in the degree of volatility of output across the twelve districts. Output is most volatile in the Chicago and Cleveland districts (with percentage standard deviations of 2.51 and 2.30 respectively) and least volatile in the Kansas City district (where the percentage standard deviation is only 1.16). But perhaps most surprising, the average level of volatility across the twelve districts is 1.60, which is strikingly similar to the 1.62 average level of volatility we find across the 15 EU countries.

Since GSP data is only available for a relatively short sample period we decided to examine some alternative indicators of aggregate output. The only such indicator which is available for a long time period in the United States is Total Personal Income. The relationship between Gross Product and Personal Income is shown in Table 3. We started by examining the correlations between the cyclical components of real total personal income for the 1966-1991 sample period for which it is available. We converted the nominal income figures to real using the CPI's for the Federal Reserve cities. There are a number of important similarities and differences between the two measures of activity. First, the Dallas district is no longer an outlier in terms of its comovement with other districts. All of the pairwise correlations between the cyclical component of real personal income in the Dallas district and the other districts are significant at the 5% level. In terms of volatility, it is no longer the case that the Chicago and Cleveland districts exhibit the greatest fluctuations:

[14]Table 2 of Sherwood-Call (1988) shows the extent to which individual states in the US are dependent on oil extraction activities. Except for Alaska, all of the heavily oil dependent states are located in the Kansas City and Dallas Federal Reserve districts.

rather, it is the Minneapolis district that exhibits the greatest volatility in the cyclical component of real income (followed by Chicago and Cleveland). If we push the sample back to the 1950, this characterization of the relative volatilities of the 12 districts is robust. Examining a plot (see Figure 3.A.1) of the cyclical component of real income in the twelve districts, it is remarkable that again the greatest comovement in activity occurs in association with the first oil price shock. We also see a lot of comovement in conjunction with the post Korean War recession and the cycle that followed it.

Employment: Next we looked at employment across the twelve Federal Reserve districts. We constructed the employment series for each district by aggregating county level employment data. As a result, of the various indicators we look at for the Federal Reserve districts, employment is the one that conforms exactly to the district boundaries. As we found in the EU, employment is somewhat less volatile than output in the twelve Federal Reserve districts. This conforms with the findings of many other students of the US business cycle (for example, Kydland and Prescott (1990), Baxter and King (1995), Stock and Watson (1996)). It is striking how much more volatile employment is across Federal Reserve districts in the US than across countries in the EU. The average standard deviation of the cyclical component of employment across the twelve Federal Reserve districts is 1.37, versus an average of 0.89 for the fifteen countries in the EU.[15] This finding is consistent with the oft-made observation that the US labor market is a lot more flexible than the EU labor market.[16] Note also that we see about the same pattern of differences in the volatility of the cyclical component of employment across Federal Reserve districts as we see in output: employment is most volatile in the Chicago and Boston districts, and least volatile in the Kansas City district, although the range of variation in volatility is not as great as in output.

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[15]The sharp reader will have noticed that the volatility of aggregate US employment in Table 1b is somewhat less than the average in Table 2b. This is due primarily to our use of two different data sources to construct the estimates in the two tables. The aggregate US employment series used in Table 1b is taken from OECD so as to be comparable to the employment series used for the EU countries. The employment data used in Table 2b is based on aggregated county employment data. The latter arguably contains more statistical "noise" than the former. However the results in Table 6 of Danthine and Donaldson (1993) support our finding that employment is relatively more volatile in the US than in the EU.

[16]See for example Lindbeck (1996).

Prices: Table 2c presents the pairwise correlations between the cyclical components of the price level in the twelve Federal Reserve districts. We use the CPI's for the twelve Federal Reserve cities as our measure of prices in the districts. In almost every case the city in which the Federal Reserve Bank is located is the largest in the district: exceptions are the eleventh and twelfth districts (Dallas and San Francisco). Not surprisingly, all of the pairwise correlations are statistically significant, and none of them are less than 0.70. There is a lot less variation in the degree of volatility in the cyclical component of the price level across the twelve Federal Reserve districts than there is across the fifteen countries of the EU: the district with the least volatile price level is the New York district, while the San Francisco district has the most volatile price level. However the differences amount to less than half of a percentage point, as opposed to a nearly two percentage point spread in the EU.

We also looked at the pairwise correlations between the cyclical component of inflation in each district, given that most policy discussions tend to focus on the latter rather than on the price level. These statistics are reported in Table 2d. Again, all of the pairwise correlations are significant as we would expect. Not surprisingly the range of differences in the standard deviation of the inflation rates is a lot smaller in the US than across the EU. This is exactly the pattern we would expect to observe under and enduring and stable monetary union.

To summarize, there is a very high degree of correlation between the cyclical components of the price level and the inflation rate across the twelve Federal Reserve districts. This is exactly as we would expect under a credible and enduring monetary union. There is also a remarkably high degree of correlation between the cyclical components of output and employment. That this should be so s perhaps less obvious. We find less disparity in the volatility of the cycle across the Federal Reserve districts than across the member countries of the EU. Again it is not obvious why this should be so. While the federal government does act as a stabilizing influence on regional cycles in the US, state and local governments have a lot less discretion in terms of their ability to offset regional cycles (most states are constitutionally required to balance their budgets on an annual or biennial basis). In contrast, in the EU national governments have a much higher degree of autonomy when it comes to offsetting national business cycles, but there is no EU wide body that transfers resources between booming and slumping nations.

5. Conclusions

We can use our data to obtain some additional insights into the likely sources of shocks that drive business cycles in the US and the EU. Kydland and Prescott (1990) and Cooley and Ohanian (1991) posed a major challenge for models of the cycle driven by nominal shocks by showing that the correlation between the cyclical component of the price level and the cyclical component of output was negative in the US. Since then a number of authors have verified this finding for the US and for a variety of other countries. In Table 4 we present the correlations between the cyclical component of output and the price level for the fifteen countries in the EU and the 12 Federal Reserve districts in the US. The results in this table further confirm Kydland and Prescott's and Cooley and Ohanian's original findings about the countercyclical behavior of the price level. It is striking that averaged across Federal Reserve districts or the member countries of the EU, the pairwise correlation between the cyclical components of prices and output is in both cases about -0.5. It is also interesting that the range of variation is a lot lower in the EU than in the US. Within the US, the Dallas district once again stands out in that the correlation between prices and output in that district is approximately zero. The finding that the correlation between the cyclical component of the price level and the cyclical component of output is negative poses a major problem for models where nominal shocks are a major source of business fluctuations. One interpretation of our finding that this correlation is very similar in the US and US is that nominal exchange rate changes are a relatively unimportant source of fluctuations in the EU. By extension countries may not be losing a lot by giving up their ability to set their nominal exchange rate.

Tables 1 and 2 summarize the pairwise correlations between the cyclical components of various indicators of economic activity in the EU and the US. It would be useful to have a single summary statistic that gave us some sense of the degree to which the cyclical component of activity in all of the countries moved together. While no such statistic exists, Figure 4 presents what we believe is a useful answer to this question. In each panel of the Figure we have plotted the histogram for the pairwise correlation coefficients reported in each of the Tables, along with a sampling distribution generated under the null hypothesis that the (population) pairwise correlation coefficient is zero. In each case the sampling distribution is generated with the same degrees of freedom as available in calculating the correlation coefficient (typically the number of observations minus two). We derive the sampling distribution of correlation coefficients (r) from the relation between t distribution and r in a simple regression model using the change of variable method. It is worth noting that the distribution assumes that at least one variable is independently and normally distributed. As we can see from the cyclical components of the series, they are serially correlated, and we should be cautious when we try to use the distribution to get the sense of testing a hypothesis. We reported the GMM estimated standard error of the correlation coefficient to avoid this problem. Insofar as the US is a model for what the EU can expect under EMU, Figure 4 gives us a sense of where the EU is today and can expect to go under monetary union.

Business cycles may differ across nations or regions within a nation for a variety of reasons. First, regions and nations may experience different shocks. Second, regions and nations may respond differently to common shocks. This can come about because of differences in the reaction of policy makers to the common shock, or because of differences in the regional or national composition of output. The former is more likely to be a factor when the regions are sovereign nations that retain control over the levers of economic policy, while the latter is more likely to be important when the regions are highly specialized. A number of authors have found that specialization is greater within the United States than within the EU (for example, Bini Smaghi and Vori (1992)). However there is also evidence to suggest that these regional differences are disappearing over time. For example, Kim (1995) finds evidence of a steady decline in regional specialization of manufacturing in the US since the 1930's.

Much of the existing discussion surrounding the viability of EMU has tended to center on questions of whether different countries are subject to demand or supply shocks, or whether national or sector specific shocks have tended to drive the business cycle in the different countries. However there has been remarkably little effort to bring the tools and language of modern dynamic macroeconomics to bear on the question of what monetary union will mean for Europe.[17] Specifically there have been not attempts to formally model how the

[17]Christodoulakis, Dimelis, and Kollintzas (1995) is an exception.

introduction of a common currency will affect the business cycle in the member nations of the EU.[18] The exercise undertaken in this paper is a necessary first step towards such a study. Any plausible model of the existing regime must be capable of replicating the business cycle facts as outlined above. And insofar as the US can be taken as a model of what Europe might look like with a credible monetary union we would have greater confidence in a model that was capable of replicating the key stylized facts about the business cycle in the twelve Federal Reserve districts.

[18]The pioneering dynamic general equilibrium analysis of the implications of monetary unification would appear to be Sargent and Velde (1990). However they do not consider the business cycle implications of unification.

Appendix: Data Sources

1. European Union.

Aggregate Output (1963-1992): We take as our measure of aggregate output in the EU economies the RGDPCH (per capita chain-weighted GDP in 1985 international prices) series from Summers and Heston (1991). This data is available for the period 1950-1992 for all of the EU countries.

Employment (1960-1996): We obtain data on aggregate employment in most of the EU economies for the period 1960-1996 from OECD Economic Outlook. In the case of France and Netherlands, the starting years are 1965 and 1970 respectively. We use the West Germany employment data adjusted by *Bureau of Labor Statistics* in *Foreign Labor Statistics* since OECD Economic Outlook do not report the West Germany data after the reunification.

Prices (1950-1995): We use the CPI for each country from *International Financial Statistics* with 1990 price = 100 as our measure of price.

2. United States.

Aggregate Output (1963-1992): We examine the behavior of two measures of aggregate activity. The first, Real Gross State Product (RGSP) from Bureau of Economic Analysis of the Department of Commerce, is the preferred measure but is only available from 1963 to 1992. RGSP is only available at the state (as opposed to county) level. We handle the problem of split states by allocating GSP to Federal Reserve Districts on the basis of employment shares, which is stable over the sample period. The second, Real Total Personal Income (RTPI), is constructed using Total Personal Income available from Regional Economic Information System (REIS) of Bureau of Economic Analysis of the Department of Commerce and the corresponding price index explained below. Total Personal Income is available at county level from 1969 to 1994 and available at state level from 1929. Since the income share and employment share of split states are similar and stable over the time, we can construct total personal income of federal reserve districts back to 1929 by allocating the split states' share based on income share or employment share.

Employment (1960-1996): Total employment data is available at county level from REIS starting from 1969. At state level, we can get total employment date from 1939 to present from BEA. We use the total employment share of REIS for split states to calculate the federal reserve district total employment based on state level total employment data of BEA.

Prices (1950-1995): We use consumer price indices of the cities where Federal Reserve Banks are located except Richmond and Dallas. While CPI's are available for both the Dallas and Richmond, they only go back to 1960. Thus for the Richmond district we average the CPIs of Washington D.C. and Baltimore; for the Dallas district, we use the CPI of Houston. Except for Atlanta, Minneapolis and Kansas city, we use the CPI series (82-84 = 100) of BLS publication. For Atlanta, Minneapolis, Kansas city, we use the related volumes of Statistical Abstracts of the U.S. by the Bureau of Census.

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Table 1a
Correlation of business cycle component of GDP in the EU

	% Std. Dev.	Fra	Ger	Ita	Lux	Net	Den	Ire	U.K.	Gre	Por	Spa	Aus	Fin	Swe	U.S.
Belgium	1.25** (0.20)	0.76** (0.10)	0.58** (0.04)	0.77** (0.09)	0.70** (0.11)	0.63** (0.12)	0.30 (0.18)	0.28 (0.14)	0.37* (0.15)	0.27* (0.13)	0.51* (0.24)	0.56** (0.15)	0.70** (0.17)	0.60** (0.12)	0.42** (0.13)	0.28 (0.18)
France	0.99** (0.20)		0.64** (0.12)	0.66** (0.13)	0.69** (0.11)	0.55** (0.17)	0.46* (0.18)	0.38** (0.07)	0.58** (0.16)	0.46** (0.10)	0.62* (0.26)	0.53** (0.11)	0.64** (0.16)	0.46** (0.16)	0.07 (0.21)	0.46 (0.28)
Germany	1.53** (0.22)			0.48** (0.15)	0.75** (0.09)	0.74** (0.06)	0.67** (0.12)	0.43** (0.12)	0.45* (0.18)	0.64** (0.06)	0.20 (0.21)	0.26* (0.10)	0.61** (0.11)	0.29 (0.27)	0.20 (0.32)	0.58** (0.19)
Italy	1.63** (0.33)				0.45 (0.25)	0.65** (0.13)	0.24 (0.19)	0.27* (0.1)	0.36* (0.14)	-0.01 (0.10)	0.47* (0.2)	0.42** (0.14)	0.54** (0.22)	0.43* (0.17)	0.44* (0.17)	0.32 (0.17)
Luxembourg	2.55** (0.58)					0.54** (0.11)	0.38** (0.08)	0.37** (0.08)	0.38 (0.19)	0.46* (0.17)	0.30 (0.34)	0.49* (0.18)	0.50 (0.27)	0.62** (0.18)	0.31 (0.16)	0.42* (0.16)
Netherlands	1.08** (0.11)						0.52** (0.09)	0.48** (0.13)	0.32 (0.17)	0.33 (0.16)	0.29 (0.31)	0.24 (0.21)	0.54** (0.14)	0.19 (0.15)	0.30 (0.28)	0.48* (0.20)
Denmark	1.52** (0.17)							0.10 (0.20)	0.46 (0.27)	0.56** (0.09)	0.05 (0.26)	0.20 (0.25)	0.44** (0.15)	-0.04 (0.17)	0.02 (0.21)	0.55** (0.13)
Ireland	1.64** (0.13)								0.24 (0.24)	0.41** (0.09)	0.30 (0.20)	0.20 (0.14)	0.15 (0.15)	0.13 (0.16)	-0.02 (0.19)	0.34* (0.14)
U.K.	1.64** (0.25)									0.39* (0.18)	0.47* (0.25)	0.45** (0.14)	0.37* (0.15)	0.26 (0.13)	0.18 (0.20)	0.67** (0.13)
Greece	1.67** (0.40)										0.16 (0.09)	0.08 (0.09)	0.29* (0.14)	0.20 (0.18)	-0.07 (0.17)	0.42** (0.15)
Portugal	2.52** (0.68)											0.41 (0.41)	0.51* (0.23)	0.19 (0.30)	-0.19 (0.19)	0.23 (0.34)

Spain	1.37** (0.18)												0.46** (0.14)	0.43 (0.27)	0.28* (0.12)	0.28* (0.12)
Austria	0.99** (0.15)													0.42** (0.14)	0.10 0.21	0.44* (0.18)
Finland	2.32** (0.33)														0.67** (0.08)	0.03 (0.17)
Sweden	1.12** (0.19)															-0.05 (0.34)

Notes to Table: Sample period 1963-1992. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3. * denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 1b
Correlation of business cycle component of employment in the EU

	% Std. Dev.	Fra	Ger	Ita	Lux	Net	Den	Ire	U.K.	Gre	Por	Spa	Aus	Fin	Swe	U.S.
Belgium	0.58** (0.06)	0.54** (0.19)	0.65** (0.08)	0.40* (0.19)	0.39** (0.11)	0.73** (0.1)	0.43 (0.24)	0.52** (0.18)	0.63** (0.10)	-0.13 (0.15)	0.24 (0.2)	0.54** (0.18)	0.53** (0.09)	0.46 (0.23)	0.46* (0.19)	0.37** (0.12)
France	0.43** (0.06)		0.51** (0.12)	0.19 (0.19)	0.31* (0.12)	0.23* (0.09)	0.31 (0.3)	0.46** (0.07)	0.43* (0.21)	0.03 (0.17)	0.21 (0.30)	0.79** (0.11)	0.35** (0.11)	0.51 (0.31)	0.54 (0.29)	0.26 (0.24)
Germany	0.90** (0.16)			0.15** (0.50)	0.51** (0.15)	0.81** (0.07)	0.49* (0.24)	0.35 (0.88)	0.20 (0.16)	0.02 (0.14)	-0.09 (0.28)	0.27 (0.21)	0.76** (0.10)	0.24 (0.13)	0.28 (0.24)	0.23 (0.31)
Italy	0.63** (0.12)				0.15 (0.23)	0.59** (0.16)	-0.12 (0.10)	0.14 (0.14)	0.01 (0.16)	-0.28 (0.14)	0.45** (0.12)	0.32 (0.18)	0.26 (0.24)	0.21 (0.15)	0.36 (0.19)	-0.13 (0.13)
Luxembourg	0.90** (0.24)					0.50** (0.17)	0.08 (0.17)	-0.01 (0.17)	0.04 (0.09)	0.02 (0.16)	0.43** (0.15)	0.35* (0.16)	0.59** (0.07)	0.30* (0.12)	0.34** (0.11)	-0.26* (0.11)
Netherlands	0.73** (0.13)						0.29 (0.22)	0.35 (0.24)	0.28 (0.19)	-0.16 (0.14)	0.02 (0.29)	0.28 (0.23)	0.71** (0.13)	0.05 (0.11)	0.24 (0.13)	0.31 (0.2)
Denmark	0.84* (0.10)							0.17 (0.16)	0.38 (0.24)	-0.07 (0.20)	-0.31* (0.15)	0.10 (0.12)	0.24 (0.24)	0.17 (0.12)	0.00 (0.18)	0.56 (0.17)
Ireland	0.88** (0.08)								0.43* (0.20)	0.01 (0.18)	0.03 (0.22)	0.34 (0.17)	0.16 (0.24)	0.28 (0.19)	0.28* (0.11)	0.37* (0.17)
U.K.	1.12** (0.17)									0.03 (0.33)	0.13 (0.13)	0.45** (0.08)	0.04 (0.17)	0.49* (0.19)	0.45** (0.11)	0.70** (0.08)
Greece	0.68** (0.17)										-0.16 (0.12)	-0.16 (0.10)	0.11 (0.22)	0.31** (0.05)	0.02 (0.11)	0.16 (0.29)
Portugal	1.48** (0.30)											0.46 (0.23)	-0.03 (0.17)	0.55** (0.10)	0.70** (0.08)	-0.36* (0.16)

Spain	1.02** (0.27)												0.24 (0.13)	0.47 (0.28)	0.67* (0.25)	0.15 (0.10)
Austria	0.51** (0.06)													0.09 (0.16)	0.05 (0.16)	0.11 (0.27)
Finland	1.48** (0.35)														0.79** (0.08)	0.10 (0.17)
Sweden	1.01** (0.20)															0.00 (0.15)

Notes to Table: Sample period 1960-1996. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3.* denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 1c
Correlation of business cycle component of the price level in the EU

	% Std. Dev.	Fra	Ger	Ita	Lux	Net	Den	Ire	U.K.	Gre	Por	Spa	Aus	Fin	Swe	U.S.
Belgium	1.30** (0.22)	0.46* (0.19)	0.61** (0.08)	0.71** (0.12)	0.91** (0.03)	0.75** (0.11)	0.37* (0.18)	0.73** (0.08)	0.59** (0.2)	0.34 (0.23)	0.58* (0.26)	0.43* (0.18)	0.75** (0.09)	0.72** (0.08)	0.50** (0.12)	0.35 (0.21)
France	1.73** (0.34)		0.39* (0.18)	0.52* (0.20)	0.39 (0.22)	0.21 (0.21)	0.27 (0.28)	0.60** (0.17)	0.40* (0.16)	0.17 (0.29)	0.33 (0.24)	0.42 (0.23)	0.38 (0.19)	0.42* (0.18)	0.38* (0.15)	0.55** (0.15)
Germany	0.88** (0.09)			0.59** (0.17)	0.61** (0.08)	0.64** (0.14)	0.56** (0.13)	0.58** (0.19)	0.48** (0.17)	0.23 (0.22)	0.16 (0.27)	0.32 (0.16)	0.59** (0.13)	0.47** (0.10)	0.60** (0.14)	0.39** (0.13)
Italy	1.78** (0.41)				0.68** (0.11)	0.56** (0.13)	0.57** (0.15)	0.74** (0.10)	0.67** (0.08)	0.56** (0.18)	0.49 (0.30)	0.43* (0.17)	0.60** (0.09)	0.48 (0.18)	0.54** (0.13)	0.47** (0.16)
Luxembourg	1.32** (0.18)					0.75** (0.11)	0.27 (0.17)	0.74** (0.08)	0.52* (0.21)	0.21 (0.16)	0.46 (0.23)	0.41* (0.18)	0.68** (0.08)	0.64** (0.09)	0.55** (0.12)	0.25 (0.18)
Netherlands	1.12** (0.09)						0.16 (0.21)	0.59** (0.16)	0.55** (0.13)	0.30** (0.09)	0.25 (0.25)	0.37* (0.14)	0.57** (0.14)	0.51** (0.15)	0.42** (0.15)	0.31* (0.13)
Denmark	1.45** (0.14)							0.42* (0.20)	0.39** (0.14)	0.20 (0.38)	0.31 (0.23)	0.28 (0.14)	0.36* (0.17)	0.40* (0.15)	0.43** (0.13)	0.41 (0.21)
Ireland	2.18** (0.31)								0.77** (0.09)	0.26 (0.20)	0.24 (0.27)	0.31 (0.23)	0.74** (0.04)	0.63** (0.10)	0.61** (0.09)	0.57** (0.08)
U.K.	1.91** (0.46)									0.27* (0.11)	0.19 (0.24)	0.28 (0.19)	0.59** (0.08)	0.48** (0.13)	0.57** (0.08)	0.62** (0.17)
Greece	2.72** (0.56)										0.26 (0.33)	-0.07 (0.30)	0.35 (0.21)	-0.02 (0.35)	0.07 (0.19)	0.38 (0.25)
Portugal	2.32** (0.75)											0.39* (0.17)	0.35 (0.22)	0.33 (0.17)	0.27 (0.26)	0.16 (0.34)

Spain	2.13** (0.22)												0.19 (0.16)	0.52* (0.12)	0.46** (0.10)	0.15 (0.26)
Austria	0.98** (0.08)													0.67** (0.07)	0.57** (0.10)	0.43** (0.10)
Finland	2.50** (0.34)														0.47** (0.13)	0.43** (0.15)
Sweden	1.24** (0.08)															0.42* (0.19)

Notes to Table: Sample period 1950-1995. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3.* denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 1d
Correlation of the business cycle component of inflation in the EU

	% Std Dev	Fra	Ger	Ita	Lux	Net	Den	Ire	U.K.	Gre	Por	Spa	Aus	Fin	Swe	U.S.
Belgium	1.08** (0.18)	0.24 (0.25)	0.43** (0.11)	0.59** (0.12)	0.78** (0.05)	0.55** (0.09)	0.20 (0.16)	0.63** (0.09)	0.55** (0.14)	0.30* (0.13)	0.46** (0.16)	0.18 (0.09)	0.60** (0.12)	0.62** (0.11)	0.35** (0.08)	0.46** (0.17)
France	2.00* (0.72)		0.26* (0.12)	0.46** (0.11)	-0.02 (0.31)	-0.12 (0.23)	0.20 (0.23)	0.40** (0.11)	0.30** (0.08)	0.14 (0.18)	0.21 (0.18)	0.32** (0.11)	0.19 (0.16)	0.17 (0.15)	0.23** (0.08)	0.35 (0.21)
Germany	0.71** (0.06)			0.48** (0.10)	0.43* (0.16)	0.33 (0.17)	0.48** (0.11)	0.53** (0.14)	0.43** (0.13)	0.17 (0.18)	0.06 (0.16)	0.18 (0.11)	0.46** (0.15)	0.28** (0.13)	0.35 (0.23)	0.35** (0.10)
Italy	1.50** (0.23)				0.50** (0.16)	0.26 (0.18)	0.46** (0.13)	0.56** (0.11)	0.55** (0.14)	0.52** (0.15)	0.28 (0.31)	0.26** (0.07)	0.42* (0.19)	0.39* (0.15)	0.46** (0.13)	0.52** (0.17)
Luxembourg	1.16** (0.14)					0.59** (0.21)	0.07 (0.13)	0.57** (0.14)	0.42* (0.18)	0.08 (0.11)	0.20 (0.21)	0.24** (0.07)	0.41* (0.17)	0.52** (0.08)	0.31** (0.09)	0.25 (0.15)
Netherlands	1.13** (0.13)						-0.24 (0.18)	0.46** (0.13)	0.37** (0.12)	0.21 (0.11)	0.09 (0.19)	0.05 (0.12)	0.39** (0.16)	0.34 (0.18)	0.19 (0.14)	0.27** (0.10)
Denmark	1.52** (0.19)							0.21 (0.14)	0.19* (0.09)	0.18 (0.30)	0.27 (0.24)	0.17 (0.17)	0.29 (0.14)	0.23 (0.13)	0.34** (0.08)	0.33 (0.17)
Ireland	1.91** (0.30)								0.74** (0.08)	0.07 (0.13)	-0.01 (0.21)	0.15 (0.13)	0.60** (0.09)	0.55** (0.11)	0.35** (0.10)	0.48** (0.06)
U.K.	2.00** (0.43)									0.13 (0.13)	0.06 (0.23)	0.12 (0.08)	0.45** (0.09)	0.39** (0.09)	0.45** (0.09)	0.56** (0.12)
Greece	2.70** (0.51)										0.22 (0.27)	-0.06 (0.11)	0.20 (0.16)	-0.03 (0.14)	0.10 (0.15)	0.47** (0.16)
Portugal	2.36** (0.43)											0.15 (0.11)	0.23 (0.20)	0.23* (0.11)	0.14 (0.21)	0.24 (0.26)

Spain	1.77** (0.27)												0.11 (0.09)	0.20* (0.09)	0.27** (0.09)	0.00 (0.17)
Austria	0.95** (0.10)													0.62** (0.13)	0.35* (0.16)	0.42** (0.10)
Finland	2.37** (0.45)														0.30* (0.12)	0.38** (0.12)
Sweden	1.58** (0.20)															0.36** (0.10)

Notes to Table: Sample period 1951-1995. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3.* denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 2a
Correlation of the business cycle component of GSP in the US

	% Std. Dev.	NY	Phi	Cle	Ric	Atl	Chi	StL	Min	KC	Dal	SF
Boston	1.93** (0.34)	0.96** (0.02)	0.94** (0.06)	0.88** (0.14)	0.94** (0.03)	0.90** (0.14)	0.84** (0.11)	0.85** (0.14)	0.77** (0.18)	0.55 (2.15)	0.33 (0.18)	0.82** (0.06)
New York	1.60** (0.22)		0.93** (0.03)	0.85** (0.07)	0.89** (0.04)	0.87** (0.06)	0.80** (0.08)	0.81** (0.08)	0.75** (0.14)	0.58* (0.26)	0.30 (0.17)	0.77** (0.06)
Philadelphia	1.79** (0.29)			0.97** (0.01)	0.98** (0.01)	0.94** (0.02)	0.93** (0.03)	0.92** (0.04)	0.89** (0.05)	0.65** (0.16)	0.37* (0.14)	0.87** (0.05)
Cleveland	2.30** (0.40)				0.96** (0.05)	0.93** (0.02)	0.98** (0.01)	0.96** (0.02)	0.92** (0.03)	0.71** (0.13)	0.48** (0.11)	0.90** (0.04)
Richmond	1.54** (0.29)					0.94** (0.02)	0.94** (0.02)	0.94** (0.03)	0.87** (0.05)	0.64** (0.15)	0.39* (0.15)	0.90** (0.05)
Atlanta	1.80** (0.34)						0.90** (0.03)	0.92** (0.02)	0.87** (0.06)	0.74** (0.13)	0.45** (0.11)	0.81** (0.06)
Chicago	2.51** (0.33)							0.98** (0.01)	0.92** (0.02)	0.71** (0.13)	0.49** (0.11)	0.87** (0.05)
St. Louis	2.00** (0.28)								0.89** (0.03)	0.71** (0.13)	0.48** (0.12)	0.85** (0.05)
Minneapolis	1.68** (0.26)									0.77** (0.10)	0.52** (0.09)	0.83** (0.05)
Kansas City	1.16** (0.14)										0.84** (0.06)	0.62** (0.13)
Dallas	1.46** (0.28)											0.43** (0.14)
San Francisco	1.30** (0.20)											

Notes to Table: Sample period 1963-1992. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3.* denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 2b
Correlation of the business cycle component of employment in the US

	% Std. Dev.	NY	Phi	Cle	Ric	Atl	Chi	StL	Min	KC	Dal	SF
Boston	1.61** (0.15)	0.93** (0.02)	0.91** (0.02)	0.87** (0.05)	0.91** (0.02)	0.87** (0.04)	0.85** (0.05)	0.86** (0.05)	0.82** (0.09)	0.69** (0.17)	0.48* (0.19)	0.79** (0.08)
New York	1.15** (0.13)		0.92** (0.02)	0.87** (0.03)	0.88** (0.05)	0.86** (0.06)	0.81** (0.04)	0.81** (0.05)	0.78** (0.07)	0.69** (0.16)	0.55** (0.14)	0.83** (0.07)
Philadelphia	1.16** (0.09)			0.97** (0.01)	0.93** (0.04)	0.9** (0.03)	0.94** (0.02)	0.93** (0.02)	0.91** (0.03)	0.79** (0.10)	0.61* (0.10)	0.90** (0.03)
Cleveland	1.47** (0.20)				0.92** (0.04)	0.90** (0.03)	0.97** (0.01)	0.96** (0.01)	0.95** (0.01)	0.82** (0.07)	0.63** (0.10)	0.94** (0.02)
Richmond	1.33** (0.17)					0.93** (0.02)	0.91** (0.04)	0.94** (0.03)	0.88** (0.05)	0.75** (0.11)	0.47** (0.11)	0.86** (0.05)
Atlanta	1.56** (0.31)						0.88** (0.02)	0.92** (0.02)	0.85** (0.03)	0.86** (0.06)	0.62** (0.07)	0.84** (0.04)
Chicago	1.59** (0.19)							0.99** (0.01)	0.95** (0.01)	0.80** (0.07)	0.58** (0.13)	0.90** (0.03)
St. Louis	1.45** (0.21)								0.95** (0.01)	0.83** (0.08)	0.57** (0.12)	0.89** (0.03)
Minneapolis	1.28** (0.21)									0.86** (0.07)	0.65** (0.10)	0.92** (0.04)
Kansas City	1.12** (0.14)										0.88** (0.02)	0.84** (0.06)
Dallas	1.28** (0.13)											0.70** (0.10)
San Francisco	1.42** (0.16)											

Notes to Table: Sample period 1960-1995. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3.* denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 2c
Correlation of the business cycle component of the price level in the US

	% Std. Dev.	NY	Phi	Cle	Ric	Atl	Chi	StL	Min	KC	Dal	SF
Boston	1.33** (0.23)	0.94** (0.02)	0.93** (0.03)	0.85** (0.05)	0.91** (0.04)	0.89** (0.04)	0.86** (0.04)	0.85** (0.04)	0.77** (0.06)	0.83** (0.04)	0.85** (0.04)	0.83** (0.04)
New York	1.11** (0.15)		0.95** (0.02)	0.87** (0.03)	0.94** (0.01)	0.9** (0.05)	0.89** (0.02)	0.88** (0.03)	0.83** (0.03)	0.82** (0.04)	0.85** (0.05)	0.85** (0.03)
Philadelphia	1.33** (0.27)			0.87** (0.06)	0.96** (0.01)	0.93** (0.03)	0.93** (0.02)	0.89** (0.03)	0.84** (0.05)	0.84** (0.03)	0.87** (0.03)	0.89** (0.02)
Cleveland	1.46** (0.24)				0.91** (0.03)	0.87** (0.04)	0.94** (0.02)	0.92** (0.02)	0.82** (0.07)	0.90** (0.03)	0.90** (0.02)	0.77** (0.07)
Richmond	1.28** (0.28)					0.92** (0.03)	0.95** (0.01)	0.93** (0.01)	0.83** (0.06)	0.88** (0.03)	0.89** (0.01)	0.86** (0.02)
Atlanta	1.35** (0.27)						0.91** (0.03)	0.89** (0.04)	0.86** (0.04)	0.83** (0.04)	0.87** (0.05)	0.89** (0.04)
Chicago	1.35** (0.37)							0.95** (0.02)	0.86** (0.04)	0.90** (0.03)	0.91** (0.02)	0.85** (0.04)
St. Louis	1.36** (0.30)								0.88** (0.04)	0.90** (0.04)	0.95** (0.02)	0.85** (0.05)
Minneapolis	1.36** (0.26)									0.73** (0.11)	0.89** (0.03)	0.88** (0.03)
Kansas City	1.34** (0.35)										0.89** (0.03)	0.71** (0.09)
Dallas	1.45** (0.31)											0.83** (0.06)
San Francisco	1.47** (0.49)											

Notes to Table: Sample period 1950-1995. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3.* denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 2d
Correlation of the business cycle component of inflation in the US

	% Std. Dev.	NY	Phi	Cle	Ric	Atl	Chi	StL	Min	KC	Dal	SF
Boston	1.40** (0.28)	0.91** (0.03)	0.88** (0.05)	0.77** (0.06)	0.86** (0.04)	0.81** (0.08)	0.79** (0.05)	0.74** (0.06)	0.59** (0.12)	0.76** (0.05)	0.77** (0.06)	0.67** (0.11)
New York	1.13** (0.16)		0.94** (0.03)	0.82** (0.05)	0.93** (0.02)	0.85** (0.06)	0.88** (0.03)	0.82** (0.04)	0.71** (0.11)	0.75** (0.06)	0.82** (0.04)	0.73** (0.08)
Philadelphia	1.42** (0.24)			0.81** (0.09)	0.93** (0.03)	0.88** (0.04)	0.91** (0.03)	0.83** (0.05)	0.75** (0.10)	0.76** (0.07)	0.80** (0.04)	0.79** (0.04)
Cleveland	1.40** (0.19)				0.84** (0.06)	0.75** (0.09)	0.88** (0.07)	0.84** (0.08)	0.59** (0.19)	0.86** (0.05)	0.80** (0.08)	0.53** (0.18)
Richmond	1.34** (0.22)					0.88** (0.03)	0.91** (0.03)	0.86** (0.04)	0.67** (0.16)	0.79** (0.05)	0.80** (0.04)	0.72** (0.06)
Atlanta	1.35** (0.23)						0.83** (0.05)	0.83** (0.06)	0.70** (0.09)	0.72** (0.09)	0.81** (0.05)	0.78** (0.07)
Chicago	1.29** (0.19)							0.92** (0.04)	0.73** (0.12)	0.81** (0.07)	0.87** (0.02)	0.71** (0.06)
St. Louis	1.31** (0.16)								0.73** (0.09)	0.80** (0.12)	0.90** (0.03)	0.68** (0.08)
Minneapolis	1.39** (0.21)									0.49 (0.24)	0.79** (0.05)	0.74** (0.07)
Kansas City	1.41** (0.30)										0.81** (0.09)	0.45** (0.16)
Dallas	1.35** (0.18)											0.68** (0.10)
San Francisco	1.57** (0.30)											

Notes to Table: Sample period 1951-1995. All calculations performed by posing the estimation problem as a generalized-method of moments (GMM) problem using Masao Ogaki's (1993a, b) GAUSS programs. Standard errors are robust to both heteroskedasticty and autocorrelation. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3.* denotes significance at the 5% level; ** denotes significance at the 1% level.

Table 3
Relation between GDP or GSP and Personal Income

	Gross Domestic Product
less	Capital consumption allowances
=	**Net Domestic Product**
less	Indirect business tax and nontax liability
plus	Subsidies less current surplus of government enterprises
=	**National Income**
less	Corporate profits with inventory valuation and capital consumption adjustment
plus	Government transfer payments to persons
=	**Personal income**

Table 4
Correlation between cyclical component of price level and cyclical component of output
15 EU countries and 12 Federal Reserve districts

EU countries		US Federal Reserve districts	
Belgium	-0.38** (0.07)	Boston	-0.57** (0.19)
France	-0.48** (0.14)	New York	-0.68** (0.09)
Germany	-0.47** (0.15)	Philadelphia	-0.62** (0.06)
Italy	-0.18 (0.16)	Cleveland	-0.60** (0.08)
Luxembourg	-0.35 (0.18)	Richmond	-0.55** (0.09)
Netherlands	-0.35 (0.22)	Atlanta	-0.59** (0.08)
Denmark	-0.63** (0.09)	Chicago	-0.66** (0.06)
Ireland	-0.38 (0.22)	St. Louis	-0.72** (0.07)
UK	-0.71** (0.07)	Minneapolis	-0.51** (0.06)
Greece	-0.74** (0.09)	Kansas City	-0.23 (0.28)
Portugal	-0.54** (0.13)	Dallas	0.01 (0.23)
Spain	-0.44 (0.25)	San Francisco	-0.42** (0.09)
Austria	-0.23 (0.15)	US	-0.57** (0.12)
Finland	-0.38** (0.10)	-	-
Sweden	-0.52** (0.11)	-	-
Max.	-0.18	Max.	0.01
Min.	-0.74	Min.	-0.72
Average	-0.45	Average	-0.51
Std. Dev.	0.16	Std. Dev.	0.21

Notes to Table: Correlation between cyclical component of GDP and CPI for the 15 EU countries. GDP series from Penn World Table. CPI series from IFS. Cyclical component defined using Baxter and King's (1995) band pass filter, with parameter settings "Up"=2, "Down" =8, K=3. Sample period was 1963-1992.

For the US Federal Reserve districts we used the CPI for the Federal Reserve city, and real GSP, with GSP for "split states" allocated on the basis of employment shares. Same sample period and band pass filter parameter settings as for EU countries.

Figure 1A. RGDP of EU and US (1966-89)

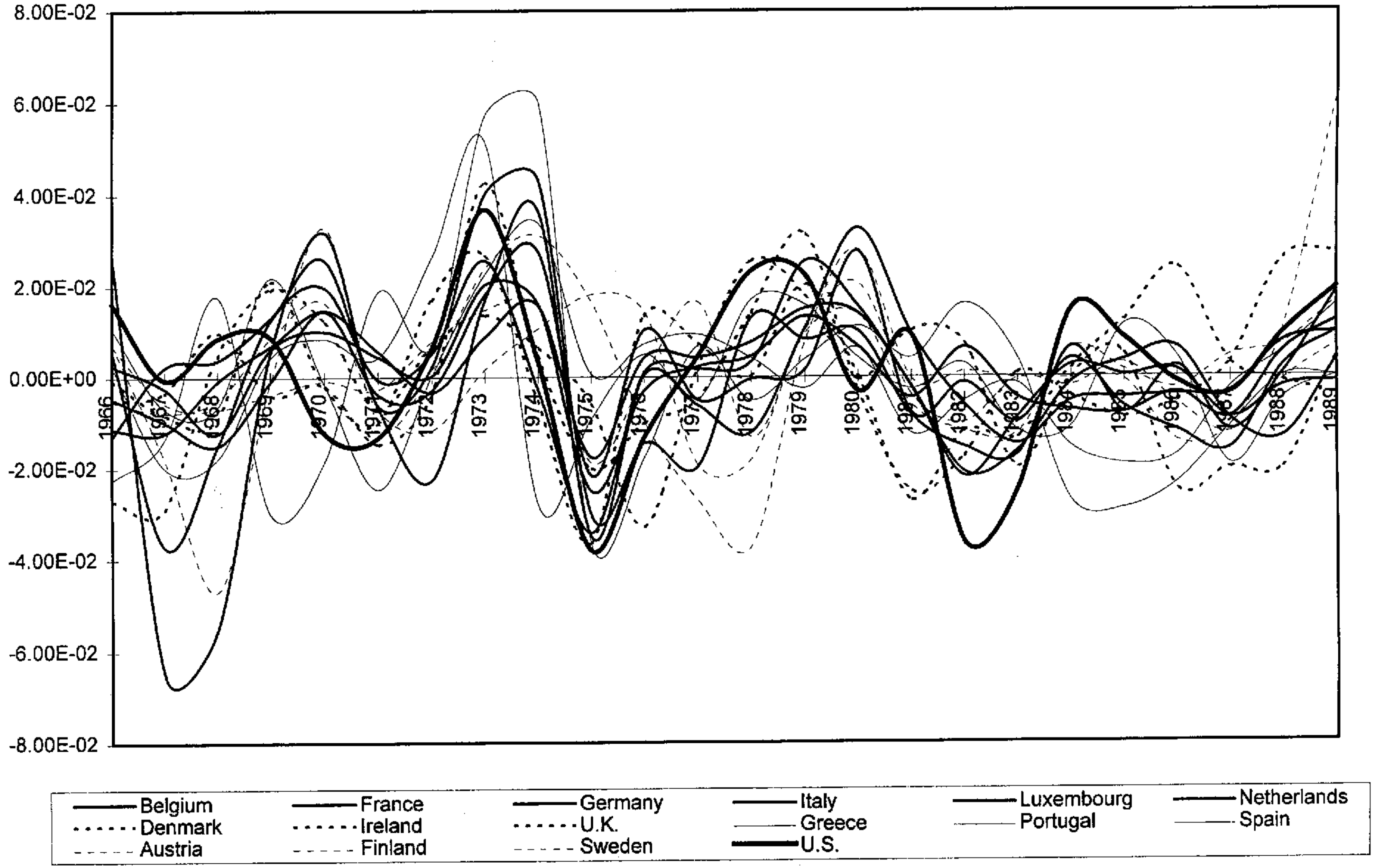


Figure 1B. Employment of EU and US (1963-93)

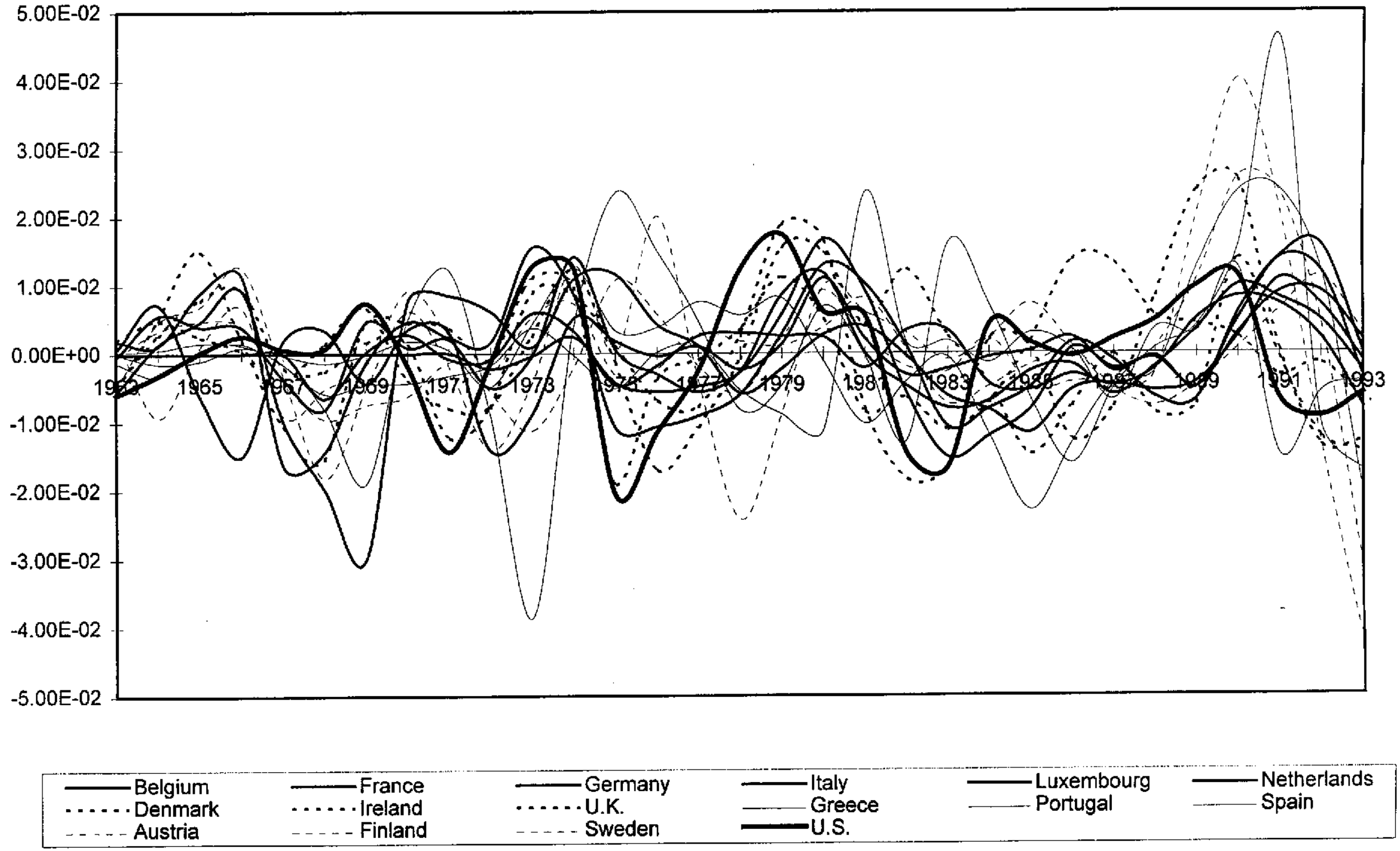


Figure 1C. CPI of EU and US (1953-92)

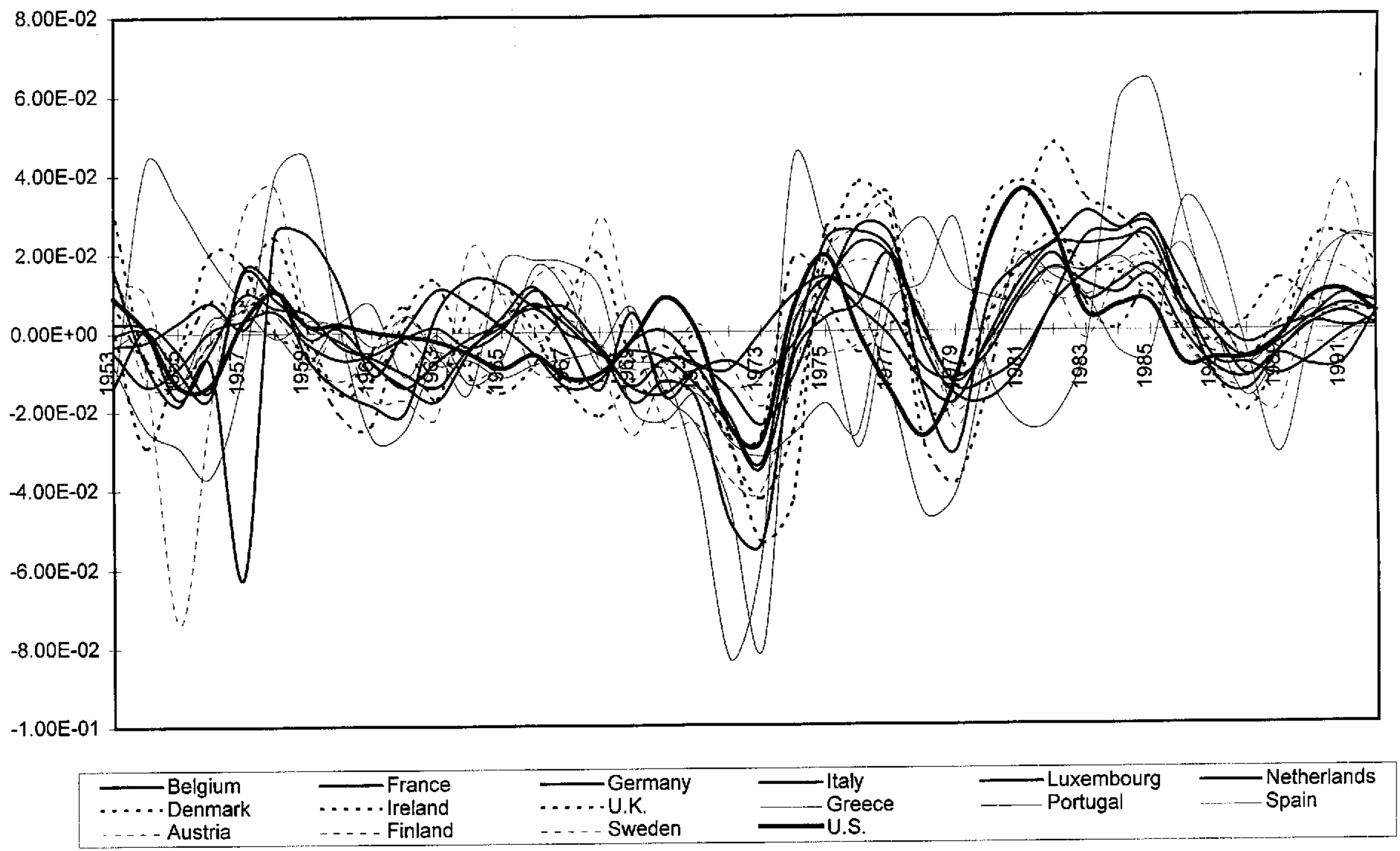


Figure 1D. Inflation of EU and US (1954-92)

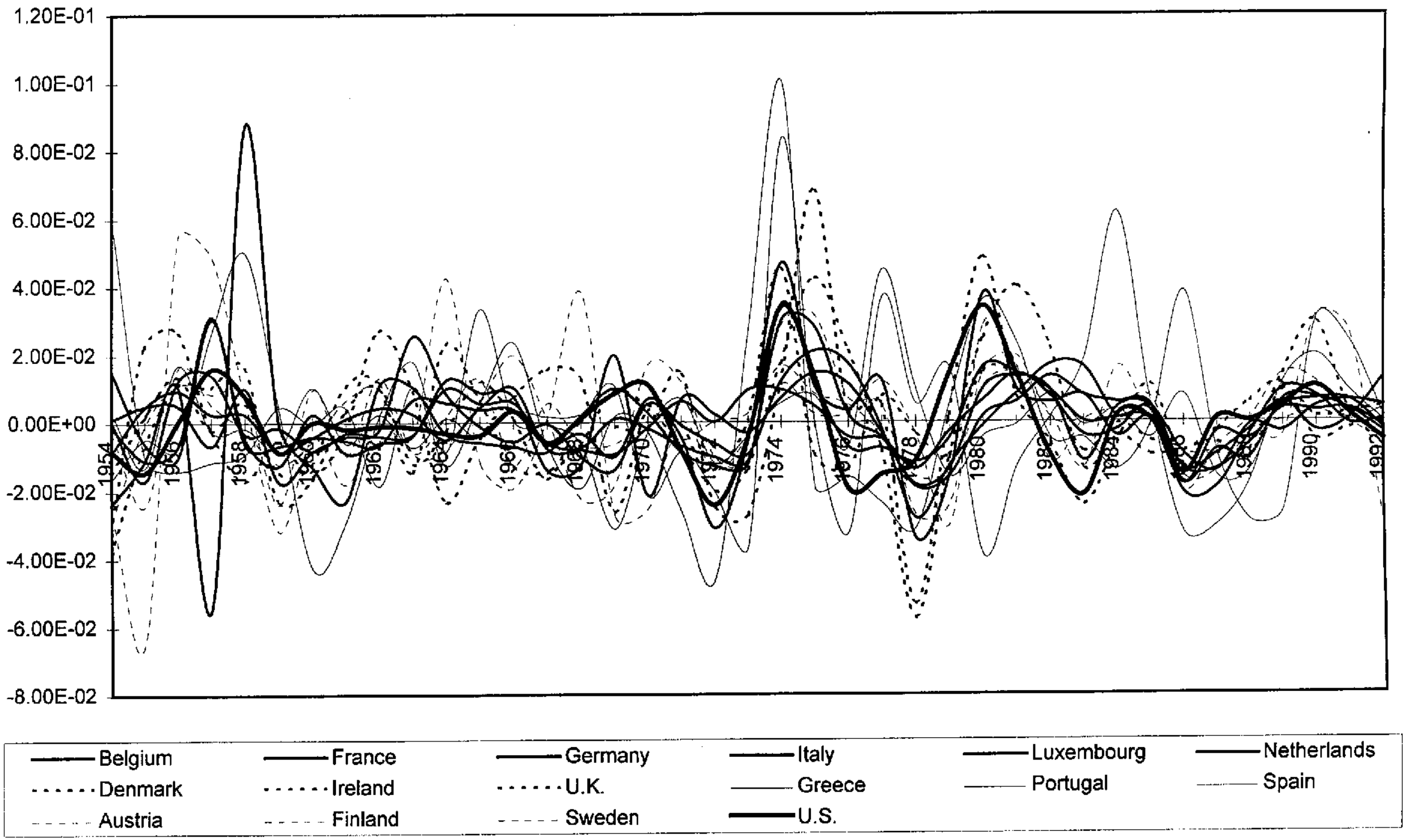


Figure 2
U.S. Federal Reserve Districts

Figure 3A. RGSP of FRB districts (1966-89)

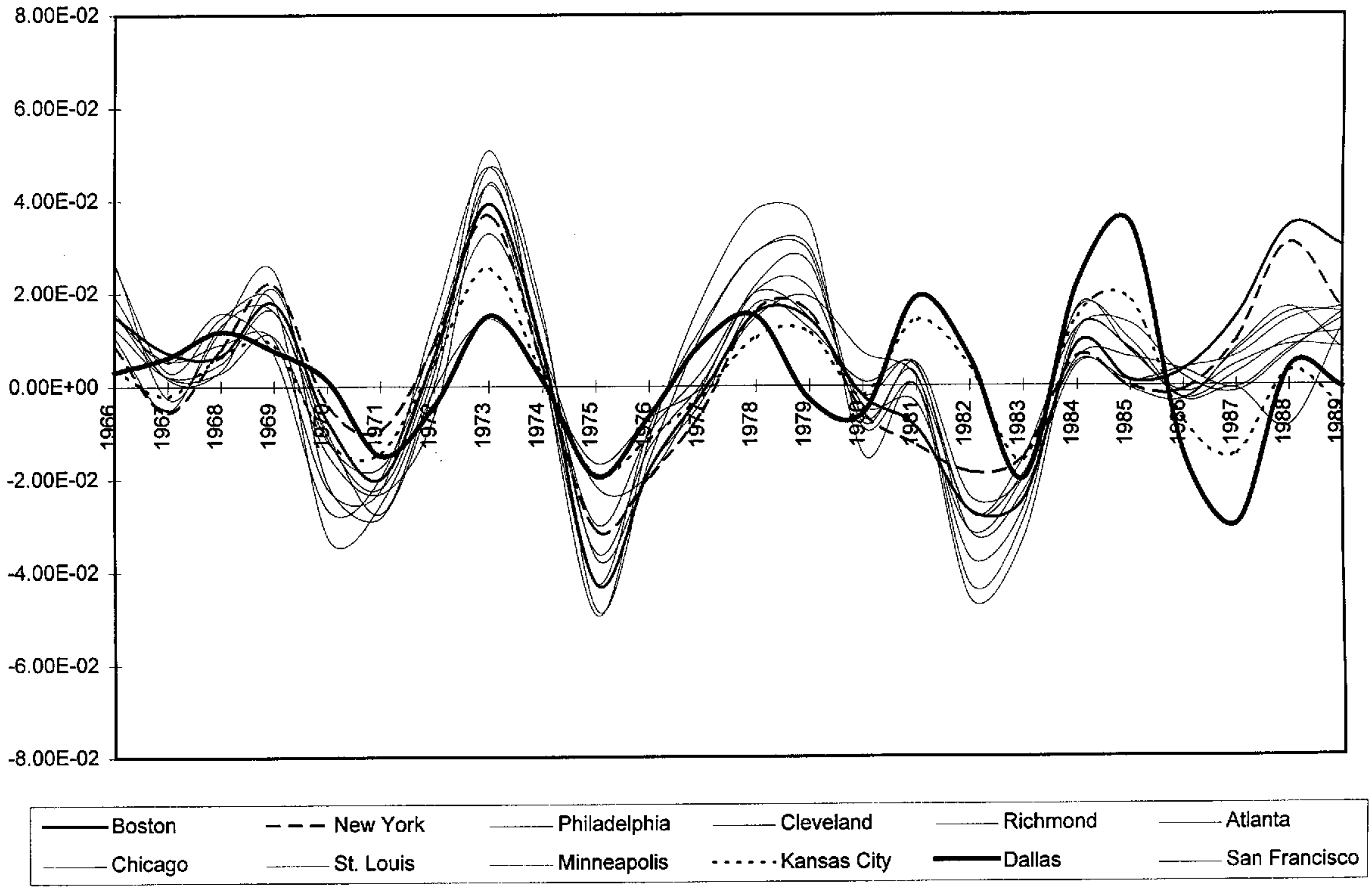


Figure 3B. Employment of FRB districts (1963-93)

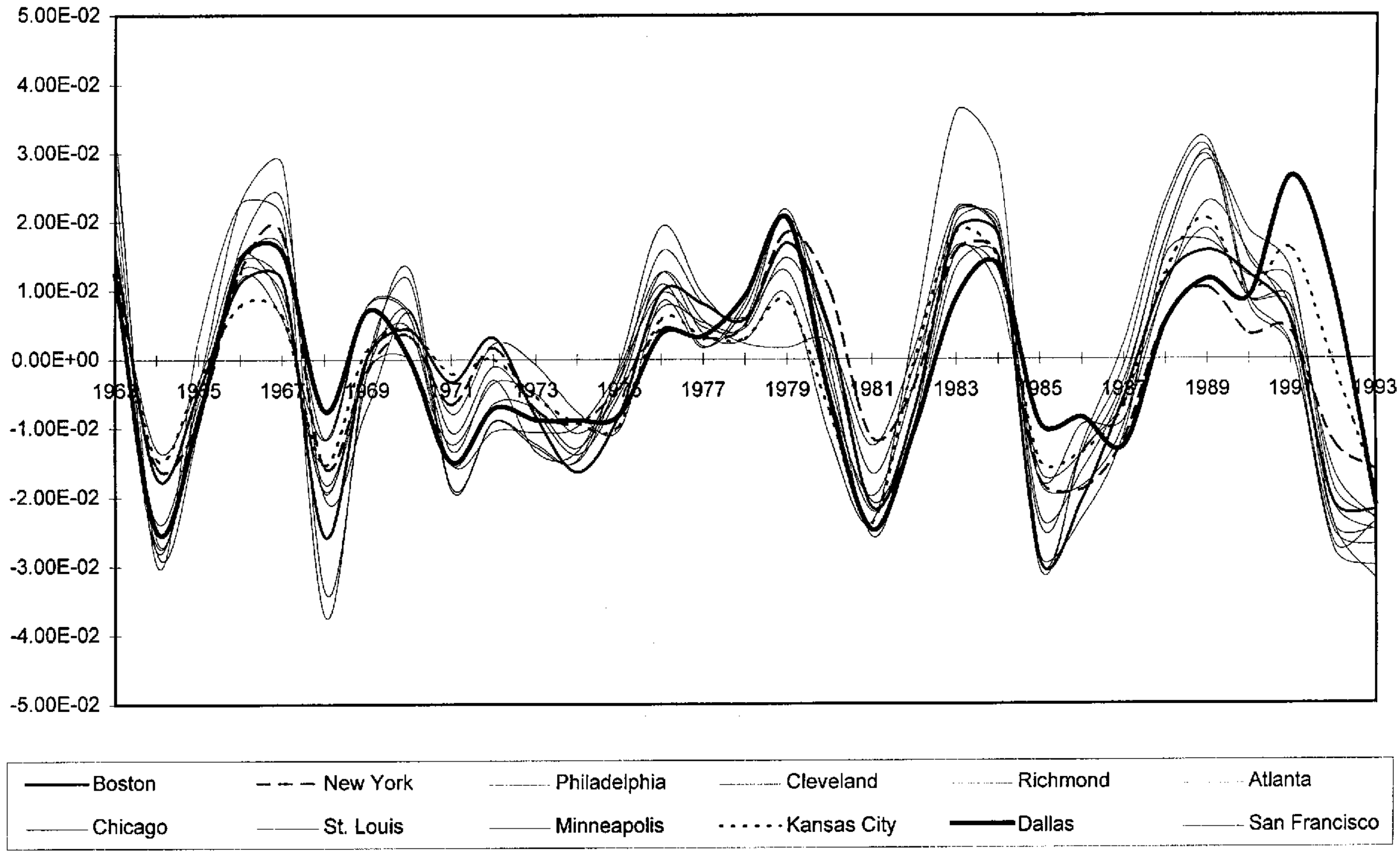


Figure 3C. CPI of FRB districts (1953-92)

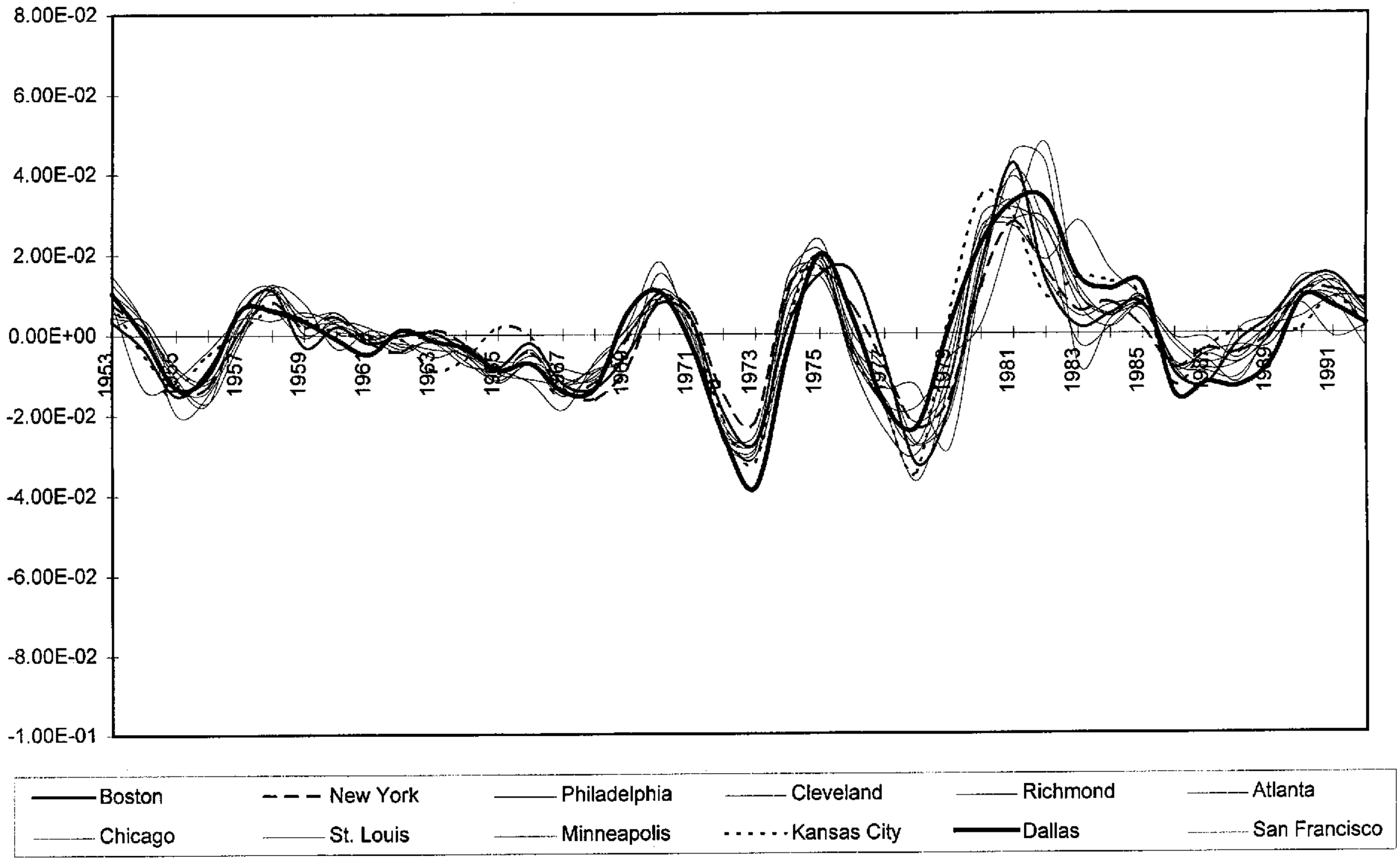


Figure 3D. Inflation of FRB districts (1954-92)

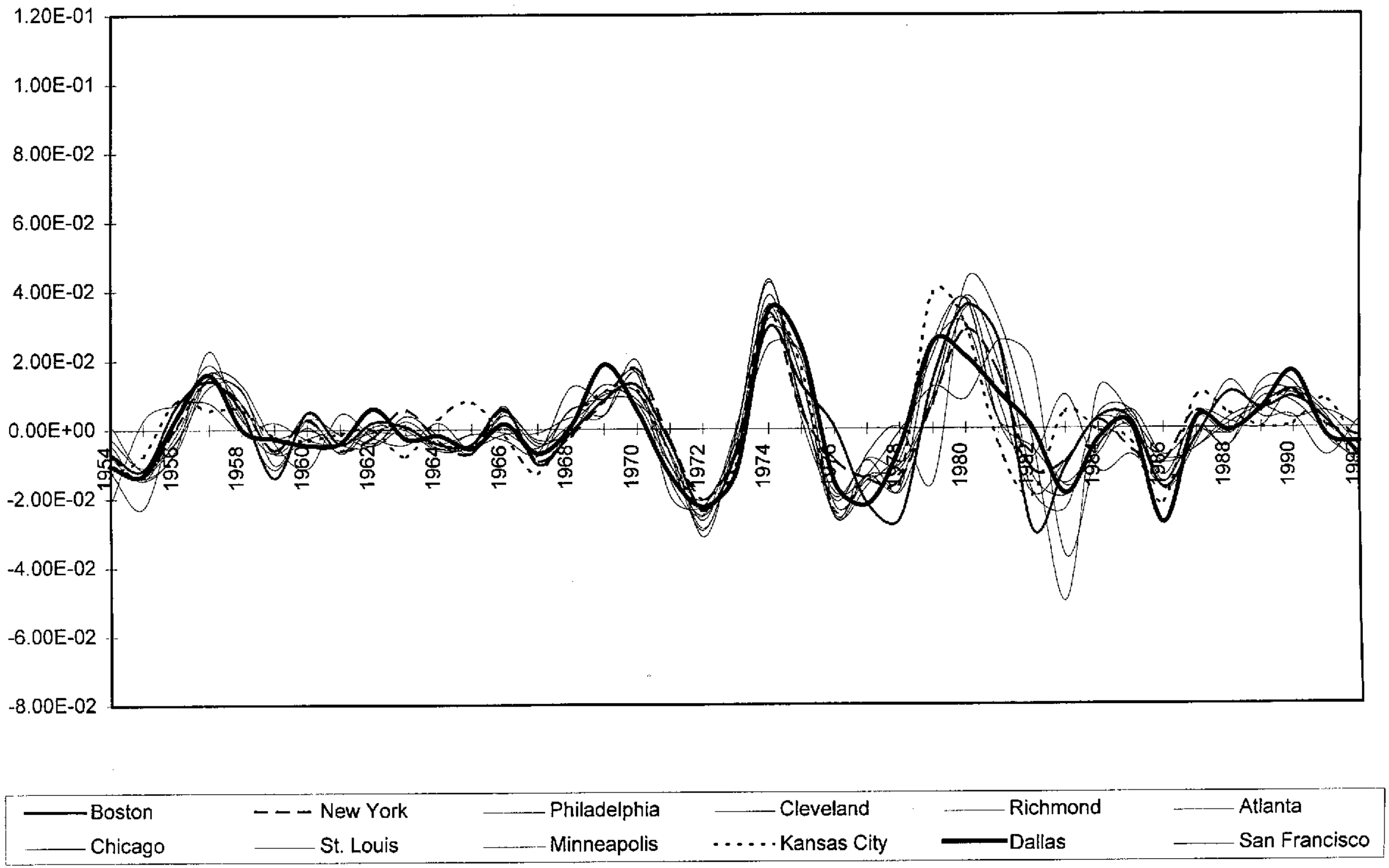


Figure 3A.1. Real Total Personal Income of FRB districts (1953-91)

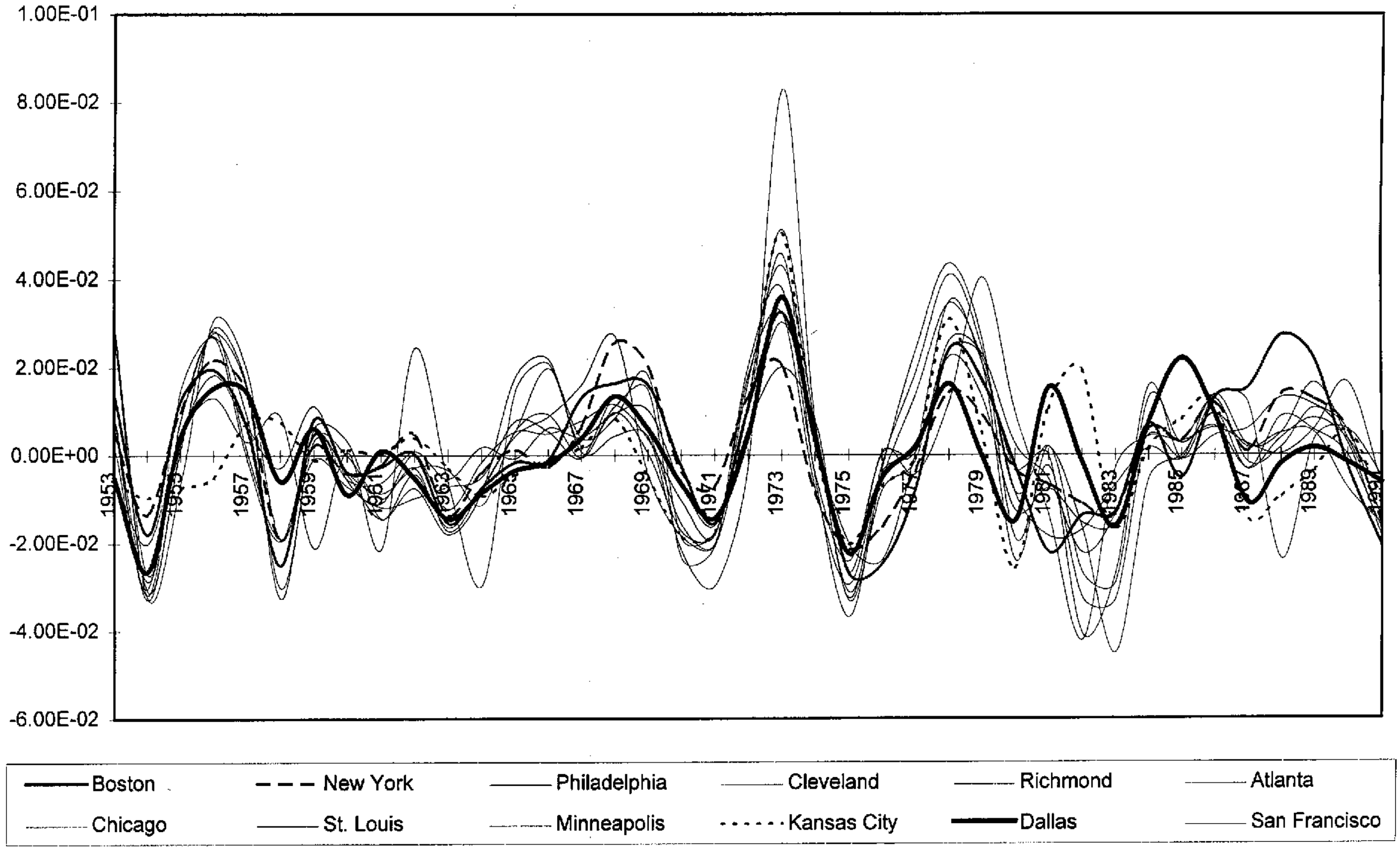


Figure 4. Distribution of Correlation Coefficients

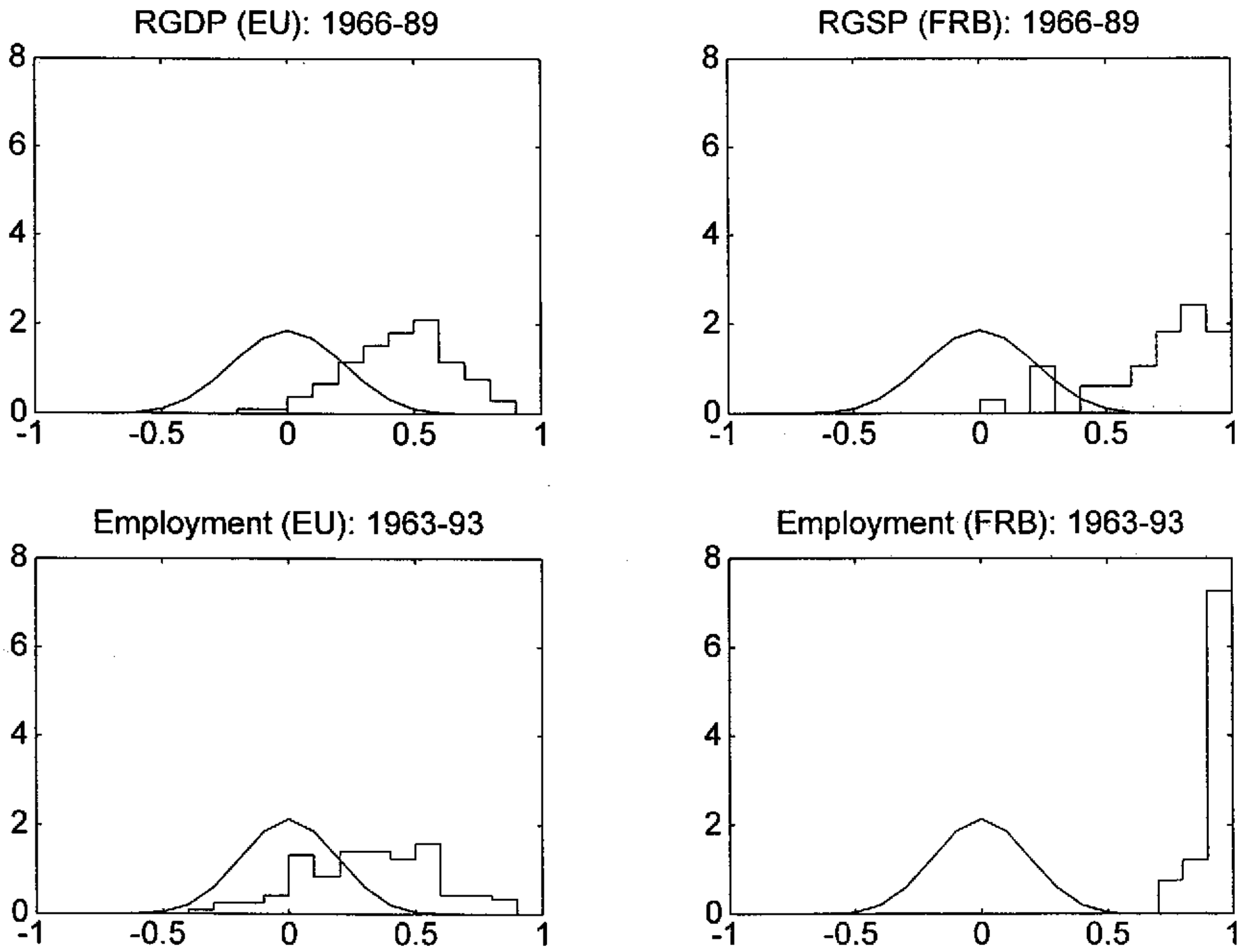
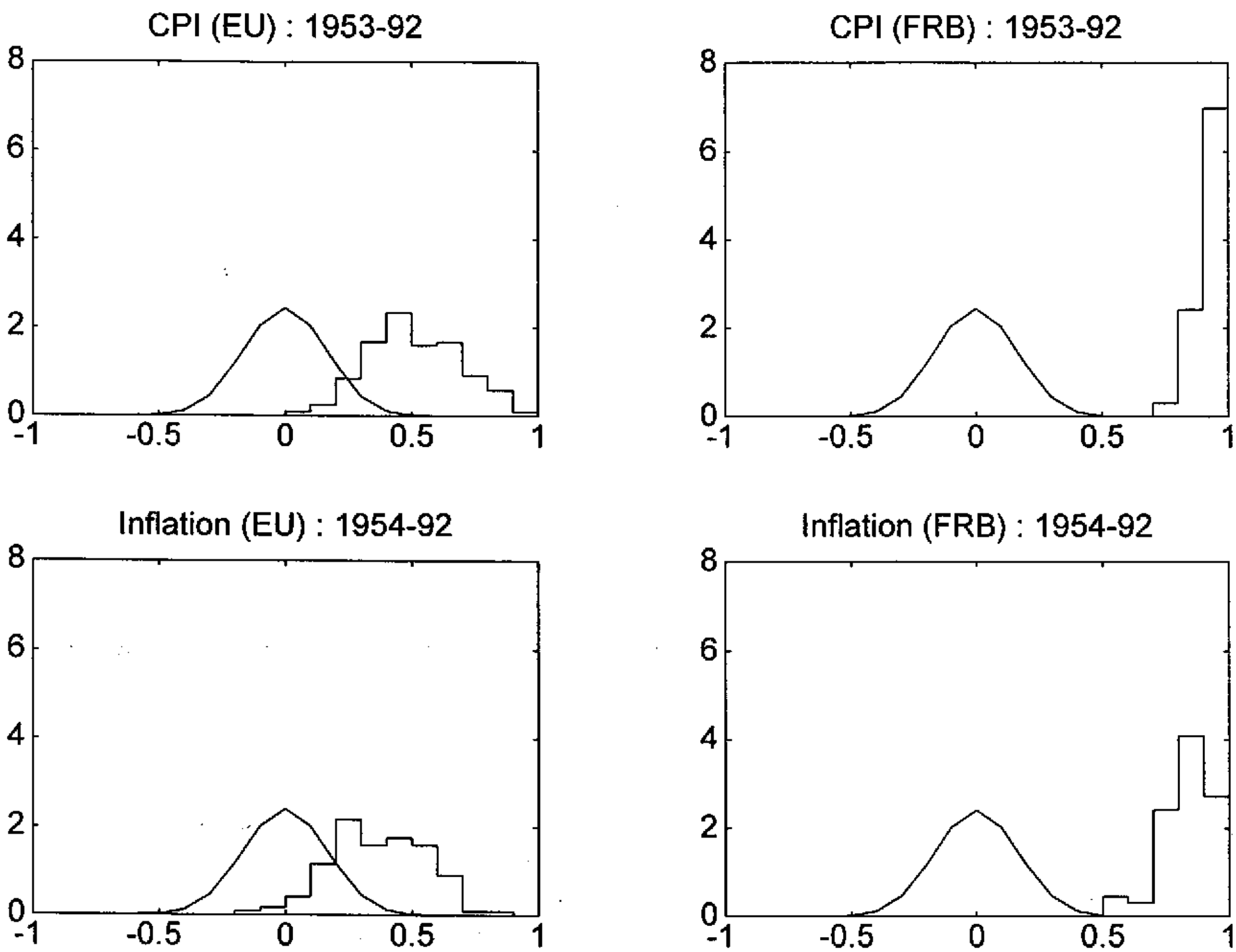


Figure 4. Distribution of Correlation Coefficients



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