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BOND MARKET INFLATION EXPECTATIONS AND LONGER-TERM TRENDS IN BROAD MONETARY GROWTH AND INFLATION IN INDUSTRIAL COUNTRIES, 1880-2001

BY WILLIAM G. DEWALD

September 2003

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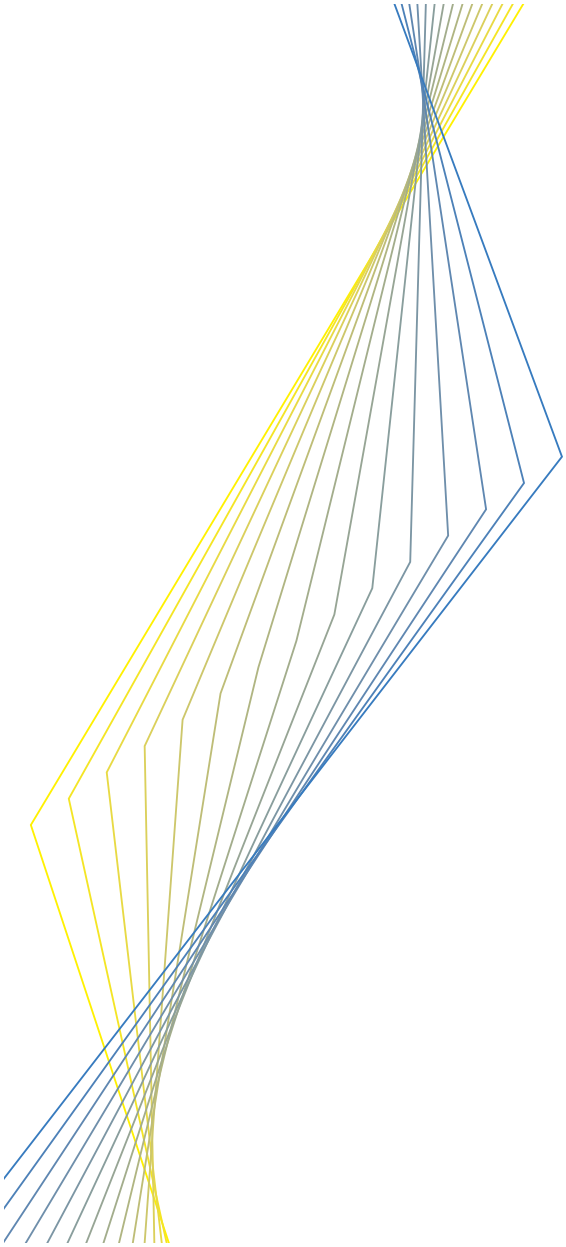

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BOND MARKET INFLATION EXPECTATIONS AND LONGER-TERM TRENDS IN BROAD MONETARY GROWTH AND INFLATION IN INDUSTRIAL COUNTRIES, 1880-2001[1]

BY WILLIAM G. DEWALD[2]

September 2003

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Abstract

"Bond Market Inflation Expectation and Longer-term Trends in Broad Monetary Growth and Inflation in Industrial Countries, 1880-2001" by William G. Dewald, Professor of Economics Emeritus, Ohio State University and Former Director of Research, Federal Reserve Bank of St. Louis.

Annual data for thirteen countries revealed three long up trends and down trends in inflation that were matched by growth rates in M2 and nominal GDP but not real GDP in each country and cross-country averages. Inflationary expectations as estimated by bond rates less real growth trends indicated little inflation expectation until the 1960s. Central banks had credibility to keep inflation low even during wartime. It was lost as inflation rose in the 1970s and regained only as inflation fell subsequently. Although relationships with annual data were not as reliable as with ten-year averages, annual inflation was significantly related to annual M2 growth and inflationary expectations which should not be ignored in central bank decision making.

JEL Classification: E3: Prices, Business Fluctuations, and Cycles
E40: Money and Interest Rates, General
E50: Monetary Policy, Central Banking, and the Supply of Money and Credit, General
N10: Economic History, General, International, or Comparative

Key words: Money
Inflation
Interest Rates
Central Bank
History

Non-technical summary

The methodology of this paper is simple, non-technical, and unabashedly old-fashioned. It focuses on longer-term trends in broad monetary growth and inflation, and between inflation and longer-term interest rates. The data are annual for thirteen major industrial countries, 1880-2001. The countries are Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and the United States. Data are available for every country over recent decades. Earlier there are gaps, particularly for Belgium and Germany during wartime and the German hyperinflation. Bond rates are also unavailable for Japan before 1966. Relationships for individual countries are presented and also cross-country averages. The latter provide not only a pattern against which individual country experiences are compared but also smoother, more reliable relationships than in often-noisy data for each country.

The first part of the paper shows that there were three persisting up trends followed by three persisting downtrends in ten-year average inflation in each country, 1880-2001. Amplitudes differed but frequencies were much the same. The sustained inflation trends were closely matched by sustained trends in growth rates in broad measures of the money supply and nominal GDP but not real GDP. Relationships between unweighted cross-country averages of percent changes were generally more reliable than those based on data for a single country. The data essentially speak for themselves in revealing that longer-term monetary growth trends have been closely related to longer-term trends in inflation, thus tending to confirm a crude Quantity Theory.

A second part of the paper focuses on the relationship between long-term bond rates and inflation. On the assumption that the real growth trend is a proxy for the expected real rate of interest, the difference between ten-year bond rates and a real growth trend is a crude measure of bond market inflationary expectations over the maturity of the bonds. Such measures for the thirteen major industrial countries are calculated based on alternative assumptions about real growth trends. The measures indicate that inflationary expectations did not foresee the surges in inflation that occurred during and after World Wars I and II. Furthermore, bond rates did not even rise much then despite the observation of high inflation. This pattern is interpreted as the monetary authorities having had substantial credibility to restore price stability despite current inflation being high. As it turned out, inflation during World War I and its immediate aftermath was followed by deflation. Inflation during and soon after World War II was followed by disinflation to low levels of inflation. The observation that nominal interest rates had not risen much in response to such wartime bursts of inflation indicates that markets had not expected

high inflation to continue after the war. Those expectations were by and large correct. By contrast, bond market inflation expectations *followed* inflation up in the 1960s and 1970s and down in the 1980s and 1990s. This pattern is interpreted as the monetary authorities having first lost credibility to keep inflation low and then seemingly regaining it only by restoring low inflation. At the beginning of 2003 longer-term bond rates in major industrial countries were indicating that future inflation was expected to stay very low. Yet, whether central banks really had re-established credibility to keep inflation low remained untested. The test would come with increases in observed inflation. If there were credibility to keep inflation low, expectations for future inflation would stay low in the face of an increase in inflation. Based on the period since 1960s, the hold on credibility to keep inflation low in the early 2000s may very well have been precarious despite the stated and implicit goal of central banks to achieve reasonable price stability by keeping inflation low.

The final section of the paper presents annual inflation estimates as a function of current and lagged annual broad monetary growth and bond market inflation expectations in major industrial countries. Although the association between monetary growth and inflation is not as close based on annual percent changes as on ten-year percent changes, it is close and particularly for nations that had very high inflation. Annual inflation was significantly related to current and past values of annual monetary growth and to measured bond market inflationary expectations which marginally moderating the inflationary impact of major shifts in monetary growth on inflation. Regarding the future, longer-term monetary growth trends in major industrial nations turned up in the late 1990s. Although in early 2003 neither bond rates nor forecasters were indicating concern about inflation reigniting, that observation did not necessarily mean inflation trends would stay low. The historical record was that inflationary expectations erred whenever there were major changes in inflation trends but that major changes in inflation trends had been closely linked to monetary growth trends. Thus, if monetary growth remains high, it is not unreasonable to expect that the regularities revealed in the historical record would be repeated in the future and that inflation would rise despite widespread expectations to the contrary.

On the basis of the historical record, the lesson is that central banks and market participants remain cognizant of monetary trends in generating longer-term inflation forecasts. They should be wary of forecasting longer-term inflation trends based on inflation expectations embodied in interest rates, which have generally been wrong when ever inflation trends changed very much. To keep the longer-term inflation trend low, central banks need to keep the longer-term broad monetary growth trend low. If, as is frequently asserted today, everyone accepts Milton Friedman's dictum that "*inflation is always and everywhere a monetary phenomenon*", then central banks always and everywhere need to fashion policy actions to take that empirical verity into account.

Introduction

This paper extends to other industrial countries analysis of U.S. data that the author prepared when he was Director of Research at the Federal Reserve Bank of St. Louis in the 1990s.[1] The methodology is simple, non-technical, and unabashedly old-fashioned. It involves mainly charts and tables that focus on longer-term trends in broad monetary growth and inflation, and between inflation and longer-term interest rates. The data are annual for thirteen major industrial countries, 1880-2001[2]. Relationships for individual countries are presented and also cross-country averages. The latter provide not only a pattern against which individual country experiences are compared but also smoother, more reliable relationships than in often-noisy data for each country.

Milton Friedman: Inflation is always and every where a monetary phenomenon.

Milton Friedman's one-liner reflected the Quantity Theory of Money as supported from many historical observations and his detailed knowledge about the U.S. economy. What is shown in this paper in charts and tables tends to confirm his famous dictum for major industrial countries in the long run. The first part of the paper shows that there have been three persisting up-and-down trends in ten-year average inflation in each country during a 120-year period. Amplitudes differed across countries but frequencies were much the same. The sustained inflation trends were closely matched by sustained trends in growth rates in broad measures of the money supply[3] and nominal GDP but not real GDP. Relationships between simple cross-country averages were generally more reliable than those based on data for a single country. The data essentially speak for themselves in revealing that longer-term monetary growth trends have been closely related to longer-term trends in inflation and nominal spending but not real output, thus tending to confirm a crude Quantity Theory. The charts tell the story in Part I and statistical tests in Part II confirm the relationships.

---

[1] I am indebted to Milton Friedman who liked one of my presentations comparing ten-year averages of U.S. M2 growth and inflation for the period 1959-1998. He extended it to his historical data, which I have replicated with historical data for twelve other countries. I am also indebted to Michael Bordo and Lars Jonung who provided most of the data for the period before the late 1940s. Data sources are listed in an Appendix. The series for the period since World War II were updated from a 2002 vintage International Financial Statistics CD-ROM. Real GDP data for Switzerland for 1914-1928 were constructed from various sources by Felix Andrist while he was visiting the Federal Reserve Bank of St. Louis on leave from the Swiss National Bank. A proxy for broad monetary growth during the German hyperinflation 1918-1923 was the high-powered money estimate from Webb (1989).

[2] The countries are Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, and the United States. Data are available for every country over recent decades. Earlier there are gaps, particularly for Belgium and Germany during wartime and the German hyperinflation.

[3] The reason a broad measure of monetary growth was used when possible is that it fits well over long time spans when narrower measures do not because of ever changing technological and regulatory factors. When Friedman and Schwartz wrote their *Monetary History* (1963) they focused on M2 rather than M1 because, before the establishment of the Federal Reserve, time deposits in the United States were often checkable and thus like demand deposits as they often are again today. Also time and demand deposits were sometimes not separated in the records.

Irving Fisher: the nominal interest rate equals an expected real interest rate plus expected inflation.

Irving Fisher formulated his theoretical relationship that market nominal interest rates would embody expectations of a future real rate of return and a future inflation rate. Before he died in the 1940s the data had not yet shown a systematic link between inflation and interest rates. Empirical evidence in recent decades, however, has revealed that nominal interest rates have indeed reflected inflation. Part III of the current paper focuses on this relationship. On the assumption that the real growth trend is a proxy for the expected real rate of return, the difference between ten-year bond rates and a real growth trend is a crude measure of bond market inflationary expectations over the maturity of the bonds. Such measures for the thirteen major industrial countries are calculated based on alternative assumptions about real growth trends. The measures indicate that inflationary expectations did not foresee the surges in inflation that occurred during and after World Wars I and II and contemporaneously rose little in response to observed inflation in those periods. This pattern is interpreted as the monetary authorities having had substantial credibility to restore price stability despite current inflation being high. As it turned out, inflation during World War I and its immediate aftermath was followed by deflation and inflation during and soon after World War II was followed by disinflation to low levels of inflation. Thus, that nominal interest rates did not rise much in response to such bursts of inflation was not necessarily a failure of Fisher's theory but a confirmation insofar as credit markets had not expected high inflation to continue after the wars ended. Those expectations were by and large correct. By contrast, bond market inflation expectations *followed* inflation up in the 1960s and 1970s and down in the 1980s and 1990s, a pattern interpreted as the monetary authorities having first lost credibility to keep inflation low and then seemingly regaining it only by restoring low inflation. At the beginning of 2003 longer-term bond rates in major industrial countries were indicating that future inflation was expected to stay very low. Yet, whether central banks really had re-established credibility to keep inflation low remained untested. The test would come with increases in observed inflation. If there were credibility to keep inflation low, expectations for future inflation would stay low in the face of an increase in inflation. Based on the period since 1960s, the hold on credibility to keep inflation low in 2003 may very well be precarious despite the stated and implicit goal of central banks to achieve reasonable price stability by keeping inflation low. [4]

[4] Paul A. Volcker. "We Can Survive Prosperity" Speech, San Francisco, December 28, 1983, p.5. "A workable definition of reasonable "price stability" would seem to be a situation in which expectations of generally rising (or falling) prices over a considerable period are not a pervasive influence on economic and financial behavior. Stated more positively, "stability" would imply that decision-making should be able to proceed on the basis that "real" and "nominal" values are substantially the same over the planning horizon--and that planning horizons should be suitably long."

Milton Friedman and Irving Fisher: Keep monetary growth trends low to keep both inflation and longer-term interest rates low.

Part IV of the paper relates annual inflation to current and lagged annual broad monetary growth and to bond market inflation expectations in major industrial countries. Again the analysis is largely descriptive. Although the association between monetary growth and inflation is not as close based on annual percent changes as it is based on ten-year percent changes, it is close and particularly for nations that have had very high inflation. Thus, annual inflation was significantly related to current and past values of annual monetary growth. Furthermore, measured bond market inflationary expectations were estimated to have had an independent effect on inflation, marginally moderating the inflationary impact of major shifts in monetary growth. Regarding the future, longer-term monetary growth trends in major industrial nations turned up in the late 1990s. Although neither bond rates nor forecasters were indicating concern about inflation reigniting, that observation did not necessarily mean inflation trends would stay low. The historical record was that inflationary expectations had erred whenever there were major changes in inflation trends but that major changes in inflation trends had been closely linked to monetary growth trends. Thus, if monetary growth remains high, it is not unreasonable to expect that the regularities revealed in the charts that follow would be repeated in the future.

I. The Data: Ten-year Moving Averages in CPI Inflation, Real and Nominal GDP Growth, and M2 Growth[5]

This section presents ten-year averages of the data with brief comments about the cross-country averages and individual country deviations from them. These moving averages represent the experience of the preceding ten years. The charts are best viewed in color in the electronic version of this paper. The cross-country averages are simple, not weighted, averages. Such charts are ungainly because they include an enormous amount of information but they reveal important patterns and permit some useful comparisons. References and a Data Appendix are at the end of the paper.

Chart 1. Ten-Year Average CPI Inflation 1890-2001

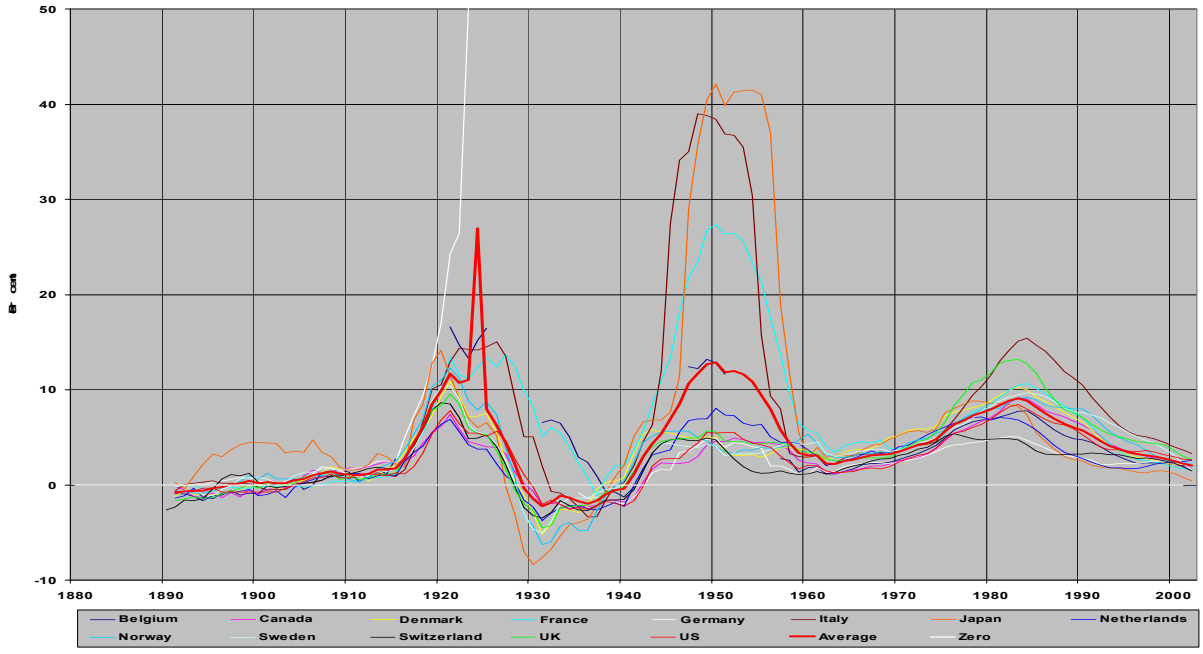


Chart 1 plots the individual country ten-year average CPI inflation trends and a cross-country average. Although amplitudes differed across countries, particularly when inflation trends were comparatively high, every country experienced three up and down trends in ten-year average inflation, 1890-2001. Even when inflation trends across countries were tightly bound before World War I, Japan's trend was out of line on the high side. It was on a silver standard until 1897 and its currency depreciated as the price of silver fell then. During the wartime 1910s inflation generally trended up, led by Japan, and Italy. Some wartime data for Belgium and Germany were not available. The post-war German hyperinflation in the early 1920s took it off the chart. Elsewhere ten-year inflation averages fell sharply with much less

[5] Some data were not available. Real GDP for Japan before 1985 and for Belgium before 1921, also CPI, real GDP, and monetary data for Belgium during World Wars I and II, and monetary data for Germany during World Wars I and II and its hyperinflation in the 1920s. Estimates of the monetary base [Webb (1989)] were used as a proxy for the German money supply during its hyperinflation. Ten-year averages of monetary growth for Germany during its hyperinflation were not available but averages for whatever years were available are plotted to show magnitudes.

than average declines in Belgium, France, and Italy. By the end of the 1920s, ten-year average inflation was negative for most countries and on average across countries. Dramatic confirmation of the magnitude of the Great Depression is that a cross-country average deflation trend persisted throughout the 1930s. The pattern was reversed during the wartime 1940s, led by France, Italy, and Japan. Again, German and Belgian data were not available. After the war, inflation trended down in each nation to a narrow positive range by the early 1960s. An inflation uptrend began in the 1960s with inflation averages comparatively high in Italy and the UK and comparatively low in Germany and Switzerland. The most recent down trend began in the early 1980s with Japan's inflation trend falling relative to the narrow band of declining averages in other major industrial countries. Over the entire 120 year period, inflation trends in Switzerland were lower and more stable than in any other country.

Chart 2. Ten-Year Average Real GDP Growth 1890-2001

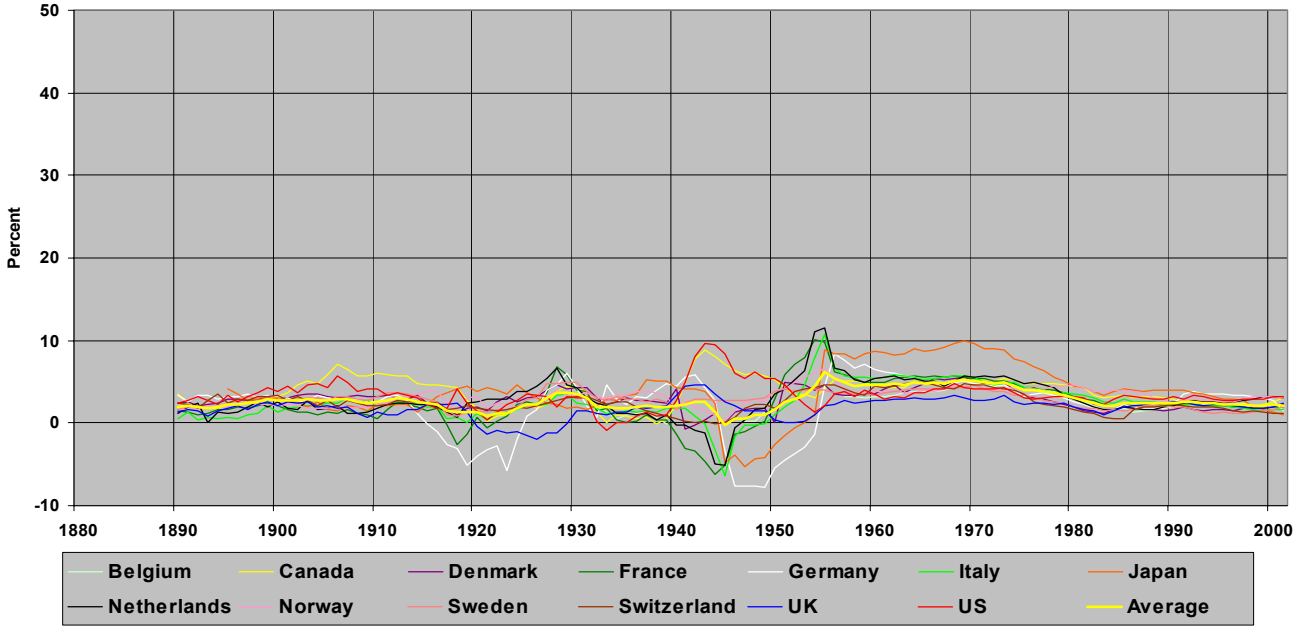


Chart 2 plots individual country ten-year average real GDP growth rates and the cross-country average. There was considerable variability in these observations across both countries and time, yet the real growth trends were far more stable than the inflation trends. The most stable real GDP growth trends were in the decades before World War I and in recent decades after the restoration of output following World War II. Canadian and US real growth ran above that in other countries around the 1900s and during World Wars I and II. Real growth contracted among other belligerents during these wartime periods. The World War I real GDP growth contraction was deep for France, especially deep for Germany, and long lasting for the UK. Belgian real GDP was not available during both World Wars I and II. World War II real GDP contractions were observed not only for France, Germany, and the UK

but also for Italy, Japan and the Netherlands. There was a surge of real growth beginning in the late 1940s following World War II, which was initially strongest in France, Italy, and the Netherlands but persisted at well above average rates for many years in Germany and especially Japan. Japan experienced phenomenal sustained real growth in the 1950s and 1960s before it rejoined other industrial nations with real growth trends in the 1 to 4 percent range in the 1980s through 2001. Between 1947 and 1973 its annual real GDP growth rate averaged 8.8 percent. The UK experienced the slowest post-World War II real GDP growth, yet by the 1990s its growth was in the middle of the narrow range across these thirteen major industrial countries, and Japan had fallen to the lowest level tied with Switzerland.

Chart 3. Ten-Year Average Nominal GDP Growth 1880-2001

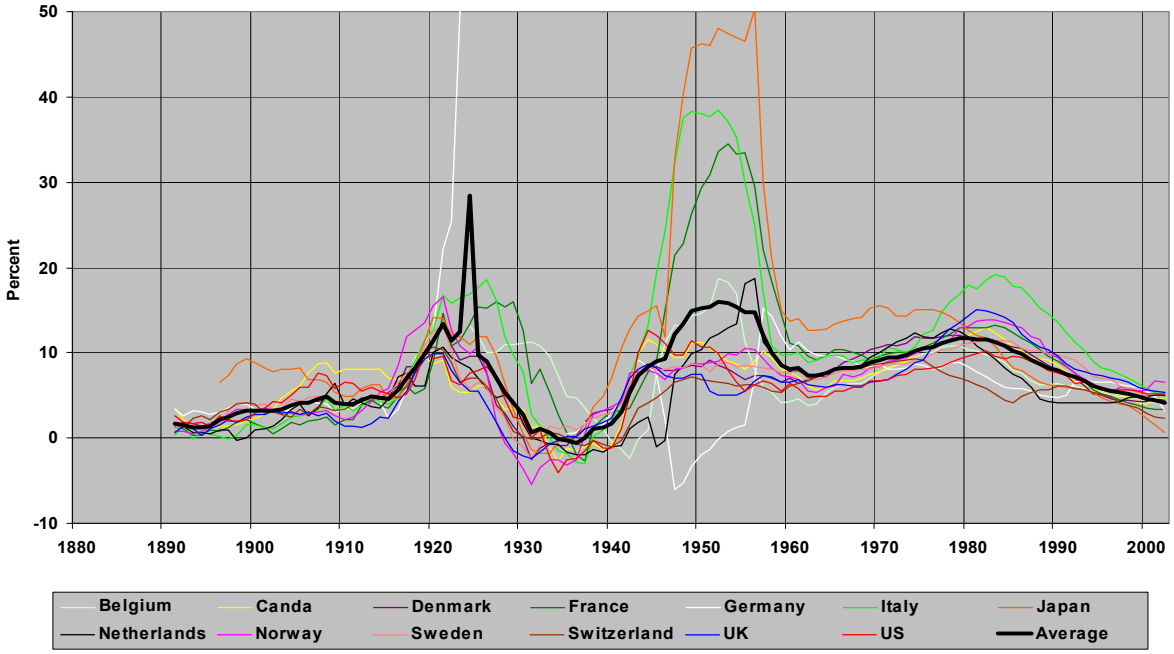


Chart 3 plots individual country and cross-country ten-year average nominal GDP growth rates. The chart looks a lot more like the inflation chart than the real GDP growth chart. There are some exceptions. The collapse of GDP in Germany and the Netherlands during World War II is reflected in their nominal GDP growth in the 1940s. Japan's extraordinary post World War II real growth pattern is reflected in its nominal GDP growth well above that of other countries. Its inflation was also somewhat above average in the 1960s and 1970s. Nonetheless, cross-country ten-year average nominal GDP growth mimics the ten-year average inflation pattern with three distinct longer-term up-and-down trends. By contrast, the charts reveal no readily discernible association between real growth trends and nominal GDP growth or inflation trends.

Chart 4. Ten-Year Average Money Growth 1890-2001

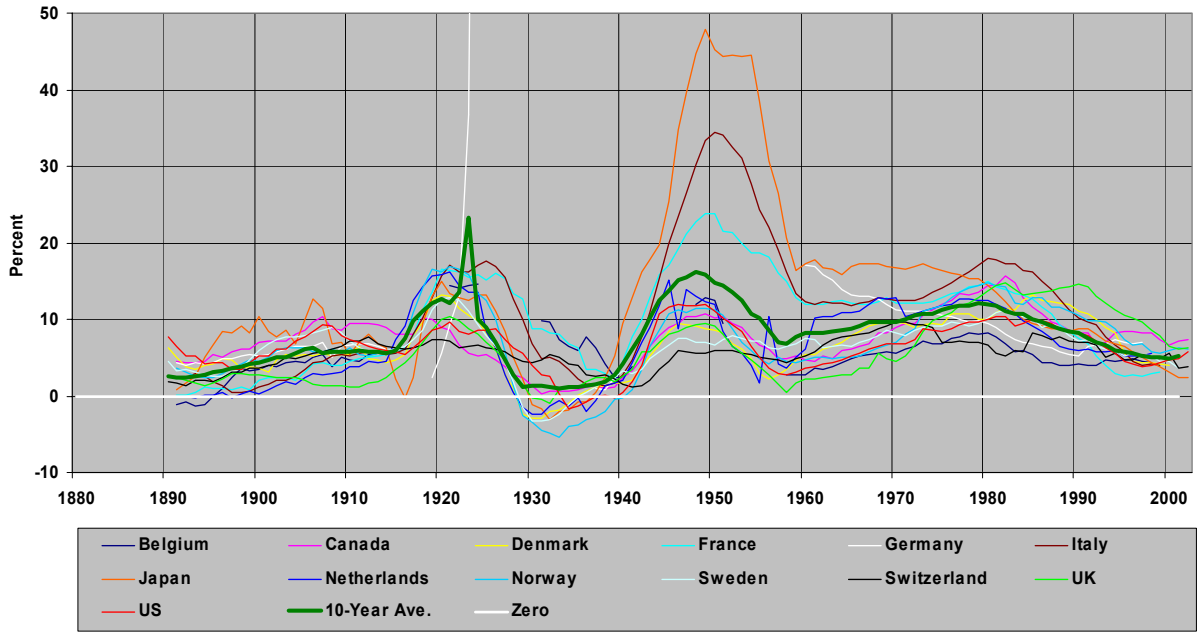


Chart 4 plots individual country ten-year average M2 growth trends. As noted, since German M2 data were not available during its hyperinflation in the 1920s, a central bank money estimate served as a proxy. Monetary data were also missing for Belgium and Germany during both World Wars I and II. The three long up and down trends in cross-country ten-year average inflation and nominal GDP growth appear to correspond closely with three long up and down trends in cross-country ten-year average M2 growth. Nonetheless, the chart shows that there was far more variability in M2 growth trends than in inflation trends across both time and countries. Corresponding with its higher than average inflation trend in the late 19th Century, Japan's monetary growth trend was generally above what was observed elsewhere. In Canada and the United States, M2 growth trends accelerated about 1900 as their real growth outpaced that in other industrial countries. Nonetheless, as Chart 1 showed, their inflation trends remained in line with those in Europe in that Gold Standard era. Extremely high M2 growth trends in Italy and France in the 1910s corresponded with their high inflation trends and their M2 growth trends remained higher than in other countries until toward the late 1930s.. The best example of the relationship between extreme changes in monetary growth and inflation is the German hyperinflation in the 1920s. Its off-the-chart increases in monetary growth in the 1920s were matched by its off-the-chart increases in inflation. M2 growth trends were negative in many countries during the 1930s corresponding with negative average inflation trends in that benighted decade. During World War II in the 1940s, comparatively high monetary growth in France, Italy, and Japan corresponded with their extremely high inflation trends which were far in excess of what they had experienced during World War I. After World War II, M2 growth trends in Germany, France, Italy, and Japan were well above their inflation trends as their real growth recovered rapidly in the 1950s and 1960s. Both M2 growth and inflation trends in Switzerland remained comparatively low when the cross-country averages were high.

Chart 5. Average Ten-year Growth Rates: M2, CPI, NGDP, RGDP 1890-2001

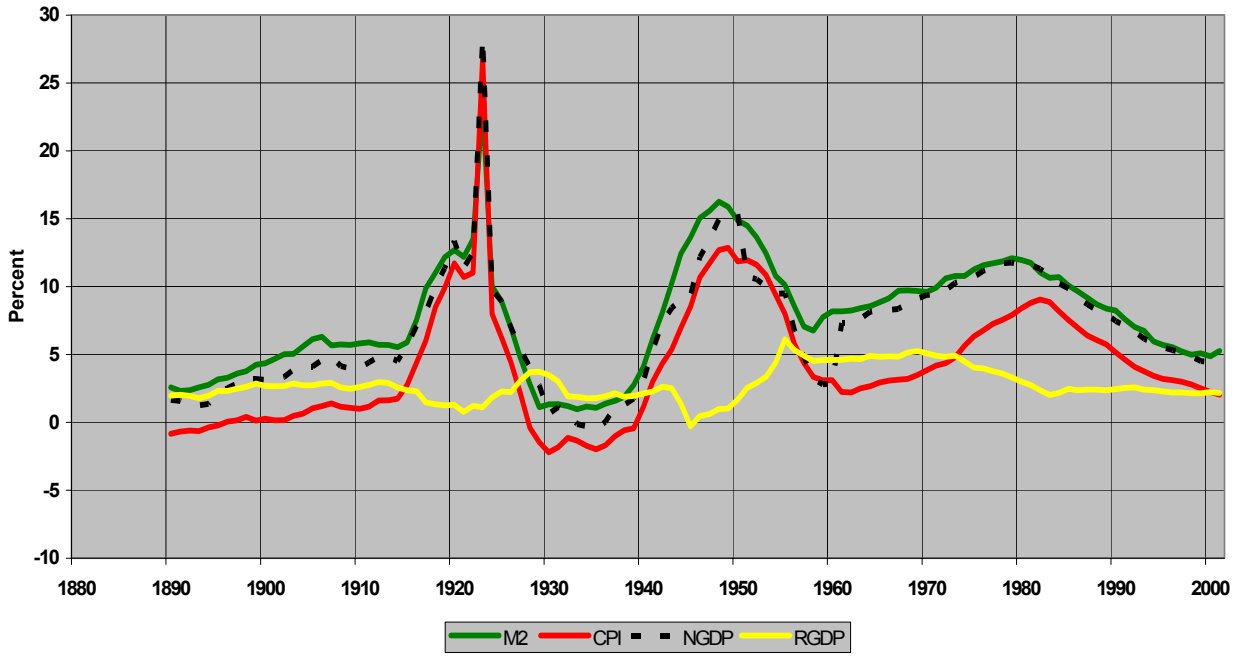


Chart 5 plots each of these cross-country ten-year averages: CPI inflation, nominal and real GDP growth, and M2 growth. The aphorism that "a picture is worth a 1000 words" may understate the message of this chart. Cross-country average M2 growth trends closely corresponded with cross-country average inflation and nominal GDP growth trends in both amplitude and frequency but not with real GDP growth trends.[6] Such evidence tends to confirm Milton Friedman's dictum that "inflation is always and everywhere a monetary phenomenon". The chart also illustrates the Friedman and Schwartz point that there is far greater variability in monetary growth and inflation than in real growth. There certainly were dips and surges in average real growth trends, but these were mainly associated with reductions in real growth during World Wars I and II followed by post war recoveries. The cross-country average ten-year real growth trend ranged from as low as 0 to as high as 6 percent. For the most part it hovered in a 2 to 4 percent range and averaged 2.75 per year. By contrast, even ignoring the German hyperinflation, ten-year average M2 growth ranged between 2 and 16 percent and ten-year average CPI inflation, between –2 and 13 percent.

[6] That money growth is reflected in inflation and not output has been confirmed in many studies including Robert E. Lucas's Nobel Lecture (1996).

Chart 6. Annual and Ten-Year Average Monetary Growth, CPI Inflation, NGDP and RGDP Growth Eleven Major Industrial Countries 1880-2001

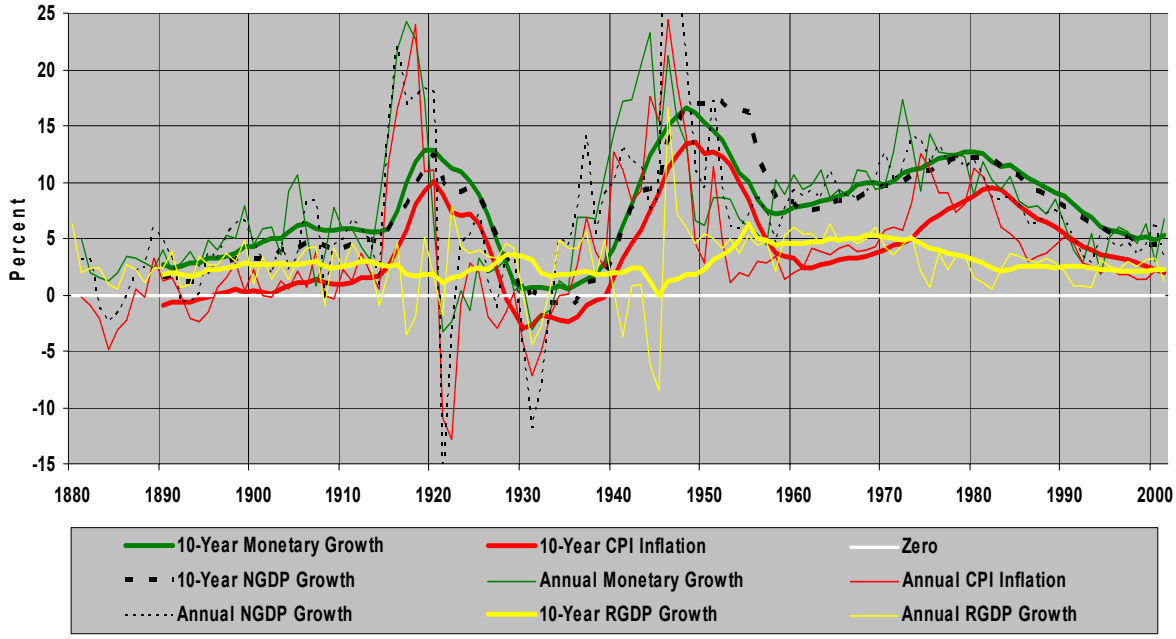


Chart 6 is a compact "Monetary History" of a major part of the industrial world. Plotted are both annual and ten-year cross-country averages of CPI inflation, NGDP and RGDP growth, and M2 growth for the eleven countries for which nearly complete data were available 1880-2001. There was considerable volatility in annual changes in the three nominal magnitudes but common long up trends and down trends in their ten-year averages. The cross-country annual inflation average rose sharply at the first two peaks in the ten-year averages and then fell sharply. The decline from 24 percent in 1918 to –13 percent in 1922 after World War I is remarkable in historical perspective. The disinflation after World War II from 24 percent in 1946 to 3 percent in 1950 was also very sharp but tame by comparison. The historical record of the past 120 years is that there have been three major accelerations in inflation across industrial countries and three major decelerations. Changes in annual average inflation in the recent inflation upturn were smoother but more persistent than in the earlier two.[7] Inflation peaked at 12.6 percent in 1974 and again at 11.2 percent in 1980. During the recent disinflation experience, inflation reversed more slowly than in previous disinflations, falling to less than 4 percent in 1986 before rebounding in the late 1980s and then resuming its downtrend in the 1990s.

[7] Inflation persistence has been studied in many papers with a variety of theoretical foundations. One example is Barsky (1987) which finds virtually no persistence in the pre World War I era, but progressively greater persistence subsequently and substantial persistence beginning in the 1960s. A recent ECB Working Paper on the topic is Batini (2002).

The cross-country average M2 growth pattern was similar, rising strongly along with inflation before peaks and then falling sharply during the first two inflation-disinflation cycles. M2 growth, with a major exception in 1972, was also smoother during the most recent up trend in the inflation cycle than it was in the first two. And, when M2 growth slowed from its high levels in the 1970s and early 1980s, it fell less sharply but more persistently than the precipitous decreases following World Wars I and II, thus corresponding with the smoother disinflation pattern during the most recent downtrend. Although on average M2 growth stayed high in the late 1970s and early 1980s, it moved down by fits and starts to a low of barely 2 percent in 1994 before turning up. The M2 growth cross-country average was running at about 5 percent in 2001.

Over the entire 120 years, whenever the annual change in cross-country average M2 growth accelerated unusually much, it corresponded with annual inflation subsequently accelerating unusually much. Two examples are that annual M2 growth in World War I and World War II peaked a year or two ahead of inflation. Another is that M2 growth sharply accelerated in 1972 after the US dollar lost its link to gold in 1971 and cross-country average inflation peaked two years later in 1974.[8]

M2 growth increased faster than nominal GDP growth during the three up trends in ten-year-average inflation, i.e. M2 velocity fell. It rose during the first two down trends, but not in the most recent down trend. Overall, average M2 velocity fell during 1881-2001.

Real GDP growth was volatile year by year, but was seldom negative and never since World War II. The annual real GDP growth average dipped sharply during World Wars I and II and the Great Depression. It surged after World War II and remained comparatively high in the 1950s and 1960s. To the extent that the three long increases and decreases in cross-country average inflation trends were reflected in real GDP growth trends, the real growth trend tended to rise during periods of disinflation. Although that pattern was mainly associated with wartime disturbances, real GDP growth also trended down in the 1970s as inflation trended up.[9]

[8] The increases in monetary growth following the demise of the Bretton Woods exchange rate system in 1971 were in turn followed by an up turn in inflation. This is an observation where changes in the institutional structure led to increases in monetary growth and in turn inflation. A classic example of such a pattern is the introduction of the cyanide process that led to increases in gold output in the late 19th Century and ,in turn, world-wide increases in monetary growth and inflation.

[9] It may be inappropriate to use the term "cycles" to describe the longer-term movements in inflation inasmuch as it invites a comparison with long cycles in real output. Nonetheless, Chart 5 reveals that decreases in the cross-country real GDP growth trend tended to coincide with rising inflation trends in the 1910s, the 1940s, and the 1970s. Whether an increase in the inflation trend caused a decline in the real growth trend or vice versa is an open question.

Chart 7.

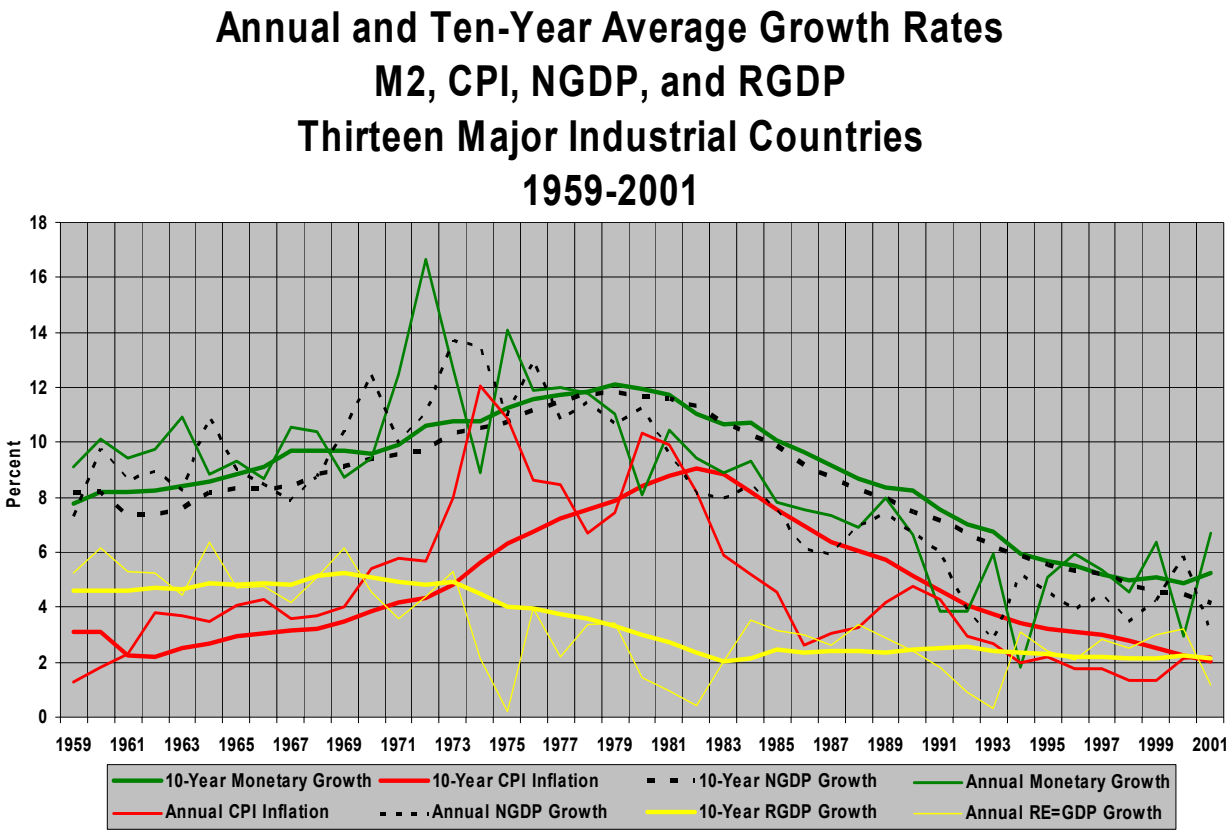


Chart 7 plots these data for thirteen countries 1959-2001. Note again the extraordinary increase in cross-country average M2 growth in 1972, two years before the peak in cross-country average inflation in 1974.

In summary of this broad brush picture, there was a close association between M2 monetary growth and inflation in both ten-year average trends and large annual percentage changes during the 120 years that are plotted. The charts reveal three up and down trends in monetary growth and inflation. Although it would be reasonable to expect that inflationary pressures would wax and wane in relation to real growth movements over a business cycle, the three major swings in average inflation trends during 1880-1921 are not cyclic in that sense. Rather, the major changes in inflationary trends appear to have reflected special events such as wars, banking crises, changes in international monetary regimes, and, differing responses of central bank policy actions to such events. Looking ahead, that central bankers have increasingly accepted the principal responsibility for major changes in inflation trends lends credence to an expectation that future longer trends in inflation might be significantly moderated compared with the historical record.

II. Individual Country and Cross-Country Average Trends in Equation-of-Exchange Variables

Although the Friedman and Schwartz *Monetary History* focused on business cycles, they observed that secular movements in money had been more closely related to secular movements in nominal income and prices than to real income.[10] Their *Monetary Trends in the United States and the United Kingdom, 1867-1975* (1982) emphasised longer-term associations. It was organised around the equation of exchange: **M + v = P + y + n** where the variables are annual percentage changes respectively in the quantity of money, its velocity of circulation, the price level, real total output per capita, and population.

Table 1 presents average growth rates in these equation-of-exchange variables, 1881-2001. As noted, some data were not available: real GDP data for Japan before 1886 and Belgium before 1921 as well as several series for both Belgium and Germany during World Wars I and II. The table includes two averages for Germany, one with and one without its hyperinflation period. Although this paper is focused on the changes in longer-term trends in these data as will be presented in the next section, the 120-year averages provide some interesting cross-country comparisons. Switzerland had the lowest M2 growth and strictly speaking the lowest inflation average 1881-2001. Germany, with its hyperinflation episode, had the highest inflation average but leaving out its hyperinflation and wartime observations, it had the lowest inflation average. Similarly, France, Italy, and Japan had both high M2 growth rates and inflation on average. As is shown below this was largely a reflection of what happened during World War II. For the eleven countries for which nearly complete data were available, population growth averaged 0.9 percent annually and real GDP growth per person, 2.0 percent, 1880-2001. Thus, despite war, depression, and inflation, 2.0 percent per person productivity growth in these industrial countries translated into an increase in their average real GDP per person by more than ten-fold in 120 years. During these 12 decades, M2 monetary growth averaged about 7½ percent a year, which was about half a percentage point higher than the nominal GDP growth. Annual real GDP growth averaged about 2¾ percent and CPI inflation 3½ to 4 percent.

[10] "Since real income tends to vary over the cycle in the same direction as money income does, we have also observed a close relation between cyclical movements in the money stock and in real income or business activity. The relation between secular movements in the money stock and in real income is much less close. Real income grew at much the same rate during each of the four periods of stability listed earlier. Yet the money stock and prices grew at quite different rates, prices declining by 1 percent a year in one period, rising by 2 percent a year in another. Apparently, the forces determining the long-run rate of growth of real income are largely independent of the long-run rate of growth of the stock of money, so long as both proceed fairly smoothly but marked instability of money is accompanied by instability of economic growth." Friedman and Schwartz (1963), p. 678.

Table 1. Equation of Exchange Trend Growth Rates, 1881-2001

Percent per Year

	Population	RGDP/Person	CPI	NGDP	M2	v
Belgium[1]	0.41	2.32	3.59	6.35	5.53	0.82
Canada	1.64	2.14	2.48	6.38	7.29	-0.91
Denmark	0.82	1.94	3.20	6.10	6.25	-0.15
France	0.38	1.96	6.20	8.71	9.28	-0.57
Germany[2]	0.50	1.72	25.43	25.72	24.46	1.26
Germany[3]	1.07	2.65	1.56	5.44	7.68	-2.24
Italy	0.59	1.78	7.16	10.01	10.57	-0.55
Japan[4]	1.03	2.65	6.27	11.50	11.91	-0.41
Netherlands	1.14	1.73	2.38	5.61	6.24	-0.64
Norway	0.71	2.31	3.24	6.30	6.80	-0.50
Sweden	0.54	2.20	3.12	6.11	6.12	-0.01
Switzerland	0.77	1.66	1.83	4.60	5.26	-0.67
UK	0.45	1.35	3.28	5.43	5.82	-0.39
US	1.43	1.85	2.41	5.70	6.47	-0.77
Average(13)[2]	0.80	1.97	5.43	8.35	8.61	-0.27
Average(13)[3]	0.85	2.04	3.59	6.79	7.32	-0.54
Average(11)[5]	0.86	1.96	3.78	6.95	7.46	-0.50

1. Excludes 1880-1920 and 1941-1947.
2. Excludes 1913-1917, 1924, and 1939-1948. (Includes hyperinflation.)
3. Excludes 1913-1924 and 1939-1948.(Excludes hyperinflation.)
4. GDP missing for 1880-1885.
5. Excludes Belgium and Germany but includes all data for 11 countries 1880-2001.

-

Table 2a. Correlation Coefficients: Equation of Exchange Trends, 1880-2001

(Excludes German Hyper Inflation Period)

	Population	RGDP/Person	Price Level	NGDP	M2	v
Population	1.00					
RGDP/Person	0.78	1.00				
Price Level	-0.42	-0.22	1.00			
NGDP	-0.13	0.14	0.92	1.00		
M2	0.04	0.27	0.82	0.94	1.00	
v	-0.51	-0.41	0.29	0.13	-0.20	1.00

Table 2b. Correlation Coefficients: Equation of Exchange Trends, 1880-2001

(Includes German Hyper Inflation Period)

	Population	RGDP/Person	Price Level	NGDP	M2	v
Population	1.00					
RGDP/Person	0.16	1.00				
Price Level	-0.32	-0.14	1.00			
NGDP	-0.25	-0.03	0.99	1.00		
M2	-0.20	-0.04	0.98	1.00	1.00	
v	-0.56	0.07	0.71	0.67	0.60	1.00

Tables 2a and 2b present correlation coefficients for the relationships across countries among the overall averages in these equation-of-exchange variables. The 120-year average changes in the nominal magnitudes: price level, nominal GDP growth, and M2 growth were highly correlated, particularly when the German hyper inflation episode is included. The inflation averages were negatively correlated with the RGDP/person growth and population growth.

Table 3. Annual and Ten-year Growth Rate Correlation Coefficients, 1880-2001

	M2 and CPI		M2 and NNP		M2 and RGDP	
	Annual	10-Year	Annual	10-Year	Annual	10-Year
Belgium	0.46	0.88	0.35	0.85	0.27	0.01
Canada	0.52	0.76	0.57	0.84	0.33	0.49
Denmark	0.51	0.88	0.54	0.88	-0.13	-0.26
France	0.65	0.89	0.50	0.86	0.00	0.16
Germany	1.00	0.98	1.00	0.99	-0.50	-0.39
Italy	0.66	0.91	0.16	0.10	-0.04	0.08
Japan	0.60	0.92	0.46	0.95	-0.23	-0.23
Netherlands	0.26	0.82	0.35	0.65	0.06	0.07
Norway	0.68	0.93	0.51	0.89	-0.20	0.00
Sweden	0.70	0.84	0.55	0.86	-0.19	-0.26
Switzerland	0.32	0.57	0.43	0.76	0.07	0.36
UK	0.65	0.89	0.62	0.87	0.04	0.07
US	0.52	0.75	0.72	0.90	0.49	0.58
Average*	0.95	0.95	0.91	0.96	-0.04	-0.03

* Correlation for cross-country average, not an average of coefficients.

Table 3 presents correlation coefficients for the association in individual countries between M2 growth and CPI inflation, M2 growth and nominal GDP growth, and M2 growth and real GDP growth. As the charts presented earlier suggested, M2 growth was positively correlated with inflation and nominal GDP growth in year-to-year and especially ten-year growth rates both in individual-country and cross-country averages. In contrast to the positive correlation among the nominal magnitudes, there was little positive correlation between M2 growth and real GDP growth either in annual or ten-year average data for nine of the eleven industrial countries for data back to 1880. The major exceptions are Canada and the

United States, which is attributed to three factors. First, before World War I, population and real output growth but not inflation trends were comparatively high in Canada and the United States along side comparatively high M2 growth. Second, because both nations suffered comparatively deep and extended depressions during the 1930s, rapid M2 growth during World War II was accompanied by increases in real growth to a larger extent than it was in other countries.[11] Third, although both Canada and the United States were belligerents, the war was not fought on their soil and thus did not directly reduce their real output.

Tables 4 and 5 present regression results. Ten-year averages of CPI inflation and nominal GDP growth were regressed on ten-year average M2 growth for individual countries (excluding Belgium and Germany) and the eleven-country equally weighted cross-country average. The estimated coefficients of the effect of M2 growth on inflation were significant for every country and close to unity for the cross-country averages. The relationships generally had lower standard errors of estimate in the cross-country averages than in the estimated relationships for individual countries. The regressions with cross-country averages tend to confirm the crude Quantity Theory that changes in M2 growth are associated with proportional changes in inflation and nominal GDP growth. In the CPI inflation regressions, the constants were uniformly negative with T-values at 2 or above, no doubt reflecting that an increase in real output growth (which was not included as a variable) would reduce inflation given other factors. The regression based on the cross-country averages fit better than any of the individual country regressions. Its estimated coefficient on M2 growth was 0.96 with a higher T-value than estimated in the comparable regression for any single country. This finding reflects that the random noise in the individual country data is smoother in cross-country averages, an observation consistent with the central limit theorem of classical statistics.[12] That the R^2 Adjusted for Switzerland was the lowest of all is perhaps a consequence of its having the lower inflation on average. It is what one would expect if a central bank were successful in managing monetary growth to keep inflation low.

The NGDP regressions yielded comparable results except that the estimated constants were more positive. Nonetheless, the estimated constants were generally negative as is consistent with a secular decrease in M2 velocity, i.e. a decrease in the ratio of NGDP to M2. Regression results involving annual data are presented in the final section of the paper.

[11] Germany also experienced a severe depression in the early 1930s and its real growth also fell sharply during World Wars I and II and its hyperinflation in the 1920s.

[14] If a population has a finite variance σ^2 and mean μ, then the distribution of the sample mean approaches the normal distribution with variance σ^2/n and mean μ as the sample size n increases.

Table 4. Regression of CPI Inflation Growth on M2 Growth

Ten-Year Averages, 1890-2001

	Constant	T-stat	M	T-stat	R^2 Adj	SE
Belgium	NA	NA	NA	NA	NA	NA
Canada	-2.20	-5.12	0.65	12.23	0.57	1.88
Denmark	-1.72	-5.61	0.81	19.67	0.78	1.66
France	-3.14	-5.42	1.01	20.19	0.79	3.20
Germany	NA	NA	NA	NA	NA	NA
Italy	-4.74	-6.77	1.12	22.20	0.82	4.31
Japan	-4.59	-7.42	0.89	24.65	0.85	4.33
Netherlands	-0.68	-2.49	0.49	14.96	0.68	1.75
Norway	-1.33	-5.73	0.69	25.58	0.85	1.46
Sweden	-1.94	-5.00	0.71	13.08	0.61	1.90
Switzerland	-1.90	-2.00	0.96	5.97	0.24	3.34
UK	-0.53	-1.97	0.66	17.97	0.74	1.70
US	-1.80	-4.76	0.62	11.49	0.54	1.72
Average(11)	-3.31	-13.08	0.96	32.88	0.91	1.24

* Regression with cross-country averages, not an average of individual country results.

Table 5. Regressions of NGDP Growth on M2 Growth

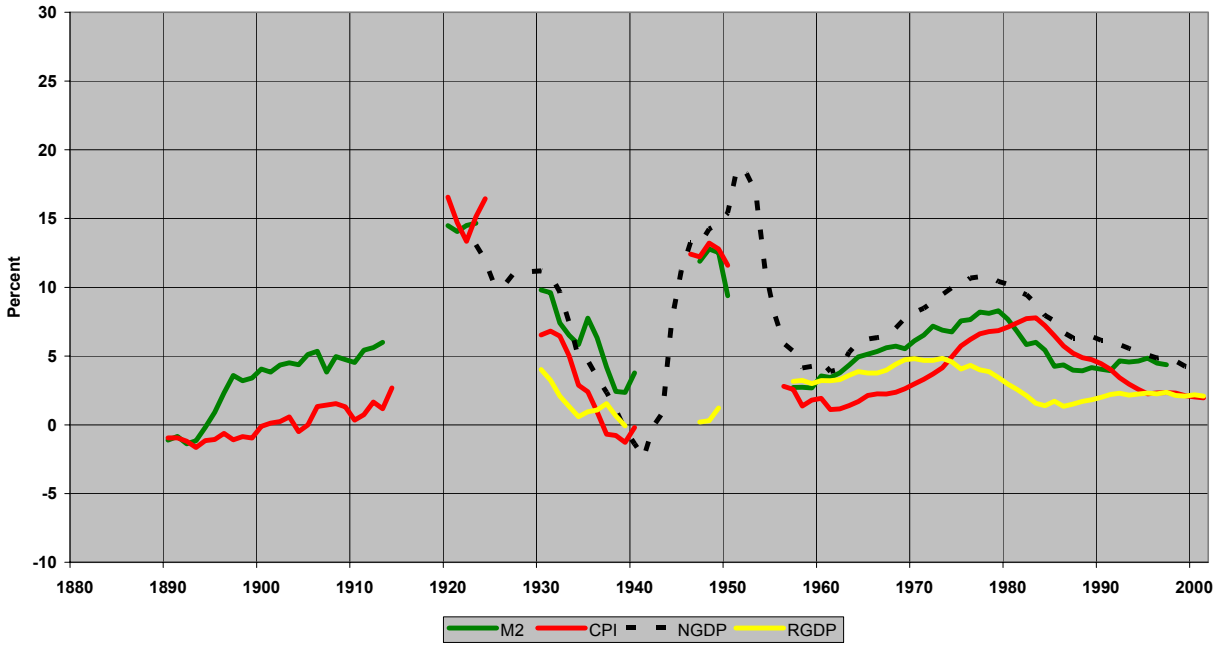
Ten-Year Averages, 1890-2001

	Constant	T-stat	M	T-stat	R^2 Adj	SE
Belgium	NA	NA	NA	NA	NA	NA
Canada	-0.32	-0.71	0.92	16.57	0.71	1.98
Denmark	1.11	3.46	0.83	19.33	0.77	1.73
France	-1.91	-2.55	1.15	17.78	0.74	4.14
Germany	NA	NA	NA	NA	NA	NA
Italy	-2.14	-5.63	1.17	42.63	0.94	2.34
Japan	-0.71	-1.27	0.98	30.50	0.90	3.78
Netherlands	1.95	3.54	0.58	8.75	0.41	3.52
Norway	0.94	2.81	0.80	20.56	0.79	2.11
Sweden	1.00	2.88	0.86	17.59	0.74	1.70
Switzerland	-1.05	-2.06	1.07	12.30	0.58	1.80
UK	1.02	3.17	0.79	18.11	0.75	2.01
US	-0.53	-1.64	1.00	22.06	0.81	1.46
Average*	-0.98	-4.29	0.99	37.75	0.93	1.12

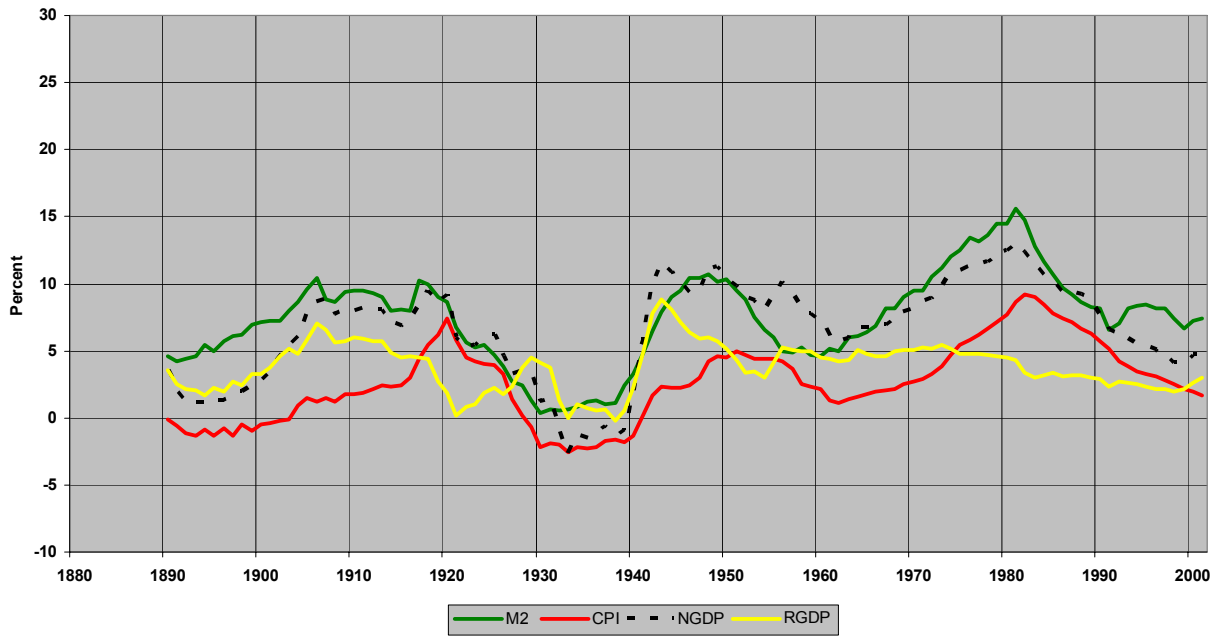
* Regression with cross-country averages, not an average of individual country results.

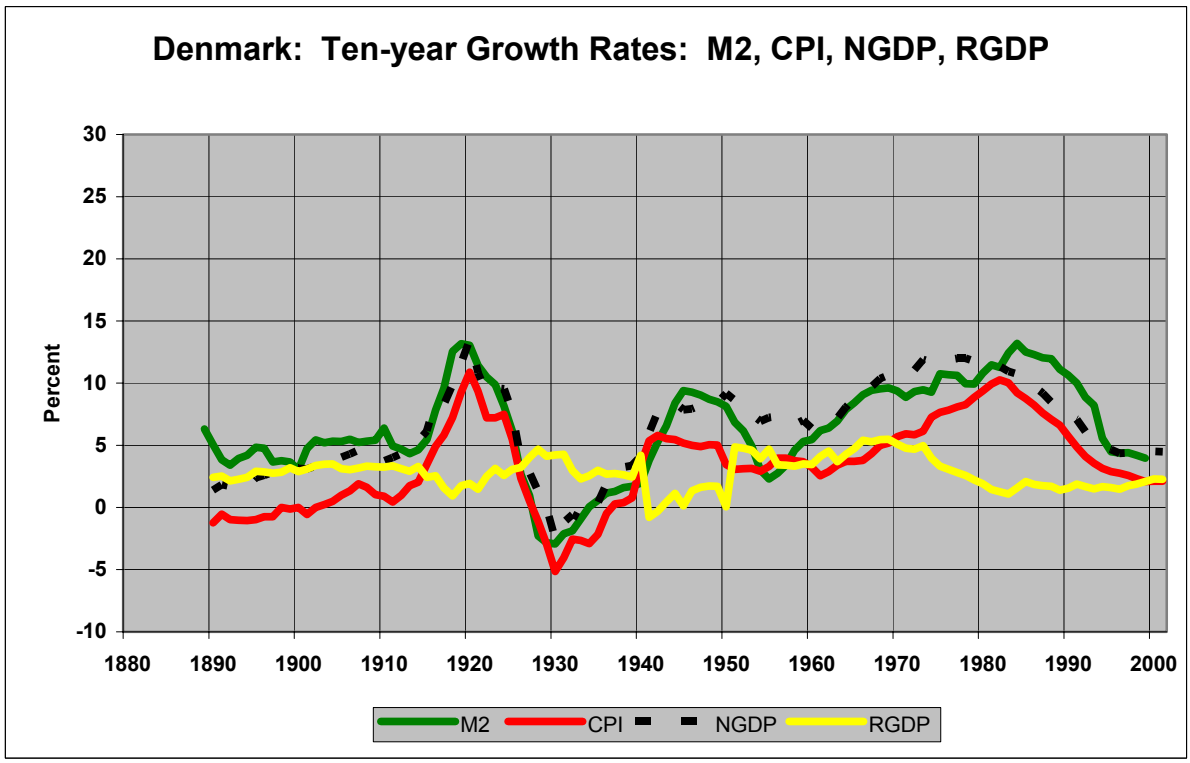
Chart 8 plots ten-year averages of M2 growth, nominal and real GDP growth, and CPI inflation for each country. Despite differences in magnitudes, the data for each country display distinct common longer-term inflation-disinflation trends in the nominal growth rates but not in real GDP growth rates. As noted, Switzerland kept average inflation comparatively low, yet it \too had three long periods of alternating inflation and disinflation, 1880-2001. The rise and fall of inflation trends during 1963-2001 were remarkably similar across countries. Monetary growth trends were generally comparable with the inflation trends. Nonetheless, the remarkably high real growth in the 1950s and 1960s in countries such as Germany and Japan that had been most devastated by World War II allowed them to have low inflation along side rapid monetary growth. In contrast, the German hyperinflation in the 1920s was the most extreme observation where high monetary growth was associated with reduced real growth.

Chart 8. **Belgium: Ten-year Growth Rates: M2, CPI, NGDP, RGDP**



Canada: Ten-year Growth Rates: M2, CPI, NGDP, RGDP




Denmark: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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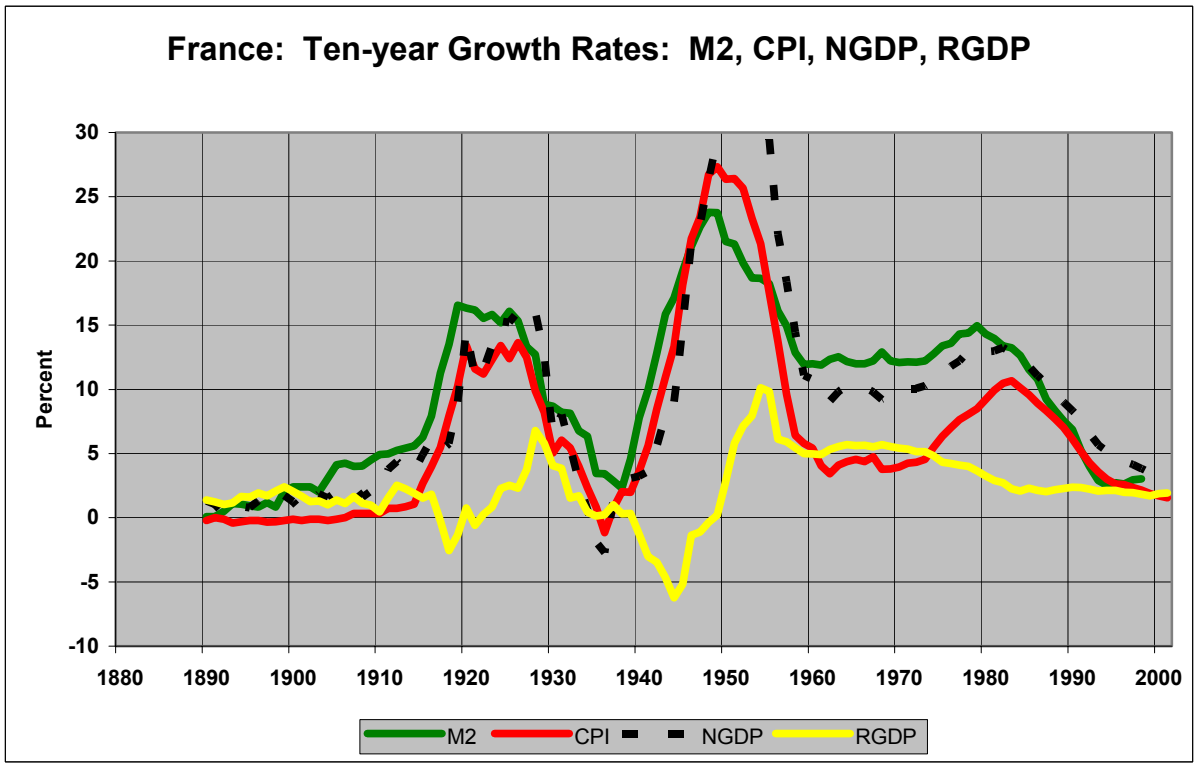
France: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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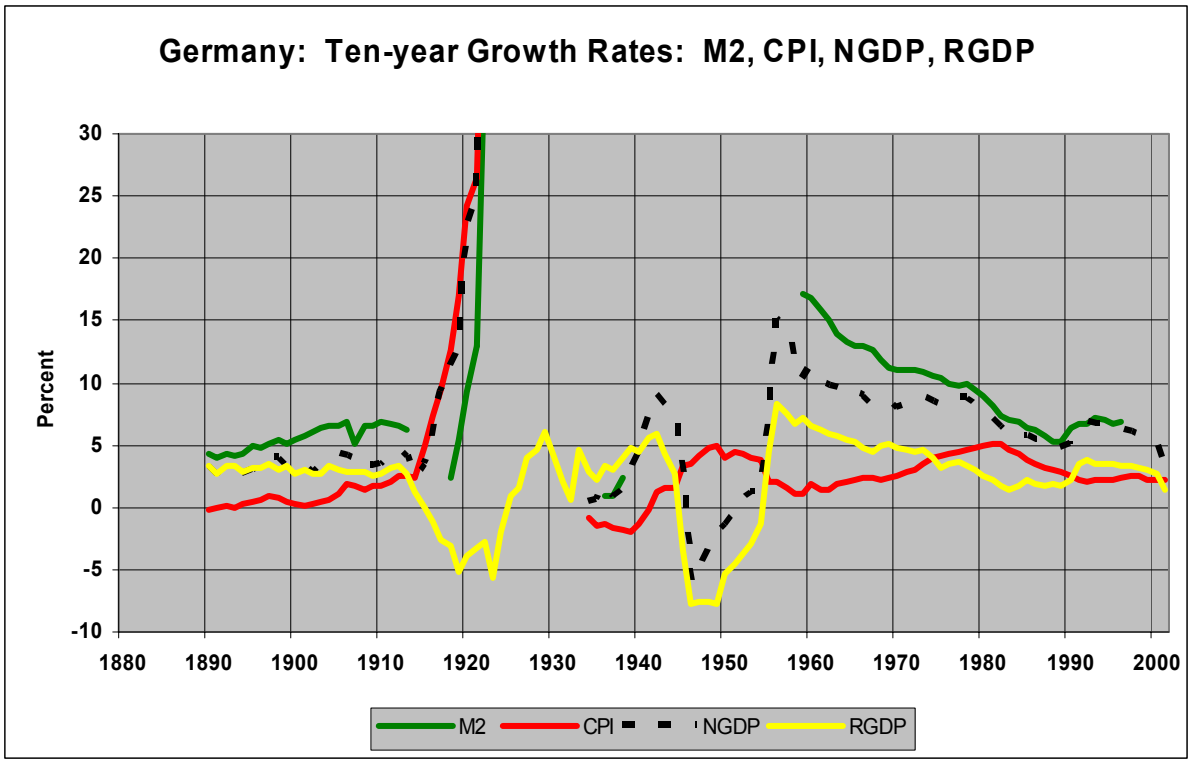
Germany: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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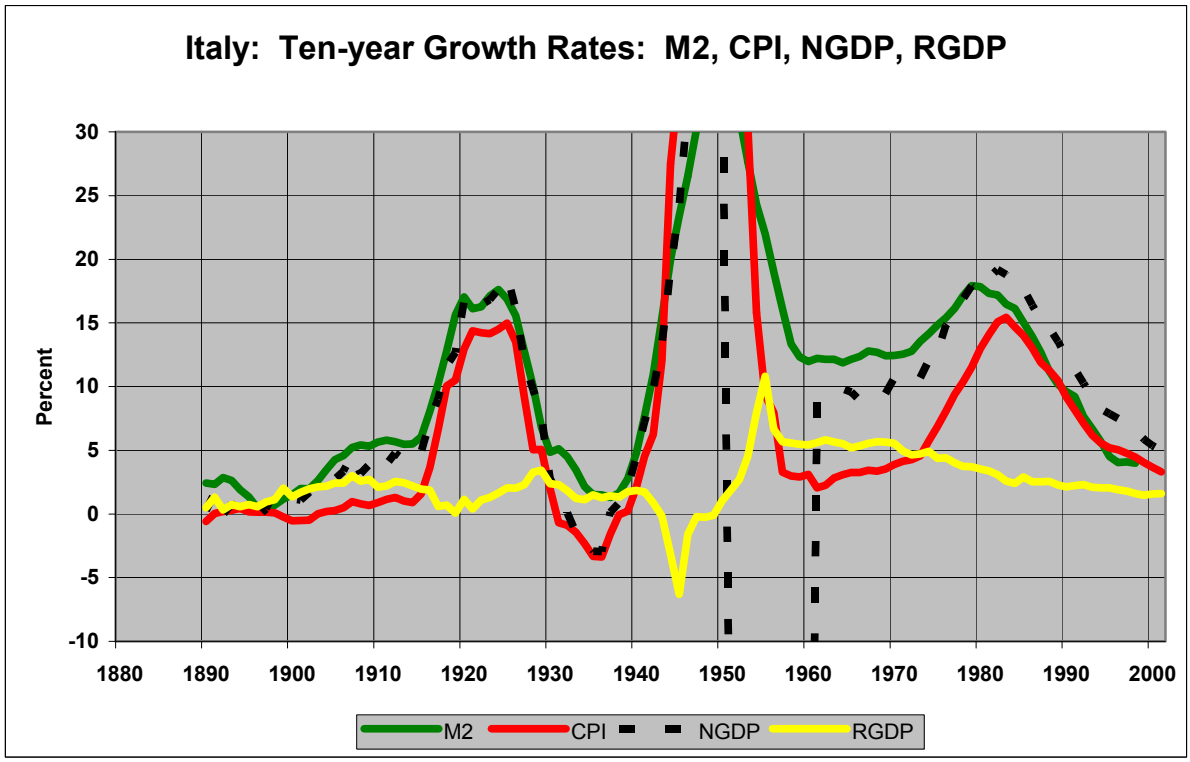
Italy: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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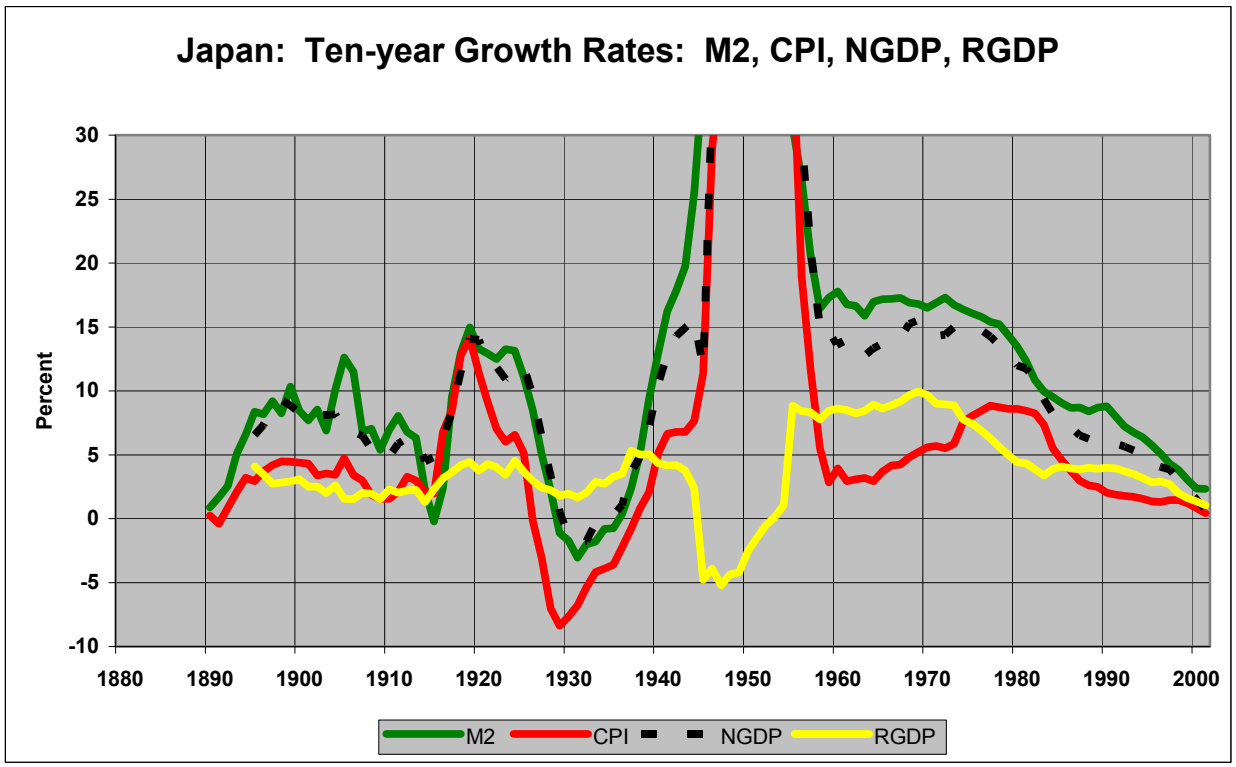
Japan: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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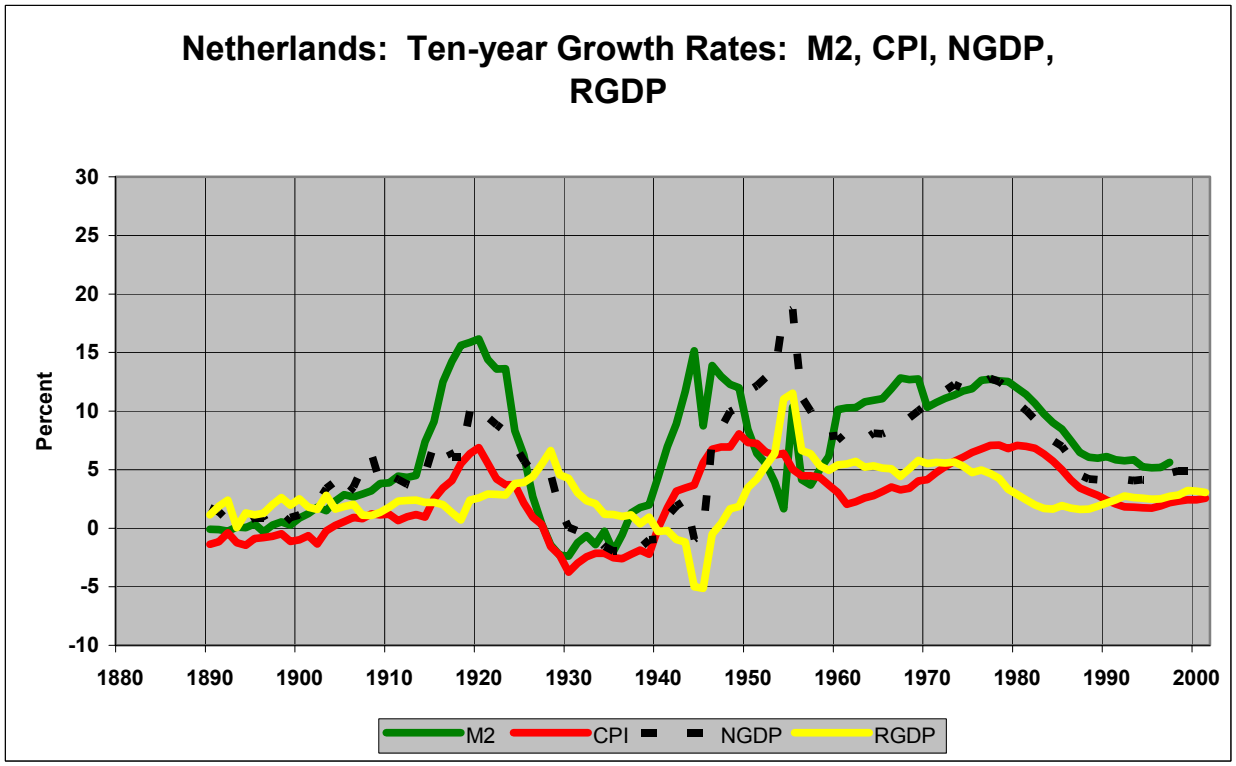
Netherlands: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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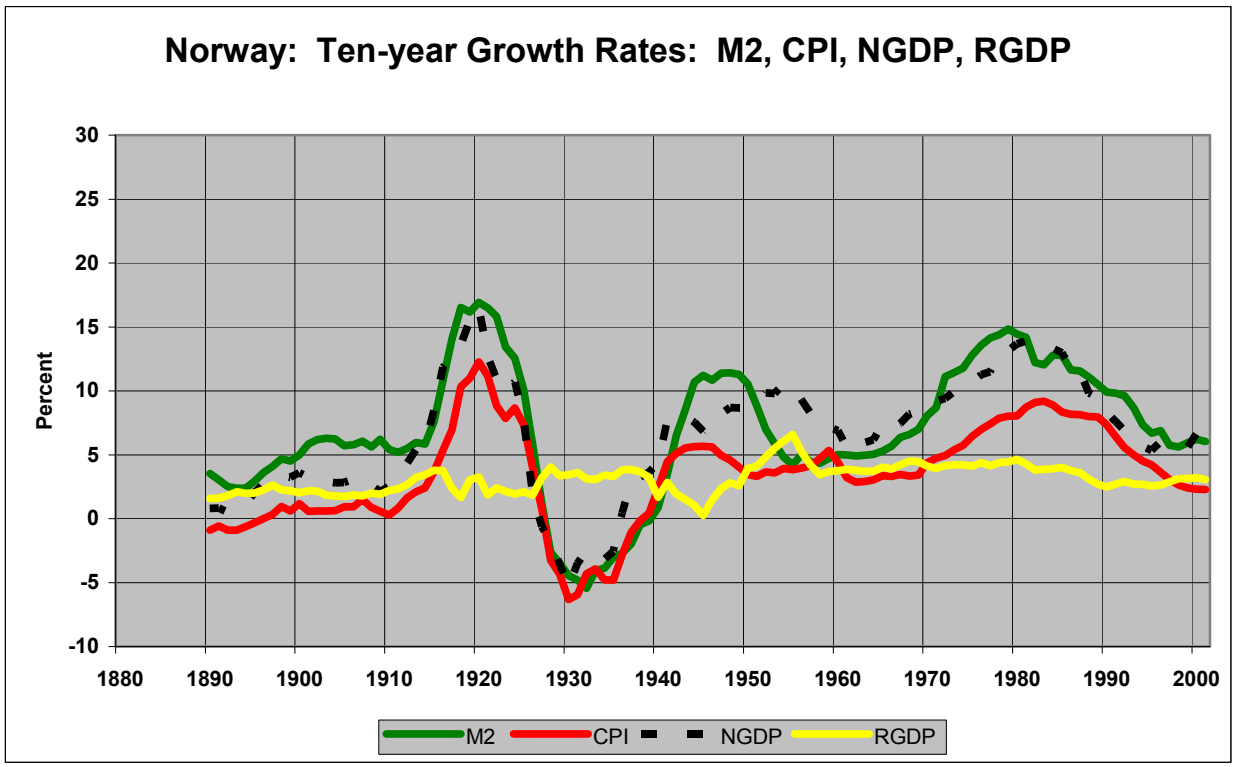
Norway: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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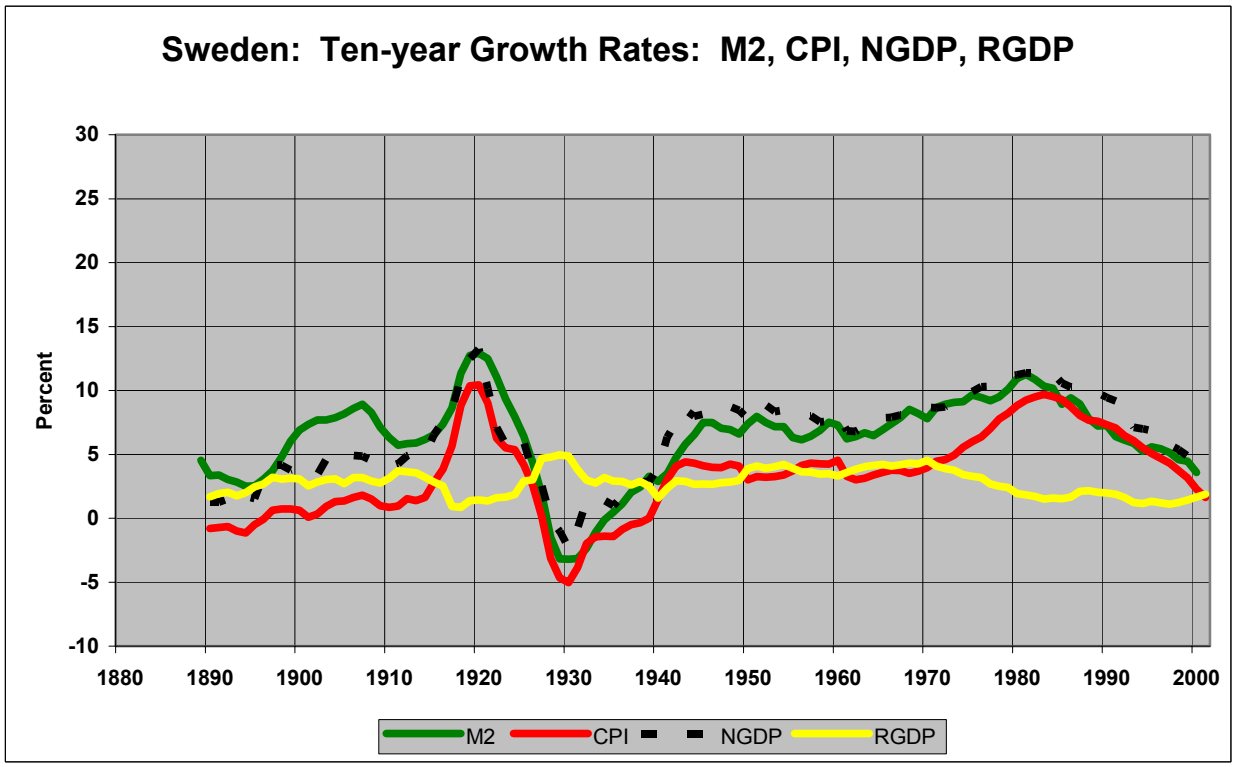
Sweden: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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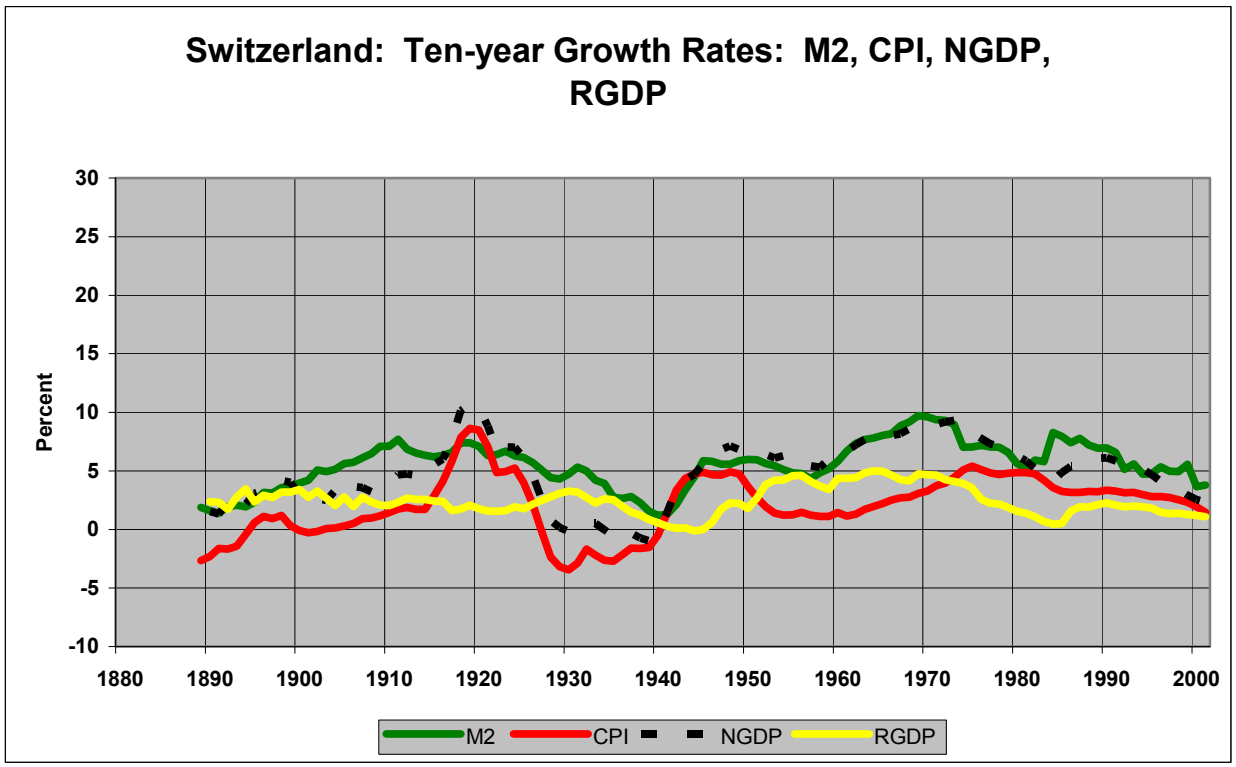
Switzerland: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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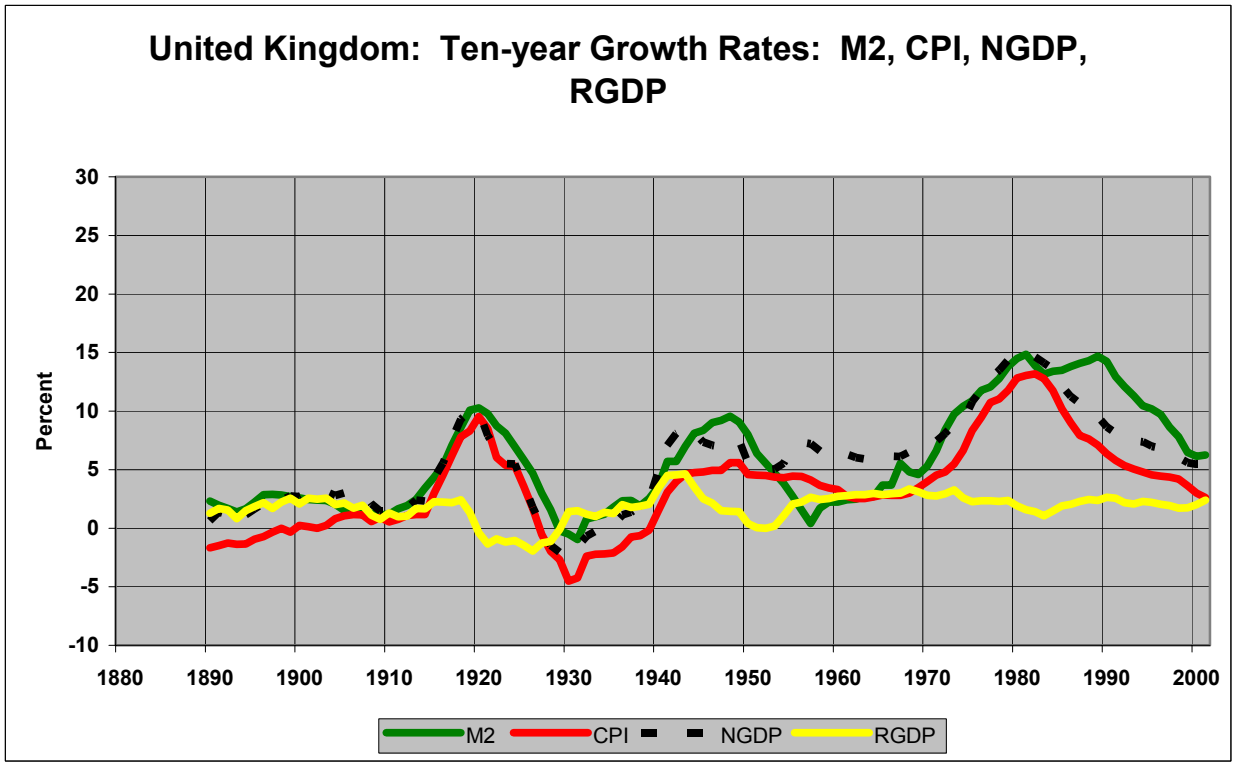
United Kingdom: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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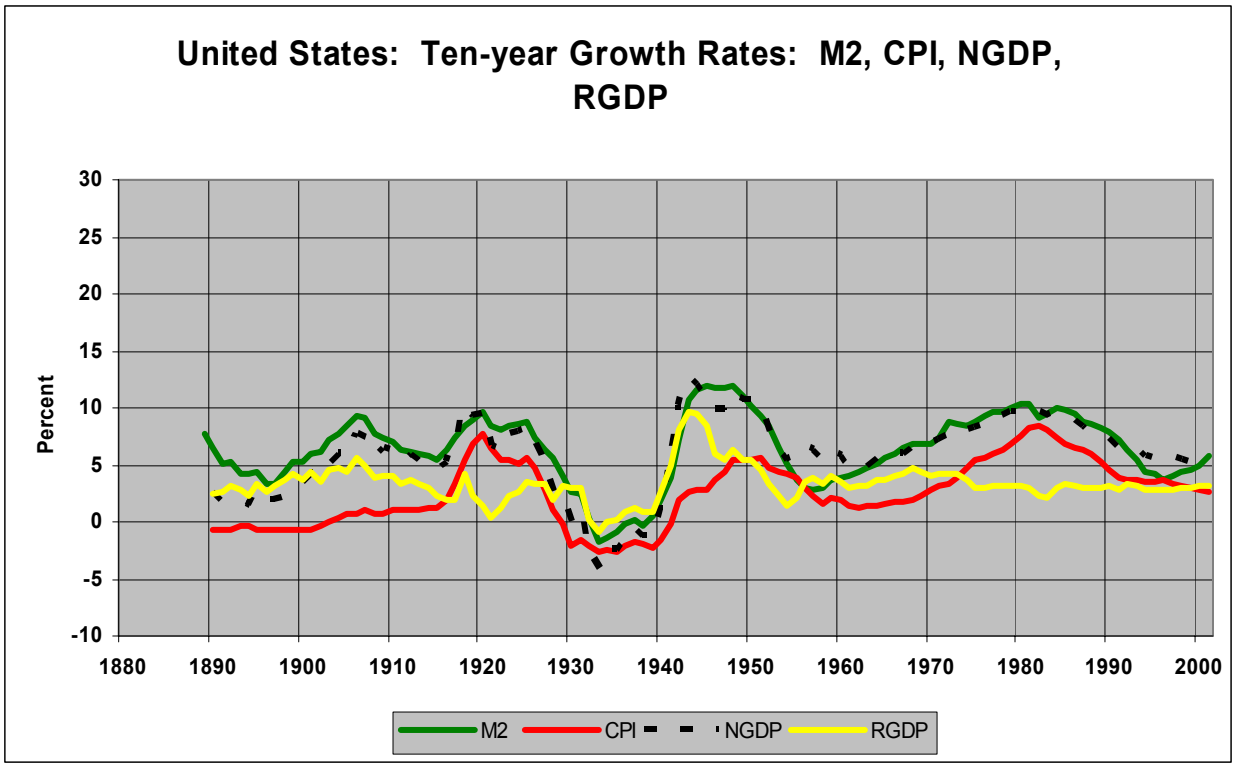
United States: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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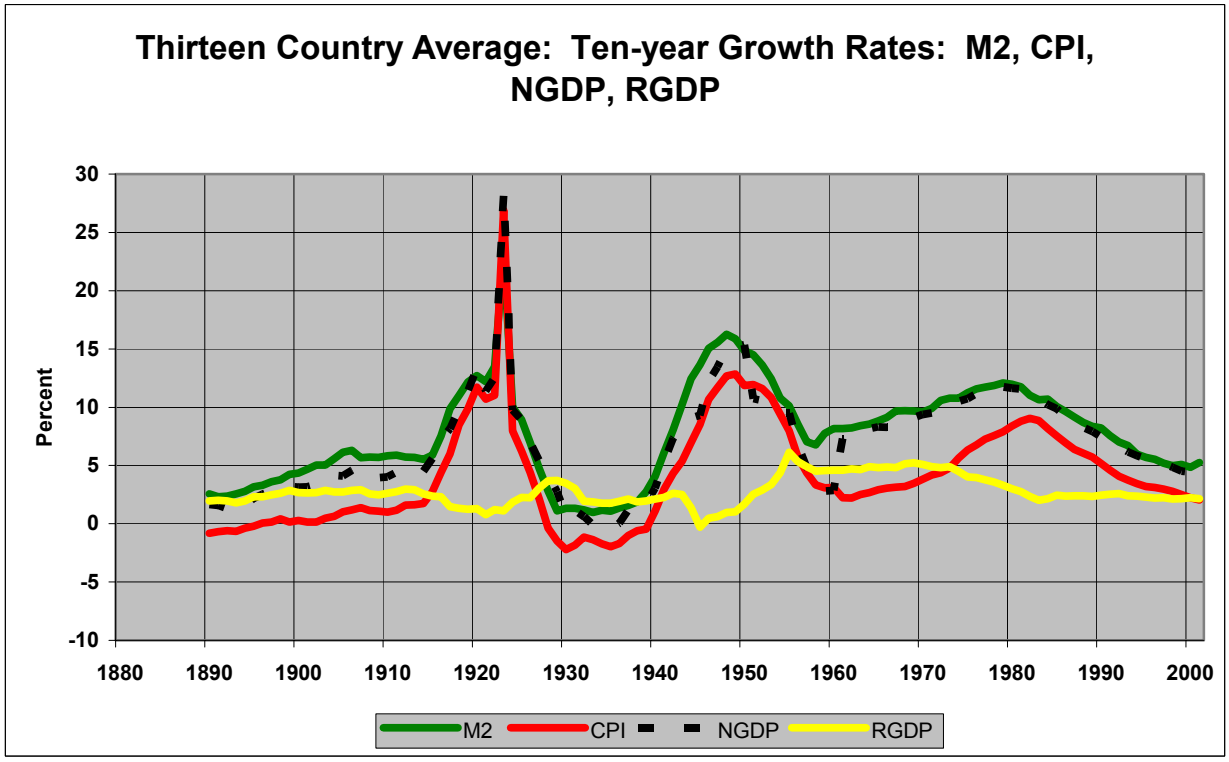
Thirteen Country Average: Ten-year Growth Rates: M2, CPI, NGDP, RGDP
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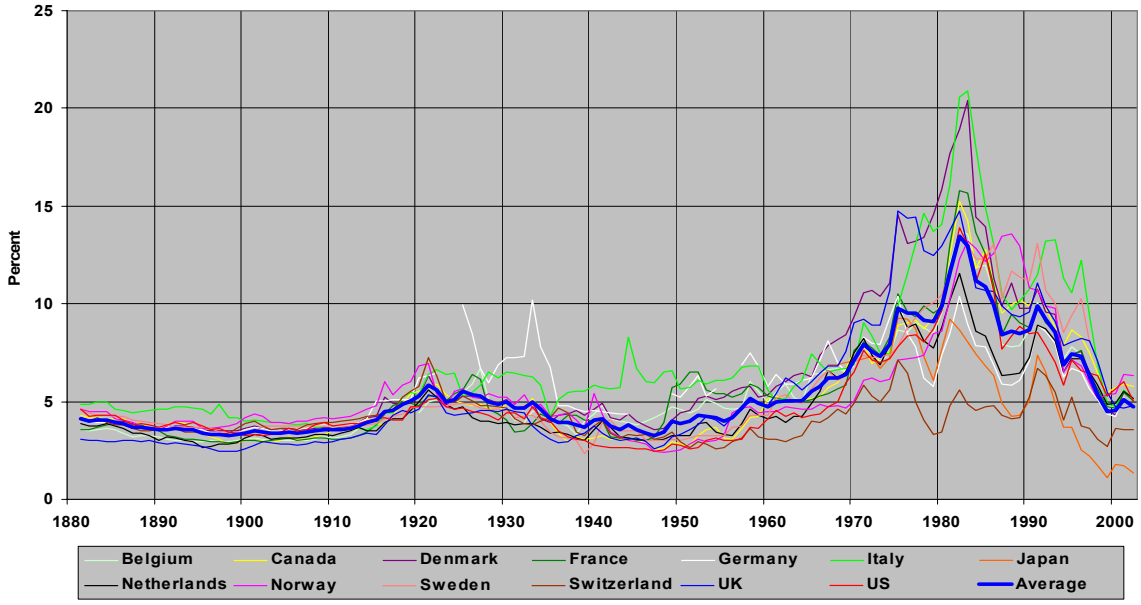
III. Inflationary Expectations Embodied in Bond Rates

An earlier paper explored historical data to show that longer-term bond rates did not change much in response to year to year variation in inflation when longer-term inflation trends remained low and price levels comparatively stable.[1] Ten-year high quality bond rates[2] in the thirteen countries included in the present study were utilized to extract a *Fisher-Golden Rule* measure of bond market inflationary expectations for 1880-1913 and 1962-1995. The interpretation was that longer-term interest rates were an indicator of how bond markets saw future inflation prospects. The reason is that bond rates incorporate both implicit expectations of future inflation, the *Fisher effect*[3], and implicit expectations of future real interest rates, the *Golden Rule effect*[4]. The latter effect is that in a long-term equilibrium, the real rate of interest would reflect the real output growth rate. Although tax, regulation, and risk factors also affect bond rates, the *Fisher-Golden Rule hypothesis* is that the difference between the bond rate and trend real growth is a crude measure of implicit bond market inflation expectations over the maturity of a bond.

Chart 9. Long-Term Bond Rates 1880-2001



[15] This section extends Bordo and Dewald(1999) which compared bond market inflationary expectations in the decades before World War I and in recent decades which in turn followed along lines suggested in Dewald (1998).

[16] Bond rate data for Japan and real GDP for Belgium are missing during 1880-1913, and inflation for Belgium during 1915-1919. Although various long-term bond rate series were used, the chart labels them as ten-year rates.

[17] "The fact that interest expressed in *money* is high, say 15 per cent, might conceivably indicate merely that general prices are expected to rise (i.e., money depreciate) at the rate of 10 per cent, and that the rate of interest expressed in terms of *goods* is not high, but only about 5 per cent." Irving Fisher *The Theory of Interest*, Reprints of Economic Classics, Augustus M. Kelly, 1961, pp. 41-42.

[18] This is a common assumption in both theoretical and empirical studies. In formulating his "Taylor Rule", John Taylor (1993) set the equilibrium short-term interest rate at the trend growth in real income because this value is approximately equal to potential growth, i.e. compatible with a long-term equilibrium growth path.

Chart 9 plots ten-year bond rates for individual countries and a cross-country average, 1880-2001. Bond rates generally rose following the inflationary experience during World War I but such increases were no where close to reflecting actual inflation. Presumably bond investors were looking into the future and did not expect a repetition of wartime inflation. There were scattered high rates in Germany at the time of its hyperinflation although the data are certainly suspect. In the 1930s there were some observations of high rates in Italy and Germany. Once again the data are questionable, although with the political disturbances in both countries, high rates would not be a surprise. The main story of this chart is that sometime in the mid-1960s or early 1970s bond rates starting rising along with the increase in inflation. And bond rates tended to rise most in the countries with the most inflation. Italy, the UK, France, Denmark, and Sweden and even Japan had comparatively high inflation rates in the 1970s. The chart shows how diverse the cross-country longer-term interest rates were in recent decades compared with earlier years. One country, Switzerland, had comparatively low inflation rates and comparatively low long term bond rates in recent decades. But even it experienced an upturn in both inflation and long-term bond rates in the 1970s and early 1980s.

Chart 10. Long-Term Bond Rates and Inflation
Major Industrial Countries, 1880-2001

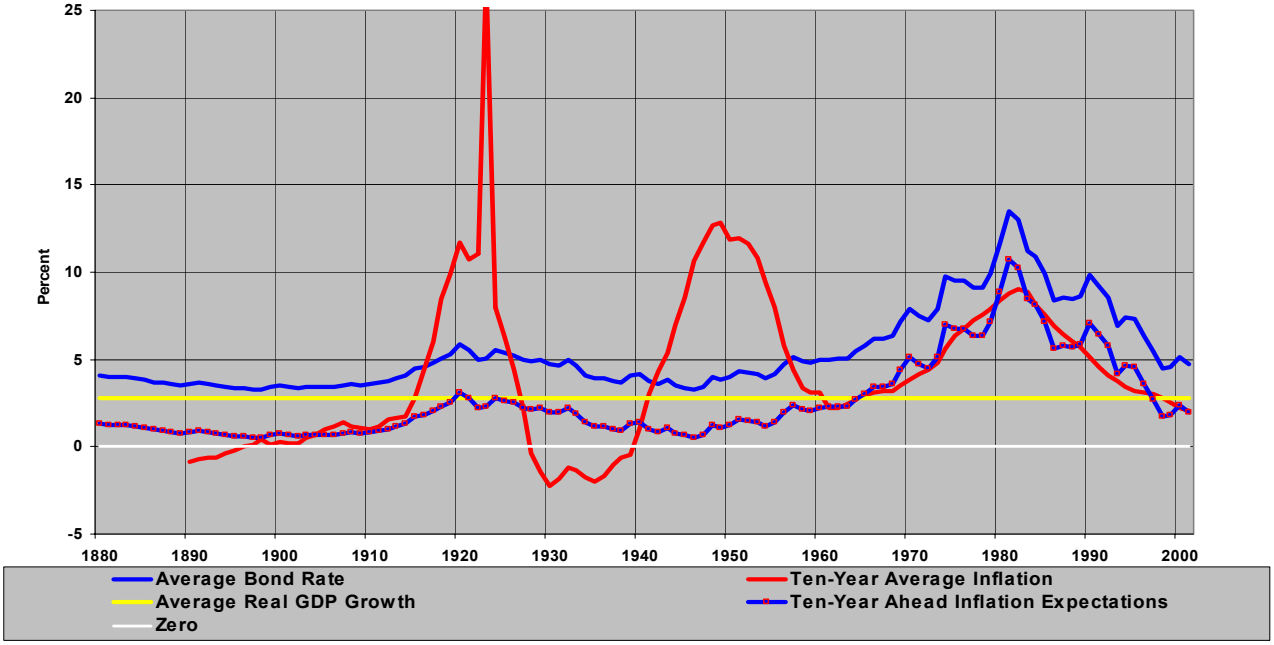
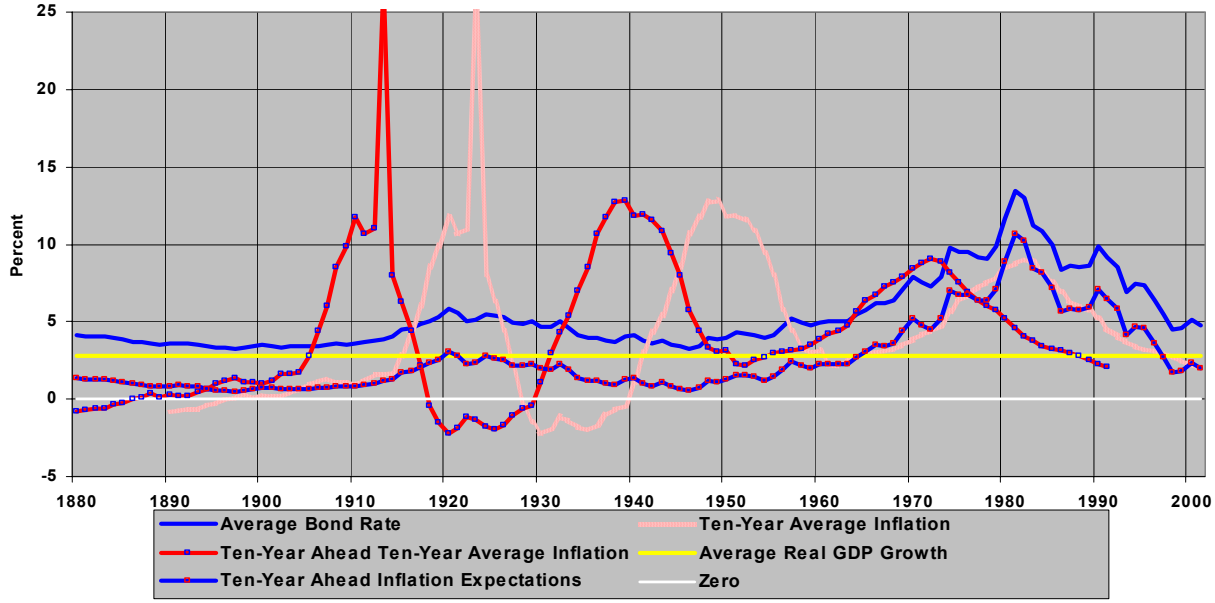


Chart 10 plots a cross-country average ten-year bond rate, the cross-country-average real growth rate, and the cross-country average ten-year inflation rate. As noted, the difference between the annual bond rate average and the overall average real growth rate is interpreted as a crude measure of bond market inflationary expectations over the ten-year maturity of the bonds.

This measure of ten-year-ahead inflation expectations rose from less than zero in 1890 to about 3 percent in 1920 following the gradual increase in inflation in the years before World War I and the surge in inflation that occurred during the war. Wartime wage and price controls no doubt contributed to keeping bond rates low during the war but bond rate averages stayed low after the war even in those countries where wartime depreciation in its currency was not fully reversed by post war deflation. Bond rates during the World War II were even less responsive to inflation. That wartime inflation was not reflected in bond rates very much presumably reflected that wartime inflation was not expected to continue.[5] Looking at the broad picture across major industrial nations, bond rates did not start following inflation trends very closely until the 1960s. Before then, bursts of inflation were not much reflected in bond rates presumably because central banks and governments had credibility in the bond market to keep price levels comparatively stable and thus inflation trends low. The cross-country average bond rate surpassed its early 1920s level in the mid-1960s. Since then, bond rates and hence expected inflation appear to have been closely linked to observed inflation trends.[6]

Chart 11. Long-Term Bond Rates and Inflation
Major Industrial Countries, 1880-2001



[5] This point is made by Barsky (1987).

[6] Bordo and Jonung (2001) emphasize varying commitments of central banks to convertibility under monetary regimes from the gold standard to various gold exchange systems, to their abandonment with floating in the 1970s, to rule-like behavior under inflation targeting coupled with limits on government debt. Although regime changes certainly were reflected in the patterns reported in the present paper, the emphasis here is on the similar relationship between monetary growth and inflation regardless of the regime as well as on the observation that bond markets retained expectations for low inflation even when inflation was high regardless of the monetary regime until sometime in the 1960s when bond market inflationary expectations started following inflation trends which took bond rates to unprecedented levels.

Chart 11 overlays the ten-year-ahead inflation average on Chart 10. What appeared as a reasonably close fit of the bond rate average to the average ten-year inflation trend in recent decades is shown to be a very bad fit to *actual* ten-year-ahead inflation. The bond market seemingly has had inflationary expectations that roughly conformed with inflation ten-years back, not ten-years ahead. It is the latter, of course, that is relevant. Hence, the observation that bond market inflation expectations for the next ten years roughly followed what inflation averaged over the preceding ten years represents expectations that deviated very much from the actual experience.[7]

Tables 6, 7, and 8 present root mean square error statistics for individual country and cross-country averages of bond market expectations. Three models with regard to underling real growth trends were specified. The first assumed that the real interest rate in each country was equal to its own ten-year real GDP growth trend. The second assumed that the relevant real growth trend for each country was the overall cross-country ten-year average real growth trend. The third assumed that the real interest rate in each country was simply its own real growth trend over the entire period.

[7] In my draft paper with Michael Bordo, we compared this measure of inflation expectations for the 33 years before World War I and the 33 years ending 1995. We found that bond rates embodied reasonably accurate expectations of inflation only when inflation trends were low but that they failed to identify major changes in inflation trends.

Table 6. Bond Market Inflation Expectations Root Mean Square Error 1890-1991						
	1. Ten-year Average Country Growth Model		2. Ten-year Average World Growth Model		3. Overall Average Growth Model	
	Ten-years Back	Ten-years Ahead	Ten-years Back	Ten-years Ahead	Ten-years Back	Ten-years Ahead
Belgium	NA	NA	NA	NA	NA	NA
Canada	3.34	4.57	2.32	3.64	2.31	3.47
Denmark	2.72	4.63	2.65	4.43	2.65	4.43
France	8.01	7.69	7.63	8.59	7.60	8.52
Germany	24.56	25.40	25.34	25.26	25.50	25.17
Italy	9.77	10.95	10.00	11.11	10.24	10.96
Japan	NA	NA	NA	NA	NA	NA
Netherlands	3.70	3.74	2.77	3.77	2.66	3.44
Norway	3.52	4.82	3.45	5.01	3.40	4.53
Sweden	2.48	4.17	2.58	4.10	2.53	3.56
Switzerland	2.40	3.18	2.56	3.43	2.31	2.74
UK	2.80	4.19	2.48	4.19	2.66	3.58
US	3.36	4.05	2.36	3.55	2.43	3.26
Average(11)*	4.12	4.96	4.12	4.96	4.08	4.79
Average(13)**	4.34	5.42	4.34	5.42	4.55	5.22
* Excludes Belgium and Germany for all years and Japan before 1966.						
** Includes all available years for thirteen countries.						

Table 7. Bond Market Inflation Expectations Root Mean Square Errors 1960-1991						
	1. Ten-year Average Country Growth Model		2. Ten-year Average World Growth Model		3. Overall Average Growth Model	
	Ten-years Back	Ten-years Ahead	Ten-years b Back	Ten-years Ahead	Ten-years Back	Ten-years Ahead
Belgium	1.62	3.94	1.44	3.95	1.46	3.16
Canada	1.11	4.10	1.22	4.33	0.82	3.39
Denmark	2.73	5.65	2.24	5.22	2.40	4.66
France	2.46	5.20	2.16	4.96	1.39	3.98
Germany	1.48	2.46	1.28	2.17	2.16	2.23
Italy	2.06	6.26	1.89	6.18	1.98	5.14
Japan	4.46	4.91	2.41	3.29	2.30	2.54
Netherlands	2.59	4.00	1.95	3.76	1.18	2.86
Norway	2.23	4.81	2.62	5.41	1.54	4.33
Sweden	1.42	4.29	1.73	4.51	0.80	3.44
Switzerland	2.05	2.91	2.59	3.18	1.45	1.79
UK	1.64	4.11	1.57	4.73	2.14	3.77
US	0.92	3.48	1.37	4.05	0.82	3.08
Average(13)	1.51	4.06	1.51	4.06	0.77	3.04

Table 8. Bond Market Inflation Expectations Root Mean Square Errors 1890-1913						
	1. Ten-year Average Country Growth Model		2. Ten-year Average World Growth Model		3. Overall Average Growth Model	
	Ten-years Back	Ten-years Ahead	Ten-years Back	Ten-years Ahead	Ten-years Back	Ten-years Ahead
Belgium	NA	NA	0.62	2.74	NA	NA
Canada	1.41	2.30	0.76	1.38	0.65	1.72
Denmark	0.61	2.05	0.72	1.93	0.55	1.91
France	0.77	2.32	0.36	2.61	0.34	2.51
Germany	0.36	25.11	0.47	25.12	0.43	25.02
Italy	1.21	2.98	0.77	2.93	0.76	2.83
Japan	NA	NA	NA	NA	NA	NA
Netherlands	0.88	1.10	0.60	1.29	0.42	1.31
Norway	0.81	2.08	0.67	2.19	0.40	2.26
Sweden	0.67	2.01	0.63	1.87	0.46	1.86
Switzerland	0.65	1.37	0.72	1.49	0.66	1.39
UK	0.72	1.52	0.56	1.90	0.60	1.65
US	0.65	1.66	0.69	1.31	0.35	1.42
Average(11)*	0.57	1.89	0.57	1.89	0.34	1.91
Average(13)	0.53	3.26	0.53	3.26	0.36	3.25
* Excludes Belgium and Germany						

Table 6 presents the root mean square errors for the three models and for errors relative to average inflation ten-years back and ten-years ahead. The ten-year-ahead errors were generally larger than errors with respect to past inflation, particularly for countries that had avoided enormous increases in inflation during wartime. For France, Germany, and Italy errors were very large whether compared with either past or future inflation. These figures include the German hyperinflation. By each measure, the country with the lowest bond-market-inflation-expectations error with respect to future inflation was Switzerland. By contrast, root mean square expectations errors for Switzerland with respect to past inflation were more or less in line with the results for Canada, Denmark, the Netherlands, Sweden, the UK, and the US. [Note that for the cross-country averages the real growth rate assumptions are identical and hence the results are identical for the Country Growth and World Growth Models.]

Table 7 presents the comparable information for 1960-1991, the most recent date for which ten-year-ahead calculations could be made. Here observations for each of the thirteen countries were complete. Many countries had root mean square errors with respect to past inflation that were about one to 2 per percentage points on the assumptions of at least one of the models with respect to real growth rates. Only Switzerland, however, had a root mean square error with respect to ten-year-*ahead* inflation expectations that low.

Table 8 presents the comparable information for the pre-World War I era. The table reveals how bond market inflation expectations with respect to past inflation were extremely low, generally one-half percentage point or less. Looking forward, the errors mushroomed but with a few exceptions were actually lower than the errors that were observed in recent decades. The pre World War I period was, of course, one where actual inflation was highly volatile from year to year but longer-term inflation trends remained low and bond rates – until 1914 – were extremely low and stable.

IV. Annual Inflation Estimates Based on Broad Monetary Growth and Bond Market Inflation Expectations

The longer-term association between broad monetary growth and inflation has been established but what about the shorter term?

Chart 12. Average Annual CPI Inflation, M2 Growth, and Bond Market Ten-Year Ahead Inflation Expectations Eleven Industrial Countries, 1880-2001

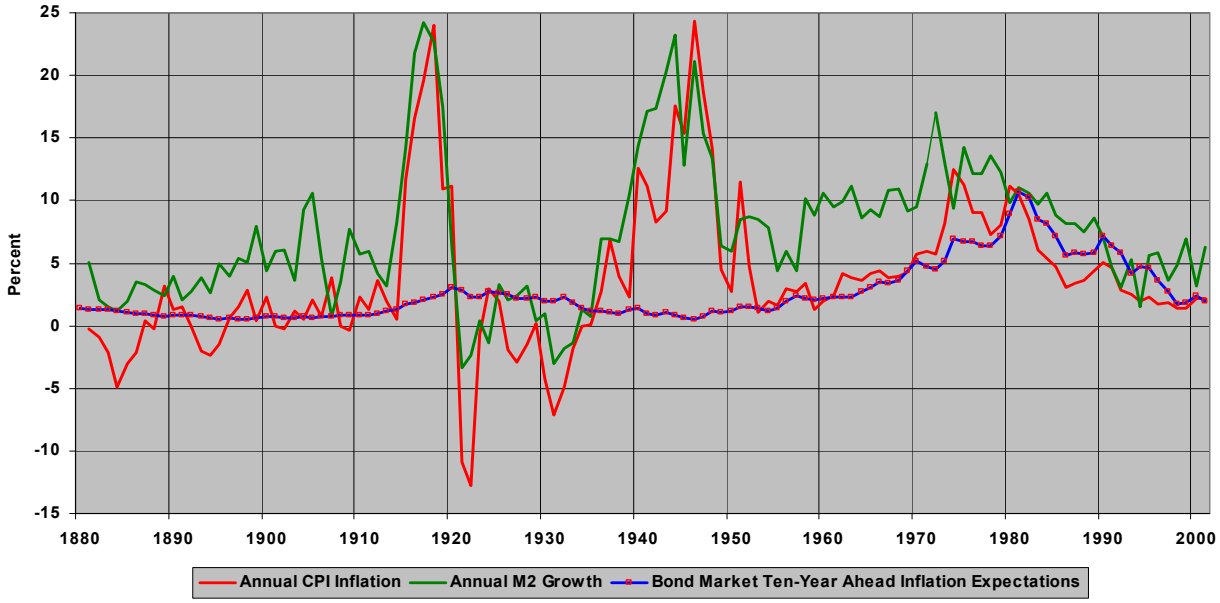


Chart 12 plots annual cross-country average M2 growth and CPI inflation and the eleven-country measure of bond-market ten-year-ahead inflation expectations. There was a close relationship between annual M2 growth and inflation, particularly with respect to enormous increases that occurred during World War I, 1914-1918, and decreases in the early 1920s. The annual inflation average was low and negative in most years from the early 1920s through the early 1930s and broad monetary growth was often negative during that period. Even the positive M2 growth rates in the 1930s were lower than for any other years that are plotted. From its nadir in the early 1930s, inflation accelerated in fits and starts over the next 15 years with the peak coming in 1946. Broad monetary growth advanced in spurts ahead of inflation through the end of World War II, 1939-1945. Inflation then fell very rapidly after World War II just as in had after World War I but this time not to negative rates. M2 growth similarly fell sharply but not to negative rates. The post-World War II disinflation was interrupted by an inflation spike at the beginning of the Korean War in the early 1950s. There followed in the 1950s and early 1960s a period of low and comparatively stable inflation. It was somewhat reminiscent of the comparatively stable inflation environment before World War I but at a higher level. Broad monetary growth fell moderately in the mid-1950s but then rose sharply

from about 5 percent a year to 10 percent in the late 1950s. That M2 growth rate was roughly matched throughout the 1960s. Cross-country average inflation correspondingly accelerated gradually from about 2 percent in 1959 to about 5 percent in 1969. M2 growth increased substantially further in the 1971 and particularly in 1972 to a rate unmatched except in the earlier war years. M2 growth stayed high throughout the 1970s. Inflation peaked in 1974 and remained elevated well above level that had been observed earlier except during war periods. Inflation peaked again in the early 1980s. The chart shows that annual M2 growth fell from a high of about 17 percent a year in 1972 to less than 2 percent a year in 1994. Inflation fell from a high of about 12 percent in 1974 to a low of about 2 percent in 1999. Compared with previous patterns the deceleration in both broad monetary growth and inflation was gradual. The chart also shows that M2 growth was running at about a 5 percent rate during 1996-2001 and inflation at about 2 percent, as stable an annual monetary growth and inflation pattern as had been observed for approximately a hundred years.

All said, the pattern in annual M2 growth and inflation over the three episodes of rising and falling inflation reveals a very different dynamic than was shown in terms of ten-year averages. The inflation onsets in World War I, the late 1930s and World War II, and the 1960s and 1970s were successively slower and, correspondingly, the subsequent disinflations were also more gradual. Each of the peaks in annual average inflation was preceded a year or two earlier by a peak in M2 growth. Although low levels of inflation were always preceded by a declining M2 growth trend, there was no clear link between troughs in M2 growth and troughs in inflation. The bond market inflation expectations measure suggests that bond markets for whatever reason were definitely not building in much if any expectation of continued high inflation during World War I and World War II. That pattern changed in the 1960s with bond market inflation expectations quite closely following the annual inflation rate up in the 1960s and 1970s and down in the 1980s and 1990s. The data reveal an association between M2 growth and inflation, which is incorporated in the specification that is estimated below. The data also reveal that the bond market inflation expectations variable might play a role both in damping inflation increases when monetary growth is accelerating and inflation decreases when monetary growth is decelerating.

Table 9 reports regressions of annual CPI inflation on current annual M2 growth and four lags in annual M2 growth for each of the eleven countries for which nearly complete data were available. There is also a regression based on the cross-country averages. The results differed across countries for the 1880-2001 sample period with R^2 adjusted varying from 0.39 in Switzerland to 0.93 in France. In every case M2 growth was a significant explanatory factor with estimated coefficients for current M2 growth and at least one lagged M2 growth more than

twice their standard errors. The one exception was Italy where only the estimated coefficient on M2 growth lagged one year was more than twice its standard error. The regression based on the cross-country averages fit best. The R^2 adjusted was 0.73. The estimated coefficients of M2 growth in both the current and the previous year were highly significant; and the sum of the M2 growth distributed lag over five years was 0.96. Interpreted as monetary history, the record is that inflation in major industrial nations on the average varied nearly proportionally with monetary growth in the shorter run of a few years and as well as in the longer-run of ten years.

Table 10 reports comparable results for thirteen countries 1954-2001. Absent the close link between annual M2 growth and inflation that was observed during war time, the association was not nearly so consistent across countries as it was for 1890-2001. Nonetheless, the cross-country average revealed significant impacts of monetary growth lagged two, three, and four years. Significant lagged M2 impacts were found for Belgium, Canada, Norway, Sweden, Switzerland, and the US. The results do not support a conclusion that current monetary growth has had all that powerful an effect on current inflation but rather that sustained monetary growth has had a significant effect on inflation.

Table 11 and **Chart 13** report an attempt to extract information from the inflation expectations embodied in bond rates in estimating annual inflation. Only results for the cross-country averages are presented. For 1890-2001, estimated coefficients on current and one lag of monetary growth were twice their standard errors and thus interpreted as statistically significant. The sum of the coefficients on current and four lagged M2 growth rates was 0.92. The coefficient of the bond market inflation expectations variable was 0.31 which was also more than twice its standard error. In the specification excluding contemporaneous explanatory variables, only the coefficient on M2 growth lagged one year was twice its standard error. The coefficient of the bond market inflation expectations variable was less than twice its standard error. For the 1954-2001 period, estimates based on these specifications were much the same although the coefficient of the bond market inflation expectations variable was more than twice its standard error both for specifications that included current explanatory variables and only lagged variables. Including a long-term interest rate variable in an inflation estimation equation in effect introduces a variable, increases in which would increase monetary velocity and inflation. When monetary growth trends exceed the real growth trend, the inflation trend would be increased both directly through excess monetary growth above real growth and indirectly through the faster utilisation of money balances. This is an old story with antecedents in Irving Fisher and Milton Friedman among many others. Exploring the ramifications of the bond market inflation expectations in affecting inflation will have to await further analysis beyond the broad descriptions that have been considered in the present paper.

Table 9. Annual CPI Inflation Regressed on Current and Lagged M2 Growth Eleven Major Industrial Nations, 1880-2001									
		Const	m0	m1	m2	m3	m4	m Sum	R^2Adj SE
Average(11)	Coefficients	-3.31	0.59	0.34	0.06	-0.10	0.07	0.96	0.73
	Standard Error	0.58	0.09	0.13	0.13	0.13	0.10		3.09
Belgium	Coefficients	NA	NA	NA	NA	NA	NA	NA	NA
	Standard Error	NA	NA	NA	NA	NA	NA		NA
Canada	Coefficients	-2.67	0.22	0.24	0.14	0.11	0.01	0.71	0.39
	Standard Error	0.74	0.07	0.08	0.08	0.08	0.07		3.64
Denmark	Coefficients	-0.19	0.31	0.22	0.06	-0.10	0.10	0.60	0.31
	Standard Error	0.79	0.08	0.09	0.09	0.09	0.08		5.12
France	Coefficients	-2.44	0.41	0.57	-0.12	-0.04	0.11	0.93	0.51
	Standard Error	1.22	0.11	0.13	0.13	0.12	0.11		7.26
Germany	Coefficients	NA	NA	NA	NA	NA	NA	NA	NA
	Standard Error	NA	NA	NA	NA	NA	NA		NA
Italy	Coefficients	-3.59	0.41	1.19	-0.39	0.19	-0.37	1.03	0.49
	Standard Error	1.93	0.24	0.33	0.33	0.33	0.24		12.74
Japan	Coefficients	-5.10	0.24	0.72	0.13	-0.06	-0.11	0.92	0.55
	Standard Error	1.89	0.11	0.13	0.13	0.13	0.11		14.11
Netherlands	Coefficients	-0.24	0.07	0.11	0.09	0.09	0.08	0.44	0.29
	Standard Error	0.60	0.03	0.03	0.03	0.03	0.03		4.39
Norway	Coefficients	-0.55	0.48	-0.05	0.12	0.22	-0.19	0.78	0.50
	Standard Error	0.67	0.08	0.10	0.10	0.10	0.08		4.71
Sweden	Coefficients	-0.68	0.62	0.15	0.09	-0.19	-0.02	0.66	0.49
	Standard Error	0.76	0.10	0.12	0.13	0.13	0.10		4.46
Switzerland	Coefficients	0.06	0.24	0.21	0.08	-0.08	-0.05	0.39	0.10
	Standard Error	1.06	0.10	0.10	0.11	0.12	0.11		4.76
UK	Coefficients	-0.53	0.41	0.24	0.08	0.00	-0.04	0.69	0.42
	Standard Error	0.67	0.10	0.11	0.11	0.11	0.10		4.50
US	Coefficients	-1.27	0.31	0.18	0.00	0.12	0.00	0.61	0.31
	Standard Error	0.72	0.08	0.10	0.10	0.10	0.08		3.99

Table 10. Regressions: Annual CPI Inflation on Current and Lagged M2 Growth, 1954-2001

		Const	m0	m1	m2	m3	m4	m Sum	R^2Adj SE	n
Average(13)	Coefficients	-3.53	-0.02	0.00	0.37	0.26	0.31	0.92	0.66	48
	Standard Error	0.87	0.12	0.14	0.14	0.14	0.13		1.62	
Belgium	Coefficients	-0.53	0.12	0.13	0.21	0.19	0.19	0.84	0.27	44
	Standard Error	1.04	0.12	0.12	0.12	0.12	0.10		2.42	
Canada	Coefficients	-2.39	0.14	0.18	0.21	0.13	0.07	0.72	0.70	48
	Standard Error	0.67	0.06	0.06	0.06	0.06	0.06		1.69	
Denmark	Coefficients	1.29	0.14	0.11	0.07	0.04	0.11	0.48	0.19	46
	Standard Error	1.14	0.08	0.08	0.08	0.08	0.08		3.02	
France	Coefficients	0.92	-0.03	0.10	0.12	0.10	0.14	1.20	0.18	45
	Standard Error	1.28	0.16	0.19	0.19	0.19	0.16		3.46	
Germany	Coefficients	1.69	0.10	-0.01	0.01	0.03	0.00	0.12	0.01	45
	Standard Error	0.64	0.08	0.09	0.10	0.10	0.08		1.72	
Italy	Coefficients	-1.58	-0.16	0.20	0.23	0.20	0.25	0.71	0.37	45
	Standard Error	1.72	0.21	0.26	0.26	0.25	0.23		4.11	
Japan	Coefficients	-0.86	-0.16	0.16	0.22	0.09	0.08	0.38	0.32	48
	Standard Error	1.10	0.12	0.13	0.13	0.12	0.11		3.28	
Netherlands	Coefficients	0.19	0.08	0.01	0.07	0.10	0.15	0.41	0.27	44
	Standard Error	0.93	0.07	0.07	0.07	0.07	0.06		2.17	
Norway	Coefficients	-0.56	0.11	0.08	0.11	0.21	0.13	0.64	0.62	48
	Standard Error	0.69	0.06	0.06	0.06	0.07	0.06		1.88	
Sweden	Coefficients	-2.03	0.12	0.16	0.30	0.23	0.16	0.97	0.47	47
	Standard Error	1.17	0.09	0.10	0.10	0.10	0.10		2.42	
Switzerland	Coefficients	0.33	-0.04	-0.01	0.09	0.19	0.16	0.39	0.36	48
	Standard Error	0.84	0.05	0.05	0.06	0.06	0.06		0.28	
UK	Coefficients	0.33	0.15	0.03	0.19	0.22	0.04	0.63	0.41	48
	Standard Error	1.07	0.11	0.12	0.13	0.12	0.11		3.56	
US	Coefficients	-0.35	-0.09	0.05	0.25	0.18	0.25	0.64	0.39	48
	Standard Error	0.90	0.11	0.13	0.13	0.13	0.11		2.23	

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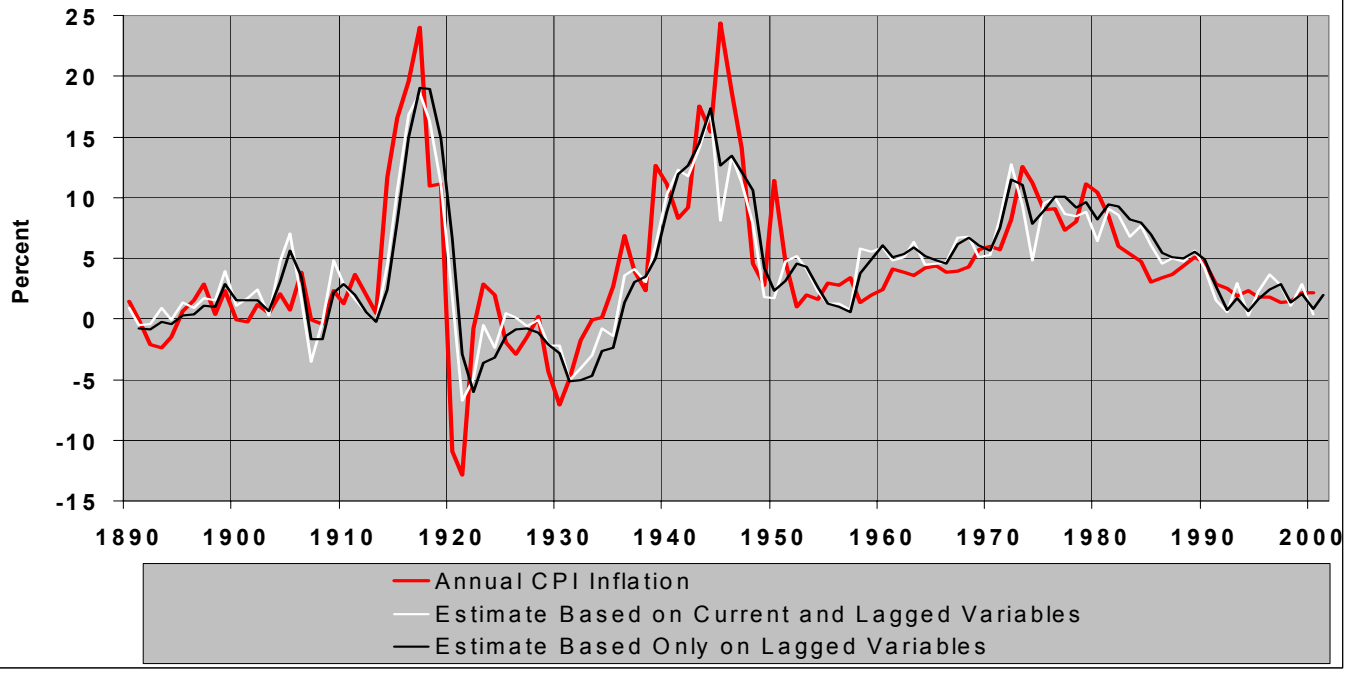
Table II. Annual CPI Inflation Regressed on M2 Growth and Bond Market Ten-year Ahead Inflation Expectations 1890-2001 and 1954-2001

	Const	m0	m1	m2	m3	m4	m5	m sum	P*	P*1	R2Adj SE
1890-2001 Eleven countries											
Coefficients	-3.84	0.60	0.34	0.05	-0.11	0.04		0.92	0.31		0.75
Standard Error	0.60	0.09	0.12	0.12	0.12	0.09			0.12		3.02
Coefficients	-2.80		0.88	0.10	-0.19	-0.04	0.06	0.81		0.24	0.64
Standard Error	0.71		0.11	0.15	0.15	0.15	0.11			0.14	3.59
1954-2001 Thirteen countries											
Coefficients	-3.96	0.10	0.05	0.34	0.19	0.14		0.83	0.34		0.80
Standard Error	0.67	0.10	0.11	0.11	0.11	0.10			0.06		1.24
Coefficients	-4.06		0.07	0.37	0.26	0.13	0.05	0.88		0.24	0.75
Standard Error	0.77		0.11	0.12	0.12	0.13	0.11			0.07	1.39

Chart 13. Annual CPI Inflation and Alternative Estimates Based on Current and Lagged Variables Eleven Major Industrial Countries, 1890-2001



V. Conclusions

Many studies have identified the systematic relationship between longer-term trends in monetary growth and inflation and between inflation and bond rates. The present paper has focused on presenting such relationships in charts and tables with data for thirteen major industrial countries spanning 120 years. There are three conclusions.

- **Since 1880 there have been three waves of longer-term monetary impulses and inflation in major industrial countries. Although magnitudes differed, the timing was similar.**

- **Inflation expectations implicit in longer-term bond rates in these countries were reasonably accurate only when longer-term inflation trends stayed low.**

- **Cross-country averages of the relationships between M2 growth and CPI inflation were smoother and more reliable than relationships based on individual country data.**

On the basis of this historical record, there is a lesson. It is that central banks should remain cognizant of monetary trends in generating longer-term inflation forecasts and then act to align forecasts with the goal of keeping the inflation trend low. Central banks should not forecast longer-term inflation trends based on longer-term interest rates (or surveys of inflation expectations), which have generally been wrong when inflation trends changed. To keep the longer-term inflation trend low, central banks need to keep the longer-term broad monetary growth trend low. If, as is frequently asserted, everyone now accepts Milton Friedman's dictum that "inflation is always and everywhere a monetary phenomenon", then central banks always and everywhere need to fashion policy actions to take that empirical verity into account.

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DATA APPENDIX

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(4) *Inflation.* 1880–1948: CPI, Mitchell (1992), except 1914–20 and 1941–46: Not available. 1949–2001: CPI, *IFS*, series 64.

(5) *Long term interest rate.* 1880–1947: Yield of long-term Belgian Government Securities (3% Rentes, 4% Unified Debt (No Maturity), 2,5% Rentes and Government Bond Average), Homer and Sylla (1991), tables 30 and 66, except 1914–18: Not available. 1948-2001: Government bond yield, *IFS*, series 61.

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Canada

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(2) *Real national income.* 1880–1950: GDP, Mitchell (1992). 1951–2001: GDP, *IFS*, series 99B.P.
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France
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(6) *Money stock.* 1880–1980: M3, Fratianni and Spinelli (1991), pp. 48-51, series U1+U2+D. 1981–2001: M2, IMF (1997), series 39M.

Japan

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(4) *Inflation.* 1880–1922: WPI, Mitchell (1991). 1923–48: CPI, Mitchell (1991). 1949–2001: CPI, *IFS*, series 64.
(5) *Long term interest rate.* 1880–1965: Not available. 1966–2001: Government bond yield, *IFS*, series 61.
(6) *Money stock.* 1880–1955: M1, data supplied by the Bank of Japan. 1956-2001: Money plus quasi money, *IFS*, series 34 and 35.

Netherlands

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(5) *Long term interest rate.* 1880–1969: 2.5% Perpetual Debt of the Central Government, Homer and Sylla (1991), tables 28 and 64. 1970–2001: Government bond yield, *IFS*, series 61.

(6) *Money stock.* 1880–1900: Currency, data supplied by Mr W. F. Vanthoor at De Nederlandsche Bank. 1901–47: M2, Central Bureau voor de Statistiek (1976), *75 Jaar Statistiek van Nederland*. 1948-2001: Money, Currency, Demand Deposits and other Deposits, *IFS*, series 34A, 34B, and 35.

Norway

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Sweden

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(4) *Inflation.* 1880–1948: CPI, Statistiska Centralbyrån (1996), *Statistiska Meddelanden P15 SM9501*, p. 22. 1949–2001: CPI, *IFS*, series 64.
(5) *Long term interest rate.* 1880–1921: Effective average return on the total government debt, data supplied by SAF. 1922–47: Market yield on long-term government bonds, Homer and Sylla (1991), table 72. 1948–1986: Government bond yield, *IFS*, series 61, 1987-2000: Riks Bank.

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Switzerland

(1) *Population.* 1880–1988: Mitchell (1992). 1989–2001: *IFS*, series 99Z.
(2) *Real national income.* 1880–1913: GDP, H. Ritzmann-Blickensdorfer (ed.) (1996), *Historical Statistics of Switzerland*, Zürich: Chronos-Verlag, henceforth *Historical Statistics (1996)*, table Q.1a. 1914–29, NNP, Mitchell (1992), 1914-1928: GDP, *Felix Andrist*. 1949–2001: GDP, *IFS*, series 99B.R.
(3) *Nominal national income.* 1880–1913: GDP, *Historical Statistics (1996)*, table Q.1a. 1914–28: Constructed from CPI and interpolated data on real GDP. 1929–47: Chained NNP, Mitchell (1992). 1948–2001: GDP, *IFS*, series 99B.C.
(4) *Inflation.* 1880–90: CPI, *Historical Statistics (1996)*, table Q.1a. 1891–1980: CPI, Federal Office of Statistics (1990), *Statistical Year Book of Switzerland*, Berne, table T 5.7. 1981–2001: CPI, *IFS*, series 64.
(5) *Long term interest rate.* 1880–1916: Mortgage bond yield (Taux d'intérêt pour obligations de caisse), *Historical Statistics (1996)*, tables O.18b and O.18c. 1917–47: Government bond yield (Rendement d'obligation de la confederation), *Historical Statistics (1996)*, table O.18c. 1948–2001: Government bond yield, *IFS*, series 61.
(6) *Money stock.* 1880–1907: M1, *Historical Statistics (1996)*, table O.3. 1908–1948: M3, *Historical Statistics (1996)*, table O.4. 1949–2001: Money plus quasi-money, *IFS*, series 35L.

United Kingdom

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(2) *Real national income.* 1880–1948 GDP, B. R. Mitchell (1988), *British Historical Statistics*, Cambridge: Cambridge University Press, pp. 831-835. 1949–2001: GDP, *IFS*, series 99B.R.
(3) *Nominal national income.* 1880–1947: GDP, Mitchell (1988), pp. 837-841. 1948–2001: GDP, *IFS*, series 99B.C.
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(6) *Money stock.* 1880–1966: Net money Supply (M2), Sheppard (1986), table A.3.3, column 6. 1967–69: Money plus quasi-money, *IFS*, series 35L. 1970-2001: M4, *Bank of England*.

United States

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(2) *Real national income.* 1880–1948 GNP, N. S. Balke and R. J. Gordon (1986), Appendix B, Historical data in R. J. Gordon (ed.), *The American Business Cycle, Continuity and Change*, Chicago: The University of Chicago Press, pp. 781-783. 1949–2001: GDP, *IFS*, series 99B.R.

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(6) *Money stock.* 1880–1971: M2, Balke and Gordon (1986), pp.784-786. 1972–2001: Money plus quasi-money, *IFS*, series 34 and 35.

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