Department of History and Civilization

Essays on Stability of the Classical Gold Standard:

Money Supply, International Capital Mobility and Symmetry of Business Cycles

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Department of History and Civilization

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Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
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Abstract of the thesis

The three essays of the thesis have the common topic of monetary integration and financial instability in Europe during the period of precious metal standard in the second half of the 19th century. The first essay discusses mainly European business cycles and their inter-country symmetry from 1865 to 1913. An indicator is developed to measure the symmetry in a way which depicts temporal changes in the development. The main result of the study is that symmetry of European business cycles increased considerably from the late 1870s, and was strongest in the heyday of the Classical Gold Standard, in the 1880s and 1890s. Nevertheless, there was a clear decrease in symmetry of business cycles in half of the country-pairs of the sample during the last decades before the First World War.

The second essay studies the impact of international capital transfers on inter-country symmetry of business cycles in the second half of the 19th century. Money stocks in financially advanced European countries were found to be connected with both domestic investments and capital exports in those countries which could export capital. New money tended to be directed to foreign investments rather than domestic ones. As investments had a crucial impact on economic growth, international differences in growth of money supply, and differences in growth rates of investments and net capital exports determined international differences in cyclical growth rates.

The third essay studies the possibility that money supply was determined endogenously in the advanced European economies in the late 19th century; the evolution of banking as a cause of that endogeneity, and the consequences of this development on capital flows between countries participating in the pre-First World War gold standard. It is found that money was supplied by the private banking sector independently of the gold stocks and independently of central banks' monetary policy, rendering the financial system potentially unstable. It is also found that money supply in financially advanced countries was connected with indebtedness of peripheral countries.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

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Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
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Table of contents:

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
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European University Institute DOI: 10.2870/38202

1. Introduction to the three essays

The three essays of the thesis have the common topic of monetary integration and financial instability in Europe – more than two hundred years ago. Even if the essays take the reader to the time passed long time ago, my motivation to choose writing about these issues is in our time: the problems of the present monetary unification in Europe, namely the enlarging Economic and Monetary Union, and the financial turbulence since 2007 which is undermining the monetary integration.

The historical experience of the late 19th century European monetary integration offers an opportunity to investigate the combined issues of fixed exchange rates and financial crises. There were a couple of currency unions and an international monetary arrangement called the Classical Gold Standard in the last decades of the 19th century till the outbreak of the First World War, which fixed the exchange rates of the participating countries. The countries participating in these monetary arrangements faced very much the same problems as the nations joining the present EMU.

The essays

The following three essays address the questions of stability by studying the dominant currency area of the 19th century, the classical gold standard. The first article, named *Measuring the inter-country symmetry of late 19th century business cycles*, introduces an entirely new way to evaluate symmetry, or co-movement of business cycles. Measurement in the article avoids the rather sloppy practices of filtering out cycles of time-series, still common among students of economic growth and fluctuations. The suggested method is based on rigorous principles to avoid mixing up cycles and stochastic trends. The article establishes some stylized facts of the late 19th century business cycles and their symmetry among European economies: these facts should lead us to think that the pre-First World War gold standard was far from optimum as a currency area.

The second essay, *International capital mobility, money supply and inter-country symmetry of business cycles in 1865–1913*, studies the possibility that capital mobility caused asymmetric cycles as a rule in some cases, and symmetric cycles in other cases. The second alternative enables the formation of credible currency areas. The article takes up the controversial issue of neutrality of money. The monetary data of several pre-First World War gold standard countries shows that money was not neutral even in this period. Still, changes in money stocks cannot be said to be the cause of fluctuations in domestic or foreign investments. To use a metaphor associated to the issue, money and investment were the two sides of the same coin. Where did the created money go,

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

from where did destructed money disappear? It went to capital exports, and capital exports were the first type of investments to be curtailed in bad times, thus creating a source for short-term inter-country differences of economic growth.

The third essay is *Didn't even gold bring stability? Money supply, expanding banking and volatile capital flows during the first period of globalization, 1850–1913*. It discusses the possibility of money supply having been endogenously determined in the advanced European economies in the late 19th century, the development of banking as a cause of that endogeneity, and the consequences of this development on capital flows between countries participating in the pre-First World War gold standard. The questions of the essay are, (1) was the money creation determined inside the financing sectors of these countries, instead of having been supplied by the central banks and backed by the gold stocks in their vaults, and (2) did the endogenously determined money supply have an impact on the balance-of-payments problems of capital importing countries.

The theoretical background

The theoretical background of the first two essays is the Theory of Optimum Currency Areas (OCA). They are a set of models to explain what kind of countries should join currency areas and what is required for them to stay in. A currency area is an area of fixed exchange rates or a group of countries using common money. The common feature in the theories is always interest in employment and balance-of-payments adjustment. A commonly accepted description of a currency area being optimum is a group of countries where three objectives are sustained: full employment, stable price level, and a balanced external account in all of them simultaneously.[1]

A characteristic of the OCA theory, deriving from the considerations of employment and external balance, is that countries in a currency area should have symmetrical business cycles, and when the theory is applied to studying a currency area called the Classical Gold Standard, the emphasis is on the relation between the symmetry of business cycles and the costs of balance-of-payments adjustment. The OCA theories give the motivation of the *first essay* to find a way to measure the symmetry in a way which depicts the annual development, and produces data which has good time-series properties.

Also the *second essay* has its starting point in the OCA theory – it attempts to explain the observed changes in symmetry of business cycles by studying international capital flows. Nevertheless, the theoretical emphasis shifts towards another kind of thinking. Money supply became a

[1] Ronald McKinnon, Optimum Currency Areas, *American Economic Review*, Vol. 53 (September 1963), pp. 717–725.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

more important issue and the hypothesis related to money supply become more important tools for the research. The term symmetry of business cycles is entirely absent in the *third essay* – the debates of money supply and its possible endogeneity are the theoretical background for explaining events which undermined the stability of the classical gold standard. The underlining framework is the Financial Instability Hypothesis, developed by Hyman Minsky and applied to economic history by Charles Kindleberger.[2] In addition to these rather economics type of theories, the third essay draws from the literature of financial and banking history: it applies the ideas and notions that the financial architecture has been changing constantly in the past 150 years, a development giving rise to changes in the mode of money supply.[3] My ideas of categorization of banking regimes are indebted to this literature.

Conclusions

The essays discussed the stability of the classical gold standard, a monetary system which is praised to have been among the most successful ever. The results of these essays give reasons to doubt the record given to the system. There were systemic features in the late 19th century financial system which – perhaps independently of the existence of the gold standard – undermined its stability.

At first, using symmetry of business cycles as a measure of stability, the Classical Gold Standard was in its most stable phase in the 1880s and 1890s. Symmetry of cycles decreased after that. Second, the differences in GDP growth rates were caused by differences in growth rates of money supply, investments and net capital exports. Third, money supply became an endogenous process by the end of the 19th century in most of the European countries and the United States. Money was supplied by the private banking sector independently of the gold stocks and independently of central banks' monetary policy, rendering the financial system potentially unstable. What enabled this development was that banks became bigger and more able to acquire capital, especially after the emergence of joint-stock banking companies, coincidentally in the period when almost every country joined the gold standard.

The results of the study have implications on economic theory of money and they should contribute to financial historians understanding of the underlying causes of financial crises. At first, the conventional belief that money supply is *in general* exogenous doesn't hold in the light of the empirical results presented in these essays. During the studied period money supply was exoge-

[2] See Charles Kindleberger, *Manias, Panics and Crashes: A History of Financial Crises*, Basic Books, 1971.
[3] About financial architecture see Youssef Cassis, *Crises and Opportunities, 1890–2010: The Shaping of Modern Finance*, 2011, and Richard Grossman, *Unsettled Account: the evolution of banking in the industrialized world since 1800*, Princeton University Press, 2010.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

nous only in the underdeveloped phase of financial development. Even the heyday of the classical gold standard did not prevent money supply to become endogenous as the development of banking provided the means to endogeneity.

Further study on financial instability: a research plan

There are at least seven issues of further research for developing the arguments presented in the essays of the thesis, but which were beyond their scope.

(1) The statistical experiments of the three essays need to be extended to a longer time span. Concerning symmetry of business cycles, the extended periods would be 1919–1939, 1946–1972, 1972–1998 and the period from 1999 to the present – the division of periods is based on whether there was some kind of a reliable fixed exchange rate area in Europe, or not.

(2) Concerning the extended study on endogeneity of money supply, the periods would be 1918–1939, 1945–1975, and from 1975 to the present – the division of periods is based on whether the financial markets were regulated or not. My presumption of the type of money supply is that it was still endogenous until 1939, but became exogenous after the Second World War due to increased regulation. This period lasted perhaps until mid-1970s, after which financial liberalization allowed money supply in developed economies to function in the same way as it did there in the late 19th century.

(3) The study on endogenous money supply in the third essay developed a model explaining how endogenously determined money supply in the core spilled out to capital exports to the periphery, creating financial crises there. A new study should be made to develop the idea of endogenous money supply creating financial crises in the core – the countries where the credit booms take place.

(4) The empirical study on money supply should be extended to a larger group of peripheral countries, including those Latin American and Asiatic countries which have been so often in the centre of financial turmoil in the 20th century.

(5) Two of the theoretical claims in the third essay should be verified empirically: (i) the suggestion that the relationship between endogenous money supply and interest rate is non-linear, and (ii) that the interest rate starts to rise rapidly at full-employment equilibrium. The NAIRU (Non-Accelerating Inflation Rate of Unemployment) estimates would serve as approximations of equilibrium.

(6) This study has dealt with aggregated financial data. It would be interesting to see how deposit-reserve ratios and credit-reserve ratios develop at the level of individual banks.

(7) To introduce the ideas about different types of money supply to an audience which is larger than economic historians and economists, it would be useful to write papers which describe the actual events during credit booms and crushes, and then analyse these events using the theoretical framework developed in the third essay. How do changes in money supply coincide with individual banking crises, currency crises and sovereign debt crises?

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

The first essay of the thesis

Measuring the inter-country symmetry of late 19th century business cycles:[4]

Abstract

This paper studies mainly European business cycles and their inter-country symmetry from 1865 to 1913. I propose an indicator to measure the symmetry in a way which depicts temporal changes in the development. The business cycles of 15 countries are extracted from GDP/NNP growth series by using band-pass filters, and by applying strict rules to distinguish between cycles and stochastic trends. The resulting business cycle chronologies for Great Britain and Germany are different to those published before. The main result of the study is that symmetry of European business cycles increased considerably from the late 1870s, and was strongest in the heyday of the Classical Gold Standard, in the 1880s and 1890s. Nevertheless, there was a clear decrease in symmetry of business cycles in half of the country-pairs of the sample during the last decade before the First World War. The observed a-symmetry was caused by high volatility of cycles in France, Sweden, Spain, Russia, and possibly in the United States.

[4] Financial support from the ESF (GlobalEuroNet) is gratefully acknowledged.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

1. Introduction

Debates about the formation of a currency area, and later, of a monetary union in Europe has raged for decades. The monetary unification of a great part of the continent, looking inevitable *post festum*, has been an issue of controversy among politicians, general public and scientific communities, especially economists. The scientific debate has taken place in terms of an approach called Theory of Optimum Currency Areas, based empirically on the concept of correlation, or symmetry of business cycles. The empirical question is, how unified the business cycles have been in Europe, and how unified they will be.

As the term 'correlation' in the name of the empirical concept suggests, symmetry of business cycles is understood as being something more or less constant, much in the spirit of the thinking in economics. Even if the notion of 'endogenous formation of currency areas' implies unification of business cycles, the measurement is based on rather static correlations.[5] In contrast to this I want to propagate – also in empirical measurement – an idea more familiar to historians: the idea of constantly changing nature of the symmetry of business cycles.

My aim in this essay is to find an indicator to measure the symmetry of business cycles: specifically, the purpose is to focus on ways to evaluate *changes* in symmetry in a relatively long period, the 64 years between 1860 and 1913 in a group of European countries. By the term symmetry of business cycles I mean two things. At first, booms and depressions of two countries or a group of countries are synchronized. Second, symmetry means equality in the volatility of fluctuations between these countries. To be perfectly symmetric, growth fluctuations of two countries have to be both synchronized and of same size.

Changes the in symmetry of business cycles of a group of countries is, of course, caused by changes in the statistical characteristics of cycles in economic activity of these countries. Evaluation of symmetry leads evidently to evaluation of these statistical characteristics. Thus, in my essay I will also discuss changes in the average length of business cycles and their volatility. In the detailed analysis I focus on the major European economies, Great Britain, France, Germany and the Netherlands, four peripheral Northern European countries and Russia, three Southern European peripheral countries, two members of the British Commonwealth and the United States.[6]

[5] Delightful advancements in both business cycle measurement and measurement of their synchronization are Backus and Kehoe (1992) and A'Hearn and Woitek (2001) for their use of advanced filtering and spectral analysis. Even if both of the articles serve as inspiration to me writing this article, I choose to put the Question in a different way: my question is 'What changed?' instead of the question 'How was it?' by the above mentioned writers. Their nevertheless inspiring work assumes that there was no change in the statistical relations of filtered growth rates in the late 19th century.

[6] The whole set of countries is: Australia, Canada, Denmark, Finland, France, Germany, Great Britain, Italy, The Netherlands, Portugal, Russia, Spain, Sweden and United States.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

I develop a comprehensive and visually informative method for describing the symmetry of growth fluctuations. Thus, I am creating annual data on the symmetry both for use of econometric time series modeling and less formal analysis. In addition to comprehensibility, I am striving for reliability. Given that historical national accounts statistics are imprecise, I try to develop a method that may reduce unreliability of this data. Among the unreliable components of the time series is the trend, the problems of which are discussed in detail below.

The essay is organized as follows. In the second section I define the business cycle theoretically as a different entity to the trend. The third section reminds of some problems of using historical national accounts statistics. The upshot of discussion in the section is that constant-price time series are not suitable, as such, for comparing economic growth of different countries. In the fourth section I find a way to solve the problem: unreliable components of a time series are removed by using filtering techniques. I also define the conditions under which the results of filtering are acceptable. The fifth section presents the filtered cycles and trends. The change of the statistical characteristics of the cycles is a further topic in the chapter. The sixth chapter presents the symmetry indicator and the results: notable changes in symmetry of business cycles in 1865–1913. The seventh section summarizes.

2. Defining cycles

For any systematic evaluation of business cycles and their inter-country symmetry, the cycle has to be defined. Business cycle means fluctuations in the level or rate of change of economic activity (approximated in this study by national income or national output) which forms a regular pattern, with expansion in economic activity to a peak, followed by contraction to a through, followed by another expansion. Cycles take place around a long-run trend, which may be linear or non-linear.

Cycle is distinguished from trend by the characteristic that the cycle is a deviation from an equilibrium growth path, associated with unemployment or shortage of labour, underutilization of capital or shortage of capital, and declining prices or inflation. The non-linear trend represents the equilibrium which the economy tends to approach after any shock. Trend-cycle decomposition will be discussed more in detail below.

2.1 Volatility and regular length of cycles: speculation on causes

In this essay I shall focus on defining the statistical characteristics of business cycles rather than discussing their causes, as my purpose is to develop indicators for measurement. Nevertheless, I give a brief account of factors giving rise to fluctuations in economic activity. There are several causes to fluctua-

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

tions in economic activity: investment fluctuations, crop failures and successes, financial disruptions and special cases like wars. All of these, except investment fluctuations, are random phenomena. As the emphasis of business cycle measurement is in regularity of short term fluctuations, it is natural to look for explanations to that regularity in investments and its counterpart, consumption.

For one reason or another, investments cease at the peak of growth in activity, causing a slowdown of growth, or even decrease of production and, in the level of national economy, decrease in demand. Next, work-in-progress will be run down, until it is consistent with the new level of demand, causing further decreases in income and demand. The stimulus for recovery is the need to replace depreciated capital equipment. When even a low level of output cannot be sustained with existing run-off capital, replace investment for equipment starts taking place, giving rise for investment in the other factors of production: raw materials and work.

The cause of regularity of investment fluctuations is the physical durability of capital. Since capital wears off at regular intervals, or becomes outdated, it needs to be replaced regularly, thus increasing investments and inducing a recovery and expansion. The psychological factors concerning investors' behaviour, on the other hand, are the source of the crises and determine the amplitude of the cycle. These psychological factors mean investors' (or speculators') fears and hopes concerning future profits.

2.2 Trend-cycle decomposition: a theoretical discussion

Decomposing the trends from the cycles in economic data is a precarious exercise. It is difficult to know which part of the variation is trend and which part is cycle. Since trends and cycles represent totally different kind of changes, the attempt to separate them correctly is a major problem to be taken seriously.

A classic study of business cycle measurement is the one published by Arthur Burns and Wesley Mitchell.[7] Their contribution, in addition to suggesting a business cycle chronology to the United States, was to define the cycle and separate it from the trend. The trend was defined as a line of constant growth that moves from peak to peak of the time series. Although Burns' and Mitchell's idea of setting strict principles to define cycles and trends as separate entities has been accepted – though not followed by everyone in practice – the principle they adopted has not passed through the later critique. The main point in that critique is that there is no reason why a cyclical peak in a series should represent a point on the long-run trend.

A solution to the problem would be to define the trend as a constant rate (of growth) for long periods spanning over many business cycles. In practice, change of output would be modeled as a function of

[7] Burns, Arthur F.; Mitchell, Wesley C. (1946): *Measuring Business Cycles*, National Bureau of Economic Research.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

several economic variables and a constant. Using linear or logarithmic regression, the trend is estimated in such a way that the sum of squared deviations from the trend is minimized. While this methodology sounds good for short periods, say 20 years or less, considering longer periods, there is no reason to think that the trend could not change its rate of growth. Thus, we would end up estimating non-linear trends.

Given the possibility of non-linear trends, our problem is, what is trend and what is cycle. Either by using the technique of macroeconomic modeling, or just filtering out trends or cycles from single time series the main problem remains. A pessimistic view is that

there is no way to know in advance – or to estimate statistically – how variable the trend may be. One economists "trend" may be another's "cycle". The smoother the trend component is assumed to be, the larger will be the estimated fluctuations. The more irregularity in the trend, the smaller will be the amplitude of fluctuations.[8]

It is also argued that

… *many macroeconomic variables have time series properties that make them indistinguishable from a randomly variable trend (described in the literature as a 'random walk with a drift' or a 'stochastic trend'). If this is true, a mechanical econometric solution to separating a variable trend from the cycle that relies on no data other than the series under study is not possible.*[9]

One way to solve the above mentioned problems of trend-cycle decomposition – the question of what is trend and what is cycle in the variation of the time series – is to estimate the stochastic trend by using additional information other than GDP growth series itself. The conventional way to evaluate equilibrium growth is to estimate the non-accelerating-inflation-rate of unemployment (NAIRU), and the corresponding GDP growth. The NAIRU estimates, produced with modern unemployment and price data, indicate changes in the level of equilibrium growth path in industrialized countries in the post-war period. This is in line with the notion of stochastic trend in GDP growth.

Unfortunately statistical information on a crucial variable for the determination of equilibrium GDP growth, unemployment does not exist for the 19th century for most of the countries in my study, the exceptions being Great Britain (starting at 1855[10]) and Germany (1887). Another limitation to use that kind of information to find the equilibrium growth path of an economy is that the concept of unemployment on which NAIRU estimates are based is a product of the modern industrialized economy. In the agrarian economies of the 19th century great part of labour force consisted of part-time workers who did not seek

[8] Sutch, (2006), p. 3-73.
[9] Sutch, (2006), p. 3-74.
[10] Feinstein (1972).

DOI: 10.2870/38202

for paid employment throughout all year. “Unemployment” in that kind of an economy is not always a disequilibrium phenomenon.

Thus, I need to find another way to solve the issue, considered as non-solvable in the above discussion. The solution has to be based on the notion that the stochastic trend is the ‘randomly’ changing equilibrium of GDP growth and the business cycle is an undesired fluctuation from that equilibrium. The equilibrium may not be the optimal, long-run state of the economy. Thus, it may change also in the medium run.

2.3 A statistical solution to the theoretical problem

In addition to the theoretical definition of the cycle and the trend we need a statistical method to measure them. Fortunately such a method exists, and it is also employed in studies of economic growth. It has become common to study structural changes in the economy – that is changes in stochastic trends – by evaluating the existence of unit roots in economic time series. In such evaluations we are interested whether a time series reverts to its mean. How does this relate to separating a GDP series into a trend (equilibrium growth) and a cycle (deviations from the equilibrium)?

It is an intuitively appealing to think that when a variable reverts to a certain function, that function is the equilibrium path of the variable. If a de-trended component of that variable reverts to its mean (i.e. trend) it has to be either regular cycle or random variation of that variable. Thus, for finding the trend and cycle, a GDP series should be decomposed in such a way that the cycle reverts to the (deterministic or stochastic) trend. A stochastic trend, on the other hand, is the component in the time series which does not revert to any function, or the reversion takes place in a very long time span. Thus, we may define

- cycle as a stationary component of a time series (or a variable) with a short time dependence, and
- stochastic trend as a non-stationary component of a time series (or a variable) with a long time dependence.

Marianne Baxter and Robert King address the same problem from another point of view: how to separate business-cycle elements from slowly evolving secular trends and rapidly varying irregular components.[11] The method Baxter and King develop requires that the researcher to begin by specifying characteristics of the cyclical components. Defining the business cycle as fluctuations with a specific range of periodicities results in a band-pass filter. The filter passes through components of a time series with periodic fluctuations between the predefined minimum and maximum of years. Moreover, Baxter and King require that the method meets the following objectives.

[11] Baxter and King (1999), p. 575–576.

DOI: 10.2870/38202

(1) The band-pass filter should not introduce a phase shift, i.e., it should not alter the timing relationships between series at any frequency.
(2) The method applied in practice should be an optimal approximation to the ideal band-pass filter.
(3) It is also required that the approximate band-pass filter must result in a stationary time series, that is the cycle, when applied to trending data.

Since stationarity of a variable is influenced by the time span of the data used, it is convenient to let the definition of long run time-dependence or short run time-dependence depend on the time perspective of the study. In practical empirical investigation, *it is important to stress that the stationarity/non-stationarity or, the order of integration of a variable, is not in general a property of an economic variable but a convenient statistical approximation to distinguish between short-run, medium-run and long run variation in the data*.[12] The statement is important specifically for the kind of studies where the time series needs to split into short periods

I begin my evaluation of the cycles by specifying characteristics of the cyclical components by defining the business cycle to have a predefined minimum and maximum length of years. In addition to that I let the characteristics of cyclical components vary from one period to another. (Of course, I also define the cycles of each country individually.) In practice time series need to be split into shorter sections. How the splitting-up is done so that stationary and non-stationary components do not get mixed, is the topic of Section 4.3.

Our motivation, so far, to decompose GDP data into trends and cycles has been to distinguish between long run equilibrium growth and short run disequilibrium variation. There is another reason to decompose constant-price GDP data: the trend components of constant-price series are not usually internationally comparable. This is the topic of our next section.

3. Problems of using historical national accounts time series

3.1 The problem of comparability of constant-price time series

The international comparability of historical national accounts statistics leaves much to be desired. The figures, produced for the period before the Second World War, are often imprecise. Since the introduction of the System of National Accounts, most western countries have developed a national accounts system in line with international guidelines. Before the war there was no such commonly accepted

[12] Juselius (2006, pp. 18–19) stresses the issue by giving an example a time series of Danish inflation in three time horizons, span of 91 years, 47 years and 17 years. The two first time series are mean reverting whereas significant mean reversion would not be found in the last one.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

framework. So, even if there were national income figures of reasonable quality for a wide range of advanced countries, the comparability of those statistics was poor. All the national accounts concerning the time before the Second World War – called historical – have been reconstructed, more or less strictly, on the lines of the post-war SNA conventions.[13]

The quality of historical national account statistics varies between different countries, also in Europe. The data of Germany is considered to be relatively weak compared to those of The Netherlands, Sweden, Finland and Great Britain.[14] What is illustrating of the state of historical national accounts statistics of some countries is that they keep changing. Imperfect estimates are being improved. Thus, international statistical compilations, which aim at some kind of comparability, like that of Angus Maddison, become evidently and often very soon outdated.[15]

A major problem in inter-country comparability is sensitivity of the accounts for weighting procedures and inter-country differences of these procedures. The problems which their use arouses are related specifically to the use of *constant-price* time series. A general practice is to measure the change in production in a way which decomposes the change into two components, the portion attributable to change in prices and the portion attributable to change in production. The statistic measuring the change in production is also called *real GDP*.

Inflation is estimated with price indices: Paasche index and Laspeyres index. The Laspeyres index systematically overstates inflation, while the Paasche index understates it. This feature of the most commonly used price indexes cause serious problems when one wants to compare them to other price indices. Consequently, we have the same problem with time series which have been created by using these price indexes as their deflators, e.g. real GDP. Let us first consider GDP indices deflated by a Paasche price index.[16] Deflating by Paasche index overestimates the real GDP estimate (constant price GDP estimate) of previous years and, thus, underestimates long-term growth.

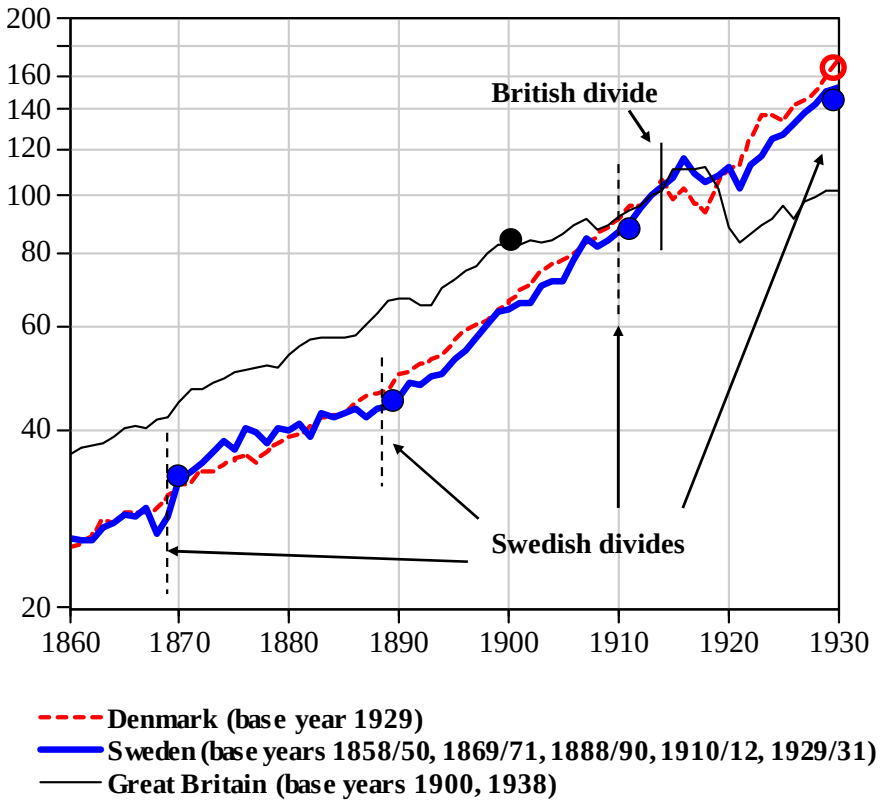
What is relevant for making comparisons is that changing the base year of the price index changes the growth rate of the constant-price GDP index. The further away in the past the current year is from the base year, the more the constant-price GDP index underestimates the growth rate. Similarly, the further away towards present time the current year is in relation to the base year, the more the constant price GDP index overestimates the growth.

[13] van Ark, 1995.
[14] Ibid.
[15] A widely employed statistical source used to be Maddison (1995).
[16] In the literature of National Accounts and Historical National Accounts there is agreement that a price index of a Paasche type should be used as deflator. This means that prices in a given year and the base year are weighted with given year quantities. A consistent Laspeyres volume index is then reached when deflation is made on a current-price time series. This in turn means that quantities of every year are weighted with base year prices. (Krantz and Schön, 2007, p. 19)

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

What makes the inter-country comparisons of constant-price GDP series difficult is that they are not based on price indices of the same base year. Figure 1 illustrates the problem using British, Danish and Swedish constant-price GDP estimates as an example. The Figure presents GDP growth in 1860–1930 as indexes calculated so that their value in 1913 is 100. Thus, what could be compared between Britain, Denmark and Sweden – in case the estimates were similar – was not the level of GDP but its growth rate. The steeper the line is, the faster the growth.

Figure 1. Constant price GDP indexes of the British, Danish and Swedish GDP, 1913=100, logarithmic scale



The base year of the Danish price index used for deflation is 1929. The resulting real GDP figure underestimates strongly the Danish growth in the 19th century. The British price index has its base years in 1900 and 1938, dividing year between the two price indexes used for deflation is 1913. The real GDP index underestimates the growth in the 19th century, but not at all as much as the Danish index. The Swedish constant price GDP index is calculated using several price indexes and the dividing years have been chosen to reflect structural changes in the Swedish economy.[17] The growth rate is fairly accurate.

[17] Krantz and Schön (2007), p. 19.

DOI: 10.2870/38202

Table 1. The base years of price indexes in the constant-price income/production series of eleven countries, concerning years 1860–1913

	Deflation period	The base years of price indexes
Sweden	1800–1826 1826–1848 1848–1869 1869–1888 1888–1910 1910–1929 1929–1953	1800/02 1826/28 1848/50 1869/71 1888/90 1910/12 1929/31
The Netherlands	1807–1830 1830–1850 1850–1870 1870–1890 1890–1913	1830 1850 1870 1890 1913
Finland	Varies depending on industry	Varies depending on industry
Great Britain	1866–1913	1900
Norway	1865–1929	1910
Denmark	1818–1969	1929
France	1815–1938	1905/13
Spain	1850–1929	1913
Germany	1850–1913	1913
Russia	1885–1913	1913
Italy	Varies depending on the industry	Varies depending on the industry
The United States	Based on constant-price estimates in 1800–1929	

None of these three constant-price GDP series can be strictly compared with each others. The information one gets at best is that the British growth was slower than the Danish and Swedish growth. *How much* slower it was, is impossible to say according to these estimates. Similarly, it is difficult to say anything about the relative speed of growth between Denmark and Sweden. These problems of comparability apply to the constant-price GDP estimates of almost all European countries. Comparison is impossible if the base years of price indices are far away from each others. Table 1 reports the corresponding information of nine European countries and the United States: the base years of price indices and deflation periods.

3.2 The problem caused by random fluctuation in the data

The rapidly varying irregular fluctuation in the time series is the other component to be separated from the trend. That fluctuation consists of random shocks which cannot be explained by business cycle theory.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

There are two sources of randomness in the historical national accounts time series. One source is the above mentioned real world phenomena, e.g. fluctuation in agricultural production caused by weather conditions, wars and economic policy changes. The other reason for volatility is that historical national accounts data is imprecise. The inaccuracy may be due to:

- measurement errors in collecting the data,
- omission of data, and
- incorrect procedures in compilation of the statistics.

By their very nature, these errors must be regarded as random phenomena.

The business cycle means fluctuation in the level of economic activity, which forms a regular pattern. Based on the discussion above, I will try to isolate the cycle from the time series in a way that specifies an important statistical property of the cycle – its length. Doing it this way, I can avoid the ad hoc method of choosing any, unspecified moving average to find the cycle.[18]

4. Filtering as a solution

4.1 Band-pass filtering

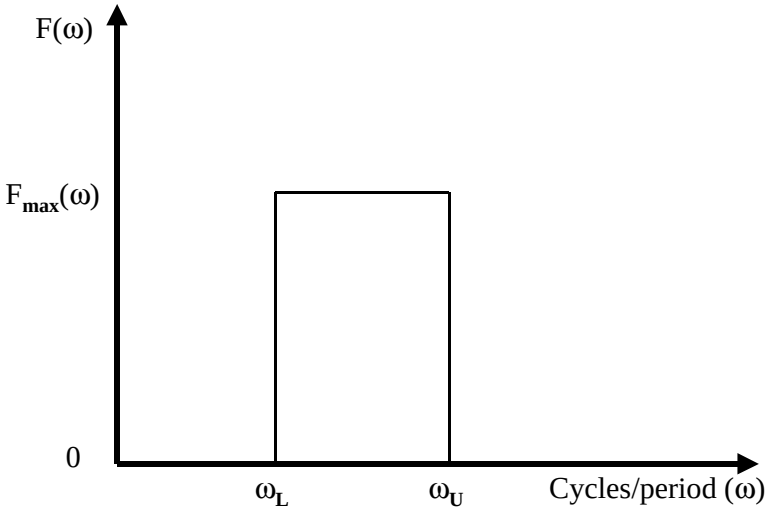
Cycles in economic time series do not have exactly equal length. One cycle may be seven years long, the next may be eight years, the third six and half years. Thus, in practice the cycles have to be defined to occur within a band of length. The low frequency variation, or “long cycles”, outside of this band is defined as the trend of the time series, and the high frequency variation is defined as irregular fluctuation. Both low and high frequency variation need to be extracted from the cycle. The formal method of extracting is called filtering. When the wanted cycle length is designed to vary inside a band, the moving average to extract the wanted time series is called a band-pass filter.

The band-pass filter allows all the frequency components of a time series inside the band (ω_U, ω_L) to pass through unattenuated, but all other frequency components are completely suppressed. Figure 2 illustrates an "ideal" filter.

[18] In their seminal paper (1999) on approximate band-pass filters Marianne Baxter and Robert King require researcher to begin business cycle measurement by specifying characteristics of the cyclical components.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Figure 2. Band-pass filter



All variation in the original time series which is passed to the resulting time series is inside the "box", limited by ω_L, ω_U and $F_{max}(\omega)$. The lower boundary ω_L means the minimum number of cycles in a period (i.e. maximum cycle length) that is allowed to pass through to the resulting time series, the "business cycle series". The upper boundary ω_U means the maximum number of cycles in a period (i.e. minimum cycle length) that is allowed to pass through.

The filter in Figure 2 is an ideal one because in practice we cannot design a filter – choose the weights of the moving average – which would produce a discontinuous form shown in the figure. When empirical data is used, F(ω) tends to have a continuous form with rounded corners.[19]

4.2 Spectral analysis

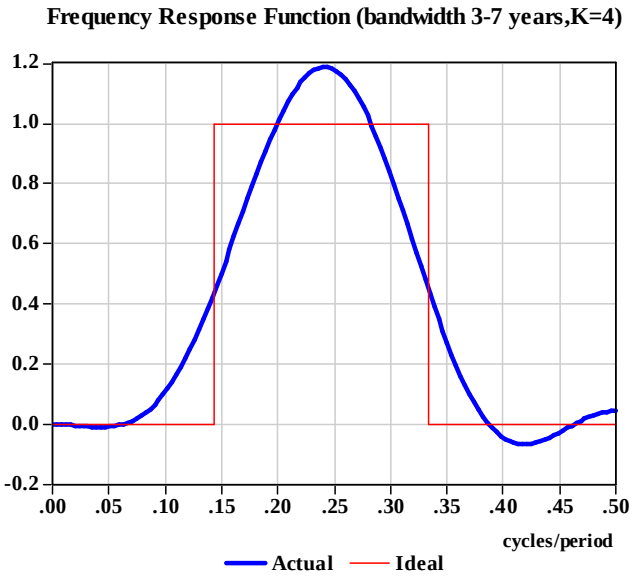
The frequency band (ω_U, ω_L) is defined by the researcher and a weighted moving average is used to extract the cycle from non-cyclical components so that the length of the resulting cycles is inside the frequency band. How do we know that the frequency band, i.e. the assumed variation in the cycle length, is chosen correctly?

[19] Priestley (1981), p. 274.

DOI: 10.2870/38202

How well the frequency band (ω_U, ω_L) and the moving average has been chosen, can be evaluated by a frequency response function: the right hand side picture in Figure 3 illustrates the method. The horizontal axis of the graph shows the number of periods, in our case years, related to the one cycle (denoted by ω cycles per period). For example, ω = 0.1 means 1 cycle / 10 years. The vertical axis shows the number of cycles passed through by the filter (actual or ideal) into the resulting time series, normalized to the range 0 to 1. The narrow line in the picture depicts the response to ideal filter at cycle/years band (ω_U, ω_L) defined by the researcher. The band in Figure 3 is ω_U = 0.333 (1 cycle / 3 years) to ω_L = 0.1423 (1 cycle / 7 years), where all cycles are passed through, but all variation outside the band is removed from the resulting time series.

Figure 3. Frequency respond function of a fixed length symmetric Baxter-King filter applied on an annual time series of British GDP growth



The thick line depicts the response to the outcome of the actual filter (weighted moving average): in addition to cycles within the defined band ω_U, ω_L, small amount of variation outside of it has been passed through to the resulting time series. Also, not all the cycles inside the band have been passed through. In addition to the indications of inaccuracy of the filter, it is possible to see in the figure that four years is the most typical length of cycles (1 cycle / 4.2 years ≈ 0.24 cycles / year), and all of them are in the created series.

To get an optimal correspondence of the actual data and researchers definition of the length of the cycle, the actual frequency distribution of the passed cycles and the ideal frequency distribution of a specified

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band for the length of cycles must be as close to each other as possible. The weighted moving average should be chosen so that the filtered cycles are inside the band (ω_U, ω_L). The method is that of trial and error: the defined band (the thin line in Figure 3) doesn't necessarily fit the frequency distribution of the estimated cycle (the thick line in Figure 3). Then the band needs to be changed and/or the filter needs to be modified. Increasing the lead/lag (denoted by K in Figure 3) of the moving average results in a better approximation of the ideal filter, but then we loose more observations. It is an empirical question, whether the use of greater values of K gives significant changes in the filtered time series. Eight observations were lost in the example of Figure 3, where K = 4. The filtered series is almost the same when K = 5 and ten observations are lost.

4.3 An additional check-up: stationarity in long and short time spans

Using spectral analysis to choose the frequency band is not enough. It was said above that a properly designed band-pass filter extracts a stationary cycle from a time series.[20] I also made the notion that the division between the stationary component (with short time dependence) and the non-stationary component (with long time dependence) should be done according to the time-span of the data under study. In Section 5 I will split my long data sets into shorter ones to capture possible changes in the time series properties of the cycles.[21] In such splitting operations it is difficult to distinguish empirically between cycles, especially long cycles, and stochastic trends. How do we manage to do this so that we avoid Richard Sutch's pessimistic result: *one economists "trend" is another's "cycle"*?[22]

Following Juselius (2006), let us consider a conventional decomposition of a time series into trend (*T*) cycle (*C*), and irregular component (*E*).

$Y = T \, x \, C \, x \, E.$

Instead of treating the trend as deterministic, as is usually done in conventional analysis, we shall allow it to be deterministic, T_d and stochastic T_s, i.e. $T = T_s \, x \, T_d$, and the cyclical component to be of long duration, say 6–14 years, C_l, and of shorter duration, say 3–5 years, C_s, i.e. $C = C_l \, x \, C_s$. The reason for the distinction is that a long/short cycle can either be treated as non-stationary or stationary depending on the time perspective of the study.

An additive is obtained by taking logarithms:

$y = (t_s + t_d) + (c_l + c_l) + e,$ (1)

[20] Following Baxter and King (1999).
[21] Especially the average length of cycles may change from one period to the next.
[22] Sutch (2006, p. 3-73) concludes that it is not possible to decompose GDP series into trends and cycles without additional information to that of the time series to be decomposed.

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where lower case letters indicate a logarithmic transformation.

After the splitting operation, the sub-series have the length of 15, 20 and 13 years. Within these sub-series, the longest cycles are almost 10 years long. The peaks of stochastic trends, at their shortest, may have a distance of 15 years. How do we distinguish between them if the time series is less than 20 years. We cannot distinguish precisely. Still, the difference between the long cyclical component c_l and the stochastic trend t_s in (2.4) is that t_s is a true unit root process ($\rho = 1$), where as c_l is a near unit root process ($\rho \leq 1$) that needs a very long sample to distinguish it from a true unit root process.[23]

5. Band-pass filtered cycles in 15 countries

5.1 Tracking changes in the average length of business cycles

It was noted in Section 2.3 an optimal band-pass filter should not introduce a phase shift, i.e., it should not alter the timing relationships between series at any frequency.[24] If the average wave length changes in the original time series, but the filtering is done assuming constant length, the timing relations do change. Therefore we need to control possible changes in the wave length.

Our next step is to study these changes from one period to another. I do this by applying spectral analysis on band-pass filtered time series when the series is divided into three periods: 1860–1880, 1880–1890 and 1890–1913. I chose the division in these periods, at first by graphic inspection of unfiltered time series, and after that by fitting the actual frequency response functions of the filtered series of each period to the corresponding ideal frequency response function, chosen by me, so that the functions are as close to each others as possible.

Figure 4 illustrates the method of estimating changes in the cycle length. The frequency response function in the left-hand side panel of the graph shows that the average wave length of our example data, the British GDP was about 6.3 years (1/0.16 cycles/year) in 1864-1890. The right-hand side panel shows that the average length in 1890-1913 was four years (1/0.25 cycles/year). In a similar way I traced changes in the length of cycles also in other countries and periods.[25]

[23] The principle is presented in Juselius (2006), p. 26. The symbol ρ refers to the sensitivity of the values of a time series to return to its mean: precisely in terms of the equation $X_t = \rho X_{t-1} + e$.
[24] The intuitively obvious condition is stated in Baxter and King (1999, pp. 575–576).
[25] The frequency response functions of other countries are shown in Appendix 2.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Figure 4. Frequency response functions of band-pass filters applied on the British GDP growth in periods 1864–1892 and 1892–1913.

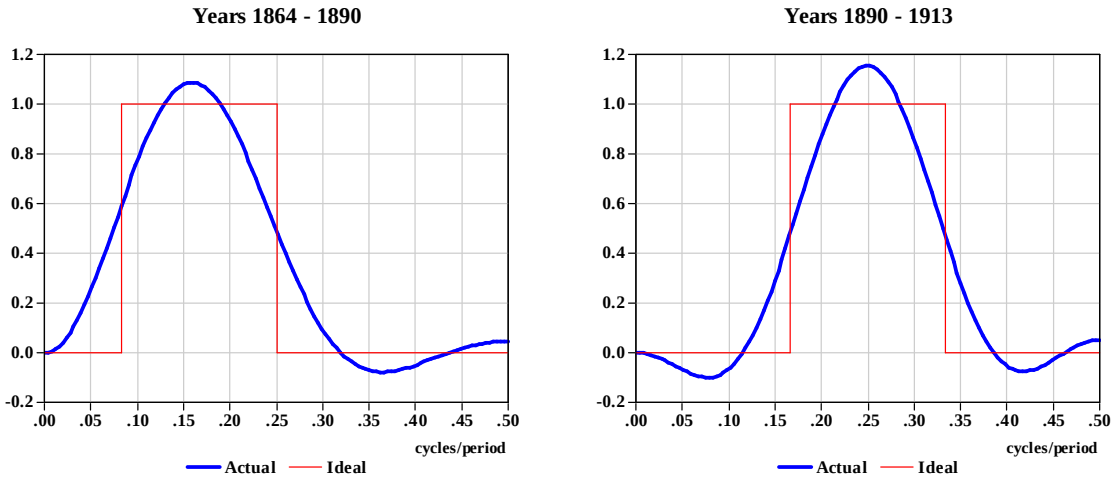


Table 3 presents estimates of the temporal development of cycle length in our sample of 15 countries. (The optimal choice of periods for Great Britain would be the one in Figure 4: 1864–1890, 1890–1913. To get Britain squeezed into the same Table 3 with other countries for comparison, the periods were, nevertheless, set also for Britain as 1864–1880, 1880–1900, 1900–1913.) Similar information is also graphed in Figures 5–10: the original time series, filtered cycles and trends.

The average length of business cycles changed in eight out of the 15 countries during the five decades before the First World War. The British cycles were clearly longer on average before 1900 than after that year. The French cycles were long, over six years in 1880–1900, but much shorter afterwards. Also Dutch and Swedish cycles were relatively long between 1880 and 1900 but short before 1880 and in the 1900s until the war. Norwegian, Spanish and Portuguese four year long cycles of 1860s and 1870s became two to three years longer in average in 1880s, 1890s and 1900s. For Italy a similar change happened around 1900.

The countries where cycle length did not change were Germany, Denmark, Finland, Russia, Australia, Canada and the United States. Estimation of German and Canadian cycles revealed that there are simultaneously long, over seven-year long cycles and short, four-year long cycles in these economies.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Table 3. Average length of the cycle of 15 countries (minimum and maximum length of cycles in parenthesis)

	Assumptions of wave length	1864–1880	1880–1900	1900–1913
Great Britain		5 (3–12)	5 (3–12)	3.6 (2–6)
France		4.2 (3–7)	6.5 (4–16)	4.3 (3–8)
Germany	a) Long b) Short	7.4 (5–14) 4.2 (3–7)	7.4 (5–14) 4.2 (3–7)	7.4 (5–14) 4.2 (3–7)
The Netherlands		4 (3–6)	7.4 (5–14)	4 (3–6)
Sweden		4.1 (3–6)	4.3 (3–8)	4 (3–6)
Denmark		4.3 (3–8)	4.3 (3–8)	4.3 (3–8)
Finland		6.3 (4–12)	6.3 (4–12)	6.3 (4–12)
Norway		4.3 (4–8)	7.4 (5–14)	7.4 (5–14)
Italy		4 (3–6)	4.2 (3–7)	6.1 (4–10)
Spain		4 (3–6)	7.4 (5–12)	7.4 (5–12)
Portugal		4 (3–6)	6.5 (4–12)	6.5 (4–12)
Russia			4 (3–6)	4 (3–6)
Australia		4 (3–6)	4 (3–6)	4 (3–6)
Canada	a) Long b) Short	7.4 (5–14) 4 (3–6)	7.4 (5–14) 4 (3–6)	7.4 (5–14) 4 (3–6)
United States		4 (3–6)	4 (3–6)	4 (3–6)

5.2 Trends of GDP growth and business cycles in 1865–1913

The results of my band-pass filtering of the GDP data of 15 countries are graphed in Figures 4–10. In the right hand panels of the Figures are depicted the filtered trends and cycles. The trends are combined deterministic and stochastic trends: $t = t_d + t_s$, in terms of equation (1). The cycles are calculated as deviations from the trend – in the Figures 4–10 they appear as deviations from the horizontal line (trend normalized to zero growth). In the left hand panel are graphed the filtered cycles and the original data: the logarithmic change of constant-price GDP. Again, the cycle is variation around the normalized trend. In

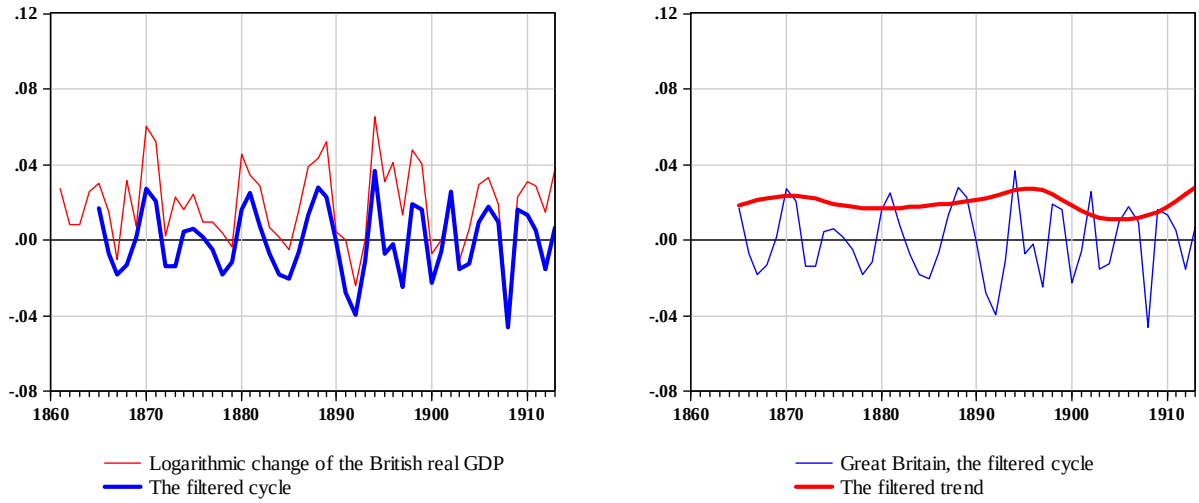
Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

the following sections I will discuss certain features of these cycles which might have had an impact on inter-country symmetry: changes in length of cycles and their volatility.

5.2.1 Great Britain

The GDP data which I use in this study for Great Britain is Charles Feinstein's compromise estimate. The British trend growth, estimated here using the methodology described above,[26] is rather stable, slightly increasing from late 1870s until the middle of 1890s. Thereafter the trend growth slows down, 1900s having clearly slower growth than that experienced before. The cycle length is five years in 1865–1900 and four years after 1900.

Figure 5. Business cycles and trend in Great Britain



Sources: See the Data Appendix of the thesis. Trend and cycle: own calculations.

The cycles which I get by band-pass filtering are shorter than those normally observed in the literature on British business cycles, especially the cycles after mid-1890s. Thus, my method identifies more downturns than in 1890s and 1900s than some – influential – studies. Table 4 reports troughs in British reference cycles according to four of these studies and in my study. In addition, in the left column there are troughs in Feinstein's compromise estimate, which is the data that I used for filtering.

[26] The extracted cycle and the random component need to be stationary and the trend is assumed to be stochastic.

DOI: 10.2870/38202

Table 4. British reference cycle troughs in different studies, 1866–1913

My study		Rostow (1948)	Friedman/ Schwartz (1982)	Capie/Mills (1991)	Craig/Fisher (1997)
Original data: trough (Feinstein's compromise estimate)	Downturns in the filtered cycle (years of growth 2 percentage points below the trend)				
1867	1867–68				1866–67
		1868 (2)	1868		
1872	1872–73				1873
1879	1878	1879 (5)	1879 (5)	1879 (8)	1878–1879
1885	1884–85	1886 (3)	1886 (3)	1886 (4)	1884–86
1892	1891-92		1893 (3)	1893 (4)	1892–93
		1894 (4)			
(1897)[27]	1897				
1900	1900				
					1902–03
1903					
	1903–04	1904 (4)	1904 (4)	1904 (5)	
1908	1908	1908 (1)	1908 (1)	1908 (1)	1908
	1912				

Definition of downturn in my study is that the filtered growth rate (cycle) is at least 1.2 percentage points below the trend (normalized to zero growth). From 1860s until early 1890s the downturns, obtained using my estimation method, are coinciding to those of Rostow (1948), Friedman and Schwartz (1982), Capie and Mills (1991) and Craig and Fisher (1997). The differences begin in the mid-1890s. The year 1894 is a trough according to Rostow, my filtering gives a peak in growth for that year, and so does Feinstein's compromise estimate. The years 1896–1897 are a downturn according to my filtering, but they are years of at least normal growth in the other studies mentioned in Table 4. In Feinstein's time series the growth is four per cent in 1896, and 1.3 per cent in 1897. The reason I define these years as those of poor development is that the growth is considerably below the trend growth, that is, below equilibrium of the economy.[28] Also 1900 is a trough in my study (and in Feinstein's data) but not in the four other studies. Years 1903–1904 and 1908 are depressions in both my study and the other studies (1904 lacking in Craig and Fisher). The downturns in years 1997, 1900 and 1912 make the British cycle length in my study so short in the period of the last 20 years before the First World War.

Thus, my assumption of non-linearity of the trend – fast trend growth in the 1890s – explains differences between my estimates of cyclical variation and cycle length with those of other studies in the literature

[27] The growth in Feinstein's compromise estimate is 1.3 per cent but it is clearly below the trend growth of 2.6 per cent. Therefore the year 1897 could be considered as a trough also in Feinstein's time series.
[28] See discussion about defining trends, equilibrium and cycles in Section 2.2.

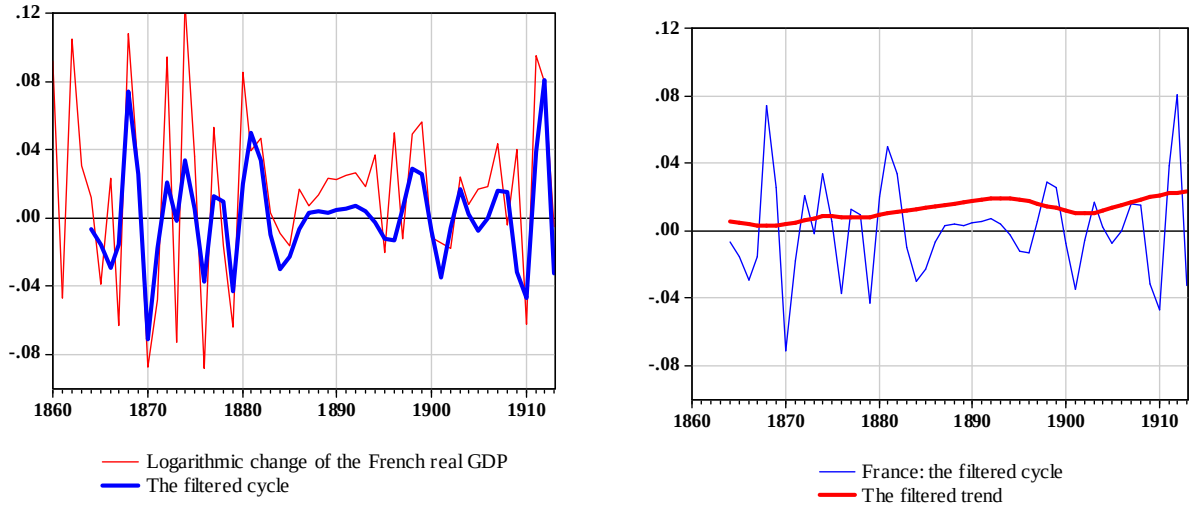
DOI: 10.2870/38202

on Great Britain. Another possible reason is the source data: I use Feinstein's compromise estimate, and e.g. Craig and Fisher use Feinstein's production estimate.

5.2.2 France

The French GDP series used here is from Jean-Claude Toutain's (1999) *Le produit intérieur brut de la France, 1789–1990*. The first differences of Toutain's aggregate series are very much similar to those of the other recently published study of the French GDP, Levy-Leboyer and Bourguignon (1990).

Figure 6. Business cycles and trend in France



Sources: See the Data Appendix of the thesis. Trend and cycle: own calculations.

The estimated growth trend increased from the half-percent level of the late 1860s to almost two percent in the late 1890s. The French growth, as well as the business cycle, was volatile compared the other industrialized countries of Europe, the exception being late 1880s and early 1890s, when the French cycles were exceptionally tranquil.[29] Craig and Fisher write about constant moderation of French cycles in the period 1850–1913.[30] My impression, based on the GDP estimate in Toutain (1997) and filtering out the cycle (separating the cycle from trend and random variation) is that the cycles were moderate in 1885–1895 and again volatile afterwards. Increase in the volatility is not insignificant to our problem – explaining inter-country symmetry of business cycles. As we will see below, the volatility of French cycles was a major cause for inter-country a-symmetries in the 20-year period before the First World War.

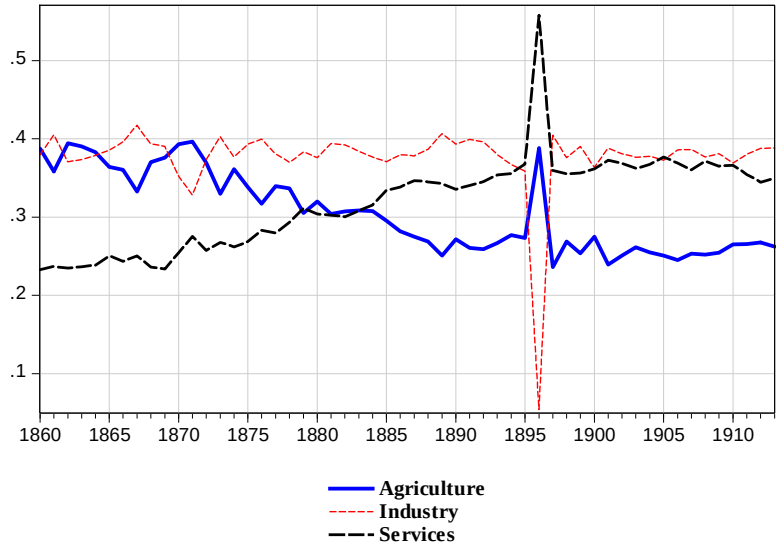
[29] It should be noted that it is meant here that cycles are un-volatility around a stochastic trend. Changes in volatility are more difficult to see when the data is not de-trended, as the narrow line in the left panel of Figure 5 shows.

[30] Craig and Fisher's (1997) story of constantly diminishing volatility of the French growth is apparently based on an older of study by Jean-Claude Toutain, published in 1987.

DOI: 10.2870/38202

The question remains, what was the reason of this volatility. The conventional solution seems to have been to look at agriculture. For example Craig and Fisher (1997, p. 247) write that "French cycles are dominated by volatile agricultural sector, which, in fact, was larger than industrial sector until twentieth century".

Figure 7. The production shares of French agriculture, industry and services sector in Toutain (1997), 1860 – 1913



According to Jean-Claude Toutain (1997),[31] both agriculture and industry each made up almost 40 per cent of the French GDP in the 1860s, and then in the early 1870s the share of agriculture started diminishing steadily until it stabilized at around 25 per net in the 1890s and 1900s. (See Figure 7.) The share of industry remained at the same level until 1913 (38 per cent on average in 1860 – 1913).

The growth of agricultural production was, indeed, always more volatile than aggregate production but, given its diminishing share, it was not the dominant sector. After 1885 the share of agriculture dropped clearly under that of the service sector. Around mid-1890s services had reached the share of industry, the leading sector since 1860s. Agriculture and industry grew counter-cyclically, smoothing out each other's influence. The growth rate of the services sector was somewhere in between these two, and the aggregate growth rate of the French economy coincides well with that of services after 1885. This applies both to the original data, and to the filtered data (the cycle) of the aggregate GDP and the data of the three sectors.

[31] Pages 30–32 for agriculture, pp. 33–38 for industry, pp. 39–43 for services sector and pp. 54–57 for total production.

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Table 5 shows that volatility of filtered cycles increased in all sectors after 1895, but much less so in the service sector. The aggregate volatility did not increase in 1895–1909 compared to years 1879–1895. On the other hand there is a clear increase in volatility if the additional four years before the war are included.[32]

Table 5. Volatility of extracted cycles as standard deviations: services, industry and agriculture, and the original aggregate data in three periods

	1864–1879	1879–1895	1895–1909	1895–1913
Agriculture	0.058	0.033	0.05	-
Industry	0.055	0.033	0.036	-
Services	0.03	0.015	0.017	-
Total	0.034	0.02	0.019	0.03
Original GDP	0.071	0.032	0.028	0.04

5.2.3 Germany

A bulk of studies on German economic growth is based on data from two contributions published in 1950s and 1960s: net national product estimates by Walter Hoffmann and Heinz Müller and Hoffmann.[33] In this study I use the data composed by Carsten Burhop and Guntram B. Wolff.[34] Also the new data is based on the four estimates of Hoffmann and Müller. Burhop and Wolff made several improvements: they recalculated industrial production, investment, home and foreign capital income. Despite improvements, differences remained between the estimates of production, expenditure and income in the during the early decades. Therefore Burhop and Wolff computed an average compromise series, which I use as the German data in my study. According to the new estimate, economic activity in 1850s was higher than the older the old estimates suggest. The average growth rate between 1851 and 1913 is thus lower than believed before.

The growth trend, estimated by filtering, has a similar shape as the French trend but is clearly faster. As the French growth is 1.3 per cent on average in 1865 – 1913, German growth is 2.4 per cent.[35] The Ger-

[32] The production data of sectors in Toutain (1997) is only until 1913. My band pass filter uses four-year moving averages, dropping the last observation off the filtered time series. Thus, the filtered series on sectors are only until 1909.
[33] Hoffmann and Müller (1959) and Hoffmann (1965).
[34] Burhop and Wolff (2005).
[35] The German and French growth rates are not exactly comparable. The base year of price indexes used for calculating the constant-price GDP/NNP is 1913 for Burhop and Wolff's data and an average of 1905–1913 for Toutain's data.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
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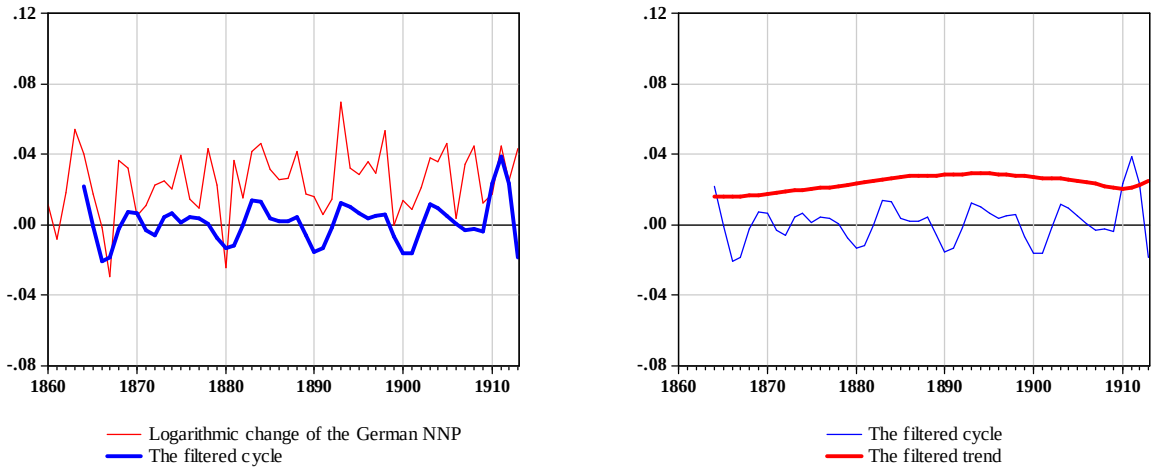
man growth increases continuously until mid-1890s, and slows down slightly after that. The estimated trend is graphed in Figure 7.

Figure 7. Business cycles and trend in Germany



Sources: See the Data Appendix of the thesis. Trend and cycle: own calculations.

Defining the length of German business cycles is not an easy job. Using the tools provided by band-pass filtering, you get two equally good outcomes. One time series contains relatively long business cycles of over seven years on average, the alternative has shorter cycles of slightly more than four years on average. Looking at the original data one observes that the German business cycles are M-shaped. Inside the long cycles, lasting sometimes even nine years, there are smaller cycles lasting four to five years. The fluctuations inside the long cycle are less severe than those caused by the big troughs.

Figure 8 illustrates the two kinds of cycles. The dashed line in the figure is the growth rate of the original data, Burhop and Wolff's compromise estimate. The thick solid line is the growth rate obtained if the cycle band is defined to be 5–14 years, and the thin solid line is the rate obtained when the band is defined to be 3–7 years. The alternative chosen here is the one giving longer cycles. That time series reveals the M-shape of the German business cycle better.[36]

[36] Two cycles of different length in German NNP data were observed also in A'Hearn and Woitek (2001). The authors also use band-pass filtering to separate the cycles from trends and random variation.

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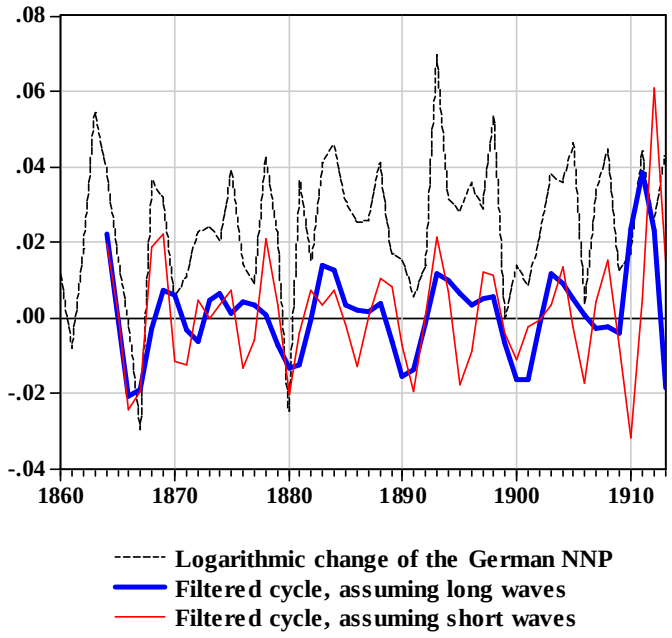
Figure 8. Long and short business cycles in Germany



Sources: See the Data Appendix of the thesis. Trend and cycle: own calculations.

The long cycle is clearly longer than the cycles in the literature on German economy. The short cycle, on the other hand is similar to the one estimated by Burhop and Wolff.[37] Table 6 reports the reference cycles according to the two alternatives (long and short) in my study, and those in Burhop and Wolff (2005) and in Craig and Fisher (1997). The last study is based on other data sets than mine and Burhop and Wolff's.

The business cycle dating for the 1870s, according to the compromise estimate, Burhop and Wolff's filtering and my filtering, diverges from the commonly assumed pattern. (Based on Hoffmann's estimates, it used to be assumed that there was a so called Gründerzeit -boom in 1870–1873 and a Gründerzeit -crisis in 1874–1879.) The crisis was in the early 1870's, 1873–1878 were years of at least normal growth, and a crisis became only in the year 1880.

My filtering produces an annoying error concerning the value of the last year, 1913. According to Burhop and Wolff's compromise estimate the German economy grew at the rate of 4.3 per cent in that year. In my filtered data the change was -1.8 per cent below trend (long cycle), or 1.9 per cent above trend (short cycle). These figures are the result of using the exceptional war-time years 1914–1917 in the moving average to get a value for the year 1913. The solution was not successful for the long cycle. Fortunately that mistake is the only one in my filtered series.

[37] Burhop and Wolff use the same method as I, namely band-pass filtering to separate the cycles from trends and random variation.

DOI: 10.2870/38202

Table 6. German reference cycle troughs in different studies, 1866–1913

My study			Burhop and Wolff's filtered cycle:	Craig/Fisher (1997)[38]: years of recession
Original data: the trough (Burhop and Wolff's compromise estimate)	Estimated cycle: long (years of growth below trend)	Estimated cycle: short (years of growth below trend)		
	1866	1866		
1867			1867	1867
1870		1870–71	1870–71	1870
	1872			1872
1876–77		1876		1876
			1877	
	1880	1880	1880	
				1881
1882				
1886–87		1886	1886–87	
				1888–89
1890–92	1890–91	1891	1890–92	
				1892
				1894
		1895–96	1895–96	
				1897
1899–1901	1900–01	1900	1900–02	1902
1906		1906	1906–07	
	1907–09			
				1908
		1909–10	1909–10	1910
	1913			

According to the original, unfiltered data the volatility of cycles was highest in the first four decades of the investigated period. My filtering results in long cycles which volatility remains almost constant from 1864 to 1910, the volatility of short cycles was smaller in the middle of the period. Unchanging volatility of the long cycle has an impact on the estimate of symmetry in relation to cycles of other countries. It contributes to at least unchanging, and possibly high symmetry with most of the countries in our sample.

Table 7. Volatility of extracted cycles as standard deviations: services, industry and agriculture in three periods

	1864–1880	1880–1900	1900–1913
Long cycle	0.01	0.01	0.017
Short cycle	0.015	0.01	0.02
Original data	0.021	0.02	0.015

[38] The data in Craig and Fisher is unfiltered and from Hoffmann (1965). They make their evaluation on the basis of unemployment, industrial production, exports and investment data.

DOI: 10.2870/38202

5.2.4 Sweden and Norway

The national accounts estimate I employ on Sweden is that of Olle Krantz and Lennart Schön (2006), and the one on Norway is by O. Grytten (2004). The Norwegian GDP data from 1865 to 1913 is from an older study published by the Norwegian Statistical office in 1978. The Swedish data is probably the most accurate description of national income of any country that one can find. The quality of the statistics is based on large amount of basic data and sophisticated methods of calculation.

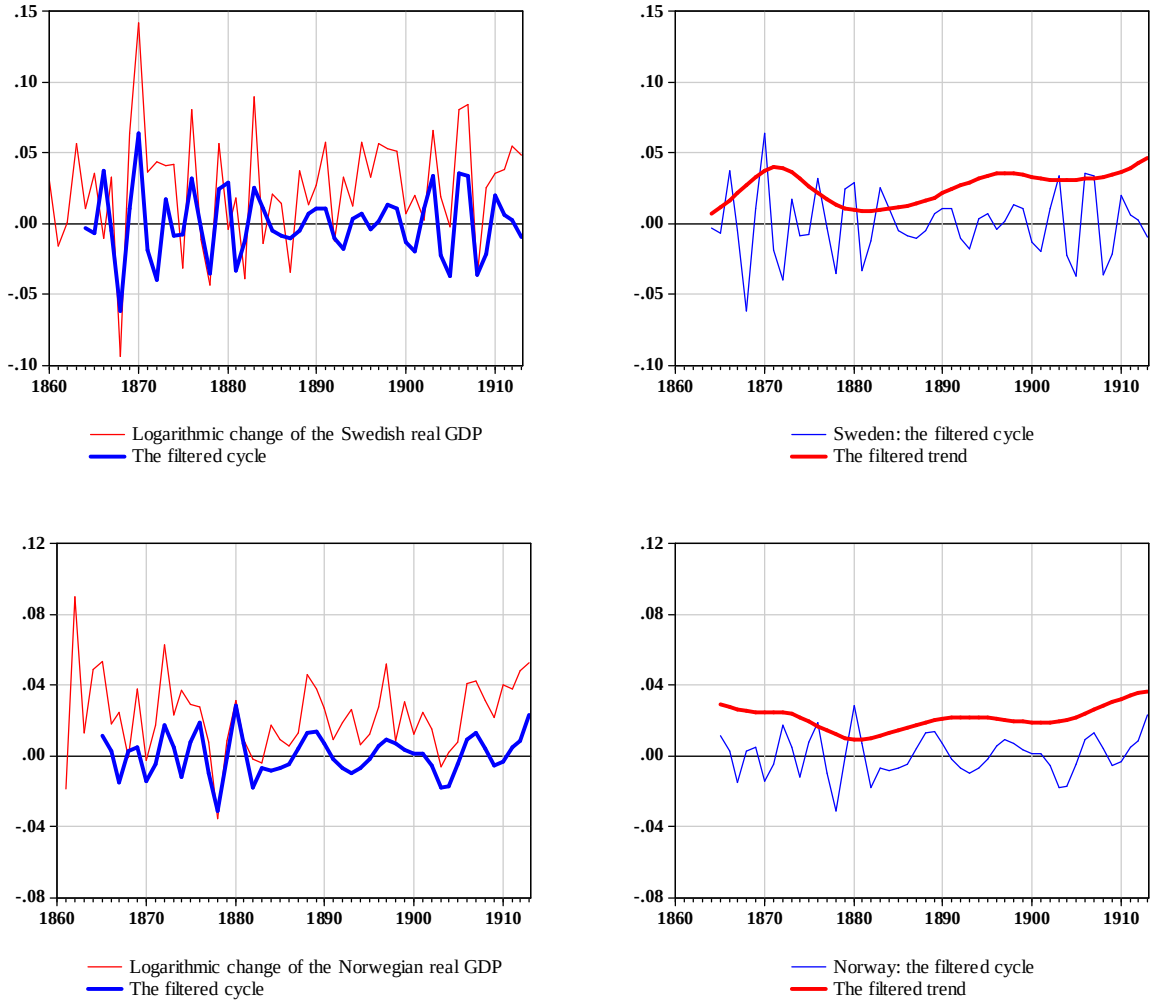
The growth trends, according to the data mentioned above and my filtering, were similar in both Sweden and Norway. After a period of slow average growth rate of 1–1.5 per cents from the end of 1870s until middle of 1880s, their growth trends increased to 3 per cents in the 1890s and to 4 per cents after 1900. The cycles around trends, on the contrary, are quite different in the half a century period before the First World War.

Swedish business cycles were exceptionally volatile until around 1885. According to filtering, after mid-1880s until around 1900, Swedish cycles became clearly milder and thereafter volatility increased again. Looking at the data of Krantz and Schön, it is not easy to see the decrease in volatility in late 1880s and 1890s: standard deviation of the original data is 0.032 in 1880–1900 and 0.034 in 1900–1913. Filtring is needed to separate the stochastic trend and cycle in the way that the cycle is stationary around the trend.

Also Norwegian business cycles were volatile in the 1860s and 1870s, and had also the same average four-year length as Swedish cycles. The similarities between Sweden and Norway end at the beginning of 1880s. Volatility of the Norwegian GDP growth decreased permanently and cycles became much longer than before. Differences in both volatility and cycle length gave rise to the periodically strong a-symmetries between Swedish and Norwegian economic growth in the 1880s and in 1900–1913.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Figure 9. Business cycles and trends in Sweden and Norway



Sources: See the Data Appendix of the thesis. Trend and cycle: own calculations.

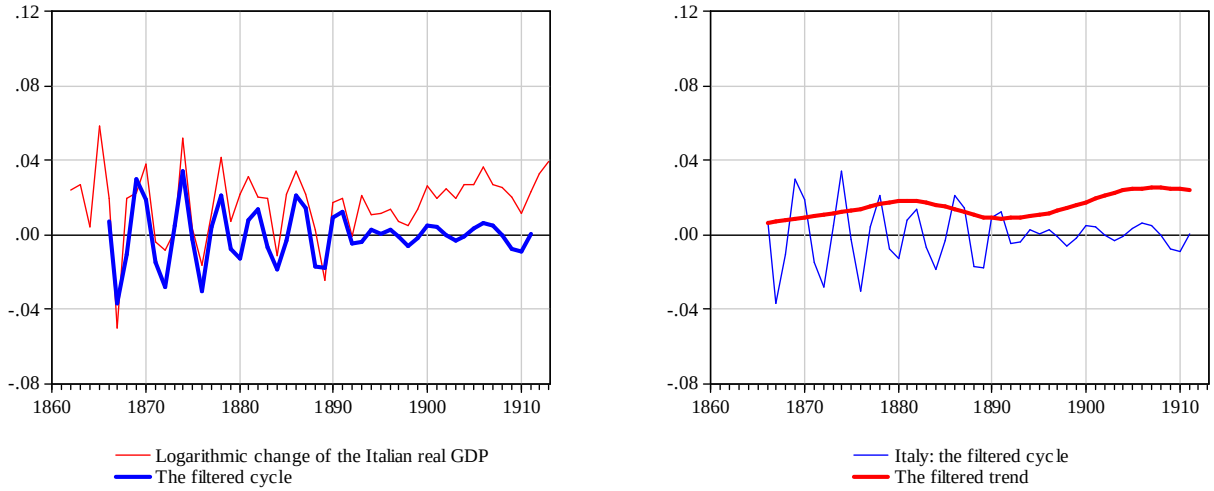
5.2.5 Italy

The estimates of the Italian aggregate production, used here, were published by Stefano Fenoaltea in 2005. That quite recent work differs in many ways from earlier studies.[39] The new estimates are based on entirely new research, incorporating recent series for agriculture by Giovanni Federico (2000), Fenoaltea's recent (2003) series for industry, and newly derived series for services by Vera Zamagni and Patrizia Battilani (2000).

[39] Fenoaltea (2005) gives a thorough discussion about the differences between his work and previous studies on the Italian pre-First World War GDP. The two previous estimates are (1) the one compiled by Istat, Instituto Centrale di Statistica in the mid-1950s, improved by Ornello Vitali (1969), and (2) the aggregate measure by Angus Maddison (1991).

Fenoaltea's characterization of his main results describes well also my extraction of the Italian growth trend: "The dominant feature of the new series is a long swing, with above-average growth from the late 1870s to the 1880s, followed by a decade of stagnation and a second upswing even stronger than the first."[40] The previous results by "Istat-Vitali" and Maddison suggest a very slow growth from 1861 to late 1890s, and exceptionally fast growth after that until the First World War.

Figure 10. Business cycles and trend in Italy



Sources: See the Data Appendix of the thesis. Trend and cycle: own calculations.

Fenoaltea doesn't write about the business cycle. This is perhaps because he doesn't believe in the short term preciseness of his estimates. Nevertheless, I took the challenge to extract the cycle also from this data set. The Italian business cycle, estimated using a band-pass filter, is graphed in Figure 10, and the estimated cycle length is documented in Table 5 on page 18. Cycles were volatile and short, four years on average until 1900. After that volatility diminished sharply and cycles became over six years long on average.

5.2.6 Denmark, Finland, Russia, Netherlands, Spain, Portugal, Australia, Canada and the United States

The graphs of the business cycles and trends for the remaining nine countries are in Appendix 3. In most of these countries the volatility of growth was rather high, though it diminished towards the end of the 19th century and in the decades after the turn of the century. Two of the countries, Denmark and The Netherlands grew in an exceptionally stable manner. The Dutch historical national accounts are so good quality that we can make conclusions of its trend growth: it was 2.2 per cent on average in 1860–1913.

[40] Still, it is to be noted that the trend extracted by me is not exactly the same thing to what Fenoaltea writes about. The cycle and random variation are removed from the trend, graphed in Figure 10, where as all the three components are in the series talked about by Fenoaltea. It seems Fenoaltea uses the word "cycle" for the phenomenon which I call *stochastic trend*: see Fenoaltea (2005), p. 299.

DOI: 10.2870/38202

The much more volatile Finnish growth rate was 2.5 per cent.[41] The Finnish business cycles were shaped by successful crop failures, creating deep downturns at the interval of 6–9 years.

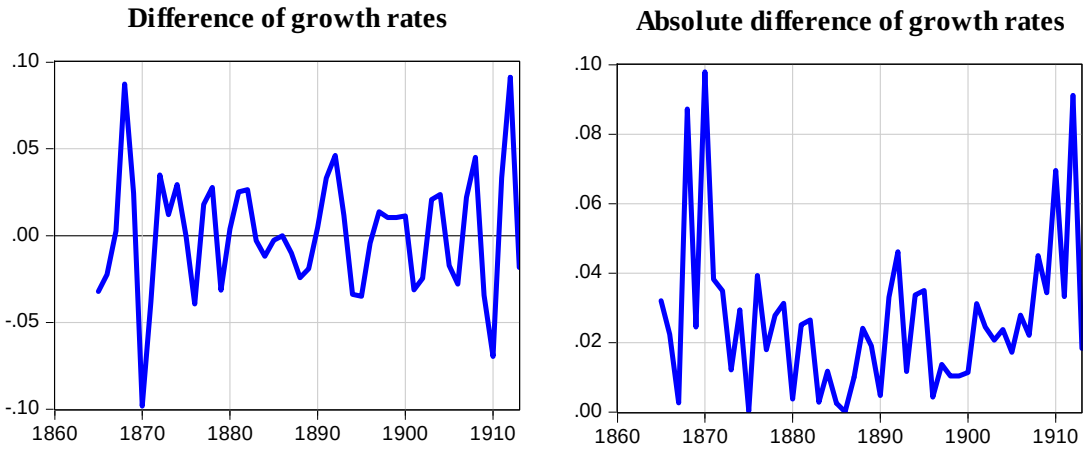
The most volatile countries, in terms of measured GDP growth, were Russia, Portugal, United States, and Spain.[42] Also the stochastic trend of growth in these countries may vary from one decade to another, and still it leaves the strong volatility for the cycle.[43] We will see below that volatility is an important determinant for the temporal development of symmetry indicator.

6. Symmetry of cycles: binary comparisons and absolute difference

6.1 Binary comparisons and absolute difference

A simple way to measure symmetry is to compare the cyclical component of two countries. The difference of growth rates gives a good picture of annual development of symmetry: the larger is the difference, the smaller is symmetry. For the purpose of visualizing the phenomenon, we have two possibilities: to use difference *d* or absolute difference $\delta = |d|$. Difference is more practical for statistical modeling since the time series composed of it is always stationary. Absolute difference δ is visually more illustrative than difference *d*, as shown in Figure 10.

Figure 10. Difference and absolute difference of the British and French cycles, 1864–1913



[41] Also the Finnish historical national accounts allow meaningful comparisons of trend growth. The corresponding Swedish figure is 2.6 per cent. See Section 3 for a discussion on biases in measurement of constant-price growth rates.
[42] See Appendix 4 for standard deviations of the first differences of original GDP series and the filtered growth rates.
[43] The more there is variation in trend, the less variable is the cycle. The total growth rate is the sum of stochastic trend, cycle and random components.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Perhaps the most striking feature of the symmetry of cycles – measured in this way – is the strong annual volatility. The differences of filtered growth rates may vary from almost zero in one year to a very high value in the next year. This way we get a totally different picture of symmetry of business cycles to the fairly monotonous one given by correlations. Other interesting features, illustrated by the indicator, are changes in the variance and mean of the absolute difference during the classical gold standard period. We will see below that the development of symmetry of business cycles was far from monotonous in Europe in the last decades before the First World War.

To study development of symmetry among European economies, I computed the absolute differences in 40 country pairs: those

- between all of the three countries in the core of the international monetary system: Great Britain, France and Germany,
- between each of the core countries and the peripheral countries for which export to Britain, France and Germany was important, or which imported a lot of capital from these three countries,
- between the three countries in the Scandinavian Monetary Union: Denmark, Norway and Sweden,
- between three Southern European countries: Italy, Spain and Portugal, and
- between Russia and three Northern European countries.

In 24 of the cases the variance and mean of absolute difference (a-symmetry) were high before 1880. It was high in almost all cases where France, the United States, Sweden and Spain were one of the countries to be compared. In the case of Russia cycles a-symmetric until 1895. The indicator shows also increasing differences between the filtered growth rates (diminishing symmetry) after 1900. Great volatility of the indicator is connected with its high absolute value (small symmetry of business cycles). Section 6.3 gives an account of all these cases in detail. Nevertheless, for analyzing those 40 cases, we need a short discussion about how different models of synchronization of cycles shape the form of what might be called ‘distance function’ of the growth rates. Basically all of this is about how a-symmetry of cycles evolves over time.

6.2 Synchronization of business cycles and the time path of a-symmetry

Symmetry of business cycles means two things. At first, booms and depressions of two countries or a group of countries are synchronized. Second, symmetry means equality in the volatility of these fluctuations between the countries. Considering the synchronization first, we assume that the volatility of cycles to be compared have the same volatility. Now, synchronization of cycles has to do, of necessity, with similarity of length of the two parallel cycles which we are comparing. We may have three different cases:

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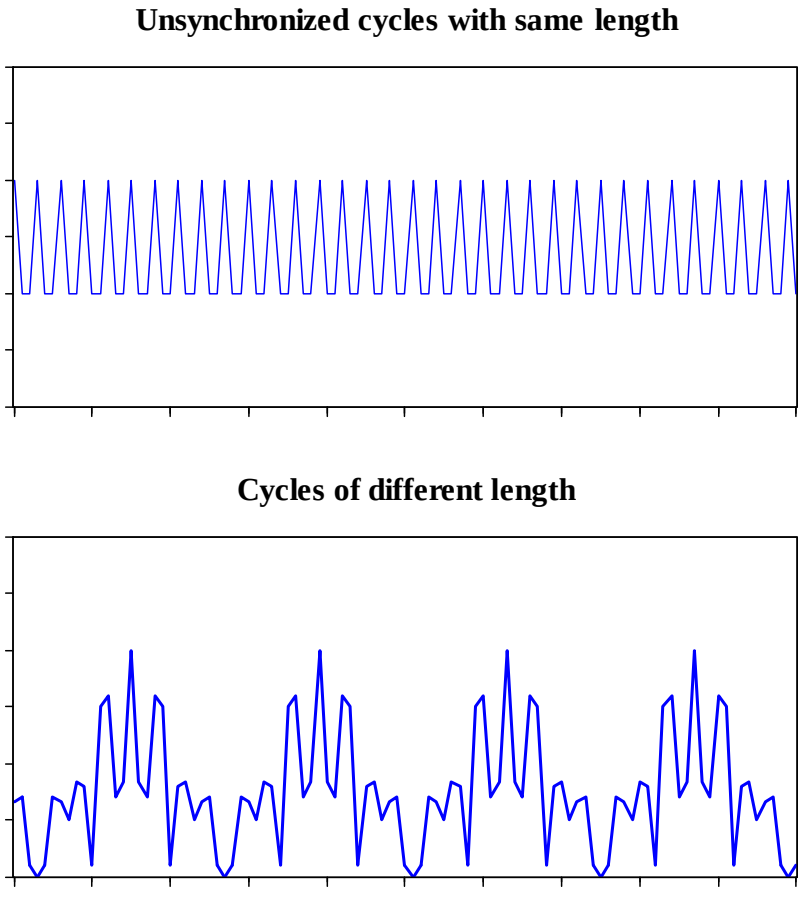
European University Institute DOI: 10.2870/38202

- First, the cycles in two time series have the same length and the booms and slumps are overlapping. This is the case of perfect symmetry. If volatility of the two time series is not the same, symmetry disappears.
- Second, the cycles of the two time series have same length but the booms and slumps are not overlapping. In this a case the cycles are always a-symmetric, and years of maximum and minimum symmetry vary at regular intervals. Unequal volatility increases a-symmetry.
- Third, if the cycles in these two time series do not have same length, we have periodical near-symmetry and periodical diversion from symmetry. Again, unequal volatility increases a-symmetry.

The upper panel of Figure 11 illustrates the second case and the lower panel the third case. Cycles are more a-symmetric on average when they are unsynchronized but have the same length, but volatility of symmetry/a-symmetry is small (upper panel, second case). When cycles have different length (lower panel, third case), on the other hand, the average a-symmetry is smaller but volatility exceeds that of the second case.

Figure 11. Examples of symmetry when the cycles have same and different lengths: differences of values of two time series



Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

6.3 Symmetry in the case of 40 binary combinations

Figures 12–17 and Appendix figures 5.1–5.3 show the clear changes in the indicator of symmetry: the absolute differences of filtered growth rates. In 17 cases of 40 there are great differences in growth rates of the cycle component before mid-1880s. Then the differences diminish, the time of strong symmetry lasting about 20 years, but start to increase again after 1905. In other words, business cycles were strongly a-symmetric in the 1870s and after 1905, but symmetric in the 1880s and 1890s. These changes happen especially in the cases where one of the countries in a binary comparison is France, Sweden, Spain, United States, or Russia.

6.3.1 France: great volatility of growth and strongly a-symmetry of cycles

Let us consider the case of France first. The absolute differences between French, British and German filtered growth rates are graphed in Figure 12. Cycles are a-symmetric in the early and late periods when France is one of the countries in the pair. (There are no such differences in filtered growth rates between British and German aggregate growth.)

Differences in volatility, cycle length and synchronization all play a role in shaping the symmetry of French cycles. The big difference between the years of symmetry, 1880–1900, and the periods of a-symmetry before 1880 and after 1900, is caused by changes in volatility of business cycles, most importantly changes in the volatility of French cycles. Measured as standard deviations, the French cycles were twice as volatile in the first and last period as they were in 1880–1900.

The volatility of cycles in the countries we compare, Great Britain, Germany, Denmark, Norway and Finland, did not change much but they were counter-cyclical to French cycles. The volatility of Swedish, Italian, Portuguese and Spanish cycles did change, their cycles were volatile in the same time as cycles were volatile in France. The cycles of these countries were also counter-cyclical to French cycles. High volatility of growth and lack of synchronization of cycles explain strong a-symmetry.

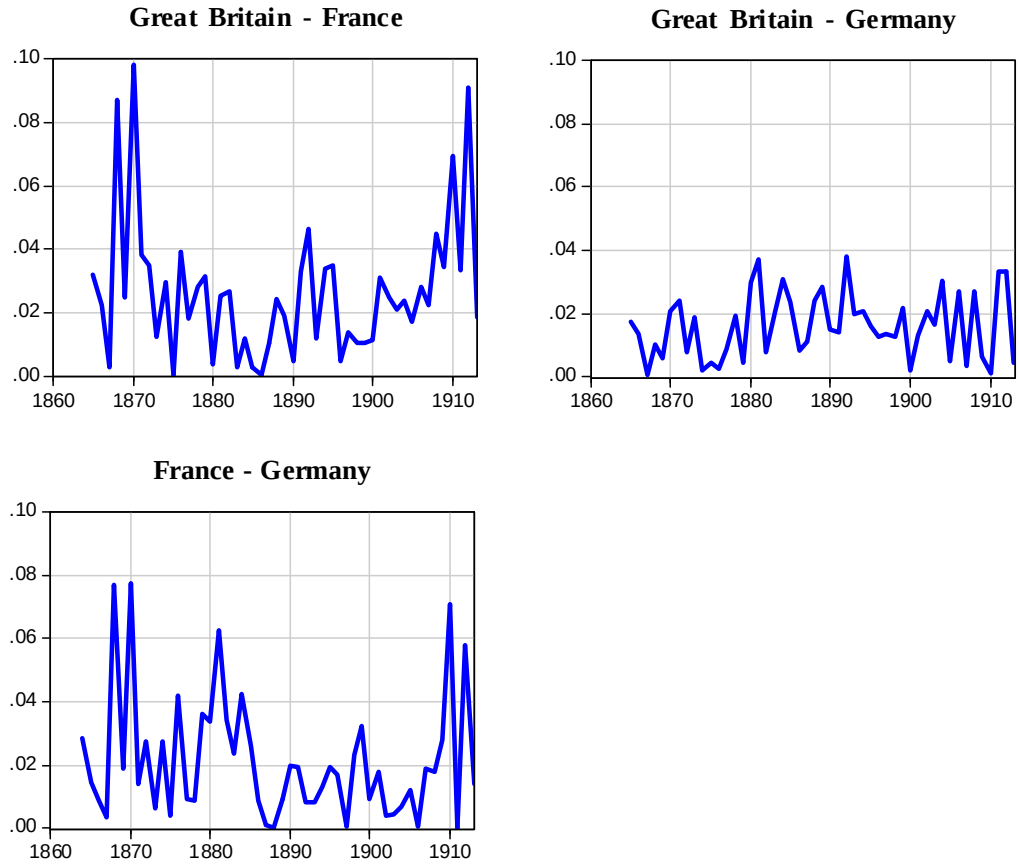
As illustrated in Figure 11, cycles become periodically a-symmetric if they have different length in the two countries which we compare. This is the case in 1880–1900 even between the French cycles, on the one hand, and cycles of Great Britain, Germany, Denmark, Norway, Finland, Spain and Italy, when the average growth rates and their volatilities are similar in these countries. The effect multiplies when volatilities are big or different between the countries, as in the 1860s and 1870s, and after 1900.[44]

[44] Changes in the volatility of French aggregate cycles were caused by volatile agriculture and industry in 1870s and after mid-1890s.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Cycles are a-symmetric also when they have same length, but they are unsynchronized. As an example, let us look at the France cycles on the one hand, and Scandinavian and Southern European cycles on the other hand. They had always equal length before 1872 and after 1908, but they were unsynchronized. Also French and Italian cycles had the same length in 1894 – 1908 and they were counter-cyclical. The result was always a-symmetry and its magnitude depended on the volatility of the cycles.

Figure 12. Absolute differences between British, French and German GDP growth rates (filtered growth, cyclical component), 1860–1913



The wave-like shape of the symmetry/a-symmetry indicator could also be the result of irregular changes in the length of one of the cycles. That is what symmetry indicators of the country pairs France-Italy, France-Spain,[45] France-Denmark, France-Norway France-Finland and France-Sweden[46] look like in 1865–1885. The length of French cycles changed from four-year length to three years in 1873. Before that the yearly values of indicators for a-symmetry were high on average, and they were volatile. In 1872–1875 their values drop down (indicating high symmetry of business cycles) and thereafter climb up again, when the cycles in comparison become counter-cyclical again.

[45] See Figure 13.
[46] See Figure 14.

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Figure 13. Absolute differences between the French GDP growth rate and growth rates of Italy, Spain and Portugal, and the absolute difference between the German and Spain growth rates (filtered growth, cyclical component), 1860–1913

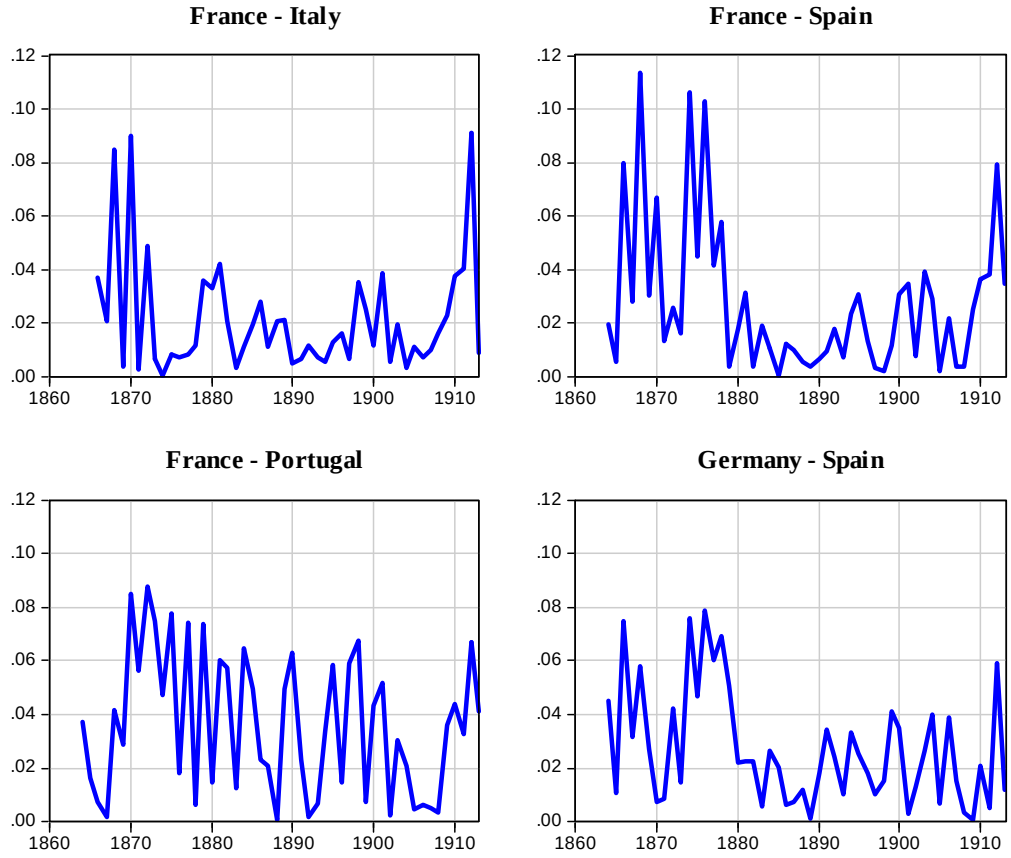

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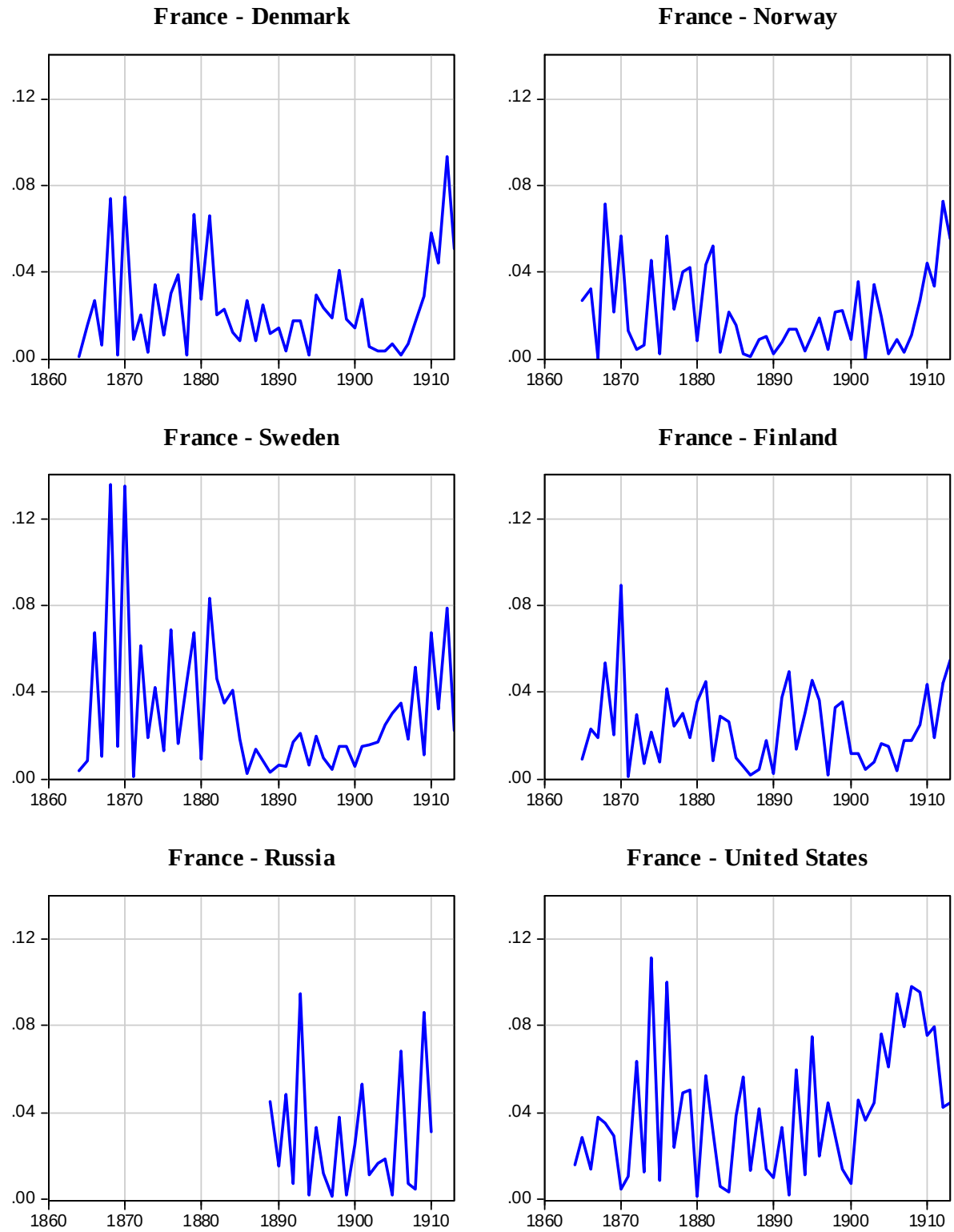
Figure 14. Absolute differences between the French GDP growth rate and growth rates of Denmark, Norway, Sweden, Finland, Russia and the United States (filtered growth, cyclical component), 1860–1913



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6.3.2 Sweden: volatile growth but symmetry of cycles with the right countries?

The choice of countries I compare with Sweden is the following. Great Britain, Germany and France were Sweden's most important trading partners. Sweden imported its capital from France and Germany. Both trade and capital imports from these three countries should have had an impact on Swedish business cycles. Denmark and Norway were far from the importance of Germany and Great Britain as trading partners to Sweden. Nevertheless, they were in the Scandinavian monetary union with Sweden. Common money should require similar business cycles, according to Optimum Currency Area Theories. Finland was not among the five most important trading partner in the Swedish perspective but Sweden was the fourth most important export destination to Finland.

The Swedish filtered growth rate is twice as high in 1865–1880 and 1900–1913 to that of 1880–1900.[47] There are no such changes in volatility of the British, German, Danish, Norwegian and Finnish growth rates.[48] Great volatility of Swedish growth is enough to produce a-symmetries between the business cycles when the cycles are unsynchronized. The a-symmetries are not strong after mid-1870s, except against French growth and British growth in late 1900s. With Germany, Denmark, Norway and Finland the Swedish cycles were often almost symmetric, although there is that wave-like development which is the result of different length of cycles in the pair of countries.

What can we say about Sweden's ability to stay in the same currency area with these countries? According to the OCA theories, countries in a currency area should have symmetric business cycles. Sweden had the most symmetric cycles with the closest countries in monetary sense, the members of the Scandinavian Monetary Union. Also German cycles developed in the same line with the Swedish ones. Was the reason that Germany's importance as an export destination for Sweden increased significantly towards the end of the 19th century. Contradicting to German trade, the importance of exports to Great Britain diminished in the Swedish perspective. We might say that Sweden could 'afford' to have a-symmetric cycles with Britain in the 1900s.

[47] See standard deviations of filtered growth rates in Appendix 4.
[48] France is the only country were volatility cycles changed considerably, as noticed in the discussion above.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
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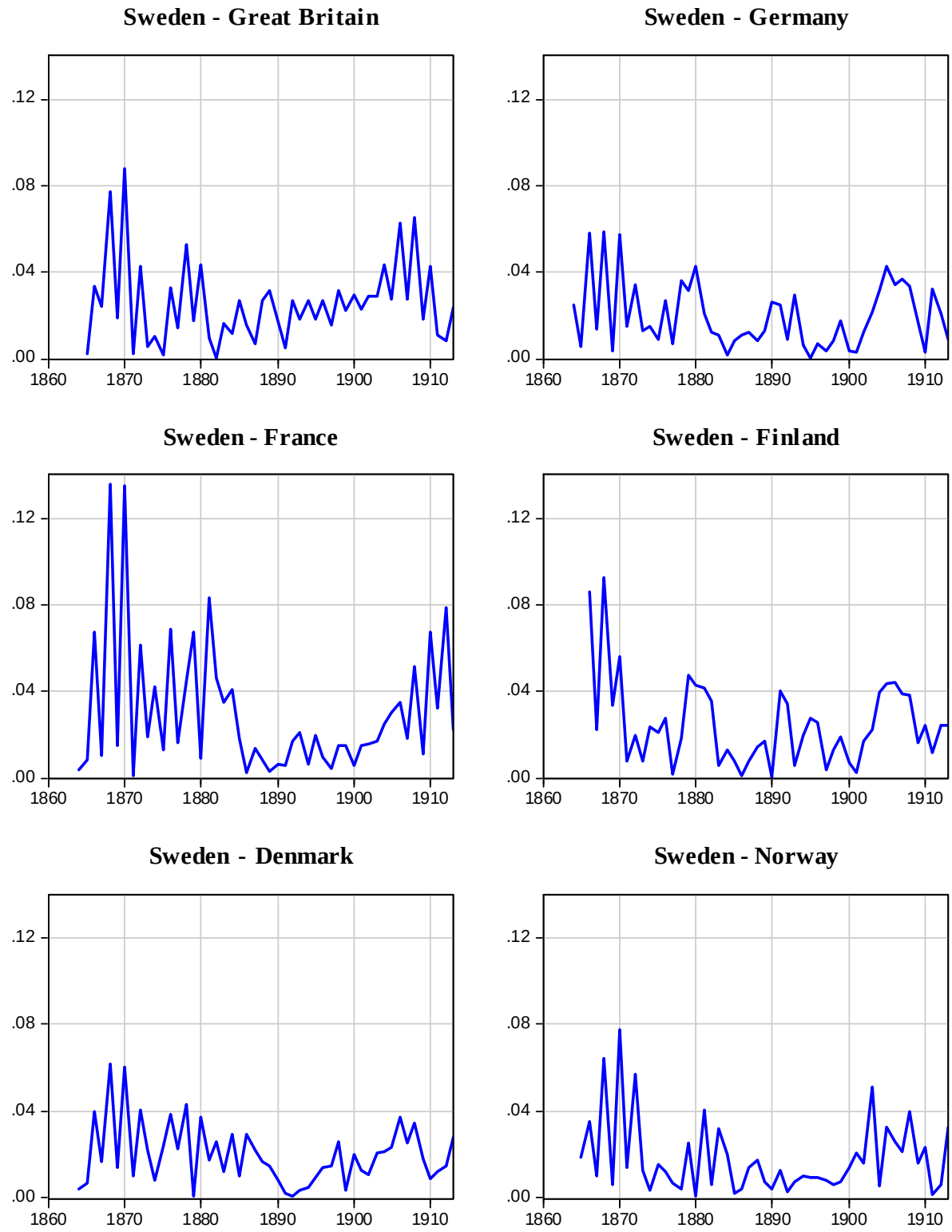
Figure 15. Absolute differences between the Swedish GDP growth rate and growth rates of Great Britain, Germany, France, Denmark, Norway and Finland (filtered growth, cyclical component), 1860–1913



Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

6.3.3. Unstable Australia, Canada and United States

I chose the non-European countries, Australia, Canada and the United States to be included in the group of symmetry comparisons since they were all important trading partners to Great Britain. The symmetry indicators of these countries with Britain are graphed in Appendix Figure 5.1. All of the three cases lack the normal shape of development: the cycles were strongly a-symmetric to the British cycles also in the 1880s and 1890s. The national accounts estimates, as well as the filtered cycles indicate that Australia, Canada and United States were much more volatile in their GDP growth than Great Britain all the time in 1865–1913. Since the length of their business cycles was also different to the length of the British cycles, the symmetry indicators depict the wave-like development with strong ups and downs.[49]

It is to be noted that the U.S. GDP estimate is not of good quality enough for measuring business cycles. The strong volatility of the American estimate, characteristic to the time series also after filtering off the random component, creates the big differences between the U.S. and British growth rates. The business cycles of these countries were, after all, fairly synchronized after 1895. A more precise estimate for the United States could change the picture in the last 15 years.

6.3.4. Countries with symmetric cycles

Among the core countries of the international monetary system, Great Britain and Germany were the stable countries in terms of GDP growth. The volatility of business cycles, measured as the filtered growth of GDP, as well as the volatility of original GDP estimates was among the lowest in the group of 15 countries studied for this paper. Even if the cycles of these two countries had totally different length, and were thus unsynchronized, the low variance of GDP growth guaranteed always small differences. The right hand panel of Figure 12 illustrates how much more symmetric the British-German business cycles were compared to the French business cycles (symmetry with France in the left panels of Figure 12).

[49] See Appendix Table 3.1 for standard deviations and Table 3 for cycle length.

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Figure 16. Absolute differences between the German GDP growth rate and growth rates of Denmark, Norway, Sweden, Finland, Russia and the United States (filtered growth, cyclical component), 1860–1913

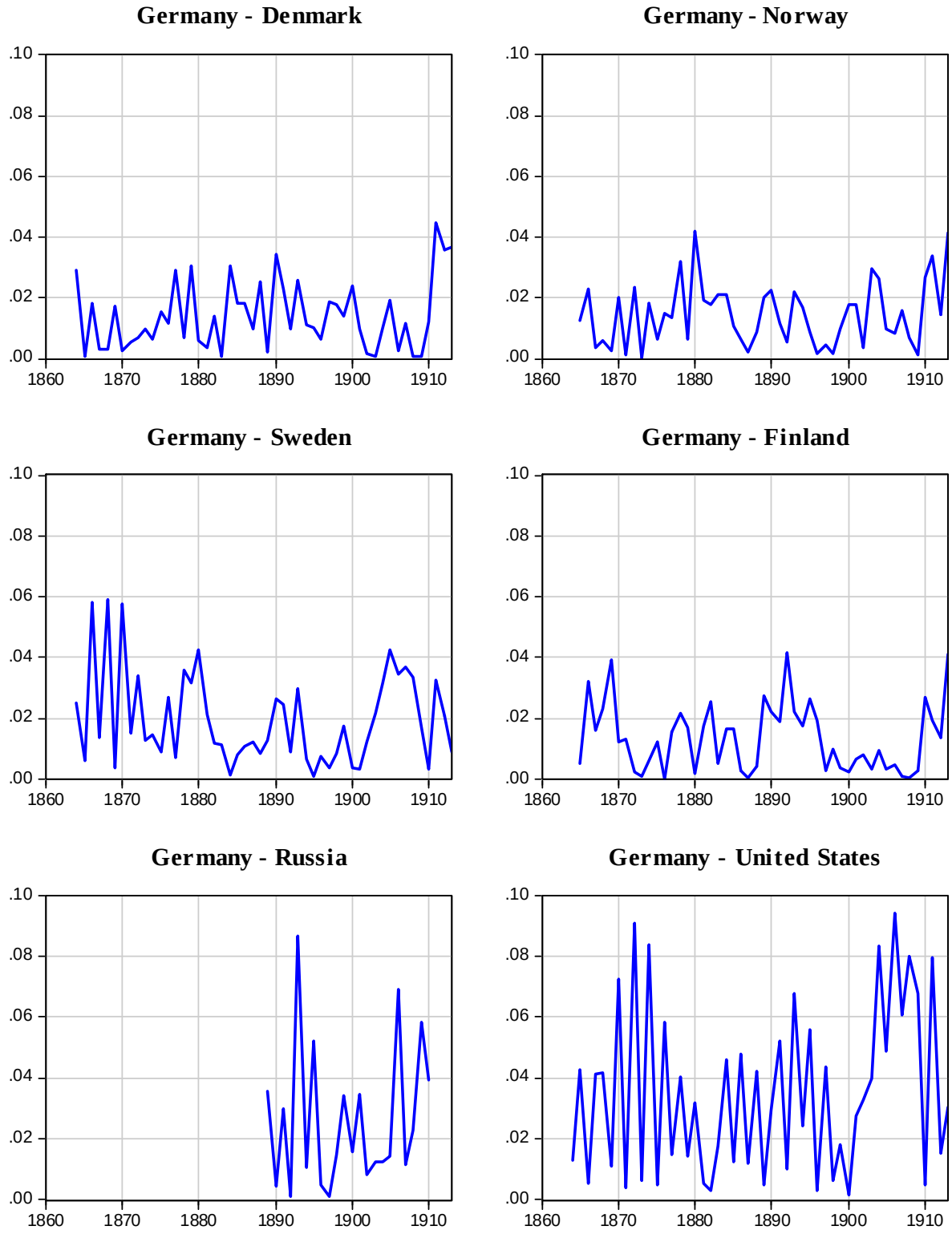

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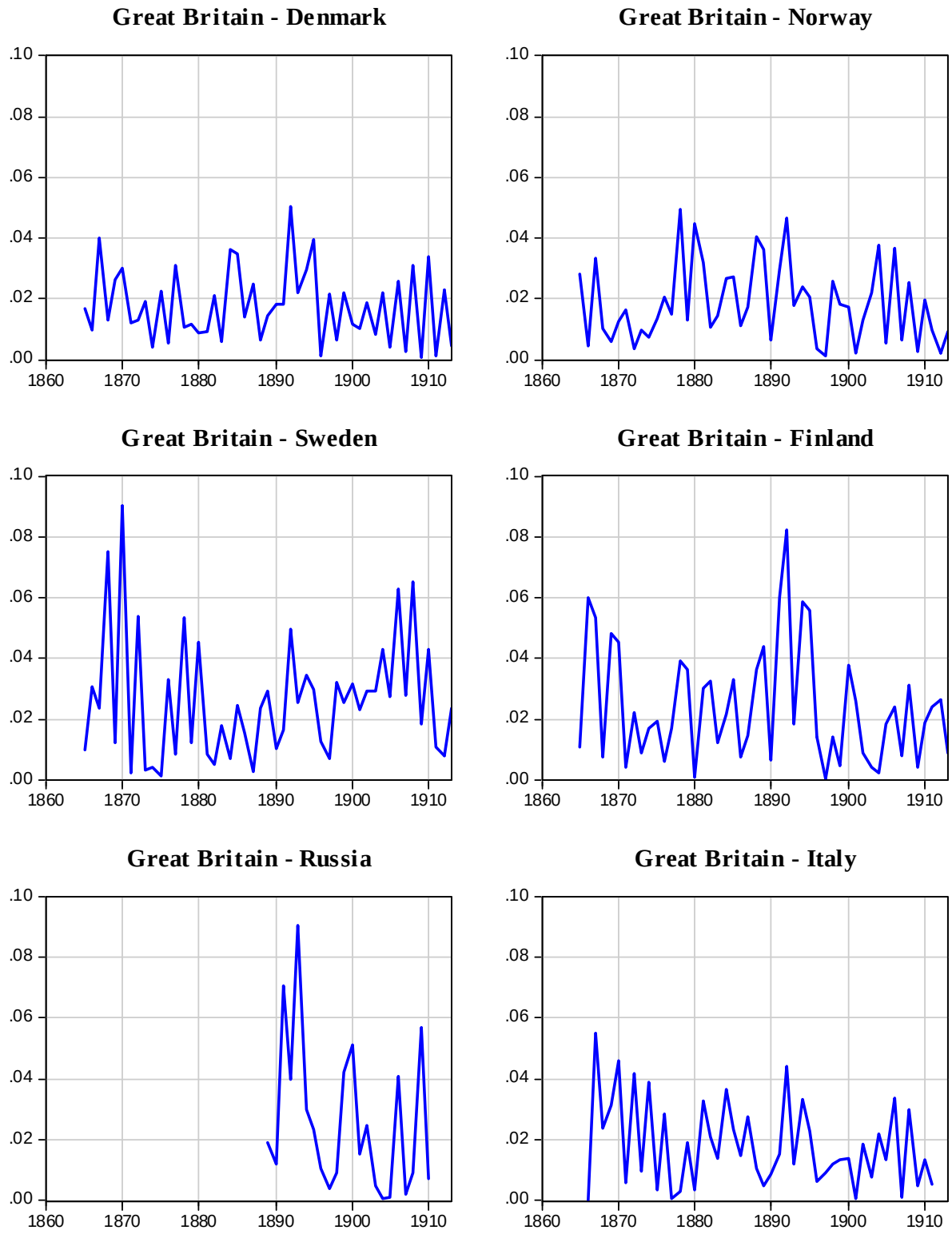
Figure 17. Absolute differences between British GDP growth rate and growth rates of Denmark, Norway, Sweden, Finland, Russia and Italy (filtered growth, cyclical component), 1860–1913



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Figures 16–17 graph the symmetry British and German indicators with the Scandinavian countries, Finland, Russia, Italy and the United States. The message of the Figures is clear with the background of what we learned in Section 5.2: the cycles are symmetric with Britain and Germany if the other country in the pair has low volatility in its GDP growth. This is the case with throughout the whole period under study with Denmark, Norway, The Netherlands and Italy.[50]

On the other hand, if the pair of comparison with Great Britain or Germany is Sweden, Finland, Russia, Portugal or Spain, the cycles are a-symmetric also in 1880s and 1890s.[51] Different cycle length combined with great volatility of growth, as in the cases of Finland and Sweden compared to Great Britain or Germany, results in strongly variable, wave-like development in, producing also a-symmetric periods in the 1880s and 1890s. Russian business cycles are always a-symmetric, whatever country is compared with it.[52]

6.4 Different cycle length or different volatility of cycles?

Finally I make an experiment with a symmetry indicator of all countries together. The purpose is to find out, what is the importance of cycle length (and thus, cycles being non-synchronized), and volatility of cycles separately. Do we get the same picture on the development of symmetry over the whole period if the volatility of cycles was same in all countries?

I computed the percentage of countries for each year in 1865–1913 in which the growth of production was below the trend, GDP^b_t, and the percentage of countries where the growth was above the trend, GDP^a_t. Then I computed the absolute value of the difference (S^V) of these two,

$$S^V = |GDP^b_t - GDP^a_t|,$$

which is an indicator of symmetry which sets the volatility of cycles equal for all the observations.
The group of countries is the same as in the rest of the study except the exclusion of United States. The U.S. GDP index grows too randomly to allow proper identification of peaks and troughs. Instead of using the business cycle chronology of NBER, I excluded United States from the sample.

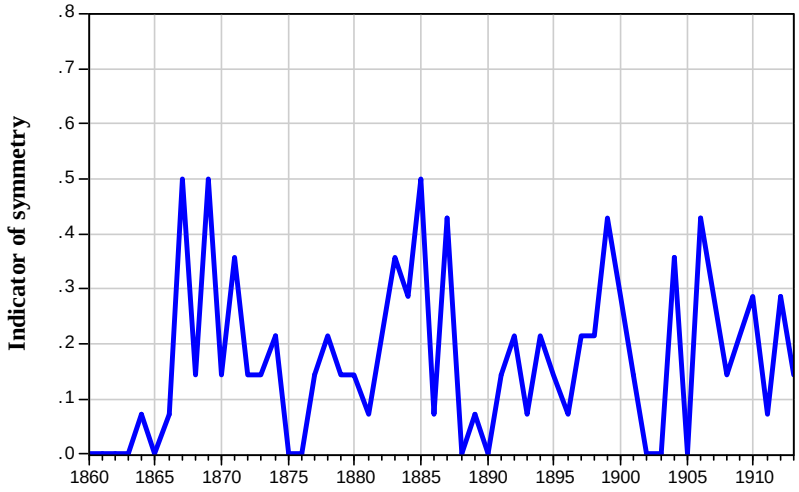
The values of the indicator are graphed in Figure 18. The higher the annual value, the greater is symmetry of business cycles in the group of 14 countries in that year. Value 1 would mean perfect symmetry and value 0 would mean total lack of symmetry. The development of the indicator is similar to those of the country-pair indicators only in the sense that it is volatile – the values vary strongly from one year to

[50] See Figures 16–17 and Appendix Figure 5.4.
[51] See Figures 16–17 and Appendix Figure 5.2.
[52] On symmetry of Russian cycles with peripheral countries, see Appendix Figure 5.3.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

the next. The indicator lacks totally the long term shape of graphs which one may observe in half of the cases of country-pair indicators: strong a-symmetry in the beginning and at the end of the period under study. I believe that the reason is elimination of the differences of volatility in GDP growth of the individual country data. The conclusion must be that the main result of this study, long term changes of symmetry are caused by changes in volatility of GDP growth, specifically changes in France, Sweden, Spain and Russia.

Figure 18. Combined indicator of symmetry for 14 countries: different length and same volatility of cycles in all countries



7. Summary

The paper developed indicators for measuring symmetry of business cycles using pre-First World War national accounts statistics. The focus of measurement was on temporal changes in symmetry. To produce time series, I abandoned the conventional approach of using correlations of two time series. Instead, I computed simple differences and absolute differences of filtered growth rates. I decomposed time series of GDP growth in three parts, the low frequency component called trend, the cyclical component, and the high frequency component, understood to be random.

For decomposing time series I employed band-pass filters and controlled the filtering with spectral analysis. This was not enough for producing properly filtered cycles. Three additional conditions were required:

- filtering should not alter the timing of cycles,
- the resulting cycle and random component have to be stationary processes,

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- the resulting stochastic trend has to be a unit-root process.

The results of applying the method on the 19th century national accounts of European countries are summarized here:

1) As a result of band-pass filtering, I suggest a business-cycle chronology for 15 countries. My chronologies of the British GDP growth and the German NNP growth are different to previously published chronologies.
2) The values of the indicators of symmetry of business cycles are very volatile. The differences in cyclical growth may vary from almost zero in one year to a very high value in the next year. This is in contrast to measuring symmetry of business cycles by using correlations, which gives an impression of a fairly monotonous development.
3) There are great changes in the average value and volatility of the indicator during the time under study. The mean and standard deviation were high before 1880 in all cases where France, Sweden, Spain or United States were one of the countries to be compared. The indicator shows increasing differences in filtered cycles (diminishing symmetry) after 1900. Great volatility of the indicator is connected with its high absolute value (little symmetry of business cycles).
4) There were great changes in the average length of business cycles between 1864 and 1913 in most of the studied fifteen countries. Different length of business cycles between the countries in comparison caused regular variation in the values of the symmetry indicator. Nevertheless, this does not explain the very strong a-symmetry before 1880 and after 1900. The reason for a-symmetry was strong volatility of GDP growth in the beginning and in the end of period studied.

The main difference between my study and the previous contributions, which use similar methods, is that here the results indicate continuous change in the average cycle length and inter-country symmetry of cycles.[53] Allowed by a more dynamic approach I put the question in a different way – I wanted to know if the monetary integration of the late 19th century increased symmetry, instead of asking whether the cycles were symmetric. According to theories of Optimum Currency Areas, business cycles have to be symmetric among members of a currency area, or at least they become symmetric after certain time countries join the currency area. My indicator suggests that this was not the case for the currency area called the classical gold standard. Nevertheless, the gold standard was there as a functioning monetary system. It did not collapse under the peace-time a-symmetries of business cycles, even when the a-symmetries became more severe after the year 1900.

This raises the question, how good are the theories of Optimum Currency Areas as descriptions of the functioning of these monetary systems. Or was the pre-First World War gold standard in difficulties al-

[53] The previous contributions are Backus and Kehoe (1992) and A'Hearn and Woitek (2001).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

ready before the outbreak of the war? Specifically, we need better understanding of the relationship between business cycles, their inter-country symmetry, and balance-of-payments problems.

Literature

A'Hearn, Brian and Woitek, Ulrich (2001): More international evidence on the historical properties of business cycles, *Journal of Monetary Economics*, 47 (2001) 321–346.

Baxter, M. and King, R. (1999): Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time-Series, *The Review of Economics and Statistics*, 81, 575593.

Backus, David; Kehoe, Patrick J. (1992): International Evidence on the Historical Properties of Business Cycles, *The American Economic Review*, September 1992, Vol. 82, no. 4.

Burns, Arthur F. and Mitchell, Wesley C. (1946): *Measuring Business Cycles*, National Bureau of Economic Research.

Capie, F.H. and Mills, T.C. (1991): *Money and Business Cycles in the U.S. and U.K., 1870–1913*, Manchester School (V. 59, Supplement).

Clapham, John (1945): *The Bank of England (1797 – 1914)*, Macmillan.

Craig, Lee A. and Fisher, Douglas (1997): *The Integration of the European Economy, 1850–1913*, Mcmillan Press ltd.

Federico, Giovanni (2000): Una stima del valore aggiunto dell'agricoltura italiana. In G.M. Rey (ed.), *I conti economici dell'Italia*, vol. 3.

Feinstein, C.H. (1972): National Income, Expenditure and Output in the United Kingdom, 1855–1965, Cambridge University Press.

Fenoaltea, Stefano (2003): Notes on the rate of industrial growth in Italy, 1861–1913, *Journal of Economic History* 63, pp. 695–735.

Friedman, M. and Schwartz A. J. (1982): *Monetary Trends in the United States and the United Kingdom, 1867–1975*, University of Chicago Press.

Hansen, Svend Aage (1972): *Økonomisk vækst i Danmark*, Bind I: 1720–1914, Akademisk forlag.

Hodne, Fritz (1975): An Economic History of Norway 1815–1970, Tapir trykk.

Hoffmann, W.G. and Müller, J. Heintz (1959): *Das deutsche Volkseinkommen 1851–1957*, Tübingen, J.C.B. Mohr.

Hoffmann, Walther G. (1965): Das Wachstum der Deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts, Berlin.

Huffman, Wallace E. and Lothian, James R. (1984): The Gold Standard and the Transmission of Business Cycles, 1833 – 1932, in Michael D. Bordo and Anna J. Schwartz (eds.): A Retrospective on the Classical Gold Standard, 1821 – 1931, University of Chicago Press.

DOI: 10.2870/38202

Juselius, Katarina (2006): The Cointegrated VAR Model: Methodology and Applications, Oxford University Press.

Krantz, Olle and Schön, Lennart (2007): *Swedish Historical National Accounts 1800-2000*, Lund studies in economic history 41, Almqvist & Wicksell International

Maddison, Angus (1995): Monitoring the World Economy 1820–1992, OECD.

Mitchell, Brian R. (1981): *European Historical Statistics 1750-1975*, second revised version, Macmillan.

Priestley, M.B. (1981): *Spectral Analysis and Time Series*, Academic Press Inc.

Rostow, W.W (1948): *The British Economy of the 19th Century*, Oxford University Press.

Schön, Lennart (2000): En modern svensk ekonomisk historia. Tillväxt och omvandling under två sekel, SNS Förlag.

Sutch, Richard (2006): Business Fluctuations and Cycles, in *Historical Statistics of the United States. Earliest Times to the Present*, Millennium Edition, Volume Three, Cambridge University Press.

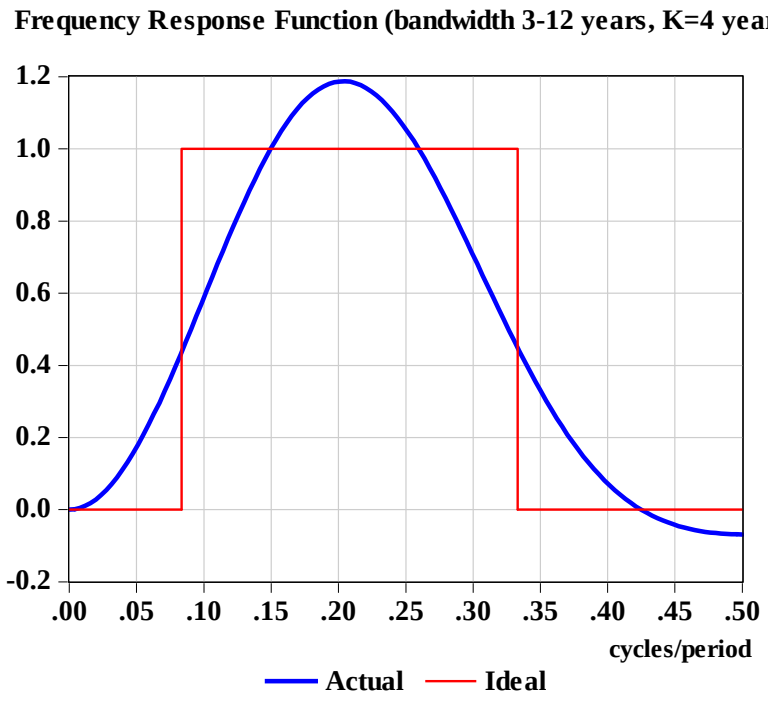
van Ark, Bart (1995): Towards European Historical National Accounts, *Scandinavian Economic History Review*, vol. XLIII, no: 1.

Zamagni, Vera and Battilani, Patrizia (2000): Stima del valore aggiunto dei servizi, in G.M. Rey (ed.) *I conti economici dell'Italia*, vol. 3.

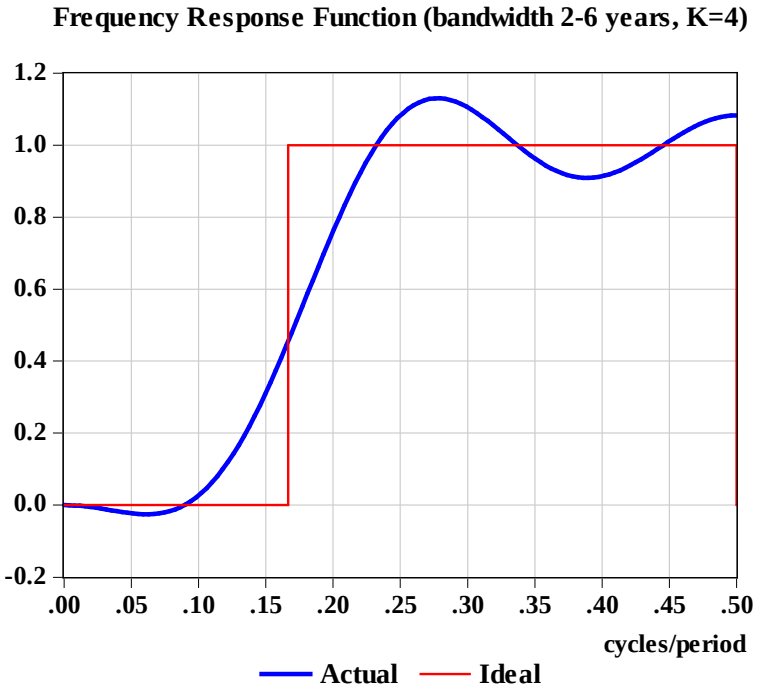
Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Appendix 1. Frequency response functions to estimate average cycle length

Appendix Figure 1.1. Great Britain 1860–1892



Appendix Figure 1.2. Great Britain 1892–1913



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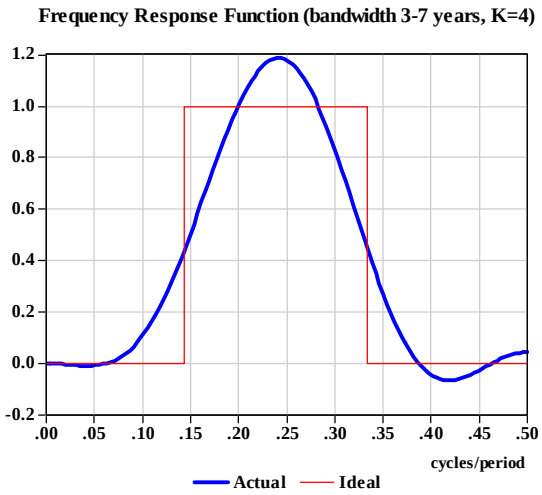
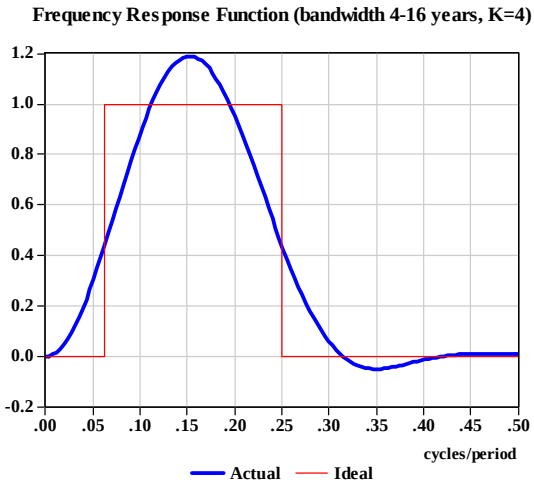
European University Institute
DOI: 10.2870/38202

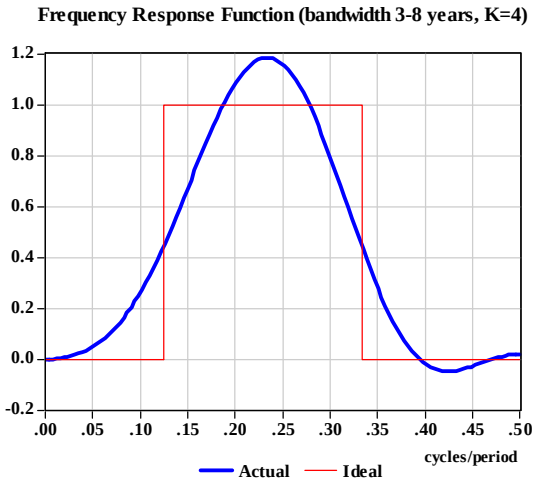
Appendix Figure 1.3. France 1860–1880



Appendix Figure 1.4. France 1880–1900



Appendix Figure 1.5. France 1900–1913



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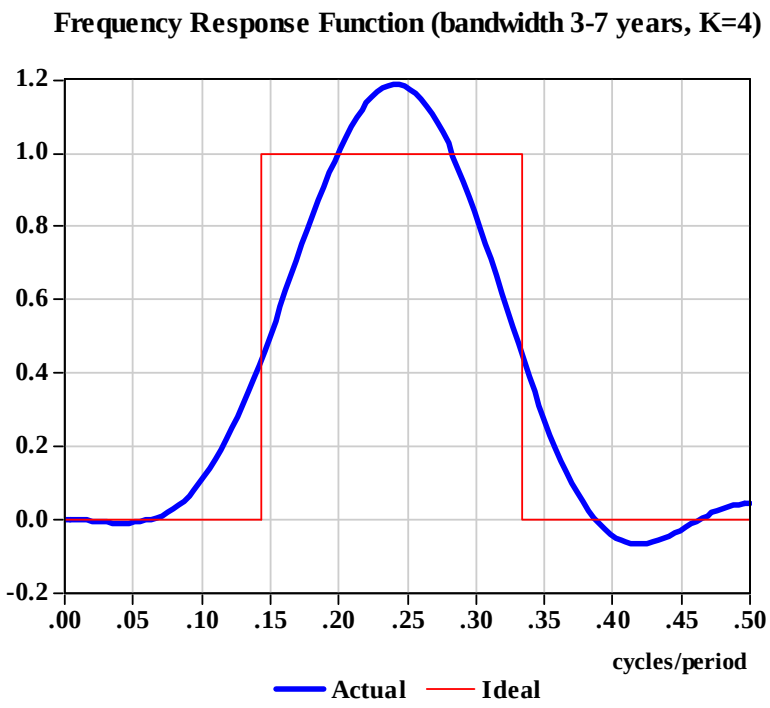
Appendix Figure 1.6. Germany 1860–1913



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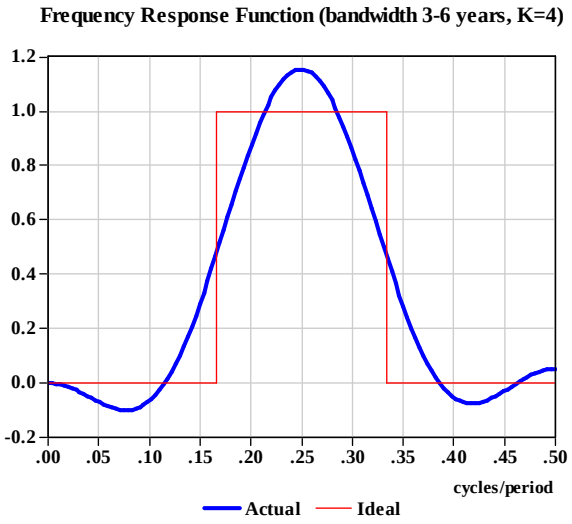
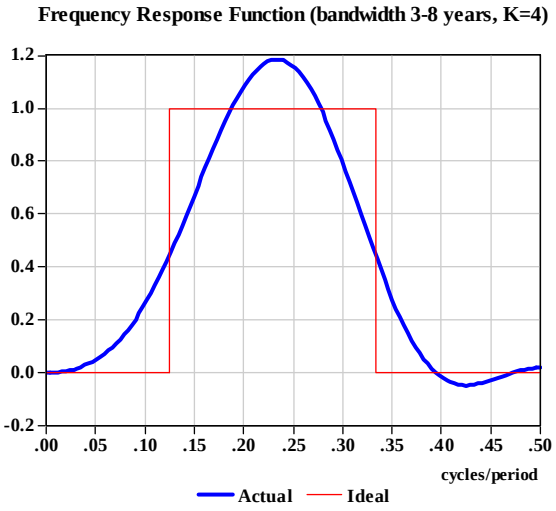
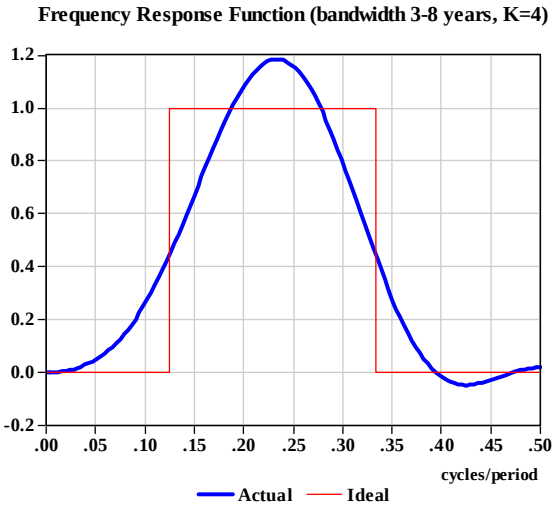
Appendix Figure 1.7. Sweden 1860–1880



Appendix Figure 1.8. Sweden 1880–1900



Appendix Figure 1.9. Sweden 1900–1913



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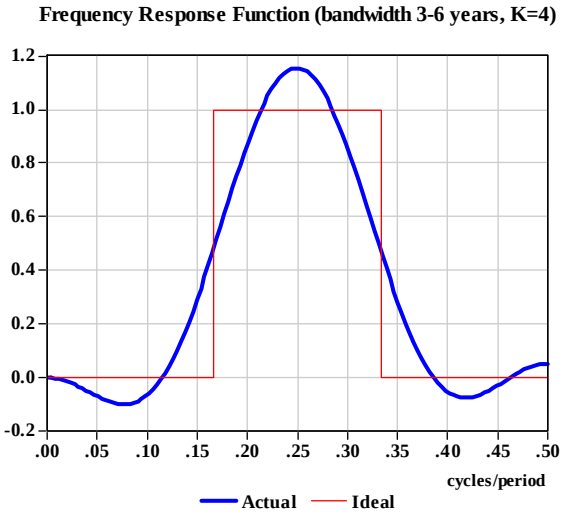
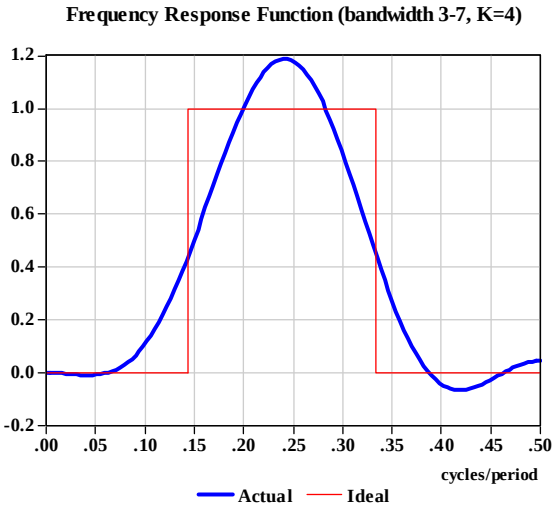
European University Institute
DOI: 10.2870/38202

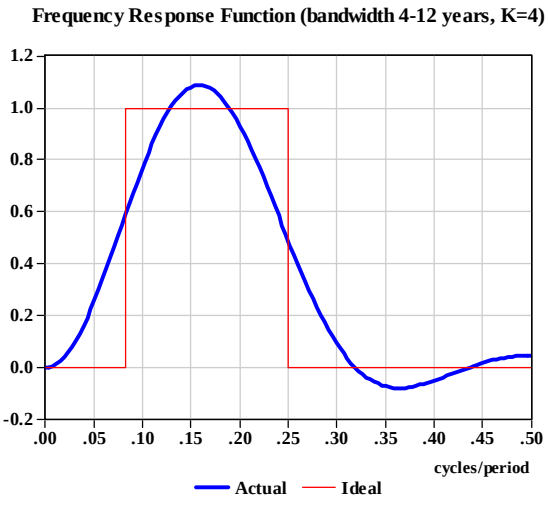
Appendix Figure 1.10. Italy 1860–1880



Appendix Figure 1.11. Italy 1880–1900



Appendix Figure 1.12. Italy 1900–1913



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European University Institute
DOI: 10.2870/38202

Appendix 2. Stationarity of filtered growth rates over short periods

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European University Institute DOI: 10.2870/38202

Appendix Table 2.1. Unit root tests in short periods: existence of unit root

Country	Type of variation	1864–1880	1880–1900	1900–1913	1864–1913
Great Britain	Cycle Trend	No Yes		No Yes	No Yes
France	Cycle Trend	No Yes	Yes* Yes*	No Yes	No Yes
Germany	Cycle Trend	No Yes			
The Netherlands	Cycle Trend	Yes* Yes	Yes* Yes*	No Yes	No Yes
Sweden	Cycle Trend	No[54] Yes[1]	Yes[55] Yes[2]	No[56] Yes[3]	No Yes
Denmark	Cycle Trend	No Yes			
Finland	Cycle Trend	No Yes			
Norway	Cycle Trend	Yes[57] Yes[4]	No[58] Yes[5]		No Yes
Italy	Cycle Trend	No Yes	Yes* Yes*	No Yes	No Yes
Spain	Cycle Trend	No Yes	No Yes		No Yes
Portugal	Cycle Trend	No[59] Yes[6]	No[60] Yes[7]		No Yes
Russia	Cycle Trend		Yes* Yes		
Australia	Cycle Trend	No Yes			
Canada	Cycle Trend	No[61] Yes[8]			
United States	Cycle Trend	No Yes*			

No = reject null hypothesis of unit root at 1 per cent significance level
Yes = fail to reject null hypothesis of unit root at 1 per cent significance level
Yes* = fail to reject null hypothesis of unit root at 1 per cent significance level but reject the null hypothesis at 5 per cent level

[54] The period is 1864–1883.
[55] 1883–1901.
[56] 1901–1913.
[57] 1865–1883.
[58] 1883–1913.
[59] 1864–1882.
[60] 1882–1913.
[61] 1875–1913.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
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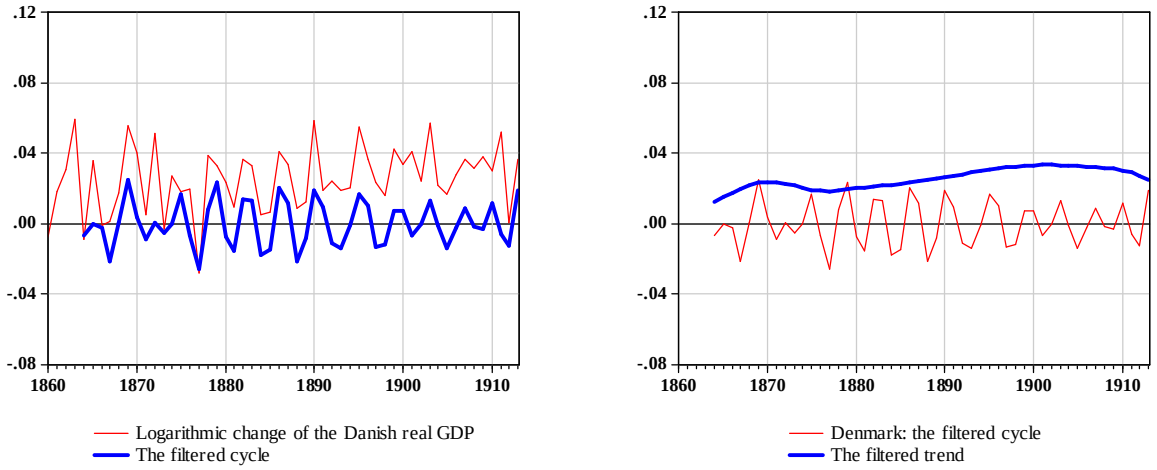
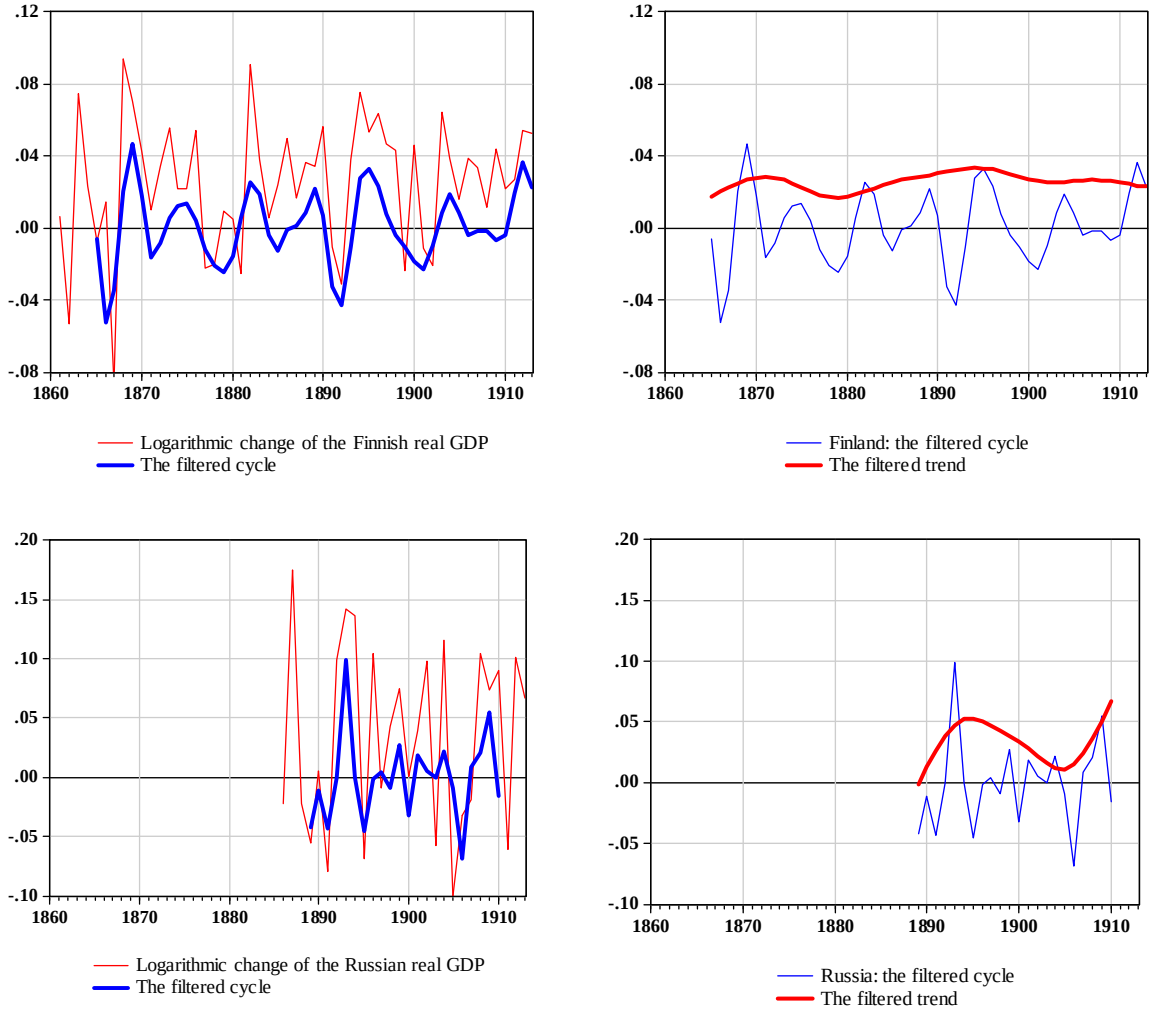
Appendix 3. Business cycles and trends

Appendix Figure 3.1. Business cycles and trend in Denmark



Appendix Figure 3.2. Business cycles and trends in Finland and Russia



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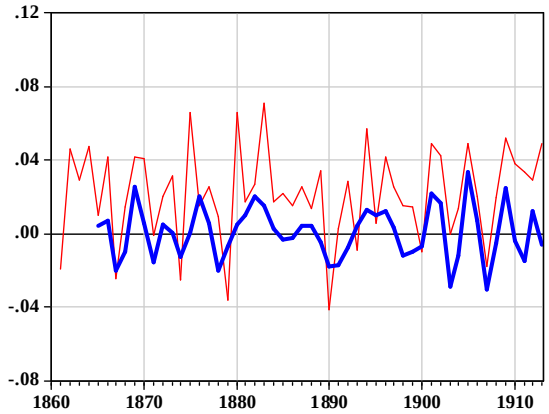
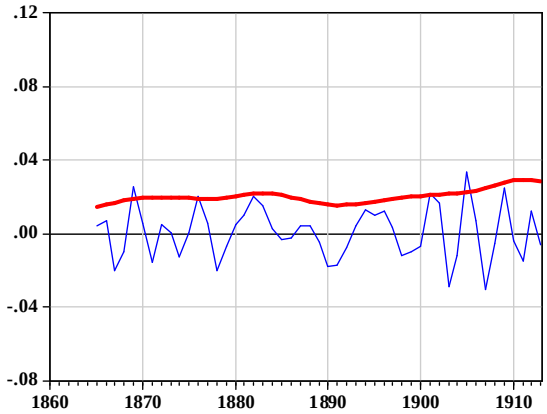
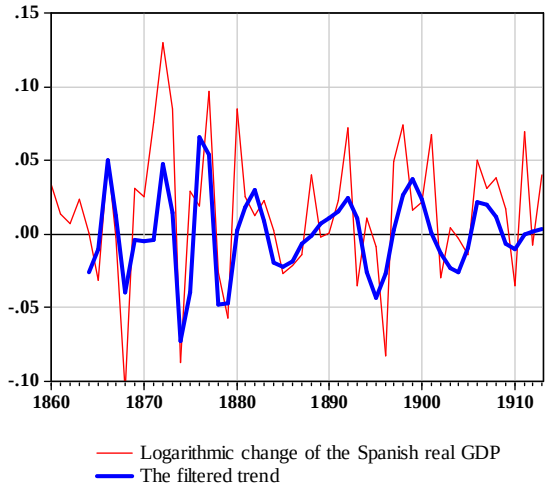
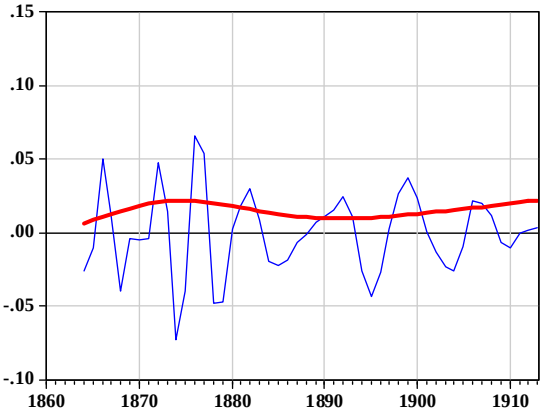
DOI: 10.2870/38202

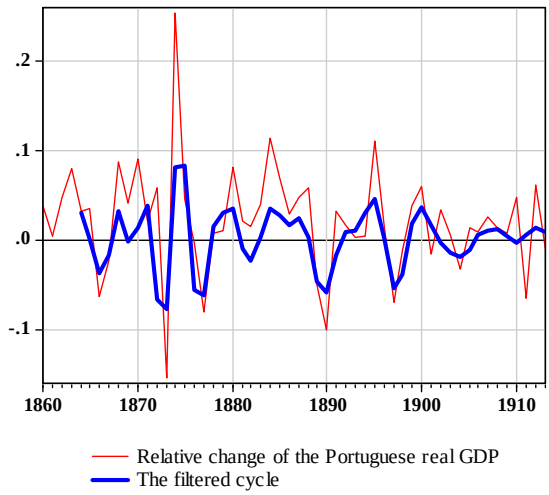
Appendix Figure 3.3. Business cycles and trends in Netherlands, Spain and Portugal

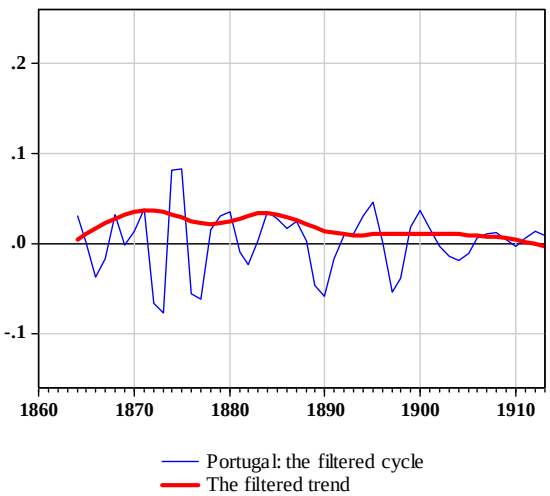












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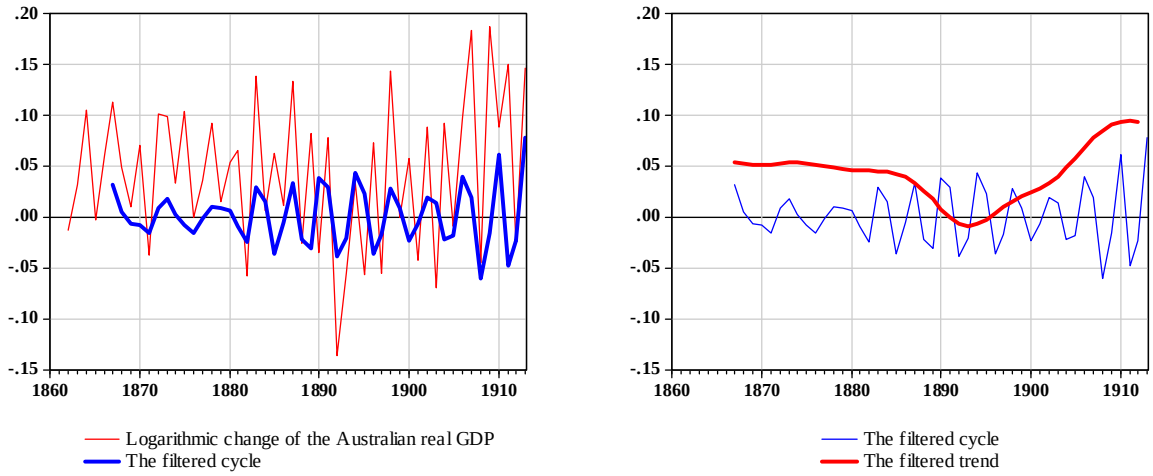
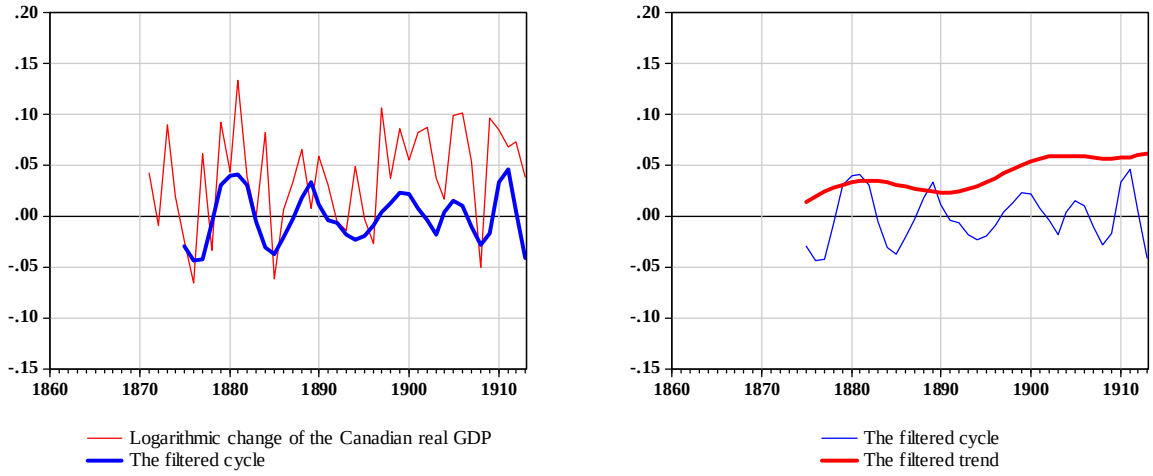
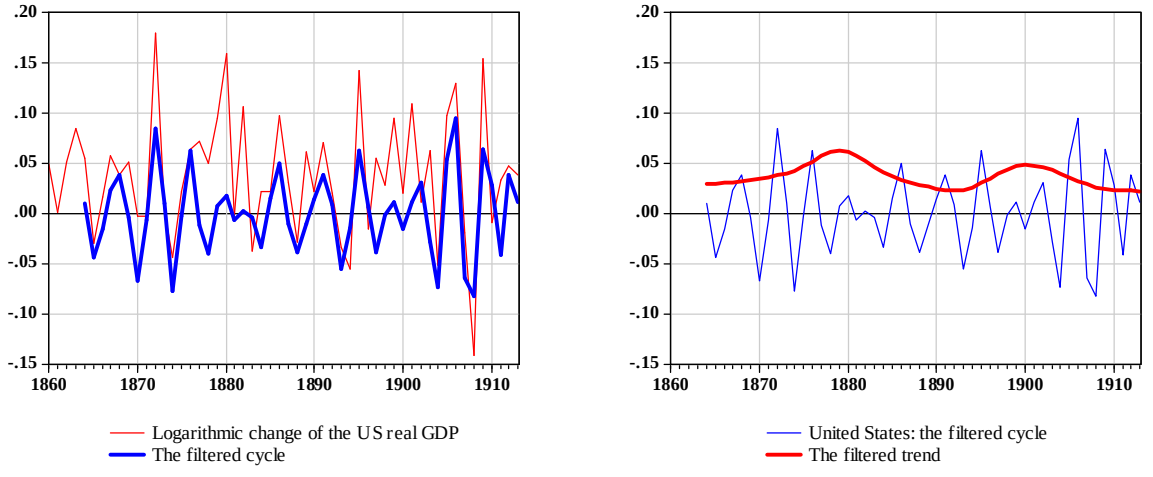
European University Institute
DOI: 10.2870/38202

Appendix Figure 3.4. Business cycles and trends in Australia, Canada and the United States







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Appendix 4. Standard deviation of time series

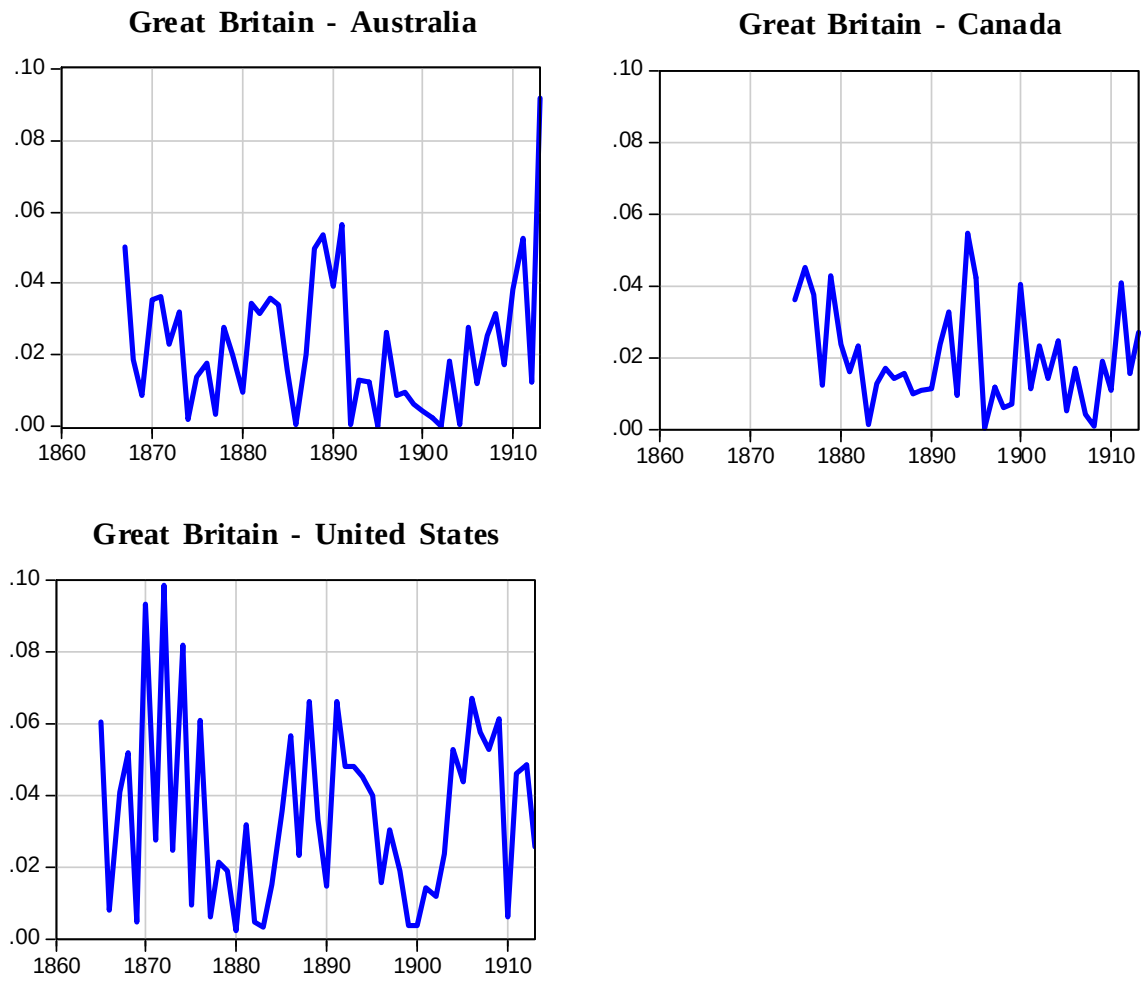
Appendix table 3.1. Standard deviation of filtered cycles and the original time series of GDP (in parenthesis) of 15 countries

	Assumptions of wave length	1864–1880	1880–1900	1900–1913
Great Britain		0.012 (0.018)	0.018 (0.024)	0.017 (0.022)
France		0.034 (0.071)	0.019 (0.027)	0.033 (0.041)
Germany	a) Long	0.01 (0.021)	0.01 (0.02)	0.017 (0.015)
	b) Short	0.015	0.011	0.021
The Netherlands		0.013 (0.03)	0.011 (0.026)	0.019 (0.023)
Sweden		0.031 (0.05)	0.015 (0.032)	0.025 (0.034)
Denmark		0.013 (0.023)	0.014 (0.015)	0.01 (0.014)
Finland		0.024 (0.043)	0.02 (0.033)	0.017 (0.024)
Norway		0.015 (0.028)	0.01 (0.015)	0.011 (0.018)
Italy		0.022 (0.025)	0.011 (0.014)	0.008 (0.007)
Spain		0.04 (0.059)	0.022 (0.039)	0.016 (0.034)
Portugal		0.05 (0.079)	0.031 (0.054)	0.014 (0.035)
Russia			0.04 (0.082)	0.032 (0.073)
Australia		0.013 (0.046)	0.028 (0.075)	0.04 (0.088)
Canada		0.037 (0.054)	0.023 (0.047)	0.024 (0.041)
United States		0.042 (0.055)	0.029 (0.059)	0.054 (0.077)

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Appendix 5. Symmetry indicators for some countries

Appendix Figure 5.1. Absolute differences between British GDP growth rate and growth rates of Australia, Canada and the United States (filtered growth, cyclical component), 1865–1913



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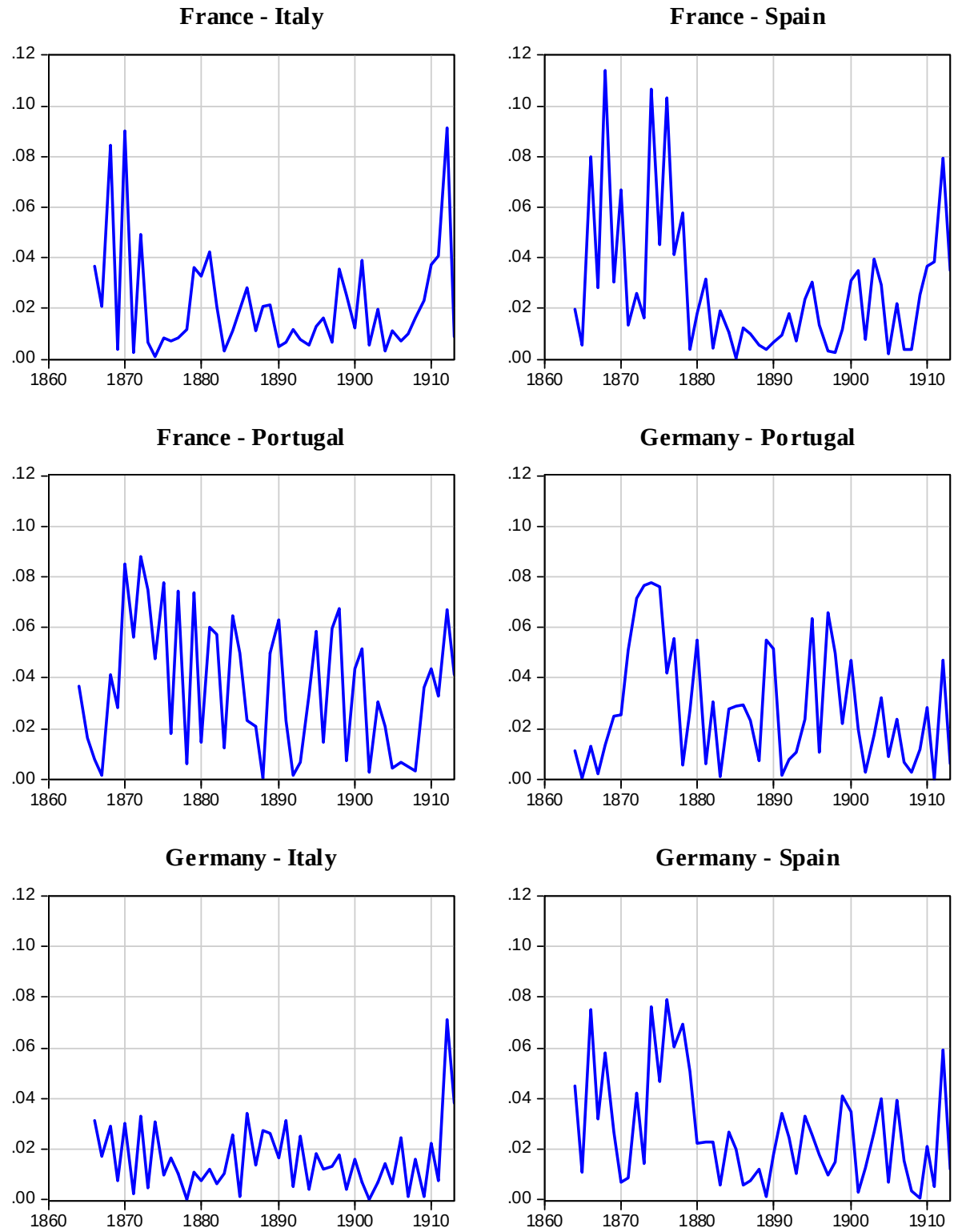
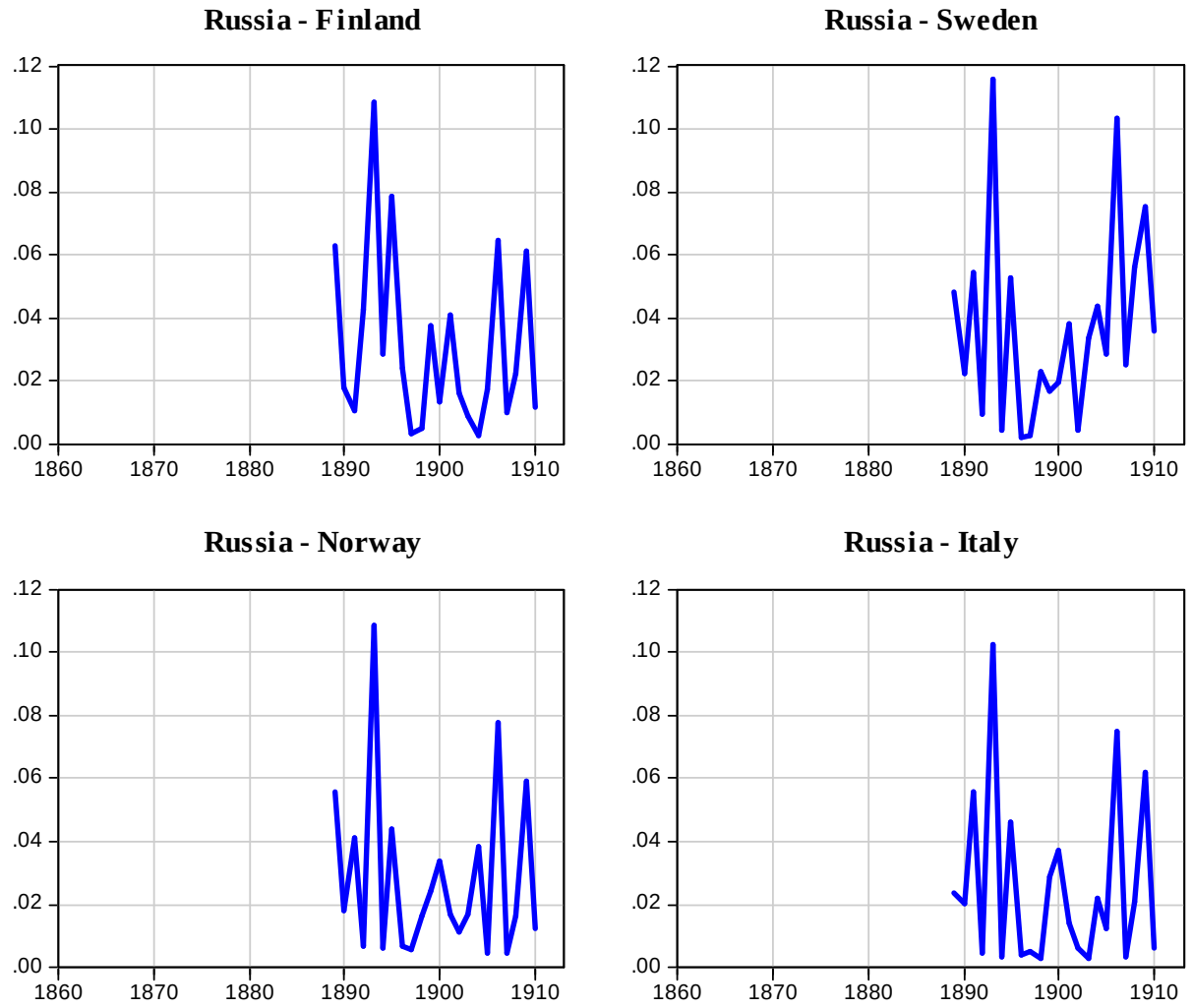
European University Institute
DOI: 10.2870/38202

Appendix Figure 5.2. Absolute differences between the French GDP growth rate and German NNP growth rate against growth rates of Italy, Spain and Portugal (filtered growth, cyclical component), 1865–1913



Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Appendix Figure 5.3. Absolute differences between the Russian GDP growth rate and growth rates of Finland, Sweden, Norway and Italy (filtered growth, cyclical component), 1889–1910



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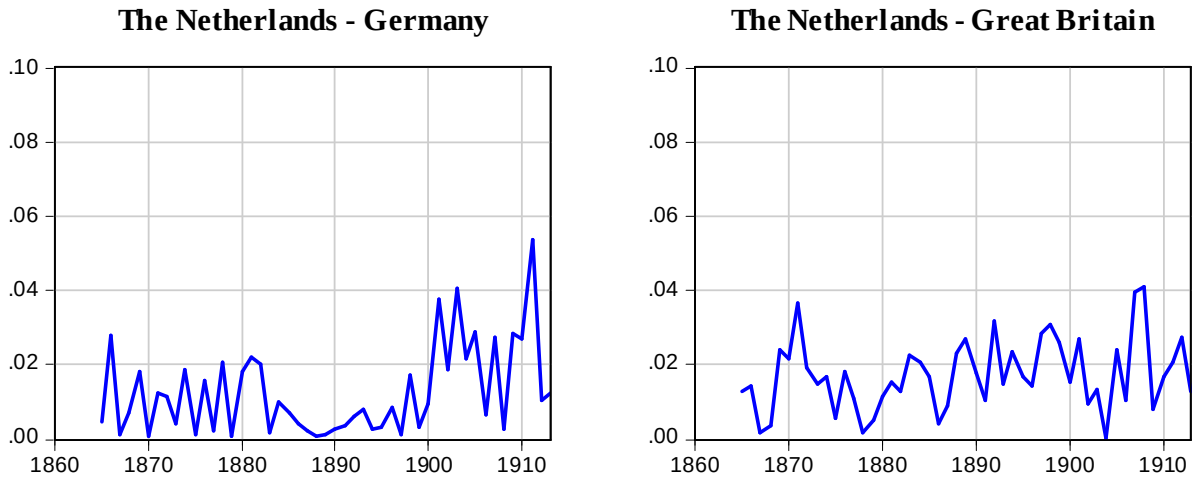
European University Institute
DOI: 10.2870/38202

Appendix Figure 5.4. Absolute differences between the Dutch GDP growth rate and growth rates of Germany and Great Britain (filtered growth, cyclical component), 1865–1913



The second essay of the thesis

International capital mobility, money supply and inter-country symmetry of business cycles in 1865 – 1913[62]

Abstract

This paper studies the impact of international capital transfers on inter-country symmetry of business cycles in the second half of the 19th century. Money stocks of the gold standard economies are shown to have been driven by other factors than the gold reserves of their central banks. The possible alternative sources of money creation are domestic banking sector, and gold and currency 'shipments' induced by international capital movements. Whatever was the source of money supply, it was connected with both domestic investments and capital exports in those countries which could export capital. New money tended to be directed to foreign investments rather than domestic ones. As investments had a crucial impact on economic growth, international differences in growth of money supply, and differences in growth rates of investments and net capital exports determined international differences in cyclical growth rates.

[62] Financial support from the ESF (GlobalEuroNet) is gratefully acknowledged.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
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1. Introduction

There were large international capital transfers in the second half of the 19th century which were caused by over-supply of resources in the industrialized core of the world and excess demand for capital in developing countries. Another thing which one may observe in that period is clear cyclical variation in the capital transfers. Nevertheless, it is not at all clear how the large scale movements of capital affected cyclical variation of economic growth in the capital exporting and importing countries. How did international capital mobility contribute to the inter-country symmetry of business cycles? My paper studies these issues using 19th century national accounts and balance of payments data of major European economies and their offshoots in North America and Australia. The ultimate purpose is to raise the question, how does capital mobility affect formation of credible currency areas?

The first generation of studies on co-movement of cycles of economic growth, appearing in the 1950s, is literature about inverse movement of building cycles and migration in the Atlantic economy of the late 19th century, later to be called the inverse business cycles.[63] The focus in these studies is in very long term movements (instead of short term fluctuations, called business cycles, and their co-movement, called symmetry of business cycles). A much more recent contribution in this literature is by Stefano Fenoaltea on the Italian economy before the First World War. Fenoaltea denies the traditional Kuznets cycle story concerning the Italian case, that the cause of movements in capital flows was migration. Instead, according to Fenoaltea, the Italian experience suggests that changes in perceived risk altered the relative supply of capital from Britain, Germany and France. Thus, there is a suggestion in Fenoaltea that monetary effects played a role in shaping the cycles. I apply the idea on short term business cycles by claiming that money was not neutral. In addition to that I suggest an entirely new idea in the economic history literature – business cycles and their international co-movements were about money creation and money destruction by the private banking sector.

The notion of private banking sector's role in non-neutrality of money, and endogeneity of its creation, is not entirely new, but also not at all widely accepted in economics literature. The endogeneity of the volume of credit in the private banking sector is recognized in Stiglitz and Weiss (1981) and in Kaldor (1982). Chick (1986) describes the historical development of the banking sector in seven stages with varying propensities to produce endogeneity in money supply. Ac-

[63] See Abramowitz (1961 and 1968), Williamson (1964), Kuznets (1961) and Harley (1980).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

cording to her, until the 1930s private banks in financially advanced countries were able to change the bank multiplier. All of this work is, nevertheless, mostly theoretical. My contribution is to study both money-neutrality and endogeneity of its creation using statistical evidence on money supply, and modern econometric techniques. Applying these techniques, I also take up the untreated issue of causality of supply of money and demand for it.

My starting point of analysis are the theories of Optimum Currency Areas (OCA), a set of models to explain what kind of countries should join a currency area and what is required for these countries to stay in the area. The common feature of studies applying this approach is interest in employment and balance-of-payments adjustment. According to OCA theories a currency area is optimal if three objectives are sustained: full employment (of capital and labour), stable price level, and a balanced external account.[64]

An important characteristic in discussions within the OCA approach about capacity employment and external balance is that countries in a currency area should have symmetric business cycles. Considering modern, post-Second World War economies, symmetry is needed for members of a currency area to be able to perform monetary policy together for smoothing business cycles. When the OCA theory is applied for studying late 19th century currency areas like the Classical Gold Standard, the emphasis must be in the relation between the symmetry of business cycles and the costs of balance-of-payments adjustment – since using monetary policy to smooth business cycles was not an issue for the *laissez-faire* economies of the 19th century. The primary objective for economic policy makers in the gold standard countries was to maintain gold adherence. The necessary condition for that in the long run was balanced current account, which was easier to achieve if business cycles were symmetric between members of the gold standard, or so the theory says.

The weakness of OCA theories for my purposes is, nevertheless, that they are mainly concerned with trade in goods and services as the means of transmitting disturbances from one country to the other.[65] Another approach, related to the topic, is concerned with capital mobility and balance of payments. Import of capital is seen merely as a useful way to escape the constraint of current account balance, and the resulting difficulty to maintain stable value of currency.[66] Still another

[64] See McKinnon (1963) and Kennen (1969).
[65] A good description of Optimum Currency Area theory is in Jeffrey Frankel's and Andrew Rose's articles (1997 and 1998).
[66] Bordo and Flandreau (2003) applies this approach.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

approach on international capital mobility is to study it as a potential source of instability, and as a source of occasional currency crises.[67]

In my paper, I will take one step further in dealing with the large scale international capital transfers of the 19th century. In addition to conventional approaches, considering capital imports as an escape from the current account constraint or as a source of occasional currency crises, I will study the possibility that capital mobility caused asymmetric cycles as a rule in some circumstances, and symmetric cycles in some other circumstances. According to Optimum Currency Area theories the latter alternative would enable formation of credible currency areas.

The paper introduces a simple and intuitive indicator for symmetry of business cycles, which are calculated for pairs of countries. The pairs are composed in the following way:

- matching Great Britain, France and Germany with each others (three pairs), and
- matching Great Britain, France and Germany with the peripheral countries which borrowed money from them. (15 pairs)

The indicator shows increasing symmetry of GDP growth among the European members of the gold standard until the end of 1890s and then decreasing symmetry until the outbreak of the First World War. The indicator also illustrates considerable variation in the synchronisation of cycles, the variation being greater in the periods of low symmetry.

How could international capital mobility affect symmetry of business cycles? Given that domestic investments and capital exports are alternatives, and given the strong influence of the former on GDP growth of the investing country, one may expect that changes in patterns of capital exports might have led to changes in the symmetry of cycles. Tentative results, using data of 11 European countries and their non-European offshoots, indicate indeed, that changes in "symmetry of investment" (between capital importers and exporters) had a mild impact on symmetry of GDP growth. In addition, periods of intensive capital export were not synchronized among the core countries Britain, France and Germany, suggesting that this could have contributed to the above-mentioned changes in symmetry of business cycles.

[67] Bordo, Cavallo and Meissner (2007) find evidence that the likelihood of experiencing a currency crisis in the period 1880–1913 was influenced by the level of hard currency debt to total debt and large current account deficits associated with reliance on foreign capital.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

The paper also raises the question, how did changing money supply affect domestic investments and capital exports. Was the excess money used for domestic investment or for exporting capital, or from which did resources disappear faster when money supply diminished?

2. Symmetry of business cycles in Europe in 1865–1913

To study symmetry of business cycles we need an indicator to measure it. The indicator which is normally used for this purpose is correlation of annual changes of GDP between two countries during a fairly long period of time, say 20 or 30 years. This kind of methodology doesn't give us proper information of the dynamics of symmetry. A way to solve this problem, and produce a time series for measuring symmetry, is to apply a kind of 'moving correlation': the indicator is the correlation of annual changes of GDP between two countries in a time span of *n* years. That time span runs through a longer period starting from year t_1 and ending in year t_p, and thus we get a new time series which starts from $t_{1+n/2}$ and ends in $t_{p-n/2}$.[68] The drawback of this method is that it attenuates the variation of symmetry.

Next I will present shortly an indicator which measures symmetry of business cycles in a way that *annual changes* are brought out in a relatively long period: the 54 years between 1860 and 1913. The method is applied on GDP series of a group of European countries. By the term symmetry of business cycles I mean that, at first, booms and depressions of two countries or a group of countries are synchronized, and second, fluctuations of the growth rates of these countries are equally volatile. To be perfectly symmetric, growth fluctuations of two countries have to be both synchronized and of same size.

2.1 Regular cycle, random shocks and band pass-filtering

A simple indicator of the symmetry of business cycles is the difference of the growth rates of two countries. It is easy to understand and easy to calculate. The difference has all the properties of a "stylized fact." The drawback of this indicator is that the volatility of the difference is great. Volatility is caused by random shocks, which happen at different times in different countries. This fluctuation cannot be explained by business cycle theory.

[68] Flandreau and Maurel (2005) employ this method.

DOI: 10.2870/38202

The business cycle means fluctuation in the level of economic activity, which forms a regular pattern. I isolate the cycle from the time series in a way that specifies an important statistical property of the cycle – its length. Doing it this way, I can avoid the ad hoc method of choosing any, unspecified moving average to find the cycle.[69]

Cycles in economic time series do not have exactly equal length. One cycle may be seven years long, the next may be eight years, the third six and half years. Thus, in practice the cycles have to be defined to occur within a band of length. The low frequency variation, or "long cycles", outside of this band is defined as the trend of the time series, and the high frequency variation is defined as irregular fluctuation. Both low and high frequency variation need to be extracted from the cycle. The formal method of extracting is called filtering. When the wanted cycle length is designed to vary inside a band, the moving average to extract the wanted time series is called a band-pass filter.

2.2 Difference and absolute difference of filtered cycles: 18 country pairs[70]

A simple way to measure symmetry is to compare the cyclical component of two countries. The difference of growth gives a good picture of annual development of symmetry: the larger is the absolute difference, the smaller the symmetry. Here we have two possibilities: to use difference *d* or absolute difference $\delta = |d|$. Difference *d* is more practical for statistical modelling since the time series composed of it is always stationary. Absolute difference δ is visually more illustrative than difference *d*, as shown in Figure 1: symmetry of business cycles between Great Britain, France and Germany. The rest of the figures depicting symmetry of cycles are in Appendix 2: those between Britain and three countries which imported capital from it; symmetry between France and six countries which imported capital from it; and symmetry between Germany and six countries which imported capital from it.

Figure 1 presents the 'stylized facts' to be explained in this paper: the clearly visible increase of symmetry of cycles (decrease of the mean of difference of growth rates) between France and

[69] In their seminal paper (1999) on approximate band-pass filters Marianne Baxter and Robert King require the researcher to begin business cycle measurement by specifying characteristics of the cyclical components.

[70] See Lessig, *Measuring the inter-country symmetry of late 19th century business cycles* for more countries and about calculating the symmetry indicators.

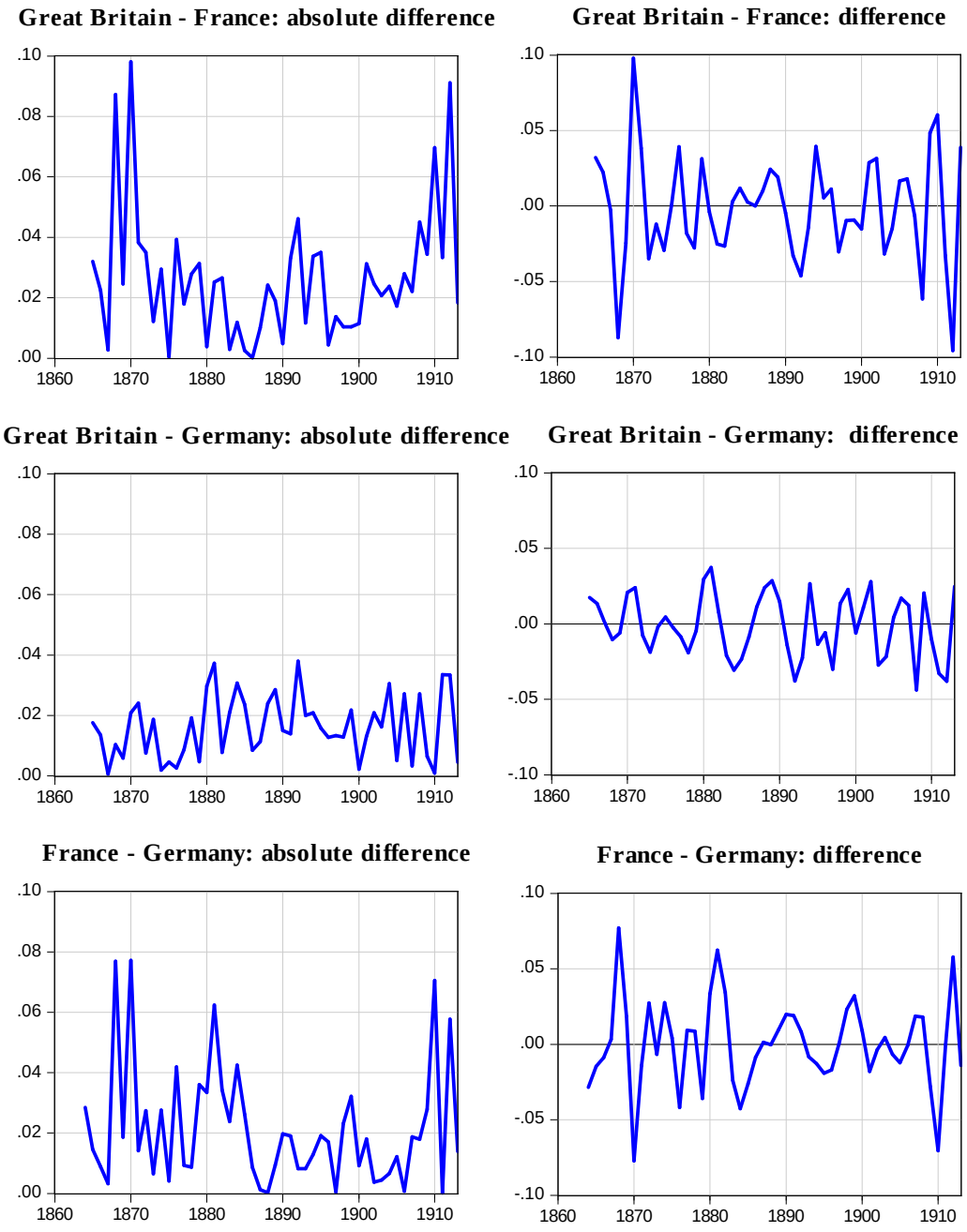
Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Great Britain, and France and Germany from 1860s to 1890s, and decrease of symmetry (increase of the mean of difference) after 1900. Similar development is visible also in the symmetry between French and German cycles, on the one hand, and the cycles of the countries which borrowed capital from them, on the other hand (see Appendix 2). British and German business cycles were, on the other hand, relatively symmetric all the time.

Another notable feature of the indicator is its strong annual volatility. The difference of filtered growth between countries in comparison may vary from almost zero in one year to a very high value in the next year. This is in contrast to measuring symmetry of business cycles by using correlations, which gives an impression of a fairly monotonous development. Other interesting features, illustrated by the indicator, are the changes in the variance and mean of the indicator.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Figure 1. Differences and absolute differences of the British, French and German cycles, 1865–1913



Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

3. A simple model of domestic investments, capital exports and money supply

My basic question is how to explain the changes in inter-country symmetry of business cycles. Instead of the traditional Optimum Currency Area approach, I look at the international distribution of investments, possibly influenced by changes of money stocks in capital exporting countries.

Investments in an open economy, under free capital mobility may be allocated to domestic production, or they may go abroad. Logically, the alternatives should have an impact on the GDP growth rates of both capital exporters and capital importers. The economies of the late 19th century were open, and capital was allowed to move freely across national borders. Thus, investors were capable of increasing or diminish their investments both at home and abroad, and, as I will prove later, these choices were often connected to changes in the domestic money stock.

Figure 2. Allocation of investments: to domestic or foreign projects

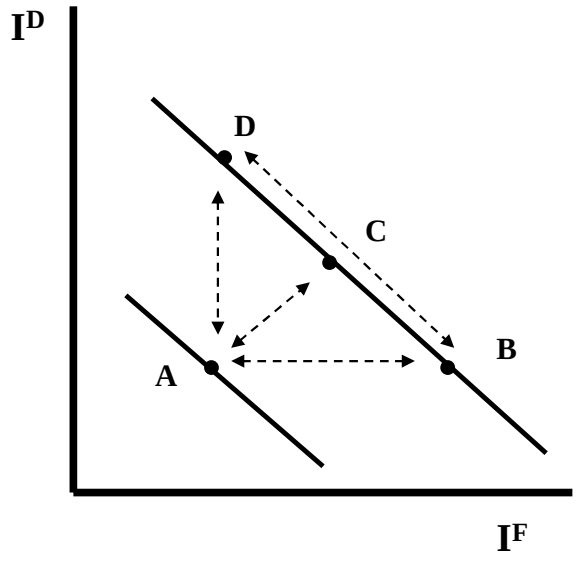


Figure 2 illustrates the setting. In the vertical axis we have domestic investments I^D and in the horizontal axis there are foreign investments I^F of a potentially capital exporting country. The relation between I^D and I^F must be negative. At given money supply, investors have the option of investing a lot at home and little abroad, or vice versa: in the Figure the shifts of allocation take place e.g. between points D, C and B. Change of money supply moves the schedule of domestic–

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

foreign investments from (or to) the origo of the Figure. Monetary expansion (or contraction) may increase (or decrease) domestic and foreign investments in the same amount (shifts between A and C) or investments may be directed predominantly to domestic projects (shifts between A and D) or they may go mainly abroad (shifts between A and B). The first alternative contributes to similar expansions and contractions of GDP growth in the capital exporting core and the capital importing periphery, and thus, to symmetry of business cycles, *ceteris paribus*. The last two alternatives mean that international capital mobility contributes to a-symmetry of business cycles.

Thus, we have a model of two equations to depict the relationship between investments, current account and money supply.

$$\Delta\left(\frac{INV_i}{GDP_i}\right) = F\left(\Delta\left(\frac{CA_i}{GDP_i}\right), \Delta\left(\frac{MS_i}{GDP_i}\right)\right), \quad (1)$$

$$\Delta\left(\frac{CA_i}{GDP_i}\right) = F\left(\Delta\left(\frac{INV_i}{GDP_i}\right), \Delta\left(\frac{MS_i}{GDP_i}\right)\right) \quad (2)$$

where INV_i is investments, CA_i is current account (approximating capital exports) and MS_i is money supply.

4. Money supply

The change of growth of the real money stock is an important part of my story of allocation choices. I claimed about investments in the discussion above that *monetary expansion (or contraction) may increase (or decrease) domestic and foreign investments.* The next question is, what causes the monetary expansion?

There are three conflicting stories in the literature about 19th century money supply:

(1) The real money stock was determined by the gold stock. The gold stock was changed by inflows and outflows of bullion between countries, the direction of flow depending on relative price levels in them. Money supply was determined outside of the financial sector, in other words it was *exogenous.*

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

(2) Another view is that central banks were able and willing to influence the size of the money stock by sterilizing the impact of gold (and currency) flows on the money stock. This was done by changing the central bank's gold holdings and its domestic assets. However, the level of the bank's domestic assets depended on its gold reserves, because the authority generated demand liabilities (notes and deposits) by increasing its assets, and convertibility of these liabilities must have been supported by a gold reserve, if the gold standard was to be maintained. Therefore, according to this view, the gold stock provided a constraint on the level (or growth) of money supply. Money supply was still *exogenous*, determined by the central bank and ultimately by its gold reserve.

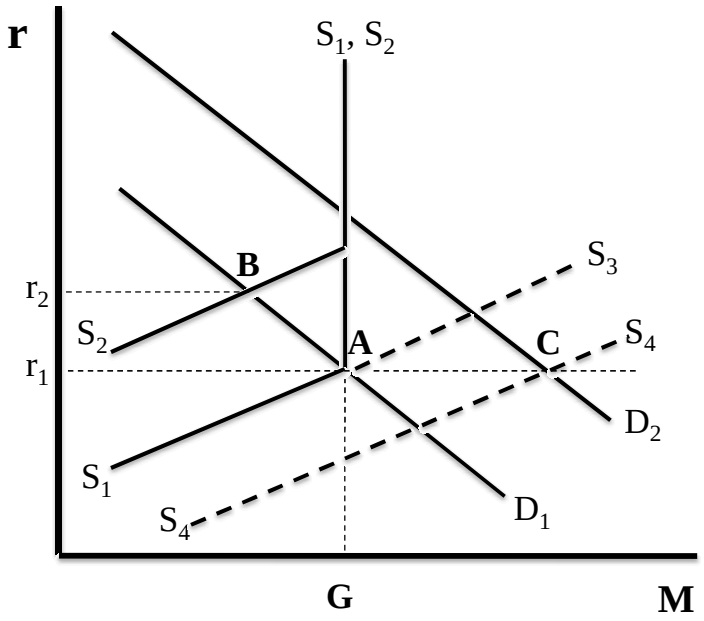
(3) An entirely conflicting view to the previous two is that money supply was determined *endogenously* by the private banking sector. Most of the money stock was not coins and notes supplied by the central bank, so called high-powered money, but money on accounts of private banks. Since there was no required reserve ratios imposed on private banks' deposits or lending during the pre-First World War gold standard, the banks were free to expand their activities to accommodate public's demand of money. Thus, the money stock could fluctuate independently of the nation's gold stock or its central bank's monetary policy.

Figure 3 illustrates the differences of the three theories for money supply and interest rates. Money supply is depicted in the Figure on the horizontal axis and interest rate on the vertical axis. Point G on the horizontal axis denotes the gold stock in the economy, whether in the possession of the central bank or the banking system in general. Curves S_1–S_1 and S_2–S_2 denote the supply of money by the central bank. The vertical, solid part of the slopes denotes supply according to the alternative (1), that the real money stock was determined by the gold stock. Money supply is totally inflexible but interest rates respond strongly to any disturbances. The upward sloping parts of the slopes denote the relation according to the theory (2), that the central bank influences the size of the money stock up to the constraint of the gold stock. Below that constraint, operations changing money supply have an impact on interest rates, like the shifts between curves S_1–S_1 and S_2–S_2 in the Figure, and shifts between points A and B.

If money supply was endogenous, it may have shifted independently above and below the gold constraint. Since the supply accommodates demand, the interest rate may not change even when the volume of money stock changes, like shifts between points A and C illustrate in Figure 3. The accommodation would mean that money supply was a function of investments.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Figure 3. Determination of the money stock and interest rates under the classical gold standard: three alternatives



The propositions of the theories (1) to (3) will be studied empirically in following two sections. The questions are, (1) did money stock change independently of gold reserves, and (2) did central banks sterilize the impact of gold flows on their reserves, and thus on the money stock. Before that we take a look at a set of stylized facts about the development of money stocks during the gold standard in 12 countries.

4.1 Nominal and real money stock: a look at the data

The rationale to the proposition that gold stock determines real money stock is the quantity theory of money. It implies that changes in the quantity of money, *ceteris paribus*, drive price levels but not income in the long run. In addition, a normal interpretation of the 'long run' is that it is rather short – agents adjust to changes in the money stock almost instantaneously. (The *ceteris paribus*

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

condition reminds us that when output[71] or velocity of money is changing, the relationship does not hold.) For my empirical investigation, I assume the long run to be shorter than one year, the level of observation in our data.

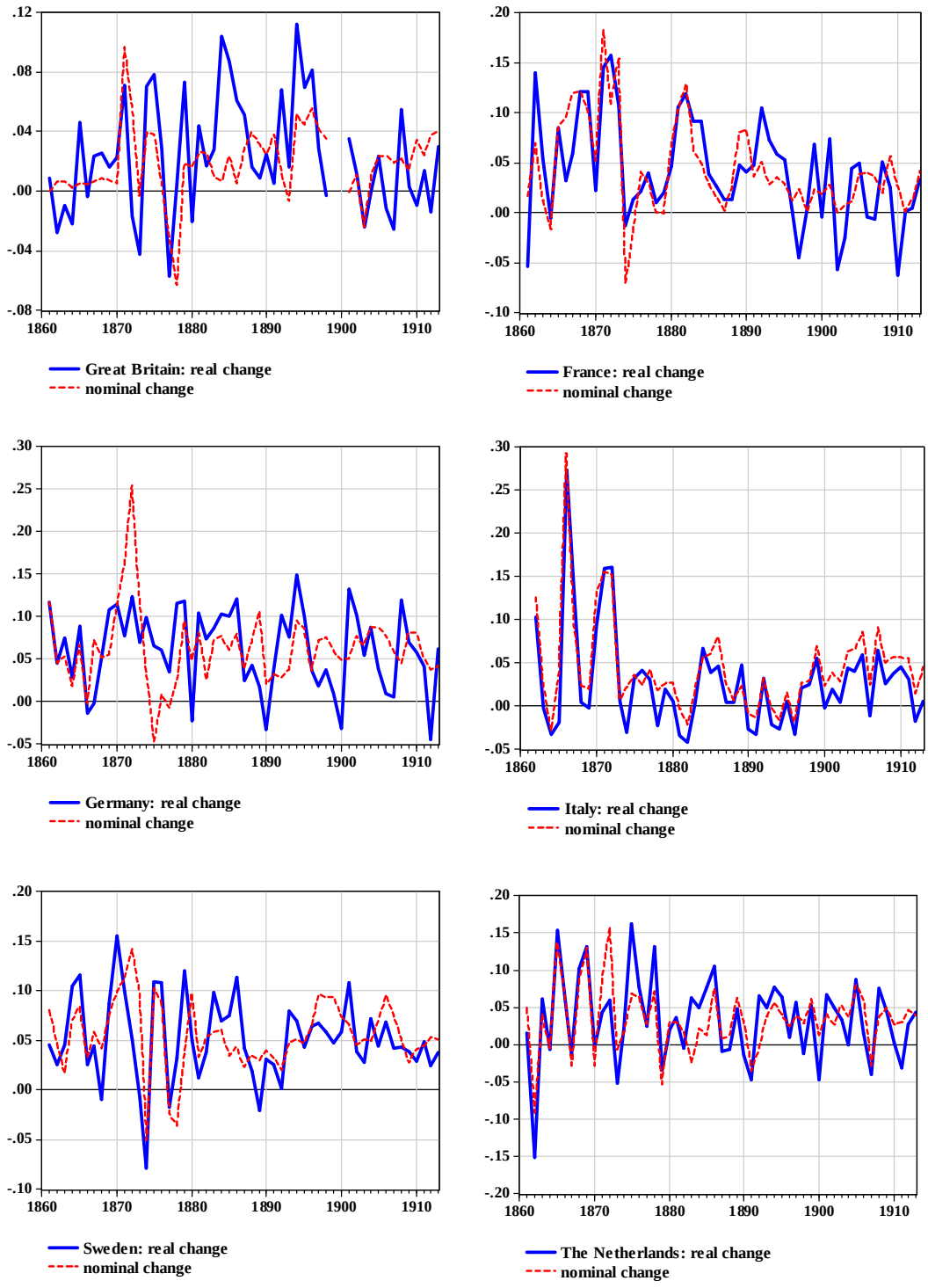
If money was neutral, and if changes in the gold stock determined changes in the real money stock of the late 19th century gold standard economies, then the real money stocks of these countries should have been rather stable, even if the nominal money stocks fluctuated. That was not the case even in the gold standard countries.

To illustrate changes of nominal and real money stocks, Figure 3 graphs them in 12 countries, nine of which were in the gold standard at least from 1880 to 1913. In no one of the countries was the real money stock unvolatile even after 1880. The real money stock was even more volatile than nominal stock in Great Britain, France and Germany. The changes are cyclical in most of the countries. The cycles are long in Great Britain, France, Germany, Italy, Sweden, United States and Denmark. Volatility of the growth of real money stock and its cyclicality gives me a good reason to include money in my model with investments and current account (our substitute variable for capital exports).

[71] The change of output must be exogenous, not caused by variables in the model, for example change of money stock.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Figure 3a. Change of the real and nominal money stock in a group of gold countries



Sources: See the Data Appendix of the thesis.

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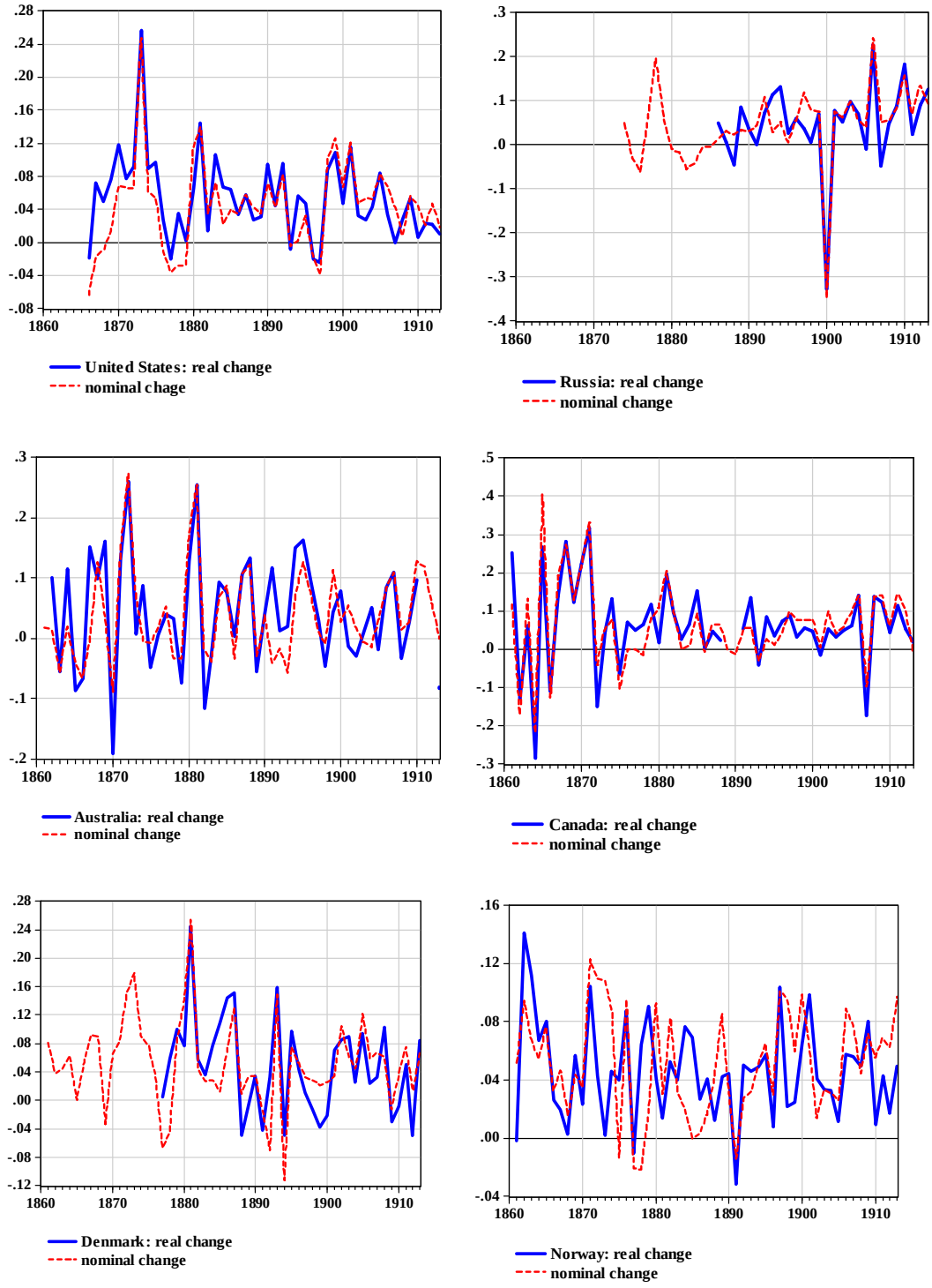
Figure 3b. Change of the real and nominal money stock in a group of gold countries



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Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
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4.2 An empirical test of international money stock and gold supply

Even if the growth of real money stocks was volatile and cyclical, it is not a proof that they were not driven by the world supply of gold. The cycles in the growth could have been caused by changes in the world gold production. But, if the variations in national money stocks had a common origin, they should have had a common stochastic trend. Existence of the common trend would mean that countries under gold standard, playing by the rules, had price levels and monetary data that were driven by world supply of gold. Constraints imposed by the gold standard would have driven money stocks back to their initial equilibrium after any shock to the system, a common stochastic trend being that equilibrium.

The practical way to evaluate the existence of a common trend is to do co-integration tests on pairs of time series of national real money stocks. The co-integration tests would fail if there is no common trend. Table 1 reports these tests made on pairs of money stocks of 10 gold standard countries and Italy and the United States in the period from 1860 to 1913, and Table 2 the same tests for the years 1895–1913.[72]

The results reported in Table 1 suggest that there are reasons to reject the co-integration hypothesis concerning the whole gold standard period. The co-integration relation was tracked by 22 tests out of 78 (28 %): most of these cases are co-integrations with Russia. Since Russia was in the gold standard *de facto* only from 1900 onwards, 28 per cent may not be a correct proportion of successful tests. Excluding Russia, the percentage of co-integration relations is only 18.[73]

[72] The data is in levels and all the time series have a unit root. Thus, it makes sense to perform the co-integration tests.

[73] Craig and Fisher (1997, p. 142) make a similar test using money stock (instead of money stock per GDP), and different data of money stock than what I have available for this study. Their test periods are 1873 – 1913, regardless of whether the countries tested were in the gold standard all of this time. Thus the results allow more clearly rejection of the co-integration hypothesis than my set of tests. Because of their choice of years for the tests, they are not a precise evaluation of co-integration of money stocks among member countries of the gold standard.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Table 1a. A set of co-integration tests on money stocks per GDP in 78 pairs of countries: the time of adherence (of each country) to gold until 1913

	Great Britain	**France**	**Germany**	**Netherlands**	**Sweden**	**Denmark**
Great Britain		no	no	no	no	no
France	no		yes	no	no	no
Germany	no	yes		no	no	no
Netherlands	no	no	no		no	no
Sweden	no	no	no	no		yes
Denmark	no	no	no	no	yes	
Finland	no	no	no	yes	no	no
Norway	no	no	yes	no	no	no
Italy	no	yes	no	no	no	no
Australia	yes	no	no	no	no	no
Canada	no	no	no	no	no	no
United States	no	yes	yes	no	no	no
Russia	yes	no	no	yes	yes	yes

Table 1b. A set of co-integration tests on money stock per GDP in 78 pairs of countries: the time of adherence (of each country) to gold until 1913

	Finland	**Norway**	**Italy**	**Australia**	**Canada**	**United States**	**Russia**
Great Britain	yes	no	no	yes	no	no	yes
France	no	no	yes	no	no	yes	no
Germany	no	yes	no	no	no	yes	no
Netherlands	yes	no	no	no	no	no	yes
Sweden	no	no	no	no	no	no	yes
Denmark	no	no	no	no	no	no	yes
Finland		no	no	yes	no	yes	yes
Norway	no		no	no	no	no	yes
Italy	no	no		yes	no	no	–
Australia	yes	no	yes		no	no	yes
Canada	no	no	no	no		no	yes
United States	yes	no	no	no	no		yes
Russia	yes	yes	–	yes	yes	yes	

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Table 2a. A set of co-integration tests on money stocks per GDP in 78 pairs of countries: 1894 (or the time of adherence to gold) until 1913

	Great Britain	**France**	**Germany**	**Netherlands**	**Sweden**	**Denmark**
Great Britain		no	no	no	no	no
France	no		no	yes	no	yes
Germany	no	no		no	no	no
Netherlands	no	yes	no		no	no
Sweden	no	no	no	no		no
Denmark	no	yes	no	no	yes	
Finland	no	no	no	yes	no	yes
Norway	no	yes	no	no	no	yes
Italy	no	no	no	no	no	no
Australia	no	yes	yes	yes	no	yes
Canada	no	yes	no	no	no	no
United States	no	yes	yes	no	no	no
Russia	yes	no	no	yes	yes	yes

Table 2b. A set of co-integration tests on money stock per GDP in 78 pairs of countries: 1894 (or the time of adherence to gold) until 1913

	Finland	**Norway**	**Italy**	**Australia**	**Canada**	**United States**	**Russia**
Great Britain	no	no	no	no	no	no	yes
France	no	yes	no	yes	yes	yes	no
Germany	no	no	no	yes	no	yes	no
Netherlands	yes	no	no	yes	no	no	yes
Sweden	no	no	no	no	no	no	yes
Denmark	yes	yes	no	yes	no	no	yes
Finland		no	yes	yes	no	yes	yes
Norway	no		no	no	no	no	yes
Italy	yes	no		yes	yes	yes	yes
Australia	yes	no	yes		yes	yes	yes
Canada	no	no	yes	yes		yes	yes
United States	yes	no	yes	yes	yes		yes
Russia	yes	yes	yes	yes	yes	yes	

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

The results in Table 2 indicate a change towards monetary unification among the gold standard members. The test periods reported in the Table are the last 20 years of the gold standard, or the time of adherence to gold after 1894 concerning both of the countries in the test pair. The percentage of successful co-integration tests is clearly higher in these late years: 42 per cent (and 35 per cent without Russia). The countries in the sample were more disciplined to follow the rules in the last 20 years than before. Still, one can hardly say that money stocks in these gold standard countries were driven by gold reserves even in the last years of the system.

4.3 Money stock created by the domestic banking sector and import and export of capital

The results of the co-integration tests in Section 4.2 support strongly the proposition made in the Section 4.1: money was not entirely supplied by central banks or backed by their gold reserves. Then, what were the other channels of money supply? I can think of are two possible explanations. First, central banks of the gold standard members did not play by the rules of the gold standard and allowed foreign currency and gold flows to change domestic money stocks. Second possibility is that also the private banking sector increased the money stock by accommodating firms wishing to invest, and in times of pessimistic expectations the money created in this way diminished.

4.3.1 Capital imports and exports influencing money stock

Let us discuss capital movements first. Capital mobility caused gold and currency flows from lending to borrowing countries when capital, imported by the borrowing country, was not used for buying goods and services from the lending country. These gold and currency flows, in turn, changed the central bank reserves of both countries. The monetary base during the classical gold standard was made of gold and currency reserves. Thus, they could influence the size of money stocks.

How did this happen? Capital imports are used to finance current account deficits,

$KA = -CA.$

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Let us we make a distinction between *ex-ante* lending and *ex-post* lending.[74] If all of the imported financial capital was not used by the receiving country to import capital goods or consumer goods, the difference needed to be paid by gold and currency 'shipments':[75]

$KA = -(CA^{goods} + monetary\ gold\ and\ currency\ shipments)$.

Bullion and currency was 'shipped' from the capital exporting country to the capital importing country. Most of it went to the borrowing country's central bank, thus increasing its reserves. In the lending country, in the contrary, the shipped gold and currency was taken from the central bank's reserves. Thus, the capital flow increased money supply in the borrowing country and diminished money supply in the lending country.

The above reasoning applies under the assumption that the central banks in these countries did not sterilize the effects of gold transfers. Next, I will test the assumption with a simple statistical model:

$$\Delta Res = \Delta gold_t + \Delta gold_{t-1} + \varepsilon$$

The results of the estimations, done on the data of seven countries and years 1881–1913, are reported in Tables 3 and 4.[76] Based on these simple regression models of individual countries we may believe that:

- gold inflow increased and outflow decreased central bank reserves in Denmark, France, Germany, Italy and Great Britain,
- the impact of gold flows may have applied also to Norway and Sweden. These results are nevertheless uncertain: the model of Norway has auto-correlated residuals, and the coefficients of Sweden's model are not significant.

Based on the data of these countries in the last 32 years of the pre-First World War gold standard, we may conclude that sterilization of the gold flows was not a common practice during the classical gold standard.

[74] The distinction was made first by Brinley Thomas (1972) in a study of migration from Great Britain to United States.
[75] Actually, 'shipments' were often account transfers in the Bank of England. The transfers were included as increased or decreased assets in the balance sheets of the borrowing and lending countries central banks.
[76] See the data in Appendix 1.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Table 3. Change in central bank reserves and gold shipments per GDP: France, Germany and Great Britain[77]

Dependent variable: log change of central bank reserves			
Sample: 1881–1913	Observations: 33 after adjustments		
	France	**Germany**	**Great Britain**
Constant	-0.03 (-1.3)	0.02 (0.5)	0.05 (-2.8)
Gold shipments / GDP	-10.3 (-3.9)	-31.4 (-3.8)	-31.8 (-6.1)
Gold shipments / GDP(-1)		26.7 (3.2)	4.2 (0.8)
R^2	0.33	0.41	0.56
Durbin-Watson	2.02		
LM test: prob. Chi-Square(1)		0.96	0.82

Table 4. Change in central bank reserves and gold shipments per GDP: Italy, Sweden, Norway and Denmark[78]

Dependent variable: log change of central bank reserves				
Sample: 1881–1913	Observations: 33 after adjustments			
	Italy	**Sweden**	**Norway**	**Denmark**
Constant	-0.03 (-)	-0.03 (-0.7)	0.006 (0.4)	0.003 (0.5)
Gold shipments / GDP	-16.0 (-1.9)	-28.3 (-1.6)	-20.5 (-5.8)	-1.9 (-1.3)
Gold shipments / GDP(-1)	-8.0 (-1.0)	-16.6 (-1.0)		-8.3 (-6.6)
R^2	0.21	0.11	0.52	0.59
Durbin-Watson			2.5	
LM test: prob. Chi-Square(1)	0.74	0.36		0.35

4.3.2 The role of domestic banking sector

Since supply of money in most of the advanced countries doesn't seem to have depended on the world gold stock, on the one hand, but the reserves of central banks in the most important countries of the international financial system did follow the gold flows into them, we should start

[77] All variables are stationary at one percent level of significance (tested using ADF).
[78] All variables are stationary at one percent level of significance (tested using ADF).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

looking for an alternative explanation of money supply during the classical gold standard than the one which is offered by the conventional monetary theory.

To repeat, the conventional view of money creation was that it is initially the result of central bank action. The Bank lends money to commercial banks, which they use as their reserves. Then the banks re-lend the amount of reserve money repeatedly to the public. The process increases the initial sum lent by the central bank, *R*, by the factor of *1/r*, where *r* is the reserve ratio imposed on the banks. During the gold standard, central banks bought gold from the market, paying it with bank notes, and then lent some of the gold to commercial banks to be used as their reserves, and commercial banks re-lent the money repeatedly to the public, nevertheless under the constraint of the central bank's gold and currency reserve.

Another view of money supply is that most of the money was created endogenously by the private banking sector, increasing the volume of their deposits without the backing of gold reserves. The private banks were responsible of most of the money creation also in the 19th century economies. Money was created by re-lending the existing deposits when there was optimistic mood in the economy: when there was both demand for credit to finance investments, and supply of it at reasonable interest rates. The growth of money stock was halted when investors and/or bankers were pessimistic about future profits of investments. Old loans were paid back but new loans were not issued. The absolute money stock could even diminish.[79] Money destruction had replaced money creation. If pessimism was strong enough, even the central bank was not able to push money into the banking system.

Whatever the initial source of the money supply was, the role of the private banking sector and investors willing to finance their projects was crucial and dominant to the volume of money created. Next, I will study the interaction between the tree variables which I suggested in Section 3 to have determined the international differences in GDP growth: money supply, investments and capital flows (current account).

[79] This happened repeatedly in Great Britain, France, Germany, Italy, Sweden, the Netherlands, United States, Australia, Canada, Denmark and Norway. According to the data provided by Khromov (1950), the nominal money stock in Russia decreased over 30 per cent in 1900. See Figures 3a and 3b.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

5. Money stock, domestic investment and current account

In Section 3 I asked the question if money stock caused investments or investments caused money stock, and answered, speculating, that the causality runs in both directions. They are part of a same phenomenon. Now, I need to evaluate my claim empirically. The method is to run a set of VAR models on the data of 11 countries.

As stated earlier, investments of the capital exporting country had to be allocated either to domestic projects or to foreign ones. The relationship between domestic and foreign investments should be negative, as speculated in terms of Figure 3 on page 8. The question was, where did investments go? Did investors prefer the home country or foreign projects? Let us consider the problem of equations (1) and (2) – on page 9 – in terms of empirical regression equations (3) and (4):

$$(\Delta inv_i - \Delta gdp_i) = \alpha_1 + \beta_1(\Delta ca_i - \Delta gdp_i) + \beta_2(\Delta ms_i - \Delta gdp_i) + \varepsilon, \quad (3)$$

$$(\Delta ca_i - \Delta gdp_i) = \alpha_2 + \beta_3(\Delta inv_i - \Delta gdp_i) + \beta_4(\Delta ms_i - \Delta gdp_i) + \varepsilon \quad (4)$$

where, Δinv_i is change of investments in a country i, Δca_i is change of current account (approximating capital exports) and Δms_i is change in money supply. All variables are in logarithms.

The values of coefficients β_1 and β_3 should be -1, and the relative values of coefficients β_2 and β_4 should indicate the direction of investment allocation – home or abroad. Since the relationship between investments and current account may be endogenous, I apply the VAR approach. A system of two equations (3) and (4) helps to answer the question, where was increase in money stock channelled, or which one, investment at home or abroad, would loose if money supply at home diminished?

In addition, also the money supply may be endogenous with both investments and current account. The domestic money stock may be a function of firms' investment decisions, and it may also be increased by flows of monetary gold and currency. To check these causal relations I need to include a third equation to the model:

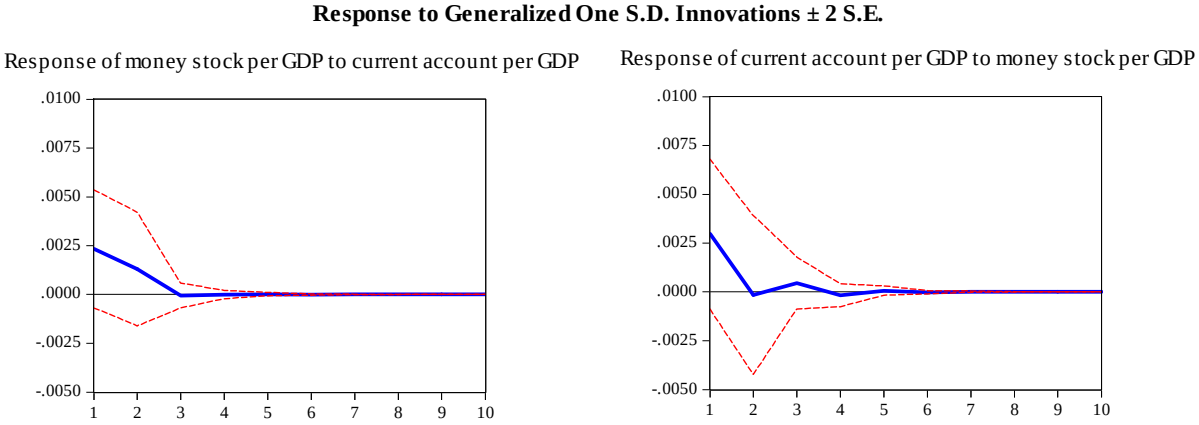
$$(\Delta ms_i - \Delta gdp_i) = \alpha_3 + \beta_5(\Delta inv_i - \Delta gdp_i) + \beta_6(\Delta ca_i - \Delta gdp_i) + \varepsilon. \quad (5)$$

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Positive and significant value of β_5 would mean that increase of domestic investments increased money demand, and negative value would mean decreasing influence. Similarly, significant value of β_6 would mean an influence of current account on money supply.

The results of the VAR models of 11 countries are reported in Appendix 3. Instead of reporting equations of the VAR models functions in the Appendix, I drew their impulse response. Impulse response functions trace the effects of one-time shock of any variable on the present and future values of other variables in the system of VAR equations. Figure 4 illustrates the information given by these functions.

Figure 4. Impulse response functions of a VAR model on French investments, current account and money stock: examples of shocks on money stock and current account



In the example of Figure 4, shocks on both money stock and current account have an immediate effect on the other variable. The effect on current account continues until the first period in the future when the shock takes place on money stock, and then declines to zero (the left panel of the Figure). A shock on current account has an effect on money stock only in the present period, and has declined to zero already in the first period in the future (the right panel of the Figure).

The results of impulse response functions graphed in Appendix 3 are summarized in Table 5. In addition, Table 6 reports Granger causality tests done on all of the variables. Impulse responses

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

offer some support to the basic ideas of my model in Section 3. Granger causality tests are more confusing:

1. Impulse responses of domestic investments and capital exports (approximated by current account) are negative on each others in 64 per cent of the countries. The percentage is higher, 73, if we accept a case where negative impact goes only in one direction (Australia). The exception is France where a shock on current account has a positive effect on domestic investments.[80]
2. Increase of money stock has a negative effect on domestic investments, and domestic investments have a negative effect on money stock, in the same way. Does this mean that increase in money stock causes the GDP share of domestic investments to decrease? Causality tests of Table 6 do not support this claim: almost all tests fail to reject the null hypothesis of no causality from money stock/GDP to investments/GDP. On the other hand, the hypothesis that investments increase money stock, does get some support from the results of Table 6. Impulse response functions suggest that the causality between money stock and investments is two-directional. Increase in the GDP share of investments is associated with decrease in real money stock, and vice versa.
3. Increase of money stock has a positive effect on current account in 54 per cent of the cases, and vice versa in 45 per cent of the cases, according to the impulse response functions. When/if the causality goes from money to current account, the positive effect means that
   - in capital exporting countries, as France and Germany, new money tends to be directed abroad, instead of domestic investments[81],
   - in capital importing countries (Sweden, Italy, Australia, Canada) increase of money stock reduces the need to import capital, which is the same as improvement of the current account.

   When/if the causality goes from current account to money stock, positive effect means that surpluses increase domestic money supply.

[80] Even in this case the effect is small and statistically uncertain. See Appendix Figure 3.1.
[81] Note that for Britain there is no such effect.

Table 5. Summary of results from VAR models on interaction of domestic investments/GDP, current account/GDP (proxy of net capital exports/GDP) and real money stock/GDP: impulse responses

Impulse responses						
	Invest-ments to current account	Current account to invest-ments	Money stock to invest-ments	Investments to money stock	Money stock to current account	Current account to money stock
Great Britain	-	-	+	+	-	-
France	0	+	-	-	+	+
Germany	0	0	0	+	+	+
Sweden	-	-	-	-	+	+
Norway	-	-	-	-	0	0
Denmark	0	0	0	0	0	0
Italy	-	-	0	+	+	+
Russia	-	-	0	0	-	-
Australia	0	-	-	-	+	0
Canada	-	-	-	-	0	0
United States	-	0	0	0	+	+
Per cent of nega-tive impulses	**64**	**64**	**45**	**45**	**2**	**2**
Per cent of posi-tive impulses	**0**	**9**	**9**	**27**	**54**	**45**
Negative in either case	**73**		**45**		**2**	
Positive in either case	**9**		**27**		**54**	

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Table 6. Summary of results from VAR models on interaction of domestic investments, current account and money stock: Granger causalities

Granger causalities						
	Invest-ments to current account	Current account to invest-ments	Money stock to invest-ments	Investments to money stock	Money stock to current account	Current account to money stock
Great Britain	No*	No	Yes	Yes	Yes	No
France	No	No	No	No	No	No
Germany	Yes	Yes	No	No	Yes	Yes
Sweden	No	No	No	No	No	No
Norway	Yes	Yes	No	Yes	No	No
Denmark	Yes	No	No	No	No	No
Italy	No	Yes	No	No	No	Yes
Russia	No	Yes	No	No	No*	Yes
Australia	Yes	No	No	Yes	Yes	Yes
Canada	No	No	No	No	No	No
United States	Yes	No*	No	Yes	No	No
Per cent of rejec-tions of the H_0 of no cause	**45 (55*)**	**36 (45*)**	**9**	**36**	**27 (36*)**	**36**

Yes = reject null hypothesis of no cause at 5 per cent significance level
No = fail to reject null hypothesis of no cause at 5 per cent significance level
No* = fail to reject null hypothesis at 5 per cent significance level but reject it at 10 per cent significance level

6. Symmetry of business cycles: what was the impact of money and investments?

Our basic question was how to explain the changes in inter-country symmetry of business cycles. As we saw in Section 2, these cycles were a-symmetric before 1880 when France, Sweden, or United States were compared to their trading partners or their partners in the international capital market, and became very symmetric in the 1880s and 1890s. After 1900 differences in growth rates started to increase again.[82] To explain this development, I had a look at the international distribution of investments from the core countries of the international financial system. Investments were allocated either to domestic or foreign uses. Both domestic investments and capital

[82] See Lessig, *Measuring the inter-country symmetry of late 19th century business cycles* for more details.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

exports were influenced by changes in money stocks of the capital exporting countries. My hypothesis is now that these allocation decisions had a decisive role in the development of symmetry of business cycles between countries that were involved in large scale capital movements.

Thus, the final stage of my study is to find out empirically, if differences in domestic and foreign investments and money stock growth had an effect on international differences of GDP growth. The variable to be explained is the symmetry indicator: the difference of filtered GDP growth rates. Potential explaining variables are those which we have been studying so far: domestic investments, current account and money stock. I proved earlier that changes in money stock had an effect on the allocation of investments to domestic or foreign uses. Thus, I include it in the model. Also, it is quite obvious that domestic investments were a major determinant of these growth rates.

I found out previously that domestic and foreign investments were negatively correlated. If investments grew faster in country A than in country B, and this made GDP grow faster in the country A, then foreign investments (current account) had the opposite effect to the relative growth rates of A and B. Increasing capital exports contributed to the GDP of country A to grow slower. Using this observation, I may leave the third variable, current account off the statistical model.

The question is now, if the international differences in growth rates of investments and money stocks match our observations of inter-country symmetry of business cycles. Following Milton Friedman's assumption that income is a function of money supply, the statistical model for finding answers to the above question is: [83]

$$DIFF\Delta GDP_{i-j} = f(DIFF\Delta INV_{i-j}, DIFF\Delta MS_{i-j}) \qquad (3)$$

where *i* and *j* mean the two countries to be compared,

[83] I created the explanatory variables, international differences of investment changes and changes of money stocks in the same way as I created the indicator for symmetry of GDP changes. The data consists of constant-price time series which I filtered with Baxter-King band-pass filters to extract the cycle. Accordingly, there are no stochastic trends or random variation in the time series. In addition, Baxter-King band pass-filters produce stationary time series.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

- $DIFF\Delta GDP_{i-j}$ is the symmetry indicator for business cycles: difference of filtered logarithmic real GDP growth rates between countries *i* and *j*.
- $DIFF\Delta INV_{i-j}$ is difference of logarithmic growth rates of real domestic investments between countries *i* and *j* ($DIFF\Delta INV_{i-j} = \Delta log.INV_i - \Delta log.INV_j$), and
- $DIFF\Delta MS_i$ is difference of logarithmic growth rates of real money stock between countries *i* and *j* ($DIFF\Delta MS_{i-j} = \Delta log.MS_i - \Delta log.MS_j$).

Table 7 summarizes the estimation results which are reported in Appendix 4. In seven cases of 15, faster growth of money stock makes GDP grow faster.[84] In all of these cases France or Germany is the capital exporting country. Not in a single model is Great Britain involved in a relationship where differences in growth rates of money stocks have an impact on relative GDP growth rates. Differences of investment growth rates have a significant and positive effect even more often: in nine cases out of 15.[85] The relative impact of investments (compared to the impact of money stock) is stronger and more often significant when Great Britain is involved in the comparison. On the other hand, when the capital exporting country is France or Germany, the effect of money stock is relatively stronger.

In cases of France and Germany where relative growth rates of domestic investments have a weak effect on symmetry of business cycles, capital exports must have a strong effect. Relatively fast economic growth in these countries was connected with relatively fast growth of money stock and capital exports. At the same time, GDP growth was relatively slow in capital importing countries, Scandinavia and Italy, which used the imported capital on buying consumer goods from abroad. Soon the relation was reversed. Money stocks grew faster in capital importing countries, and their GDP growth was also relatively fast. Investments were financed also from domestic sources. Differences in investment rates did not contribute to symmetry of business cycles as much.

Great Britain was different: its relatively slow investment growth contributed to slow GDP growth in relation to the capital importing country, in this case the United States. Differences in growth rates of money stock had a smaller effect.

[84] In two cases the model had autocorrelated residuals, which makes the results in these cases unreliable.
[85] In three of these cases the model has aurocorrelated residuals.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Table 7. Summary of OLS-estimates: the impact of differences in investments and money supply on symmetry of business cycles between two countries.

Dependent variable: differences of logarithmic filtered GDP change between two countries			
Method: Least squares			
	Independent variables		
Country pair	$DIFF\Delta MS_{i-j}$	$DIFF\Delta INV_{i-j}$	Notes
The core countries			
Great Britain – France	0.16^{*}	0.14^{***}	
Great Britain – Germany	0.18^{*}	0.05^{*}	Autocorrelated residuals
France – Germany	0.3^{***}	0.06^{*}	
Germany and countries where it exported capital			
Germany – Sweden	0.17^{**}	0.1^{***}	
Germany – Norway	0.4^{***}	0.08^{***}	Autocorrelated residuals
Germany – Denmark	0.1^{*}	0.06^{**}	
Germany – Italy	0^{*}	0.04^{***}	Autocorrelated residuals
France and countries where it exported capital			
France – Sweden	0.3^{**} 0.5^{***}	0.14^{***}	
France – Norway	0.29^{***}	-0.02^{*}	
France – Denmark	0.15^{**}	0.01^{*}	
France – Italy	0.3^{***}	0.04^{***}	Autocorrelated residuals
Great Britain, its trading partners and countries where it exported capital			
Great Britain – USA	-0.1^{*}	0.4^{***}	
Great Britain – Sweden	0.29^{*}	0.24^{***}	
Great Britain – Norway	0.04^{*}	0.7^{*}	Autocorrelated residuals
Great Britain – Denmark	0.04^{*}	-0.1^{*}	Autocorrelated residuals
Great Britain – Italy	-0^{*}	0^{*}	Autocorrelated residuals

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, where p is the significance level.

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7. Summary

I raised the question, if international capital mobility contributed to the symmetry of business cycles among some member countries of the pre-First World War gold standard. The reasoning, why capital mobility should have an effect on symmetry is basically simple. Domestic investments and exports of capital are mutually exclusive alternatives. When one of them increases, the other one must decrease, *ceteris paribus*. What may alter their relative sizes is the change of the money stock. Increase in money stock allows an increase in both domestic and foreign investments, and decrease of money stock may force both domestic and foreign investments to contract. Nevertheless, either may be more responsive to changes in money stock than the other.

The main results of the study are as follows:

1. The growth of real money stocks was volatile and developed cyclically in the economies of the late 19th century economies. Money stocks of individual countries were not driven by international gold supply even in the gold standard countries.
2. New money got created by gold and currency imports, and by the private banking sector. The domestic money creation and investments seem to have been an endogenous process: investments led to increase of demand and supply of money, and increase of supply of money induced new investments.
3. In France and Germany, increase in money stock tended to be directed to capital exports rather than to domestic investments. In Great Britain, increase in money stock increased domestic investments but did not affect capital exports.
4. Both the relative changes in money stocks and investments contributed to international differences of GDP growth rates.

It is interesting to consider the effects of capital mobility on a-symmetries caused by changes relative investment rates. The issue is relevant specifically in periods when capital moves intensively, like in the latter half of the 19th century – and like today. In principle, international mobility of capital should even out differences in economic growth rates between capital rich and capital scarce countries. Nevertheless, since the determinants of capital exports seem to be volatile, and even change in a cyclical manner, capital mobility must be an important source of occasional a-symmetries of business cycles.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

References

Abramowitz, Moses (1961): The Nature and Significance of Kuznets Cycles, *Economic Development and Cultural Change*, 9, p. 248.

Abramowitz, Moses (1968): The Passing of the Kuznets Cycle, *Economica* no. 140, p. 366.

Baxter, Marianne and King, Robert G. (1999): Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time-Series, *The Review of Economics and Statistics*, 81, 575-593.

Bordo, Michael J. and Flandreau, Marc (2003): Core, Periphery, Exchange Rate Regimes, and Globalization, in *Globalization in Historical Perspective*, (ed. Bordo, Michael; Taylor, Alan; Williamson, Jeffrey G.), The University of Chicago Press.

Bordo, Michael D.; Cavallo, Alberto F. and Meissner, Christopher M. (2007): Sudden stops: determinants and output effects in the first era of globalization, 1880-1913, *NBER Working Paper No. 13489*.

Bordo, Michael D. and Meissner, Christopher M. (2007): Foreign capital and economic growth in the first era of globalization, *NBER Working Paper 13577*.

Chick, Victoria (1986): The Evolution of the Banking System and the Theory of Saving, Investment and Interest, *Economies et Societes* 3, pp. 112–126.

Chick, Victoria (1988): Sources of Finance, Recent Changes in Bank Behaviour and the Theory of Investment and Interest, in Paul Aretis (ed.) *Contemporary Issues in Money and Banking*, MacMillan.

Flandreau, Marc and Maurel, Mathilde (2005): Monetary Union, Trade Integration, and Business Cycles in 19th Century Europe: Just Do It, *CEPR Discussion Paper No. 3084*.

Frankel, Jeffrey A. and Rose, Andrew K. (1997): Is EMU more justifiable ex post than ex ante?, *European Economic Review*, 41(1997) 753–760.

Frankel, Jeffrey A. and Rose, Andrew K. (1998): The endogeneity of optimum currency area criteria, *The Economic Journal*, 108 (July), p. 1009–1025.

Jones, Matthew T. and Obstfeld, Maurice (2001): Saving, Investment, and Gold: A Reassessment of Historical Current Account Data, in *Money, Capital Mobility, and Trade: Essays in Honor of Robert Mundell*, ed. Guillermo A. Calvo, Rudi Dornbusch and Maurice Obstfeld, MIT Press.

Harley, Nick C. (1980): Transportation, the World Trade, and the Kuznets Cycle, 1850–1913, *Exploration in Economic History*, pp. 218–250.

Kaldor, N. (1983): *The Scourge of Monetarism*, Oxford University Press.

Kennen, Peter B. (1969): The Theory of Optimum Currency Areas: An Eclectic View, *Monetary Problems of the International Economy*, ed. Robert A. Mundell and Alexander K. Swoboda, pp. 41–60, Chicago.

Kuznets, Simon S. (1961): *Capital in the American Economy: Its Formation and Financing*, Princeton.

Lessig, Jyrki Johannes: *Measuring the inter-country symmetry of late 19th century business cycles*, unpublished manuscript for a Ph.D. thesis, European University Institute.

McKinnon, Ronald I. (1963): Optimum Currency Areas, *American Economic Review*, Vol. 53 (September 1963), pp. 717–725.

Mitchell, B. R. (1993), *International Historical Statistics Europe 1750-1988*, 3rd ed., Stockton Press, New York.

Stiglitz, J. and Weiss, A. (1981): Credit Rationing in Markets with Imperfect Information, *American Economic Review*, 71, pp. 393–410.

Thomas, Brinley (1972): *Migration and Urban Development. A Reappraisal of British and American Long Cycles*, Methuen & Co ltd.

Williamson, Jeffrey G. (1964): *American Growth and the Balance of Payments, 1820–1913: A Study of the Long Swing*, Chapel Hill.

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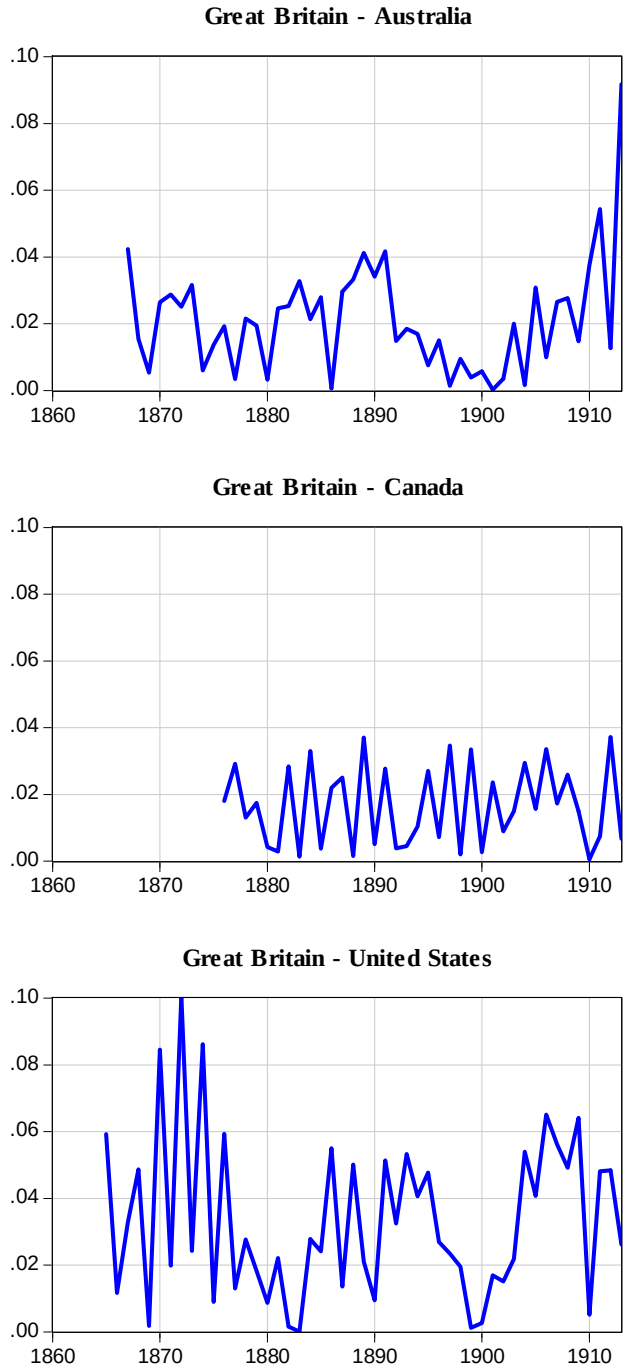
Appendix 1. Symmetry of business cycles between the core and periphery

Appendix Figure 1.1 Comparing Great Britain: absolute difference of GDP change



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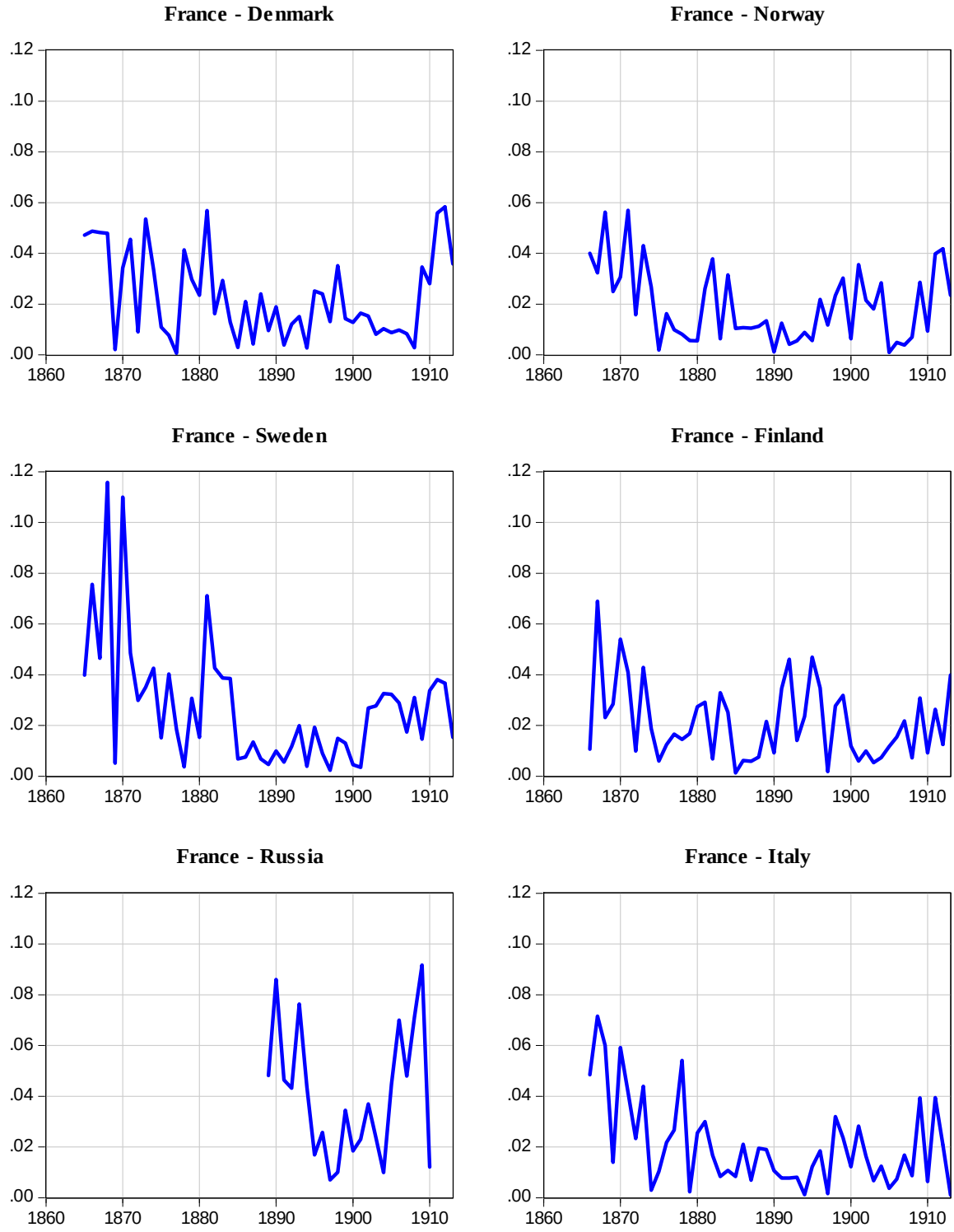
Appendix Figure 1.2. Comparing France: absolute difference of GDP change



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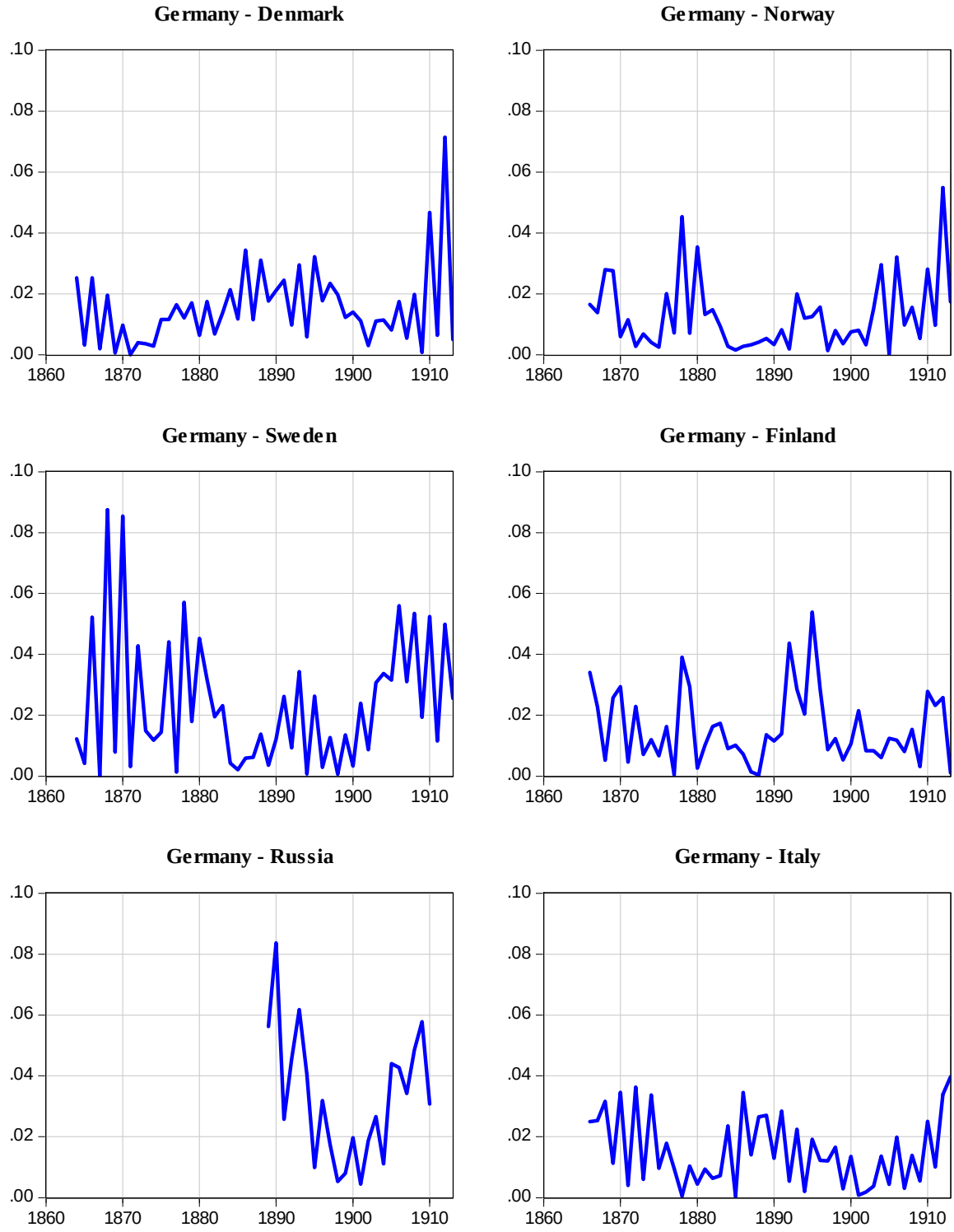
Appendix Figure 1.3. Comparing Germany: absolute difference of GDP change



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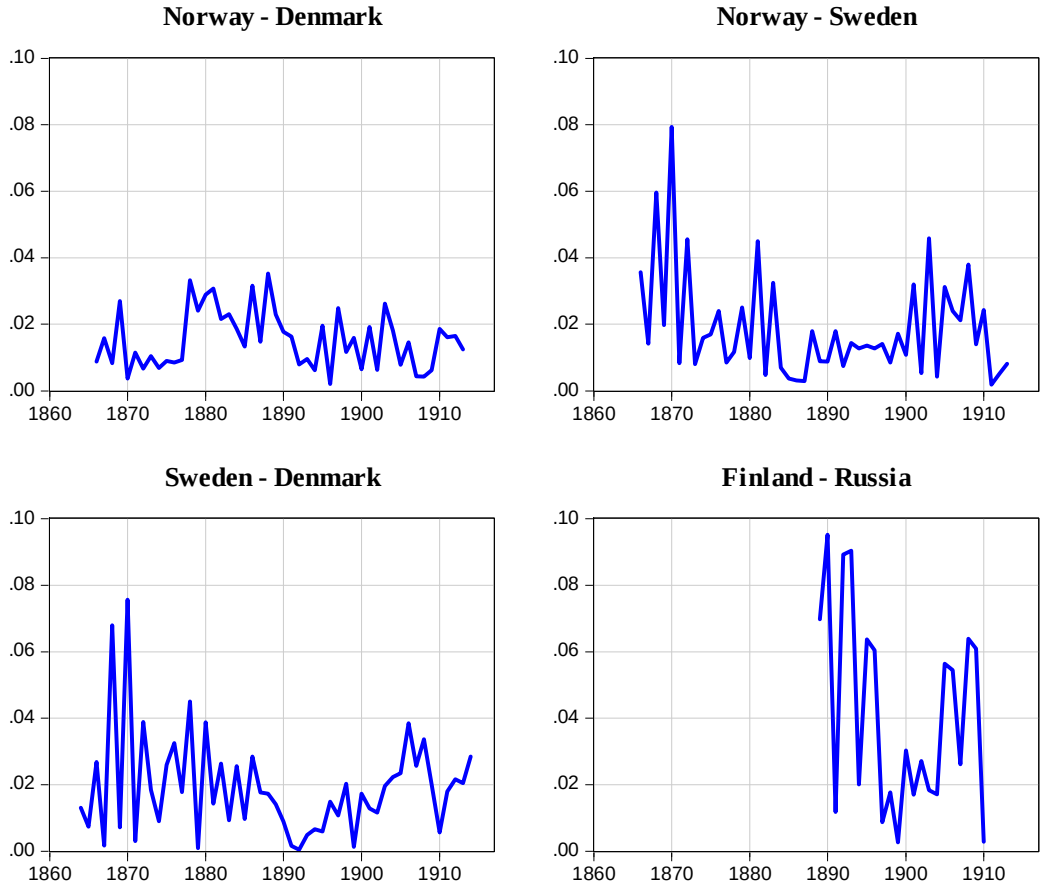
Appendix Figure 1.4. Comparing Northern periphery: absolute difference of GDP change



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Appendix 2. VAR models of investments, current account and money stock

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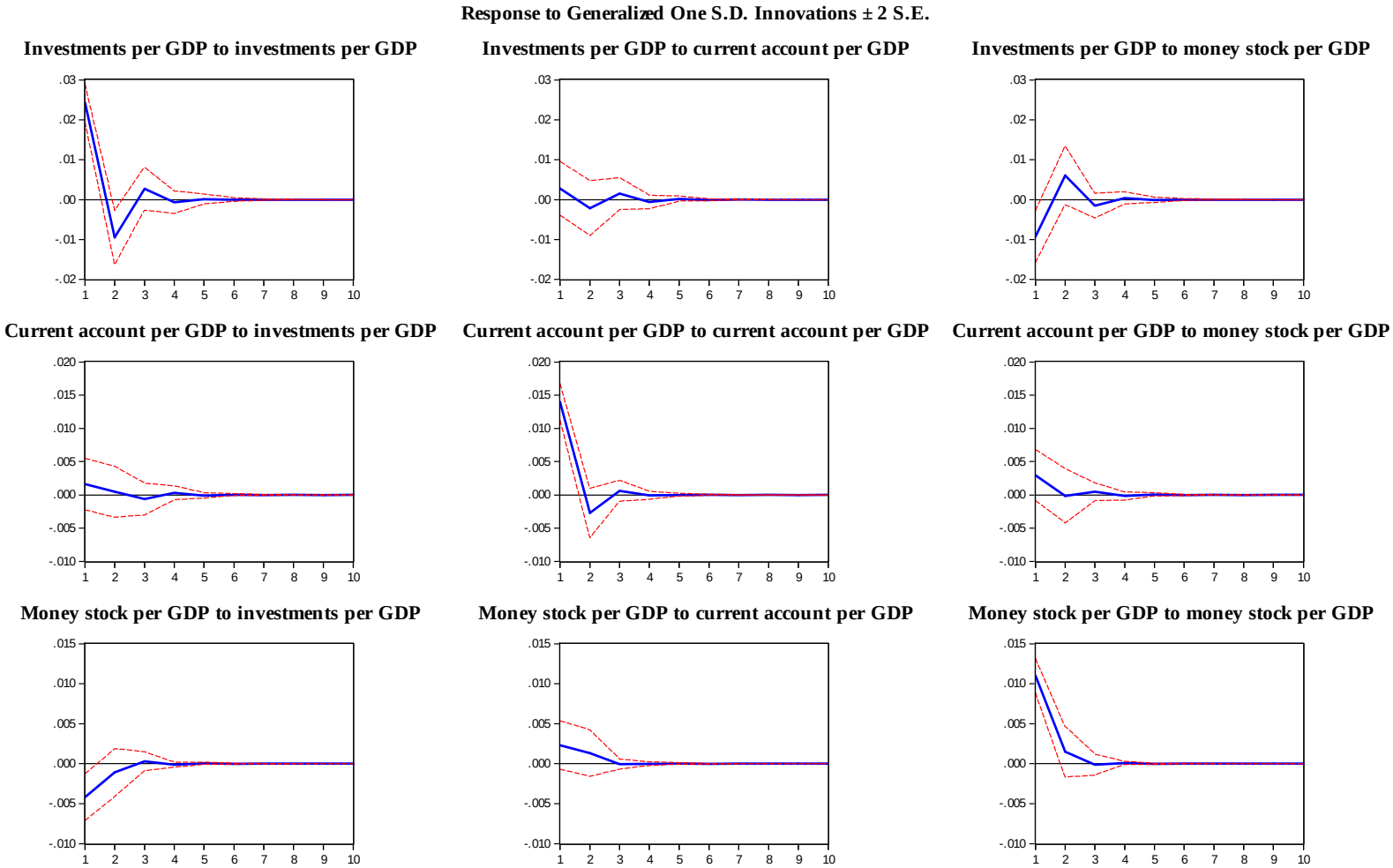
Appendix Figure 2.1. Impulse response functions of a VAR model on French investments, current account and money stock



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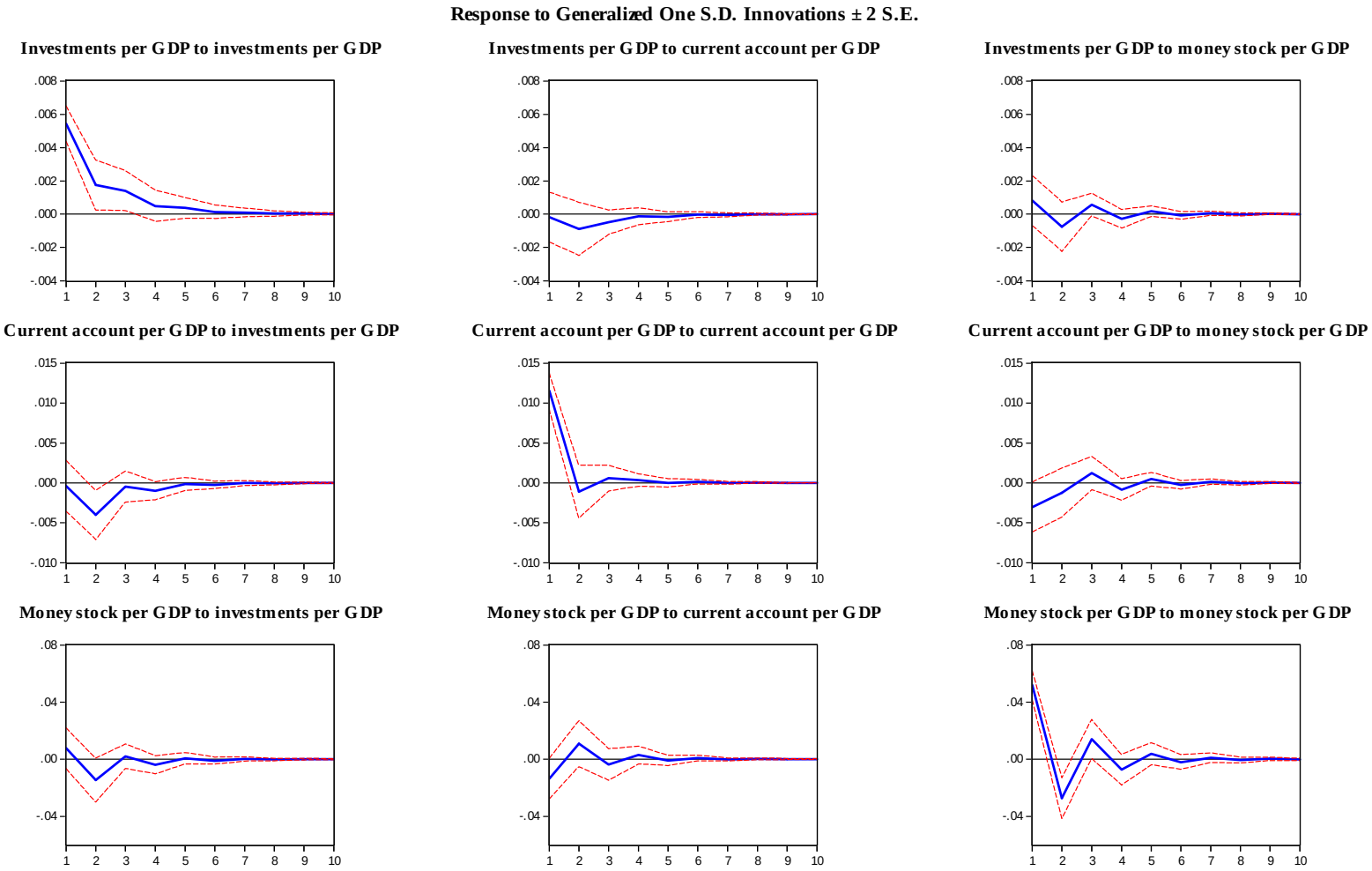
Appendix Figure 2.2. Impulse response functions of a VAR model on British investments, current account and money stock



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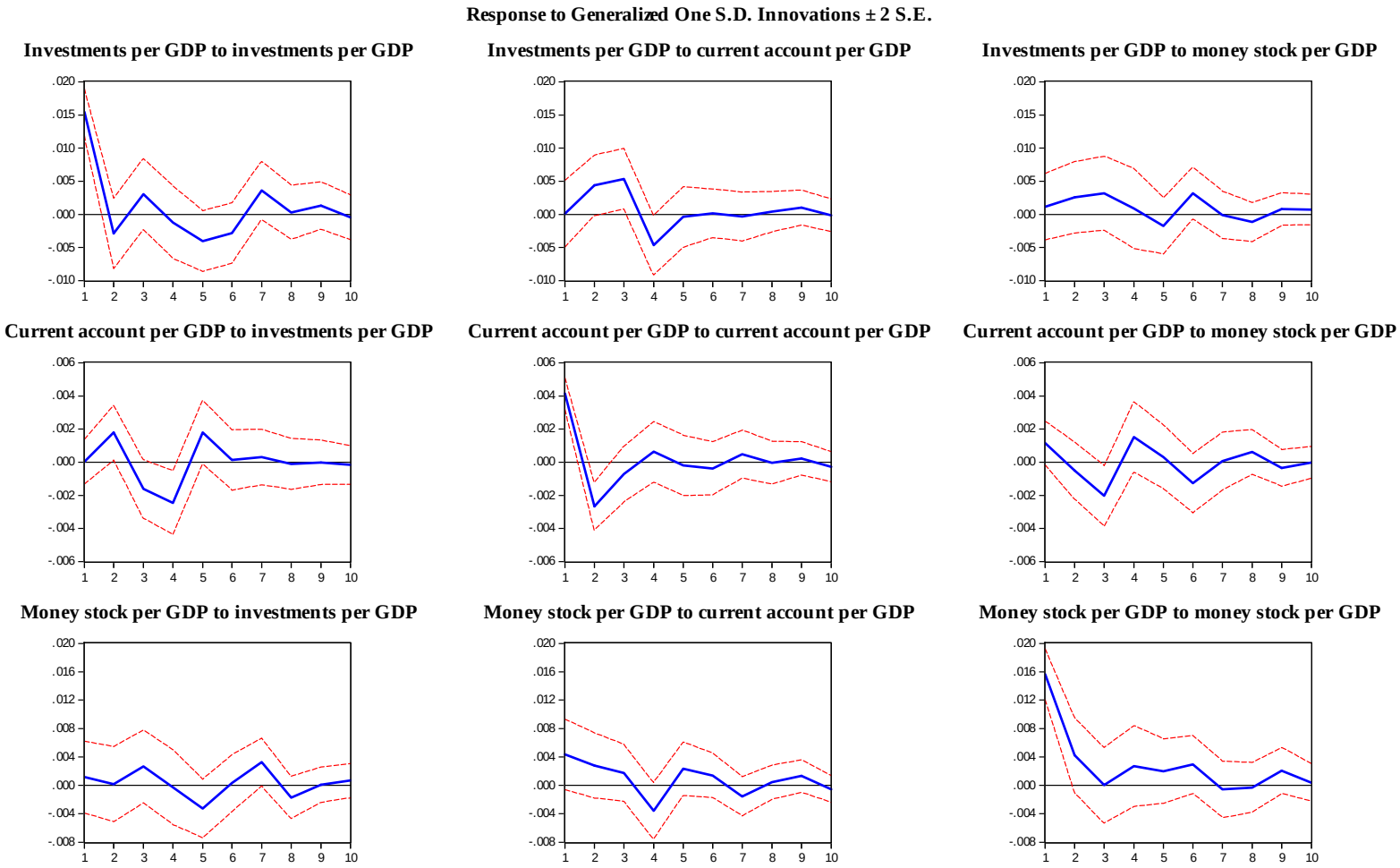
Appendix Figure 2.3. Impulse response functions of a VAR model on German investments, current account and money stock



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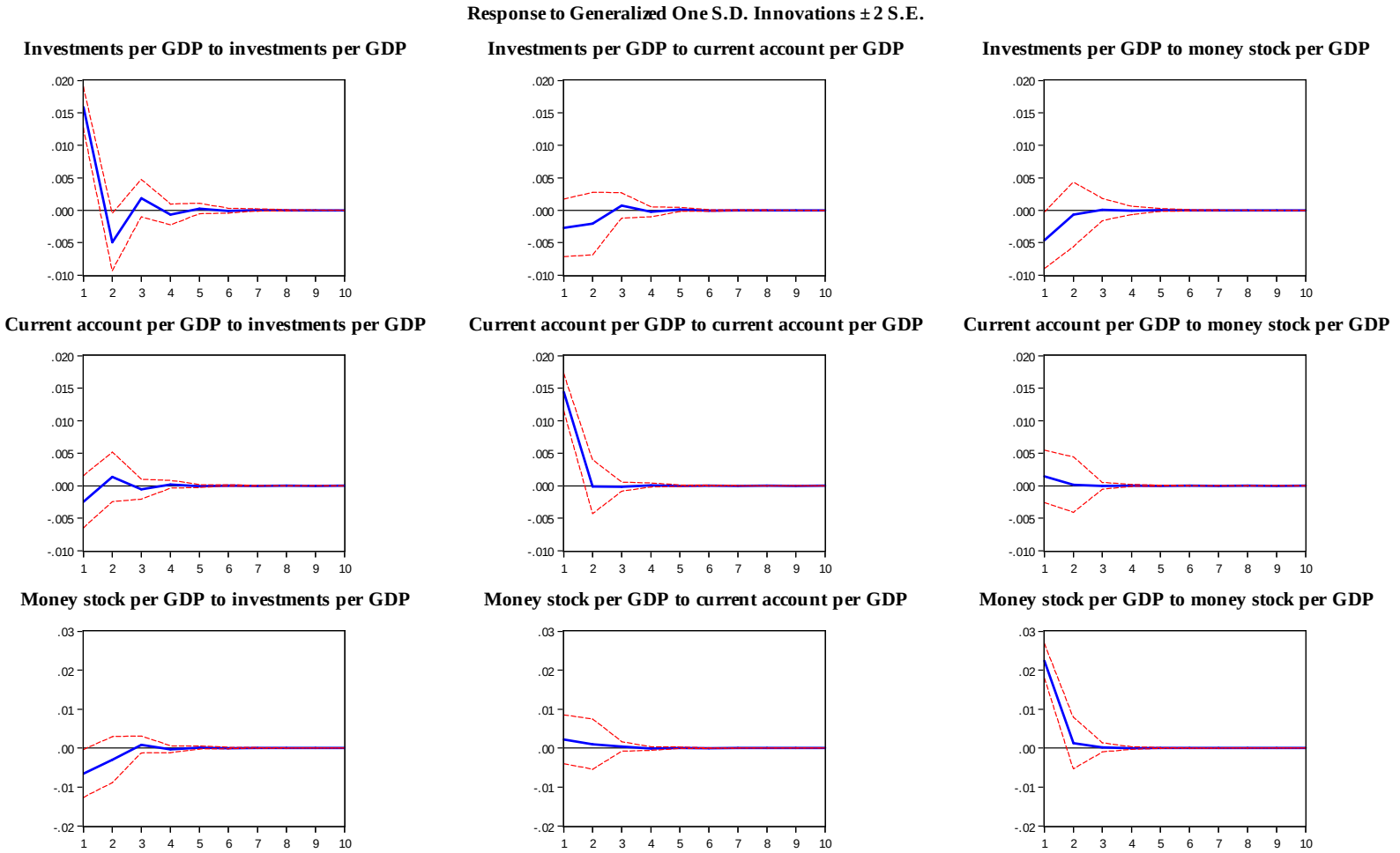
Appendix Figure 2.4. Impulse response functions of a VAR model on Swedish investments, current account and money stock



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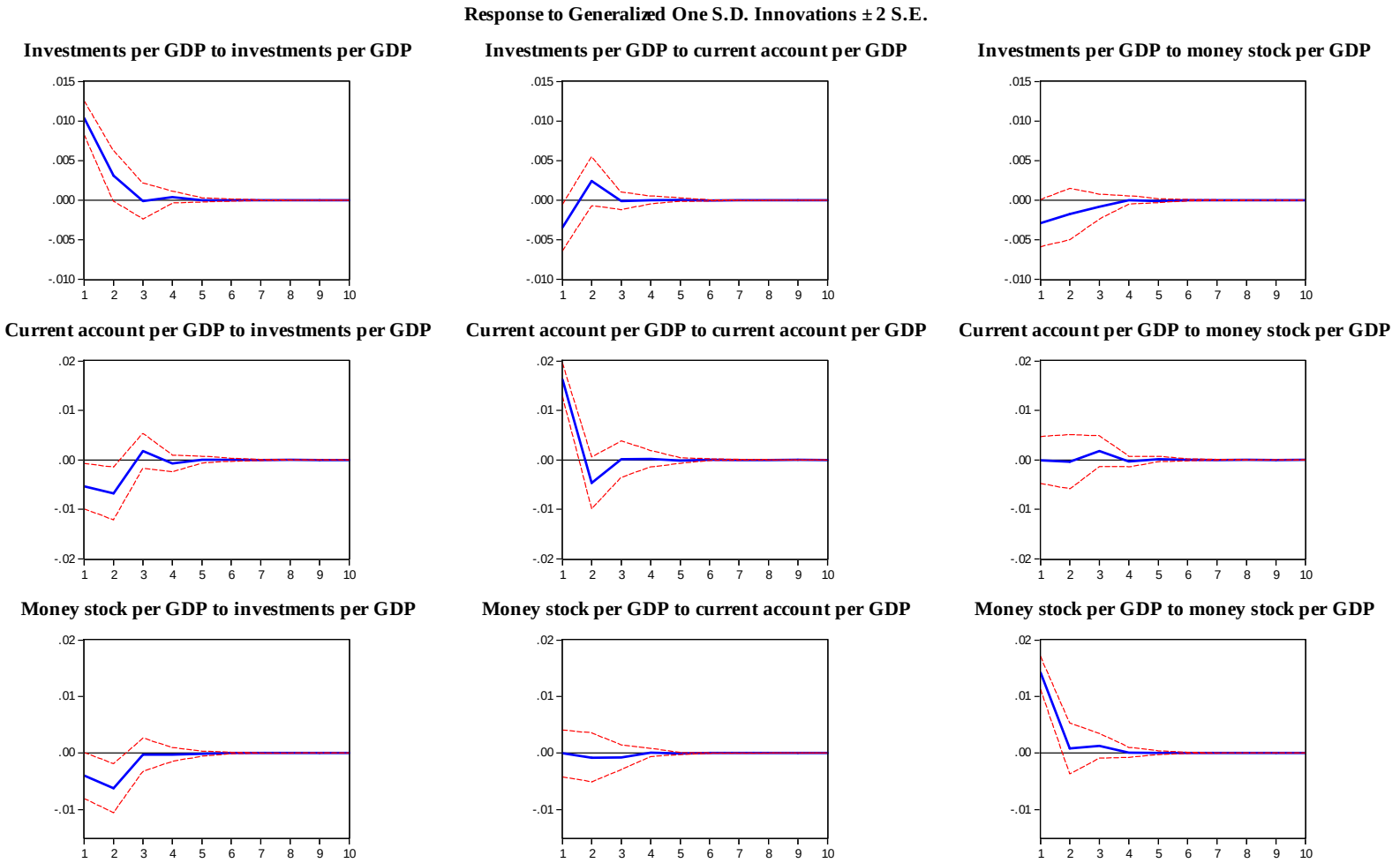
Appendix Figure 2.5. Impulse response functions of a VAR model on Norwegian investments, current account and money stock



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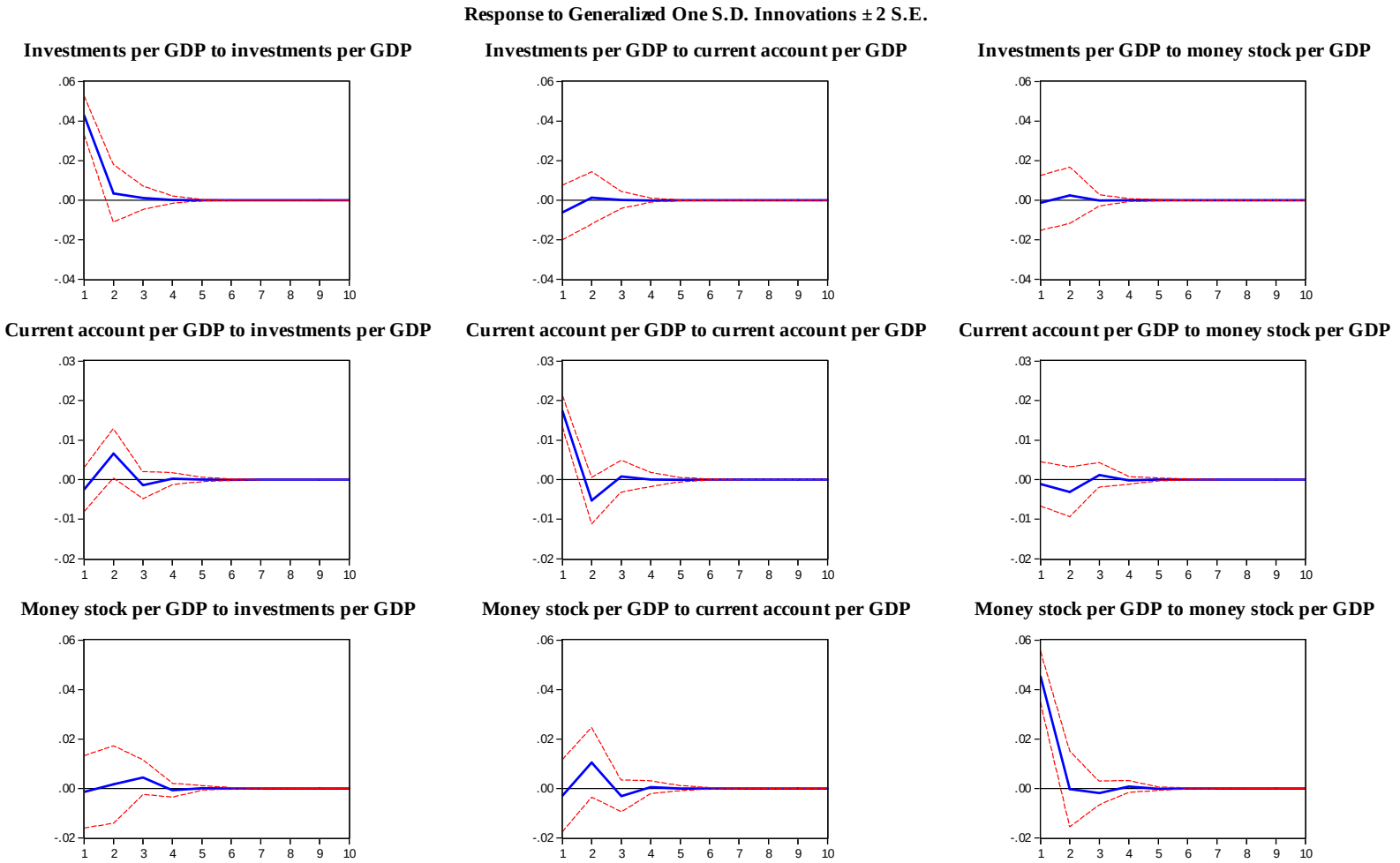
Appendix Figure 2.6. Impulse response functions of a VAR model on Danish investments, current account and money stock



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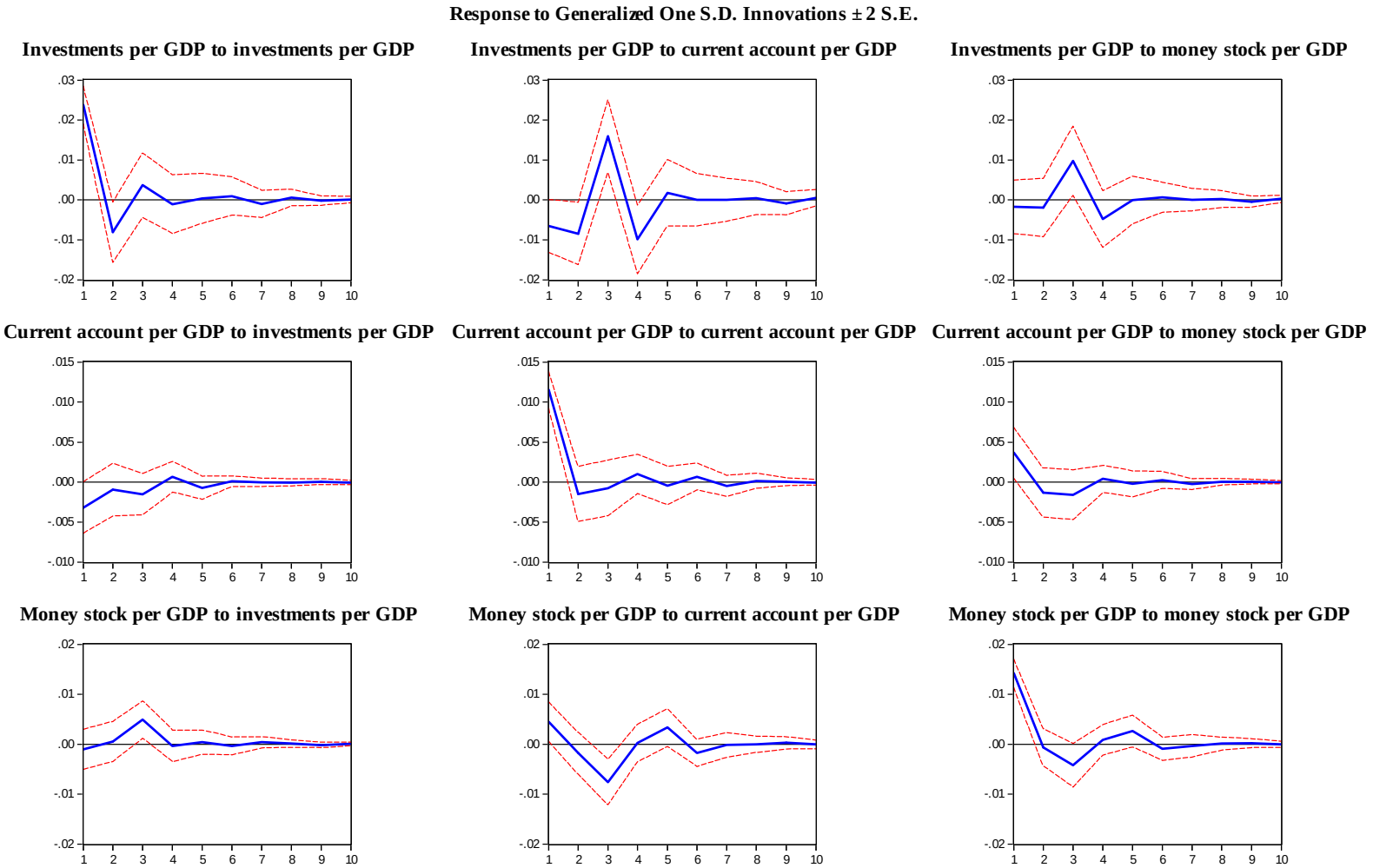
Appendix Figure 2.7. Impulse response functions of a VAR model on Italian investments, current account and money stock



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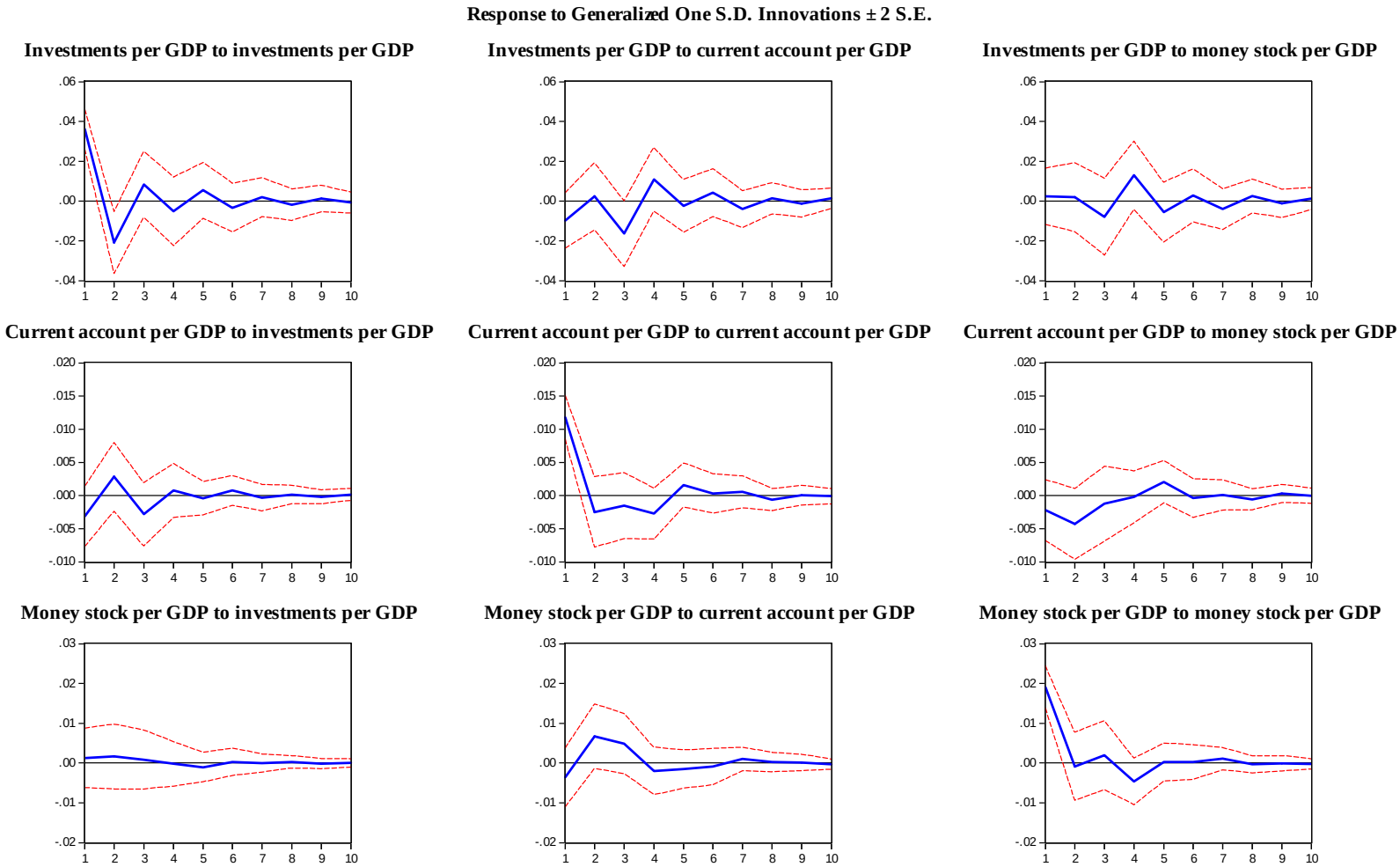
Appendix Figure 2.8. Impulse response functions of a VAR model on Russian investments, current account and money stock



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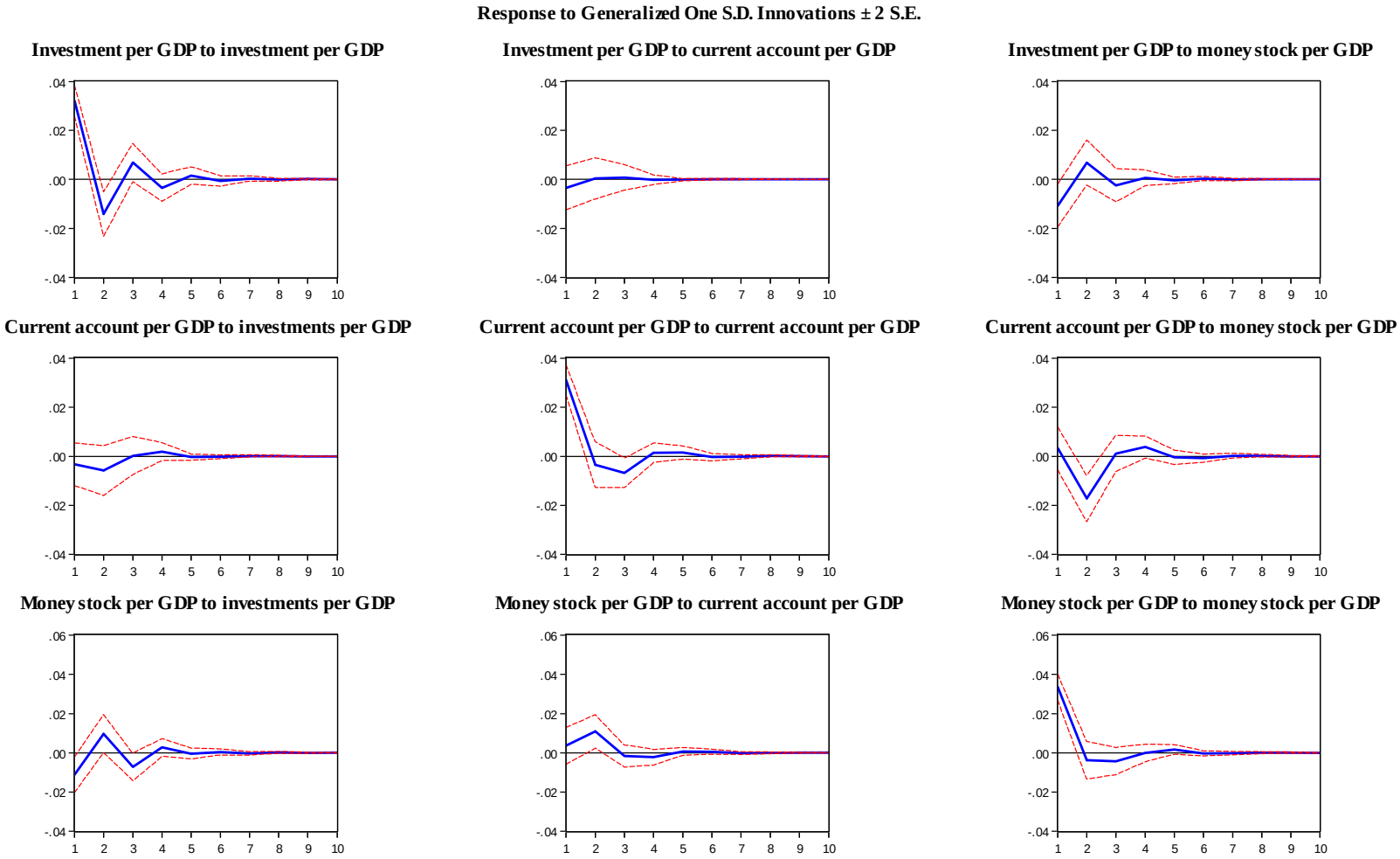
Appendix Figure 2.9. Impulse response functions of a VAR model on Australian investments, current account and money stock



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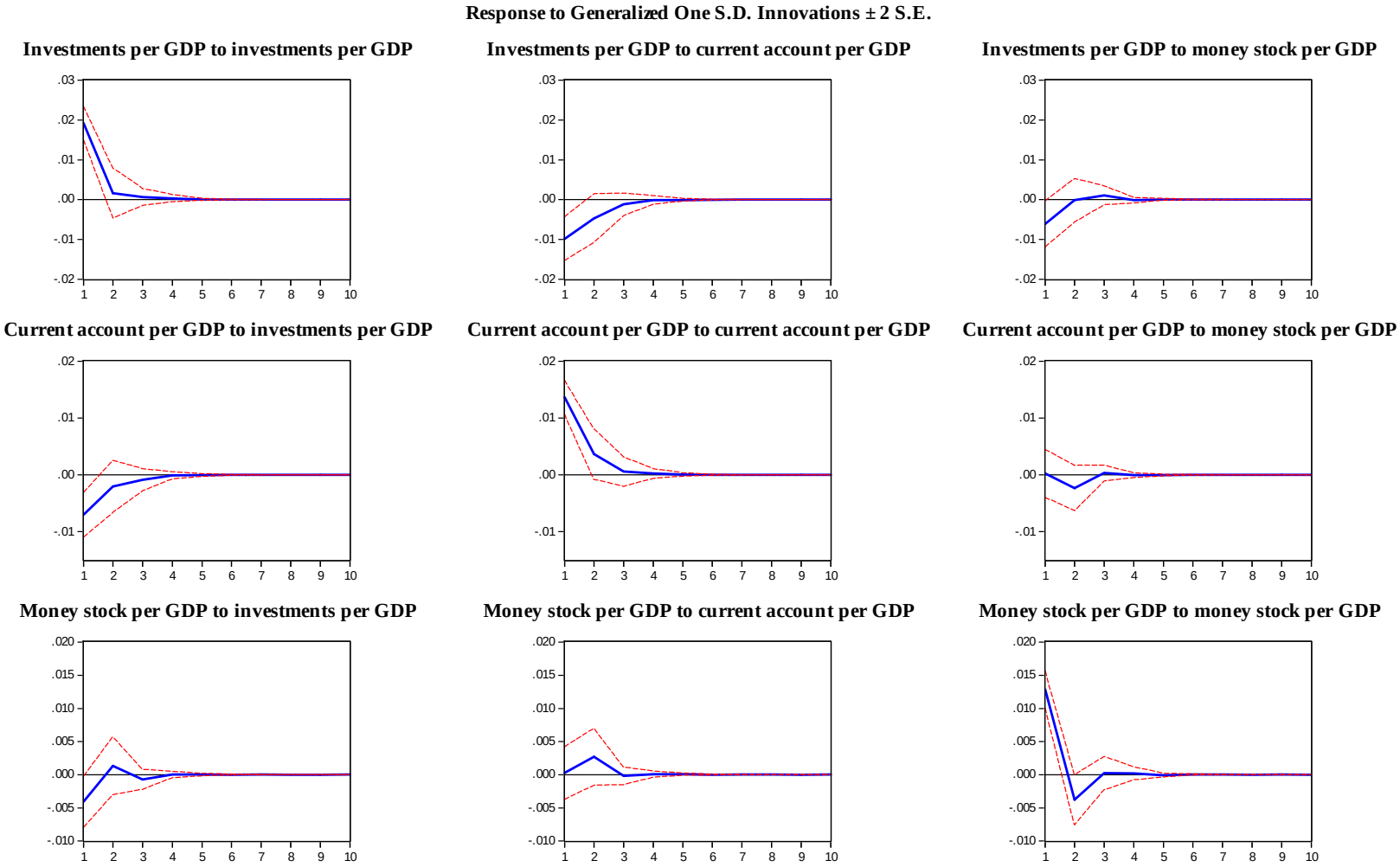
Appendix Figure 2.10. Impulse response functions of a VAR model on Canadian investments, current account and money stock



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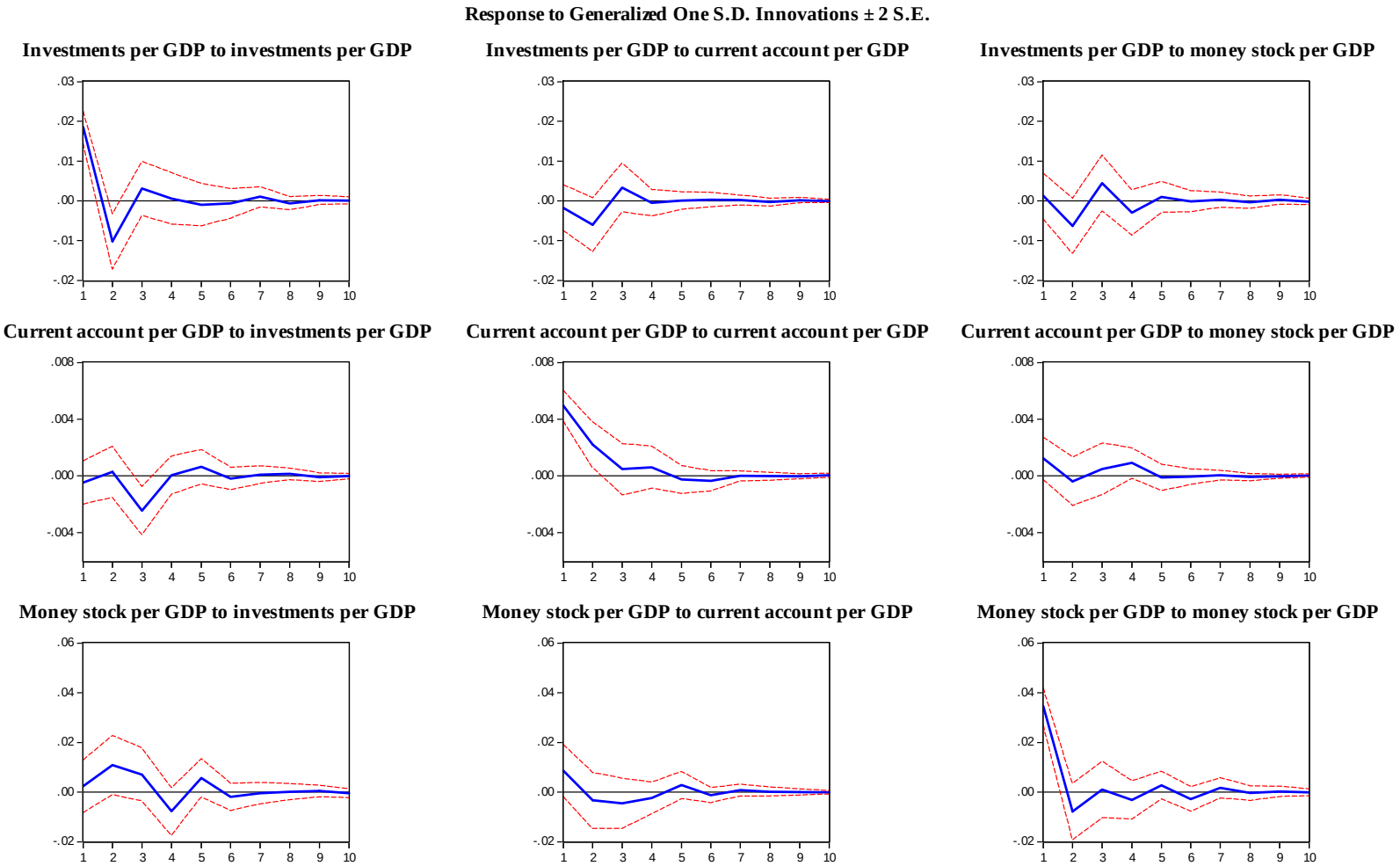
Appendix Figure 2.11. Impulse response functions of a VAR model on United States' investments, current account and money stock



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Appendix 3. Impact of international differences in investments and money supply on symmetry of business cycles

Appendix Table 3.1. OLS-estimates of the impact of international differences in investments and money supply on symmetry of business cycles between Great Britain and France.[86]

Dependent variable: differences of logarithmic filtered GDP change between Great Britain and France			
Method: Least squares			
Sample: 1866–1909			
	(1)	(2)	(3)
Constant	-0 (-0.3)	-0 (-0.3)	-0 (-0.3)
$DIFF\Delta MS_{i-j}$	0.16 (1.4)	0.25 (1.85)	
$DIFF\Delta MS_{i-j}$ (-1)	0.1 (0.8)	0.06 (0.4)	
$DIFF\Delta INV_{i-j}$	0.14 (4)		0.14 (4.4)
$DIFF\Delta INV_{i-j}$ (-1)			0.11 (3.3)
R-squared	0.37	0.12	0.45
Prob. Chi-Square(1)	0.86	0.68	0.99

[86] The first differences of all variables in the equations are stationary at 1 % of significance.

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Table 3.2. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Great Britain and Germany.[87]

Dependent variable: differences of logarithmic filtered GDP change between Great Britain and Germany			
Method: Least squares			
Sample: 1866–1909			
	(1)	(2)	(3)
Constant	-0 (-0.1)	-0 (-0.1)	
$DIFF\Delta MS_{i-j}$	0.18 (0.6)	0.18 (0.55)	
$DIFF\Delta MS_{i-j}$ (-1)	-0.1 (-0.5)	-0 (-0.2)	
$DIFF\Delta INV_{i-j}$	0.05 (1.2)		-0 (-0.12)
$DIFF\Delta INV_{i-j}$ (-1)	0.05 (1.3)		0.05 (1.3)
R-squared	0.17	0.07	0.1
Prob. Chi-Square(1)	0.18	0.2	0.1

Table 3.3. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between France and Germany.[88]

Dependent variable: differences of logarithmic filtered GDP change between France and Germany			
Method: Least squares			
Sample: 1866–1909			
	(1)	(2)	(3)
Constant	0 (0.2)	0 (0.2)	0 (0.3)
$DIFF\Delta MS_{i-j}$	0.3 (3)	0.24 (2.24)	
$DIFF\Delta MS_{i-j}$ (-1)	-0.01 (-0.06)	0.1 (0.96)	
$DIFF\Delta INV_{i-j}$	0.06 (1.7)		0.1 (0.99)
$DIFF\Delta INV_{i-j}$ (-1)	0.05 (1.7)		0.02 (0.6)
R-squared	0.33	0.22	0.1
Prob. Chi-Square(1)	0.74	0.5	0.11

[87] The first differences of all variables in the equations are stationary at 1 % of significance.
[88] The first differences of all variables in the equations are stationary at 1 % of significance

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Table 3.4. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Germany and Sweden.[89]

Dependent variable: differences of logarithmic filtered GDP change between Germany and Sweden			
Method: Least squares			
Sample: 1866–1909			
	(1)	(2)	(3)
Constant	-0 (-0.3)	-0 (-0.2)	0 (0.03)
$DIFF\Delta MS_{i-j}$	0.17 (2.3)	0.2 (2.3)	
$DIFF\Delta MS_{i-j}$ (-1)	0.15 (1.9)	0.1 (1.3)	
$DIFF\Delta INV_{i-j}$	0.1 (3.5)		0.08 (2.5)
$DIFF\Delta INV_{i-j}$ (-1)			0.06 (1.8)
R-squared	0.39	0.2	0.24
Prob. Chi-Square(1)	0.9	0.69	0.67

Table 3.5. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between France and Sweden

Dependent variable: differences of logarithmic filtered GDP change between France and Sweden			
Method: Least squares			
Sample: 1867–1909			
	(1)	(2)	(3)
Constant	0 (0.04)	-0 (-0.05)	0 (0.2)
$DIFF\Delta MS_{i-j}$	0.3 (2.5)	0.5 (3.5)	
$DIFF\Delta MS_{i-j}$ (-1)	0.16 (1.4)	0.1 (0.9)	
$DIFF\Delta INV_{i-j}$	0.13 (3.8)		0.14 (4)
$DIFF\Delta INV_{i-j}$ (-1)	0.03 (0.9)		0.1 (1.7)
R-squared	0.5	0.3	0.3
Prob. Chi-Square(1)	0.54	0.78	0.6

[89] The first differences of all variables in the equations are stationary at 1 % of significance.

DOI: 10.2870/38202

Table 3.6. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Germany and Denmark.[90]

Dependent variable: differences of logarithmic filtered GDP change between Germany and Sweden			
Method: Least squares			
Sample: 1866–1909			
	(1)	(2)	(3)
Constant	0 (0.1)		
$DIFF\Delta MS_{i-j}$	0.1 (1.7)		
$DIFF\Delta MS_{i-j}$ (-1)	0.1 (1.2)		
$DIFF\Delta INV_{i-j}$	0.06 (1.99)		
$DIFF\Delta INV_{i-j}$ (-1)	0.04 (1.5)		
R-squared	0.46		
Prob. Chi-Square(1)	0.48		

Table 3.7. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between France and Denmark

Dependent variable: differences of logarithmic filtered GDP change between France and Sweden			
Method: Least squares			
Sample: 1867–1909			
	(1)	(2)	(3)
Constant	-0 (-0.2)	-0 (-0.2)	-0 (0.2)
$DIFF\Delta MS_{i-j}$	0.15 (1.99)	0.1 (1.6)	
$DIFF\Delta MS_{i-j}$ (-1)	-0.2 (-2.6)	-0.2 (-2.9)	
$DIFF\Delta INV_{i-j}$	0.01 (0.36)		-0 (-1.7)
$DIFF\Delta INV_{i-j}$ (-1)	0.01 (2.6)		0.06 (2.1)
R-squared	0.39	0.27	0.16
Prob. Chi-Square(1)	0.93	0.54	0.32

[90] The first differences of all variables in the equations are stationary at 1 % of significance.

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European University Institute
DOI: 10.2870/38202

Table 3.8. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Great Britain and Sweden

Dependent variable: differences of logarithmic filtered GDP change between Great Britain and Sweden			
Method: Least squares			
Sample: 1867–1909			
	(1)	(2)	(3)
Constant	-0 (-0.1)	0 (-0.02)	0 (0.1)
$DIFF\Delta MS_{i-j}$	0.29 (0.96)	0.2 (1.2)	
$DIFF\Delta MS_{i-j}$ (-1)	0.2 (1.2)	0.2 (1.4)	
$DIFF\Delta INV_{i-j}$	0.24 (3.9)		0.24 (3.6)
$DIFF\Delta INV_{i-j}$ (-1)	-0 (-0.2)		-0.02 (-0.4)
R-squared	0.37	0.09	0.26
Prob. Chi-Square(1)	0.68	0.43	0.73

Table 3.9. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Great Britain and Norway

Dependent variable: differences of logarithmic filtered GDP change between Great Britain and Norway			
Method: Least squares			
Sample: 1870–1909			
	(1)	(2)	(3)
Constant	-0 (-0.1)		
$DIFF\Delta MS_{i-j}$	0.04 (0.2)		
$DIFF\Delta MS_{i-j}$ (-1)			
$DIFF\Delta INV_{i-j}$	0.05 (0.7)		
$DIFF\Delta INV_{i-j}$ (-1)			
R-squared	0.02		
Prob. Chi-Square(0)	0.01		

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European University Institute
DOI: 10.2870/38202

Table 3.10. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Great Britain and Denmark

Dependent variable: differences of logarithmic filtered GDP change between Great Britain and Denmark			
Method: Least squares			
Sample: 1870–1909			
	(1)	(2)	(3)
Constant	-0 (-0.1)		
$DIFF\Delta MS_{i-j}$	0.04 (0.3)		
$DIFF\Delta MS_{i-j}$ (-1)			
$DIFF\Delta INV_{i-j}$	-0.1 (1.6)		
$DIFF\Delta INV_{i-j}$ (-1)			
R-squared	0.09		
Prob. Chi-Square(0)	0.27		

Table 3.11. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between France and Norway

Dependent variable: differences of logarithmic filtered GDP change between France and Norway			
Method: Least squares			
Sample: 1871–1909			
	(1)	(2)	(3)
Constant	0 (0.4)	0 (0.2)	0 (0.4)
$DIFF\Delta MS_{i-j}$	0.29*** (2.8)	0.3** (2.5)	
$DIFF\Delta MS_{i-j}$ (-1)	0.02 (0.2)	0.1 (0.8)	
$DIFF\Delta INV_{i-j}$	-0.02 (-0.6)		-0.01 (-0.3)
$DIFF\Delta INV_{i-j}$ (-1)	0.05 (1.5)		0.03 (0.8)
R-squared	0.23	0.2	0.02
Prob. Chi-Square(1)	0.64	0.72	0.78

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Table 3.12. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Germany and Norway

Dependent variable: differences of logarithmic filtered GDP change between Germany and Norway			
Method: Least squares			
Sample: 1870–1908			
	(1)	(2)	(3)
Constant	0 (03)	-0 (-0.04)	0 (0.3)
$DIFF\Delta MS_{i-j}$	0.4 (5.6)	0.4 (5.9)	
$DIFF\Delta MS_{i-j}$ (-1)	-0.1 (1.0)	-0.14 (-2.3)	
$DIFF\Delta INV_{i-j}$	0.08 (2.9)		0.1 (2.9)
$DIFF\Delta INV_{i-j}$ (-1)	-0.01 (3.0)		0 (0.03)
R-squared	0.62	0.46	0.22
Prob. Chi-Square(1)	0.15	0.01	0.01

Table 3.13. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between France and Italy

Dependent variable: differences of logarithmic filtered GDP change between France and Italy			
Method: Least squares			
Sample: 1878–1909			
	(1)	(2)	(3)
Constant	0 (0.3)		
$DIFF\Delta MS_{i-j}$	0.3 (3.8)		
$DIFF\Delta MS_{i-j}$ (-1)	-0.4 (-5.2)		
$DIFF\Delta INV_{i-j}$	0.04 (3.6)		
$DIFF\Delta INV_{i-j}$ (-1)	0.02 (2.2)		
R-squared	0.62		
Prob. Chi-Square(1)	0.06		

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European University Institute DOI: 10.2870/38202

Table 3.14. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Germany and Italy

Dependent variable: differences of logarithmic filtered GDP change between Germany and Italy			
Method: Least squares			
Sample: 1878–1909			
	(1)	(2)	(3)
Constant	0 (0.13)		
$DIFF\Delta MS_{i-j}$	-0 (-0)		
$DIFF\Delta MS_{i-j}$ (-1)	0 (0.1)		
$DIFF\Delta INV_{i-j}$	0.04 (2.9)		
$DIFF\Delta INV_{i-j}$ (-1)	0.01 (1.2)		
R-squared	0.36		
Prob. Chi-Square(1)	0.2		

Table 3.15. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Great Britain and Italy

Dependent variable: differences of logarithmic filtered GDP change between Great Britain and Italy			
Method: Least squares			
Sample: 1878–1909			
	(1)	(2)	(3)
Constant	-0 (-0.1)		
$DIFF\Delta MS_{i-j}$	0.1 (0.6)		
$DIFF\Delta MS_{i-j}$ (-1)			
$DIFF\Delta INV_{i-j}$	0 (0.3)		
$DIFF\Delta INV_{i-j}$ (-1)			
R-squared	0.01		
Prob. Chi-Square(0)	0.08		

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Table 3.16. OLS-estimates of the impact of differences in investments and money supply on symmetry of business cycles between Great Britain and United States.[91]

Dependent variable: differences of logarithmic filtered GDP change between Great Britain and United States			
Method: Least squares			
Sample: 1875–1909			
	(1)	(2)	(3)
Constant	0 (0.15)	-0 (-0.1)	0 (0.2)
$DIFF\Delta MS_{i-j}$	-0.06 (-0.4)	0.2 (1)	
$DIFF\Delta MS_{i-j}$ (-1)	0.14 (0.97)	-0.2 (1)	
$DIFF\Delta INV_{i-j}$	0.4 (6.5)		0.36 (6.7)
$DIFF\Delta INV_{i-j}$ (-1)	-0.1 (-1.9)		-0.1 (-1.9)
R-squared	0.59	0.04	0.58
Prob. Chi-Square(1)	0.87	0.8	0.85

[91] The first differences of all variables in the equations are stationary at 1 % of significance.

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The 3rd essay of the thesis

Didn't even gold bring stability?

Endogenous money supply, expanding banking and volatile international capital flows during the first period of globalization, 1850 – 1913

Jyrki Johannes Lessig

Abstract

The paper studies the possibility that money supply was determined endogenously in the advanced European economies in the late 19th century; the evolution of banking as a cause of that endogeneity, and the consequences of this development on capital flows between countries participating in the pre-First World War gold standard. It is found that money was supplied by the private banking sector independently of the gold stocks and independently of central banks' monetary policy, rendering the financial system unstable. What enabled this development was that banks became bigger and more able to acquire capital, especially after the emergence of joint-stock banking companies, coincidentally in the period when almost every country joined the gold standard. It is also found that money supply in financially advanced countries was connected with indebtedness of peripheral countries.

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DOI: 10.2870/38202

1. Introduction

Ten years ago Professor Andrew Rose said that the literature on financial crises was in crises itself.[92] Following the repeated turmoil of the 1980s and 1990s, the economics profession had done a huge amount of research in the area, yet it had "left us with remarkably few concrete results", as Andrew Rose noted. The events of the last years, the subprime crises which started in the United States and soon spread world-wide, and its aftermath in Europe, the sovereign debt crises, will apparently increase the literature. Still the same applies today as ten years ago: we don't have a very good understanding of what causes these crises.

There is a need for a general model which connects evolution of banking, money supply and financial crises in a way which is not based on the conventional notion that money supply in advanced economies is controlled by the central bank's policies or another kind of anchor, like gold stock. The possibility that money supply is endogenous, and that it has been endogenous ever since our financial systems reached a sufficiently developed level in the 19th century, could be the starting point in improving our descriptions and explanations of the crises.

The possibility that money supply could be an endogenous process within the financial system is a too insufficiently explored issue among economic historians.[93] Ignoring the sparse discourse on endogeneity in economics, most of them tend to write about monetary and financial history as if money was mere paper and bullion, based on gold or currency reserves, and that the money stock circulating in the economy can be controlled by central banks. There is even less understanding of how the endogenously supplied money can create international financial crises.

[92] A panel organized by *Economic Policy* for discussing the article by Michael Bordo, Barry Eichengreen, Daniela Klingebiel and Maria Soledad Martinez-Peria, "Is the crises problem growing more severe?", Vol. 16. No. 32 (Apr., 2001).

[93] An exception is Kindleberger (1971), and a chapter in Kindleberger (1993). Still, Kindleberger's work lacks totally the empirical proof of the controversial claim of endogeneity.

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In this paper I challenge the belief that money supply was backed by central banks or gold and currency reserves the central banks had in their vaults during the gold standard period of the latter half of the 19th century. As an introduction to a treatise on endogenous money supply, I discuss the historical development of banking systems. The upshot is a model of change in financial systems: a description of back and forth going change from exogenous money supply to endogenous supply.

Then, basing on the sparse discussion among economists about endogeneity of money supply, I will elaborate a simple model in which most of the money of financially advanced economies is created by the private banking sector[94] independently of the actions or reserves of the central bank. Further, financially underdeveloped countries need to import capital from the advanced countries of the core, rendering their indebtedness dependent on the fluctuation of money supply in the core.

Using a data set of 15 countries I find clear statistical evidence in favour of the hypothesis of endogenous money supply.[95] The private banking sector's money supply was volatile both in its year-to-year fluctuation and in its long-term trends, as is illustrated in Figure 1. I also study the evolution of banking systems in these countries, trying to time the starting points of endogenous money supply in these countries. Finally, the statistical models on peripheral countries' current accounts suggest that their indebtedness and currency crises were indeed related to changes of endogenous money supply in the core of the international financial system.

At first the paper discusses the views of endogeneity and exogeneity of money supply in economics and economic historical literature. Section Three develops a general model of evolution of banking and its impact on money supply. Next, Section Four develops a model of endogenous money supply and balance of payments. The claims of the models are tested statistically in Sections Five and Six. Section Seven concludes.

[94] By private banking sector I mean what is called in the literature as private banks, joint-stock banks and savings banks.
[95] The countries are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, India, Italy, the Netherlands, Norway, Russia, Sweden and the United States.

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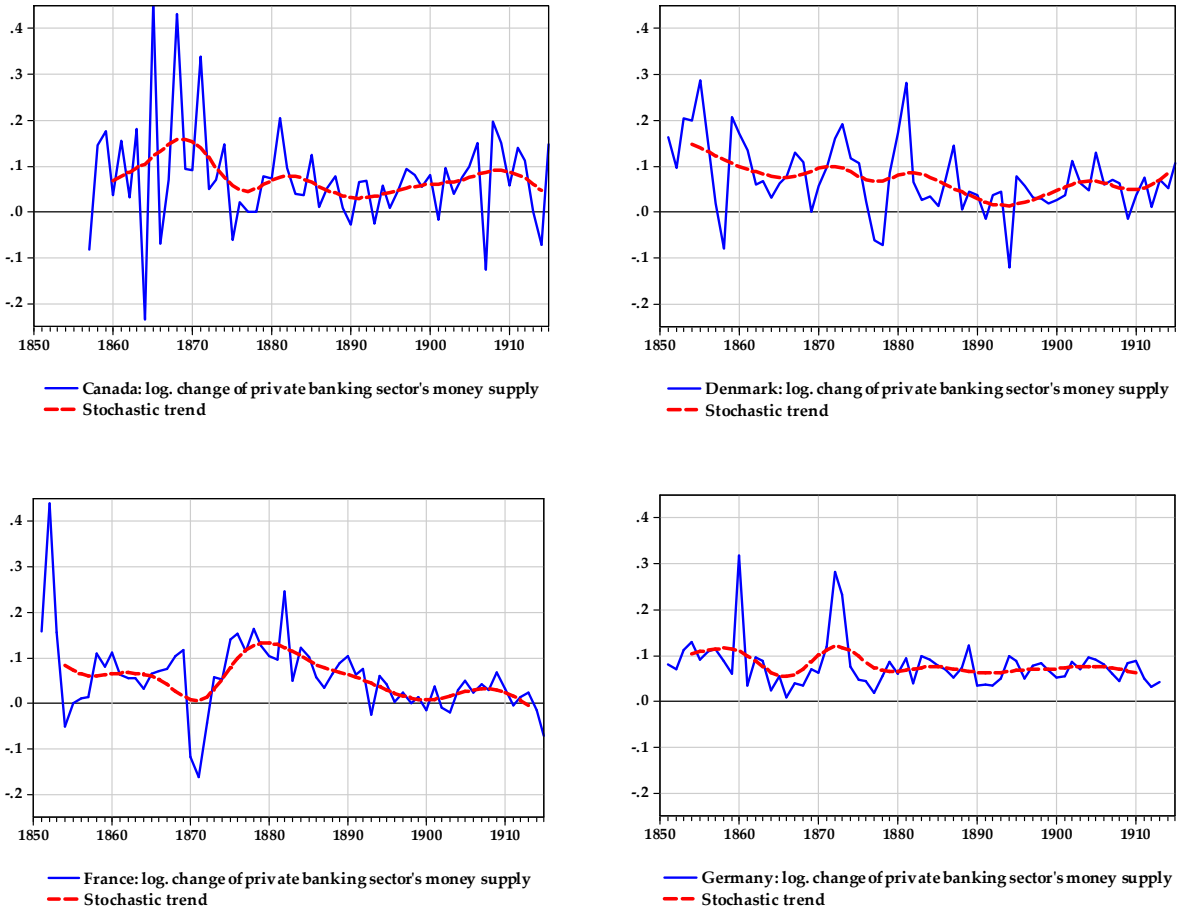
Figure 1. Logarithmic change of private banking sector's money supply in Canada, Denmark, France and Germany in the 2nd half of the 19th century



Notes: See sources of money supply in the Data Appendix of the thesis. The trends are from own calculations.[96]

2. Existing literature on money supply and capital flows

The generally accepted wisdom is that money supply is exogenous: the stock of money circulating in the economy must be backed by foreign currency reserve or – in a precious metal standard – by gold or silver reserve in the vaults of the central bank.

[96] The stochastic trend was calculated by band-pass filtering so that the resulting trend component is non-stationary with high significance and the cycle and random components are stationary with high significance.

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Classical examples of this view are the economists Milton Friedman's and Robert Barro's work.[97] The widely used text book by Paul Samuelson continues the story in the beginning of the 21st century:

> In most countries, currency is issued by central banks, while commercial banks generate the rest of the money as checking deposits. Surprisingly, however, the central bank actually controls the total supply of money.[98]

Most economic historians are satisfied to apply the view which is popular among economists. Literature on gold standard maintains in general that central bank money, and thus all money, was eventually backed by the gold reserve in the bank vaults in any country which had adhered its money to gold.[99]

The conventional view in the literature of international capital flows is that investors in the capital exporting core countries are rationally behaving and risk averse, and the borrowers in the periphery are too often irresponsible, committing themselves to excess borrowing without sound fundamentals to pay back. It is the money borrowers irresponsibility that leads to balance-of-payments problems, currency crises, and finally also to banking crises in the core.[100] The empirical approach in this literature is to study bond spreads or equity spreads of the borrowing countries to show that irresponsibly behaving countries paid higher interest on their loans.

Obstfeld and Taylor (2004) build their study of global capital markets on the same assumption of money supply: consequently their model of external balance is the conventional current account identity saying that $CA = S - I$, current account (capital account), and investments depend on saving only. There is no room for disturbances caused by changes of money supply.[101] Nevertheless, there is a recent trend in eco-

[97] See for example Friedman and Schwartz (1963 and 1982) and Barro (1979).
[98] Samuelson and Nordhaus (2001), p. 521.
[99] Examples are Eichengreen (1984) and Craig and Fisher (1997), pp. 118-121.
[100] As examples of this approach, see Bordo and Rockoff (1996), Bordo and Flandreau (2003), Flandreau and Zumer (2004), and Mauro, Sussman and Yafeh (2006).
[101] Obstfeld and Taylor (2004), p. 57–58. Still, in the introduction to the book they make the notion about the functioning of the international financial system that *market discipline often seems insufficient to deter misbehavior. Capital markets may tolerate inconsistent policies too long and then abruptly reverse course, inflicting punishments far harsher than the underlying policy "crimes" would seem to warrant*. (See page 10.) The writers do not continue to develop this idea by creating a model which would describe the mechanism how and why the markets should tolerate inconsistent policies too long.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

nomic history which is concerned with financial crises and disturbances in capital flows. Bordo and Meissner (2010) study the impact of capital flows on financial crises and incomes of emerging economies in the first era of globalization. Bordo, Cavallo and Meissner (2010) concentrate even more in sudden stops of capital inflows and their impact on financial crises. All this literature lacks a proper treatment of money supply as a potential source of instability. Money supply in the capital exporting countries is assumed to be exogenous, thus 'well behaving'.

What is the implication of the conventional wisdom of money supply – why does it lack the proper treatment of the potential source of instability? The conventional wisdom assumes that gold standard (or any modern financial system) provided an automatic or at least quasi-automatic adjustment mechanism – the scarcity of money, and thus, interest rate which rises steadily with increasing demand for money. The adjustment mechanism would bring the economy back to equilibrium, at least when helped by central bank's counter-cyclical management of interest rates. Logically, this would prevent credit booms and crises.

The conventional wisdom is not without its opponents. The first economist to argue against the above described view on money supply was Nicolas Kaldor.[102] He distinguished between two types of economies: the one using commodity money and the one using credit money. *Unlike commodity money, credit money comes into existence as a result of borrowing from banks ... and it is extinguished as a result of the repayment of bank debt.*[103] In an economy that uses credit money, the variations in the quantity of money are a consequence of changes in spending decisions of firms which request credit from banks to finance their investments. Hyman Minsky, Charles Goodhart and Victoria Chick are among the few economists who have been interested in the history of banking and money supply endogeneity are.[104] Charles Kindleberger is the outstanding economic historian who wrote about financial instability, or cycle of manias and panics as results from the pro-cyclical changes in the supply of credit.

[102] Kaldor (1970, 1980 and 1982), Kaldor and Trevithick (1981). The view that money supply is exogenous is sometimes labeled as monetarist, but actually John Maynard Keynes too neglected treatment of money supply in his *General Theory*, assuming it to be exogeneous, and choosing to render his liquidity preference theory as an explanation of economic instability. Thus the *mainstream* Keynesians also believe in exogeneity.
[103] Kaldor and Trevithick (1981, p. 7).
[104] Chick (1992), Minsky (1982) and Goodhart (2004).

DOI: 10.2870/38202

Even if Kindleberger's hypothesis, influenced by Minsky's work, states that money is primarily supplied by private banks in an instable process, it doesn't make it clear how it is possible that these banks are able to act in such a way. All this literature lacks any empirical testing of the principal assumption – that money supply would be endogenous.

In addition to the theoretical work, there is a wealth of empirical literature which touches, even though distantly and somewhat inconsistently, the issue of endogenous money supply: the studies on financial crises. The following list of literature is far from exhaustive, rather it is meant to be an illustration of the types of empirical studies in the field. Kaminsky and Reinhart (1999) studies the links between banking and currency crises in a number of industrial and developing countries in a time span covering the 1970s through 1995. Their aim is gauge whether the both crises have common macroeconomic background. The writers come close to naming endogenous money supply as a cause of the trouble: they mention "financial vulnerability as unbacked liabilities of the banking-system climb to lofty levels." The study on the same theme of financial crises is extended in Reinhart and Rogoff (2009) to include also the other kinds of financial crises in a very long historical period without a proper treatment of money supply.

Cassis (2011) studies the shaping of financial systems in the context of eight severe financial crises from the Baring Crises of 1890 to the Financial Debacle of 2007–2008. The interesting notions in the book are the way how the crises effected banks' size and ownership structure. Another interesting development illustrated by Cassis is the increasing and decreasing banking regulation after financial crises. Both of these have had an impact on money supply, though this is not a topic of Cassis' book. Grossman (2010), on the other hand, takes a look on how the volume of bank deposits has been influenced by four major elements of banking evolution: crises, mergers, bailouts, and regulation. The book studies the evolution of commercial banking over two centuries in Western Europe, the United States, Canada, Japan and Australia.

Combining the ideas and information of the literature described above, I attempt to develop models on the evolution of banking, endogenous money supply, and balance of payments problems which could contribute to better understanding of financial

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European University Institute
DOI: 10.2870/38202

phenomena, not only during the pre-First World War gold standard, but also in the last three turbulent decades. The important feature of the models is the lack of, or at least weakness of the quasi-automatic adjustment mechanism.

3. Money supply and evolution of banking

3.1 Three regimes of banking: a general view

In the following chapter I suggest a very general classification of banking systems which is based on what kind of money supply the systems induce. I define three regimes of banking according to the system's ability to supply money endogenously, and according to how the monetary authorities are able and willing to control money supply of the private banking sector. The regimes are (1) undeveloped banking under which money supply is exogenous, (2) the regime of financial innovation which allows money supply to become endogenous and (3) the regime of regulated banking which forces money supply to be determined by the central bank, meaning that it becomes exogenous.

After the initial escape from the undeveloped stage of banking, there will be regime changes back and forth between the more or less unregulated system and the regulated one, causing money supply to shift between the endogenous and exogenous type.[105] The kind of regulation which has an impact on the volume of deposits and loans may be imposed on the banks by governments and central banks, on the one hand, or by the markets, on the other hands.[106] While the market-imposed regulation tends to have

[105] Cassis (2011) gives an illustrative account of control imposed on the banking sector in 1890–2010, and its changes after eight major financial crises. Grossman (2010) offers a wealth of institutional details about the evolution of banking, including the types and ownership structures of banks and the various kinds of market and government based controls on the business of banking. Both of them fail to relate the development of banking clearly to the two types of money supply and its consequences to economic performance and stability.

[106] Grossman (2010), pp. 132, 145–157. Grossman reports declining and varying capital-to-liability ratios in 10 European and North American countries in 1840–1940. Regulation in this period is a cause of market-imposed capital requirements.

DOI: 10.2870/38202

a short lasting impact on money supply, the government-imposed rules may result in regime change which lasts several decades. [107]

3.1.1 The regime of undeveloped banking and exogenous money supply

Before the emergence of modern banking and money supply by the means of credit creation, commodity money was used as means of payment, instead the modern bank deposits.[108] There were strict rules of precious metal backing for the paper currency, not imposed by the central bank but by the banks themselves to maintain the public's trust on the bank's ability to meet its liabilities. In some rare cases the rules were not respected, banks over-issued banknotes, like John Law's bank in France around 1720.[109] These temporary and failing experiments forced, in fact, the surviving banks to follow even more rigorously the rule of strict silver or gold backing of bank liabilities. Since banks were not able to supply efficiently money for the needs of the economy, I call the system as the *regime of undeveloped banking*.

In this regime the business of supplying money was dominated by the so called private banks – financial organisations which were owned by families or by a small group of partners.[110] These banks operated under unlimited liability. Failure of the firm exposed owners to liability in excess of the money invested in the firm.[111] Such a mode of ownership and type of liability constrained the banks from acquiring large amounts of capital, and expanding their lending. The quantity of money was determined outside the financial sector of the economy by capital imports or gold production. Banks were dependent on deposits for reserves and on reserves for their lending capacity.

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[107] Cassis (2011, pp. 104–112), divides the intensity of government-imposed regulation – without mentioning explicitly capital requirements – in the period following the Baring crises to three episodes: (1) the time of weak regulation before the late 1930s, the time of financial regulation as a response to the Great Depression from the late 1930s to the late 1970s, and (3) the time of relaxed banking regulation since the 1980s. Cassis speculates on a possible new era of regulation provoked by the Financial Debacle of 2007–8.

[108] By commodity money I mean coins made of precious metals or paper currency convertible to these metals.

[109] Grossman (2010), p. 50.

[110] Examples of big private banks are *House of Rothschilds* and the *Baring Brothers* in Great Britain, the French *haute banque*, a group of some 20 banking houses based in Paris, e.g. the bank of *de Rothschild Frères*; *Bethmanns Bank* and *Mayer Amschel Rothschild's bank* in Germany. Cassis (2006), pp. 22–24.

[111] Grossman (2010), p. 29.

DOI: 10.2870/38202

In such an economy, the money supply was exogeneously determined: money was created outside of the financial sector. Saving had to precede bank loans and investments. The amount of money which could be supplied by the banking system was small and its variation was determined by factors which were external to the financial system.

3.1.2 The regime of financial innovation and endogenous money supply

A new type of bank emerged in the 1850s in Great Britain, France and Germany, and in 1820s in the United States: the joint-stock bank with limited liability for the owners.[112] The new mode of ownership enabled the bank to acquire large capital stocks and thus contributed to the significant increase in banks' size of in the coming decades.

Big banks – joint-stock or privately owned – could win the public's confidence concerning the safety of their bank notes and deposits. The liabilities did not need to have strict gold backing any more. The banks were in the position to turn to fractional reserve banking. Since there were no legal reserve requirements imposed by the government, the money supply became elastic. The linkage between the base money supplied by the central bank (often backed by silver or gold) and the total money stock in circulation disappeared. The "money multiplier" was determined by the demand for credit and loan repayment. Money supply had become endogeneously determined within the banking system.

The impact of endogenously supplied credit money was increased by the fact that the share of it exceeded considerably the share of the base money supplied by the central bank. (See Figure 2 on Great Britain, France and the United States, and Appendix 3 on Canada, Belgium, Denmark, Italy, Russia and Sweden.) The financially advanced countries shifted to the new regime at least by the early 1890s, Great Britain and Germany even before.[113]

[112] Cassis (2006), pp. 42–54. Under limited liability, if a firm fails, shareholder losses are limited to the sums invested to the firm. (Grossman (2010), p. 29)
[113] The Figure illustrates the increase of the share of exogenously supplied money, Section 5 describes the development by using co-integration test of the endogeneity.

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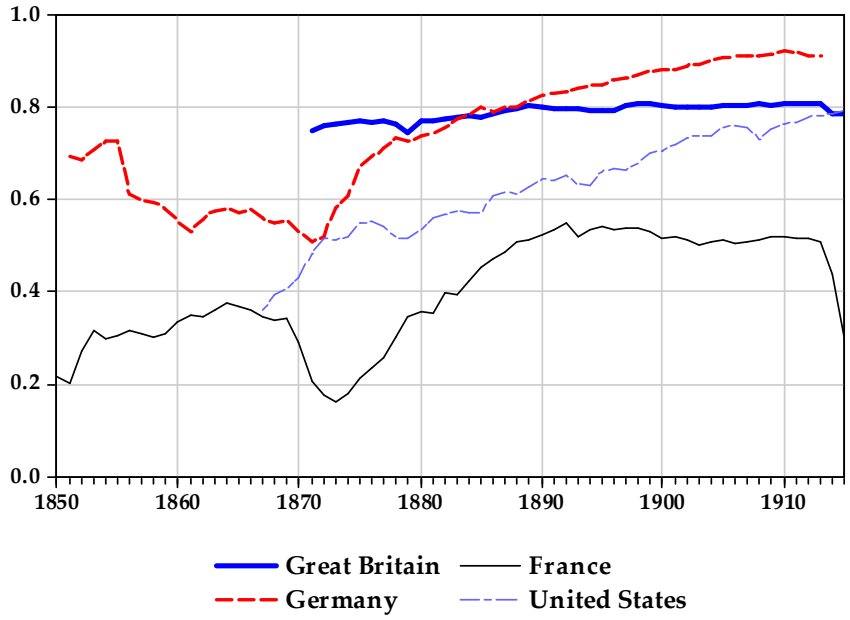
European University Institute
DOI: 10.2870/38202

Figure 2. The share of money supplied by private banking sector (i.e. private and corporate banks) in Great Britain, France, Germany and the United States, 1850–1915



Sources: See Data Appendix of the thesis.

When the monetary authority assumed the role of lender of last resort for the system as a whole – to prevent financial instability – its ability to constrain bank reserve growth disappeared. When this happened even bank reserves – in the central bank – were determined endogeneously.

3.1.3 The regime of regulated banking

After the Second World War the central banks of most European countries assumed their responsibilities of regulating money supply. They started to impose reserve requirements on the banks. The monetary authorities regained control over bank lending and the ultimate size of the money stock. The quantity of money became exogeneously determined again. If the central bank used open market operations to adjust bank reserves, its power over the money supply was enhanced.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Entrepreneurs in the financial system may discover techniques that relax the constraints imposed upon them by reserve requirements and central bank manipulation of the level of reserves. The development of an efficient system of inter-bank lending was one of these innovations: it reduces each banks' necessary level of excess reserves and allows the system as a whole to approach the maximum amount of lending for a given reserve level. Even more importantly, innovations of new forms of liabilities and assets allow banks to increase their lending for a given amount of reserves. If the monetary authorities are not able, or willing, to impose control on the new financial instruments, the money supply becomes again endogeneous.[114]

3.2 A classification of economies: sophistication of banking and the need to import capital

We still need a classification of economies on the basis of their need to import capital. The need depends on (1) the state of sophistication of their financial systems: are they able to provide the financing to employ their resources or import new resources, (2) on their state of industrialisation: how urgent is the need to import new resources, and (3) on the diversification of their export industry: how much they depended on the business cycles of the capital exporting countries to earn income for their investments.

Countries where money supply was endogenous were less likely to need capital imports. On the other hand, these countries were able to export capital.
Countries which were in the early phase of industrialisation depended heavily on capital imports, and thus the money supply of the capital exporters.
Countries which were in the early phase of industrialisation were exporters of primary products. Their export income often consisted of only a few products which prices and demand fluctuated a lot. Thus, they were prone to get indebted easily.

[114] A central theme in Cassis (2011) is the possibly ever varying increase and decrease in financial regulation.

DOI: 10.2870/38202

4. A model of endogenous money supply and balance of payments

4.1 Endogeneity of money supply

The term endogeneity of a variable in economics means that the variable's value is determined within the framework of an economic or econometric model. Consequently, money supply is said to be endogenous if its level is determined by forces within the financial system itself, such as rate of interest and business activity. The central bank does not impose any limits on the level of money supply but merely provides what is needed by private banks as notes and coins. In a similar way, also the gold stock in an economy does not impose any limits on private bank money supply.

In this chapter I will build a model of money supply, interest rate and international capital flows which is based on the story of evolution of banking in the previous chapter. There are two economies in the model: the capital exporting country (named in the literature as a country in the core of the international financial system); and the capital importing country (the label; in the literature is a country in the periphery). The regime is that of financial innovation and endogenous money supply. The economy of the capital importer functions in the regime of undeveloped banking and exogenous money supply. The economies function below their full employment equilibrium most of the time: both labour and physical capital is underemployed. Although the physical capital is underutilized, financial capital behaves in another way: it is always fully utilized. Most of the total money stock exists as bank deposits, and it is borrowed money. When borrowed money becomes redundant, it gets paid back and disappears.

The assumption of underemployment of resources is important for two reasons. At first, in such an economy monetary expansion results in increase of the real production, not in increase of price level. Second, underemployment of productive resources was a distinctive characteristic of the existing economies of the late 19th century, as well as the economies of today. Thus, the model corresponds to our observations of business cycles.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

The model, describing economies of the 19th century, is presented in terms of modern economics, like "full employment equilibrium" and "aggregate production". These concepts were not known to the financial market agents of that time, or even if there was some kind of notion of them, there were no statistics verifying them. This will be discussed at the end of the chapter.

4.2 Investments and interest rates under exogenous and endogenous money supply

Let us consider how interest rate behaves in the two alternative financial regimes. When money supply is exogenous and depends, for example, on the stock of gold in possession of the banks which lend money, increase in demand of money exhausts the gold reserves of the banks. As a result of scarcity of reserves, interest rate rises steadily until the economy reaches its full employment equilibrium. At this point rapidly rising interest rate prevents money supply exceeding the equilibrium level. (See Figure 3.) The interest rate functions as the equilibrating force. In such an economy investments are related to savings and to the change of the monetary gold stock:

$$I = S - \Delta G_m , \qquad (1)$$

where I is investments, S is savings and ΔG_m is change of monetary gold stock in the country. The causality goes from saving and gold stock to investments. The money supply equation[115] is:

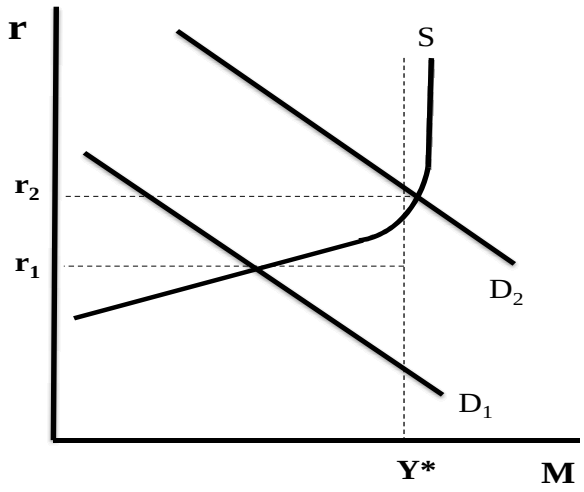
$$M^S = \frac{1}{\lambda} P_g G_m , \qquad (2)$$

where P_g is the pegged price of gold and $1/\lambda$ is the multiplier attached to the nominal value of high-powered money.

[115] See Barro (1979).

DOI: 10.2870/38202

Figure 3. Interest rate and exogenous money supply



If money supply is endogenous the banks are able to supply the demanded money without reserves. Since the demand always meets its supply in this regime increase in it may not cause any changes in interest rates, until the economy reaches its full employment equilibrium. (See Figure 4.). Before passing the equilibrium the interest rate starts rising rapidly, checking effectively the demand for money. Such a system does not offer an equilibrating mechanism against over-demand of money, until it is too late. The rise in interest rate is very sharp when demand is about to exceed the upper capacity limit of production. Sharply rising interest rate causes a contraction in economic activity, and in the worst case, financial crises.

When saving and monetary gold stock are not sufficient for financing investments, investors use the advanced banking sector's capacity to provide credit without the backing of reserves. There is a new instrument in the process of financing investments: bank deposits (*D*) which are independent of saving and monetary gold stock:

$$I = S - \Delta G_m + \Delta D\,, \qquad (3)$$

and the change in bank deposits always brings money supply into equality with money demand:

DOI: 10.2870/38202

$$M^D = M^S = \frac{1}{\lambda} P_g G_m + D. \quad (4)$$

The causality between investments and money stock is reversed to the one prevailing under exogeneity of money supply. The volume of bank deposits, and thus, money supply is a function of planned investments:

$$\Delta D = f(I). \quad (5)$$

Figure 4. Interest rate and endogenous money supply

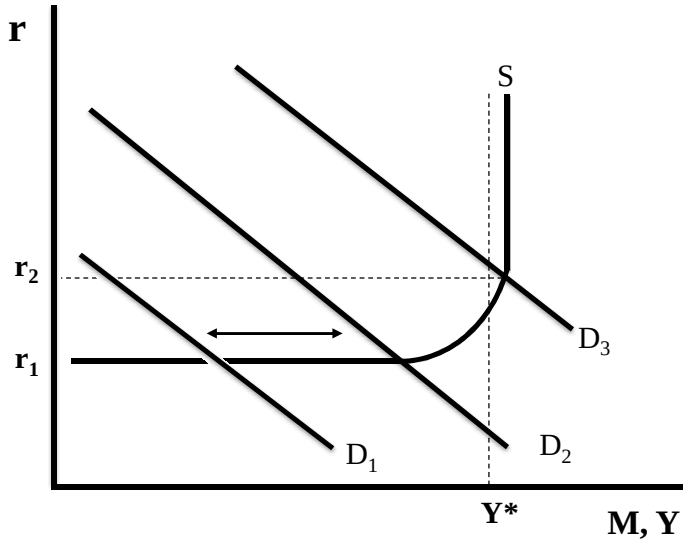


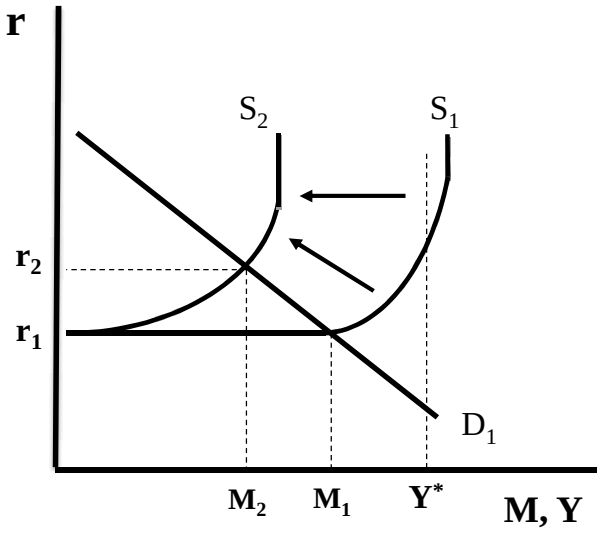
Figure 5 illustrates the financial crises scenario, which is an inseparable part of the endogenous money supply regime. If the supply schedule shifts to the left (from S_1 to S_2 in the Figure) for some reason, for example because of bank-runs, speculative panics, or sudden drops in business confidence during a normal recession, the result is a sharp and unexpected rise in interest rates (from r_1 to r_2) and strong decrease in money supply (from M_1 to M_2).

The changing shape of the money supply schedule (S) illustrates the possibility that supply becomes exogenous during the crises: the curve (S_1) which is flat even at very high levels of money supply becomes upward-sloping (S_2) even at very low levels of

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

supply. In less technical language, confidence on the banking sector has disappeared and the public wants its deposits to be backed by gold or high-powered money. When confidence is restored, the schedule becomes flat again.

Figure 5. Interest rate and endogenous money supply: a crises scenario



4.3 A model of endogenous money supply in an open economy

In an open economy, investments (purchases of investment goods) of the capital importing country are an inducement to the money demand (M^D_{ce}) in the country which exports capital. Investors in the capital exporting country borrow money for either investing in the home country or for exporting capital. The volume of bank deposits (ΔD_{ce}) is a function of planned investments at home, and capital exports:

$$\Delta D_{ce} = f(I_{ce}, KA_{ce}), \qquad (6)$$

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

where I_{ce} is investments and KA_{ce} is the capital account of the capital exporting country. Since the current account deficits (surpluses) are financed by (raise increase to) capital imports (exports) ($KA \equiv -CA$), we have the relationship between current account, investments, savings, monetary gold and bank deposits:

$$CA_{ce} = S_{ce} - \Delta G_{m,ce} - I_{ce} \pm \Delta D_{ce} \qquad \text{and} \qquad (7)$$

$$CA_{ci} = -S_{ce} + \Delta G_{m,ce} + I_{ce} \pm \Delta D_{ce}\,. \qquad (8)$$

Current account is also a function of aggregate demand so that increase in demand tends to deteriorate it: an increasing portion of additional incomes are used for buying foreign consumption and investment goods. Thus, we may write also:

$$CA = f(GDP)\,.$$

Since aggregate demand, and thus GDP is also a function of investments and money supply, we do not need it in equation (7) as a determinant of capital exporter's current account. Nevertheless, capital importer's current account is also a function of its own GDP. Thus we have:

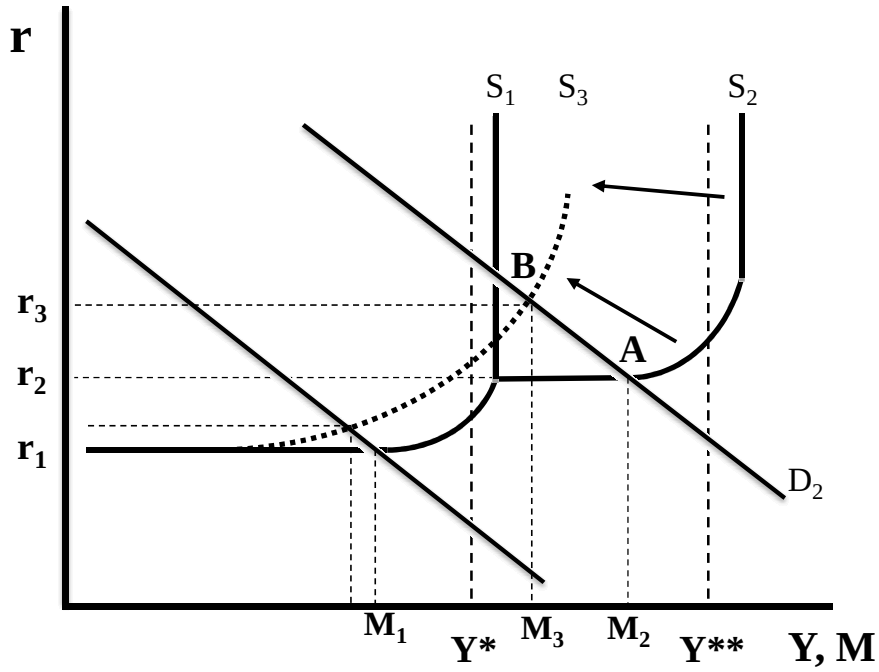
$$CA_{ci} = f(-S_{ce}, \Delta G_{m,ce}, I_{ce}, \pm\Delta D_{ce}, -GDP_{ci})\,. \qquad (9)$$

In other words, indebtedness of the capital importing country grows or diminishes jointly with the private sector banks' deposits (money supply) of the capital exporting country. Capital exports is an addition to the money supply for domestic investments, in terms of Figure 6 the addition is $M_1 + M_2$, induced by the demand schedule D_2 and the supply schedule S_2 which is correspondent with normally higher interest rate (r_2) than that prevailing with the domestic demand and supply (r_1). A financial crises changes money supply temporarily from the endogenous mode to the exogenous one, in terms of the Figure, supply curve S_2 is replaced by the steadily rising supply curve S_3. Money supply is reduced in both the capital exporting country and the capital importing country (to M_3). The loss, in terms of lent money and higher interest rate, is clearly greater in the capital importing country.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Thus, large and sudden contraction in money supply of the capital exporting country cause adjustment problems especially in the periphery, and then, in the worst case, banking crises in the very same capital exporting countries where the chain of events started.

Figure 6. Interest rate and endogenous money supply in an open economy



4.4 What was "full employment equilibrium" for the 19th century financial markets?

The model of endogenous money supply was presented in terms of modern economics, using concepts which were not known to the agents of the 19th century financial markets. What was the *full employment equilibrium* of the banker and investor of that time? Even if the agents had some kind of notion of the variables of the model, there were no statistics to measure them. Is the model useless for evaluating the behaviour of historical financial markets?

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

The investors were interested in the information of the borrowing country's ability to pay back an additional increase in its debt, whether the borrowing agent was the state or a private company. That ability to pay marginal increase in debt depends on whether the country is exceeding its productive capacity, which in our model is named as full employment equilibrium. To investors in the financial markets the indicators of the possibility of exceeding productive potential were rising prices of production inputs and squeezes profits. Thus, an approximation of a country's ability to service its debt is an approximation of the macroeconomic equilibrium.

5. Testing the premise: Was money supply endogenous during the precious-metal-standard period in 1850–1913?

5.1 The data of balance-of-payments, high-powered money, bank deposits and gold stocks

The sources of the data of balance-of-payments, high-powered money, bank deposits and gold stocks have been documented in the Data Appendix of the thesis.

The data of private sector **bank deposits** include all non-central bank deposits available: commercial bank deposits, saving bank deposits and post bank deposits. I constructed the time series of the **gold stocks** using the information in the database of *Jones and Obsfeld (2001),* selecting and splicing time series in some cases in a different way than what was done by the authors themselves. The method is described in the Appendix.

5.2 Co-integration with private sector banks' money supply: high-powered money and the gold stock

The modern theory of *exogenous* money states that the stock of money in an economy is high-powered money times the money multiplier. Money multiplier is the rate of change of money stock to the rate of change of high-powered money. It depends on

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

the bank deposit multiplier, the ratio reserves to credit imposed on the banks, which is given by the formula:

$$\Delta D = \frac{1}{c+r}\Delta R, \tag{10}$$

where *ΔR* is the initiating change in bank reserves, *ΔD* is the resulting change in bank deposits, *c* is the public's desired ratio of cash to bank deposits, and *r* is the bank's cash reserve ratio.

The change in the money stock *ΔM* (defined as cash, i.e. bank notes and coins, and bank deposits) is given by the formula:

$$\Delta M = \frac{1+c}{c+r}\Delta R. \tag{11}$$

As it was told above in section 4.2, another formulation of the theory of exogenous money supply, applicable to a currency adhered to gold, is that change of the money stock depends on change of the gold stock in possession of the central bank:

$$M^S = \frac{1}{\lambda} P_g G_m, \tag{12}$$

where P_g is the pegged price of gold and $1/\lambda$ is the multiplier attached to the nominal value of high-powered money. Since the price of gold is constant in terms of the currency, change of money stock is

$$\Delta M^S = \frac{1}{\lambda}\Delta G_m. \tag{13}$$

Now we have two tests for evaluating if money supply is exogenous, one using high-powered money and another one using gold stock. (1) If the money multiplier remains constant, the level of lending allowed for private banks, and therefore the money stock, depends on the level of central bank's high powered money. A practical way to

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

test whether money supply is exogenous or endogenous is to evaluate statistically if the time series of private bank deposits follow a common stochastic trend with the time series of high powered money, in other words, if they are co-integrated. (2) Another way to test exogeneity is to evaluate if the time series of private bank deposits follow a common stochastic trend with the time series of the gold stock in the possession of the banking sector or in the possession of the central bank. I will do the examination by using Johansen's co-integration test.

5.2.1 Co-integration tests on long periods

At first I test the existence of co-integration vectors between the time-series of private bank deposits and money supplied by the central banks (high powered money M1) in the whole period ranging from 1850 to 1913. The length of the period differs from one country to another, being as long as there is available banking data for the country in question. [116] There are two assumptions behind the choice of the time period: (1) the stage of financial development, described above in Section 3.1, is constant over the whole time period, and (2) adhering the country's currency to gold didn't have an impact on the type of money supply in that country. Thus, in the case of almost all countries there is a period in the data when the country had not adhered its currency to gold (or was in silver standard or bimetallic standard) and a period when the country had adhered its currency to gold.

Table 1 presents the results of co-integration tests for 15 countries: for Great Britain I use three time series composed by different authors. The time series are not co-integrated in the case of 10 countries. In this test, using arbitrarily long time series, there is no systematic pattern defining what kind of countries are exposed to endogenous money supply. The tests failed to tract co-integration vectors for the time series of Great Britain and France, among the financially developed capital exporting countries, but indicated the existence of a co-integrating vector for the banking series of Germany. The time series of the occasionally capital exporting but financially less de-

[116] The periods of data used for each country: Great Britain 1750–1913, France 1850–1913, Germany 1850–1913, Sweden 1850–1913, Denmark 1850–1913, Norway 1850–1913, Finland 1862–1913, Belgium 1865–1913, The Netherlands 1850–1913, Australia 1850–1913, Italy 1861–1913, Canada 1856–1913, United States 1850–1913, Russia 1870–1913 and India 1857–1913.

DOI: 10.2870/38202

veloped Netherlands had a co-integrating vector. The inconsistency concerns also the peripheral and capital importing countries: the tests failed to tract co-integration vectors for the time series of the Nordic countries, the United States, Italy, Russia and Belgium; while the time series of Australia, Canada and India are co-integrated.

The existence or non-existence of common stochastic trends among private banks deposits and high-powered money is not a conclusive requirement for making a conclusion of whether money supply should be endogenous in an economy. It may be that the private banking sector has a gold backing for its deposits, even if its money supply doesn't follow central bank's supply of high-powered money. In this case money supply should be labelled as endogenous: it would be determined exogenously by the gold supply. Thus, I tested also the possibility of co-integration among time series of private bank deposits and the gold stocks in 12 countries. (The results are reported in Table 2.) This time all the countries were in the gold standard during the test period, with the exception of Italy, while the stage of financial development is still assumed to be constant. The results are inconsistent in the same way as in the case of the previous set of tests: there is no pattern explaining existence or lack of co-integrating vectors. This time the vectors were found for six countries out of 12, which is a much bigger percentage than when co-integration was tested between private bank money and high-powered money. Among the time series of Great Britain no common stochastic trends were found, but their existence couldn't be ruled out in the cases of France and Germany. The periphery remains muddled in the same way: among the time series of five countries the tests didn't track co-integration vectors and among the time series of four countries the vectors were found. Thus, at least the possibility of endogeneity in money supply should be taken seriously.

The lack of any pattern explaining what kind of countries were exposed to endogenous money supply may be a result of regime change which took place in these countries, or some of them, in the years 1850–1913. One can make at least three hypothesis of this change:

1) The financial system shifted from the undeveloped banking (and exogenous money supply) to the regime of financial innovation (and endogenous money supply) in the test period.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

2) A major international financial crises, like the Baring crises in 1890, shifted the financial system from endogenous money supply to the regime of (market-based) regulation. The crises could have made endogenous money supply exogenous for time long enough to show up in the in the co-integration tests.
3) Joining the gold standard shifted the financial system from endogenous money supply to the regime of (market-based) regulation. The adherence to gold should have made endogenous money supply exogenous permanently until the end-year of the test period 1913.

If any of the three cases apply to a country, performing the test on the whole period is a wrong way to evaluate the type of money supply in it.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Table 1. Long-term analysis of central bank and private bank money supply: of co-integration of time series in 15 countries, varying years in 1853–1913

Country	Existence of a unit root in the time series of money supply		Co-integration of central bank and private bank money supply	Test period
	Central bank	Private banks		
Great Britain[117]	Yes	Yes	No	1874–1913
Great Britain[118]	Yes	Yes	No	1874–1913
Great Britain[119]	Yes	Yes	No	1854–1913
France	Yes	Yes	No	1853–1913
Germany	Yes	Yes	Yes	1854–1913
Sweden	Yes	Yes	No	1853–1913
Denmark	Yes	Yes	No	1853–1913
Norway	Yes	Yes	No	1858–1913
Finland	Yes	Yes	No	1865–1913
Belgium	Yes	Yes	No	1868–1913
Netherlands	Yes	Yes	Yes*	1853–1913
Australia	Yes	Yes	Yes*[120]	1859–1913
Italy	Yes	Yes	No	1864–1913
Canada	Yes	Yes	Yes[121]	1872–1913
United States	Yes	Yes	No	1870–1913
Russia	Yes	Yes	No	1873–1913
India	Yes	Yes	Yes	1865–1913

The procedure for testing the existence of a unit root: see Table 2.
Co-integration: No = the test indicates no co-integration at 5 per cent level.
Co-integration: Yes* = the test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
Co-integration: Yes = the test indicates co-integration at 1 per cent level.

[117] The data of Capie and Webber (1985).
[118] The data of Friedman and Schwartz (1982).
[119] The data of Mitchell (2000).
[120] Private bank money supply's co-integration with the gold stock.
[121] Private bank money supply's co-integration with the gold stock.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Table 2. Long-term analysis of gold stock and private bank money supply: stationarity of time series and their co-integration in 12 countries, varying years in 1853–1913

Country	Existence of a unit root in the time series		Co-integration of gold stock and private bank money supply	Test period
	Gold stock	Private banks		
Great Britain[122]	Yes	Yes	No	1874–1913
Great Britain[123]		Yes	No	1874–1913
Great Britain[124]	Yes*	Yes	No	1853–1913
France	Yes	Yes	Yes*	1853–1913
Germany	Yes	Yes	Yes	1879–1913
Sweden	Yes	Yes	Yes*	1878–1913
Denmark	Yes*	Yes	No	1876–1913
Norway	Yes	Yes	No	1866–1913
Finland	Yes	Yes	Yes	1877–1913
Australia	Yes	Yes	Yes*	1859–1913
Italy	Yes	Yes	No	1864–1913
Canada	Yes	Yes	Yes	1872–1913
United States	Yes	Yes	No	1872–1913
Russia	Yes	Yes	No	1883–1913

Yes = fail to reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 1 per cent significance level.
Yes* = reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 1 per cent significance level but fail to reject it at 5 per cent level.
No = reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 5 per cent significance level.
Co-integration: No = the test indicates no co-integration at 5 per cent level.
Co-integration: Yes* = the test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
Co-integration: Yes = the test indicates co-integration at 1 per cent level.

[122] The data of money supply is from Capie and Webber (1985).
[123] The data of money supply is from Friedman and Schwartz (1982).
[124] The data of money supply is from Mitchell (2000).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

5.2.2 Co-integration tests on two short periods: before and after 1890

Next the same exercise will be done on shorter periods, and we will see that when the time series of the two variables are co-integrated in the whole period, that may not apply for shorter periods. Consequently, we will see systematic patterns, first, one of development from exogenous to endogenous money supply and second, another one of drawing a line between financially developed and underdeveloped countries.

The dividing year is 1890? Why is that? [125] Initially I put the divide on that year to check if the Baring crises of 1890 changed the regime of money supply in the way hypothesized in the previous section. Also, by that year all the countries had adhered their currencies to gold, except Italy. If money supply was, nevertheless, endogenous in a tested country after 1890, the development of banking system in it was the strongest determinant of the type of money supply.

Tables 3 and 4 summarise the information of the tables in Appendix 1. The co-integration tests indicate endogeneity of money supply in all of the 13 countries after 1890 when the measure is co-integration with high-powered money. [126] (See Table 3.) Moreover, the tests indicate that money supply was endogenous during both test periods, before and after 1890, in Great Britain, Sweden, Finland, Italy, United States, Russia and India.

[125] I set the dividing year to be 1875 for France because of the early start of its financial development.
[126] This test was not done on the data of Australia and Canada since they did not have central banks in the test period. Endogeneity of their money supply was tested using gold stock.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Table 3. A summary of results on timing: transition to endogeneity of money supply when measured by bank deposits' relation to high-powered money

Country	Test results indicating exogeneity	Test results indicating endogeneity
Great Britain	–	1852–1913
France	1852–1875	1875–1913
Germany	1853–1890	1891–1913
Sweden	–	1852–1913
Denmark	1852–1890	1891–1913
Norway	1857–1890	1891–1913
Finland	–	1864–1913
Belgium	1867–1890	1891–1913
Netherlands	1852–1890	1891–1913
Italy	–	1864–1913
United States	–	1869–1913
Russia	–	1872–1913
India	–	1864–1913

When the measure is co-integration with the gold stock, the tests indicate endogeneity of money supply after 1890 in 10 countries of the tested 12, the only exception is Canada where money supply never got endogenous according to the data used, and possibly Germany and Russia – the test indicates co-integration only at 5 per cent level. (See Table 4.) Money supply was endogenous during both test periods in Great Britain, France, Denmark and Italy.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Table 4. A summary of results on timing: transition to endogeneity of money supply when measured by bank deposits' relation to gold stock

Country	Test results indicating exogeneity	Test results indicating endogeneity
Great Britain	–	1853–1913
France	–	1852–1913
Germany	1879–1913	(1891–1913[127])
Sweden	1877–1885	1886–1913
Denmark	–	1853–1913
Norway	1865–1890[128]	1891–1913
Finland	1877–1890[129]	1891–1913
Italy	–	1864–1913
Australia	1858-1890	1891–1914
Canada	1871–1913	-
United States	1871–1890[130]	1890–1913
Russia	(1891–1913) [131]	1883–1890

The two tests – co-integration with a country's gold stock or with central bank's high-powered money – don't give the same results for all countries in the period before 1890, which tells that those decades were a transitional time in banking. [132] Still, both sets of co-integration tests do give a picture of systematic development from exogeneity to endogeneity in money supply. The development took place independently of the country's membership in the gold standard. Instead of country's membership in the gold standard, the development of the banking system seems to have been the strongest factor determining the type of money supply.

[127] The test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
[128] The test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
[129] The test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
[130] The test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
[131] The test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
[132] The results are conflicting for Sweden, Denmark, Finland and the United States.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

5.3 Velocity of circulation and institutional change

If money supply was endogenously determined, velocity of circulation of money should be constant. Changes in aggregate demand (*Y*), and hence demand for money, would feed into changes in money supply (*M*), and velocity wouldn't change if prices (*P*) do not change, the relationship is illustrated by equation (9):

$$V = \frac{PY}{M}. \qquad (9)$$

However, velocity of circulation did change: it diminished in several European countries and the United States in the 50-year period before the First World War, with the notable exception of Great Britain.[133] At first sight this looks like evidence against the hypothesis of endogeneity of money supply. Money supply was driven by something else than aggregate demand.

It has been argued that declining velocity of the period was the result of monetization process in industrializing countries.[134] Money supply increased faster than aggregate demand (measured by the GDP) in economies which had used barter and payment in kind, in addition to money, as mediums of exchange, and where money replaced other means of exchange. Somebody may call this institutional change, somebody else may call it advance in financial sophistication, but whatever the characterization, the process took place because the previous system – or supplier of money – was not able to service the needs of the developing economy. This enability is the topic of next chapter.

[133] See Bordo and Jonung (1987 and 1989), and Craig and Fischer (1997, p. 67–74).
[134] Ibid.

DOI: 10.2870/38202

5.4 Endogenizing the regime change: why did it happen?

Why did money supply become endogenous in the 19th century in both developed and undeveloped European economies and in the United States and Australia? What was the cause of the timing: Great Britain and France first and the others a few decades after? Let us look for answers in the economic development of those countries, in their industrialization and urbanization at the end of 19th century.

There was a brief account of the change in corporate legislation in Section Three, a change which took place in several European countries between 1820s and 1860s.[135] The new laws allowed establishing of joint-stock companies, including joint-stock banks with limited liability to their owners. The new mode of ownership enabled the banks to acquire large capital stocks and thus contributed to the significant increase in their size. Big banks were in advantage of being more resistant against bank runs, and thus, could diminish their reserves on public's deposits in them. In addition, big banks were able to change their reserve ratios depending on the demand of their loans: the relationship between the bank reserves and money supplied by the banks disappeared. Why did this happen, why were the corporate laws changed?

The reason for establishment of efficient join-stock banks and for legislative changes which allowed their establishment is the demand for financial services needed to support the growth of the changing economy in the 19th century. Agriculture became commercialized, capital-intensive industries sprang up, housing and infrastructure needed to be built in growing cities, and trade commerce increased substantially. The increased demand for financing was met in part by the growth of debt and equity markets and in part by banks.[136] The fast growth and increasing complexity of economic activity raised demand for money which couldn't be satisfied anymore by inflexible gold and silver stocks or by central banks which were constrained by their reserve requirements.

[135] The first joint-stock bank in Belgium, *Societé Générale pour favoriser l'Industrie nationale* was established in 1822. A law authorized the establishment of joint-stock banks in England and Wales in 1826. Commercial banking in France began in earnest with the establishment of *Crédit Industriel et Commerciel* in 1859. Finland got its first joint stock bank *Finlands Foreningsbank* in 1862. (Grossman 2010, p. 294–295)
[136] Grossman (2010), p. 48.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

6. Money supply of the capital exporter and balance of payments of the capital importer

6.1 The hypothesis

In this section I find evidence that money supply of capital exporting countries (core) was connected with the indebtedness of the capital importing periphery. I suggested in Section 4.3 that current account is a function of money supply, change of gold stock and bank deposits, and GDP:

$$CA_{ci} = f(-S_{ce}, \Delta G_{m,ce}, I_{ce}, \pm \Delta D_{ce}, -GDP_{ci}), \quad (9)$$

where CA_{ci} is current account of the capital importing country, S_{ce} and I_{ce} are saving and investments, respectively, of the capital exporting country, $\Delta G_{m,ce}$ and ΔD_{ce} denote the change of monetary gold stock and the change of private sector bank deposits of the capital exporting country. The impact of the change of bank deposits in the core countries is ambiguous: it is positive if increase of deposits boosts commodity exports of the capital importer; it is negative if increase of deposits causes primarily capital flows.

The assumed causality goes from capital exporter's investments to capital exporter's bank deposits. This money is then offered as capital exports and it contributes to capital importer's current account:

$$I_{ce} \rightarrow D_{ce} \rightarrow CA_{ci}.$$

6.2 The long-run relationship

The relationship between capital exporter's bank deposits and capital importer's current account takes place in the long-term and in the short-term, the long-term inference producing a permanent effect on the variables. I study long-term relationships at

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

first by investigating if the time-series of money supply and current account follow common stochastic trends. The investigation is based on the capital exports of the three core countries of the international financial system, Great Britain, France and Germany (and the United States in the case of exporting capital to Canada): the tests are on the time series of levels of bank deposits in each country in the core, on the one hand, and the current accounts of a group of countries which imported capital from them, on the other hand.

The long-term relationships between bank deposits and capital imports of periphery are not similar among Great Britain, France and Germany. (See Table 5.) The time series (I_{ce} and CA_{ci}) are never co-integrated in the case of Great Britain in 1874–1913. Thus, there seems to be no permanent, unambiguous effect from British money supply to the current accounts of Australia, Canada or the United States. The same applies to the co-integration among time series of bank deposits of France and current accounts of Denmark, Norway, Sweden and Italy, suggesting that there is no permanent, unambiguous effect from French money supply to the current accounts of countries importing capital from it. If the time series of France and Italy are tested for the period 1861–1885 (the period when Italy imported capital from France instead of Germany), the result is still no co-integration. There is no co-integration among the German bank deposits and the Danish current account either, the time series of Danish current account doesn't have a unit root.

The opposite results come from the tests on the relationships among German bank deposits and the current accounts of capital importers from Germany (except Denmark). There seems to be a clear long-term relationship between German bank deposits and the current accounts of Sweden, Norway and Italy, the time series among deposits and current accounts are co-integrated at 1 percent level. The same result arises from the co-integration test on the time series of France (I_{ce}) and Russia (CA_{ci}), and the United States (I_{ce}) and Canada (CA_{ci}). Time series are co-integrated, giving support to the hypothesis that changes in the French private banking sector's deposits had an impact on Russian current account, and that changes in the United States' deposits had an impact on the Canadian current account.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

What could be the reason the inconsistency? The co-integration tests were made on long periods ranging to 40 or even 50 years. This is a time span when there were profound structural changes in the economies of both capital exporting and importing countries. Thus, the relationship among money supply and current account changed. The tests should be done on shorter periods. This will be done in the next Section which studies short-term relationships among the variables.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Table 5. Co-integration of money supply by private banks in the core countries and balance-of–payments in periphery: the first period

Great Britain and the United States, and countries importing capital from them				
Existence of unit root in the time series of the British private bank money supply: yes				
Country pair	**Test period**	**Existence of unit root in current account of the capital importing country**	**Co-integration at 5 % level**	**Co-integration at 1 % level**
Great Britain (C-W)–Australia	1873–1890	Yes	No	No
Great Britain (F-S) – Australia	1873–1890	Yes	Yes	No
Great Britain (C-W) – Canada	1874–1890	Yes	No	No
Great Britain (F-S) – Canada	1874–1895	Yes	Yes	No
Great Britain (C-W) – USA	1874–1890	Yes	No	No
Great Britain (F-S) – USA	1874–1890	Yes	No	No
USA (F-S) – Canada	1873–1890	Yes	Yes	No
France and countries importing capital from it				
Existence of unit root in the time series of the French private bank money supply: yes				
Country pair	**Test period**	**Existence of unit root in current account of the capital importing country**	**Co-integration at 5 % level**	**Co-integration at 1 % level**
France – Denmark	1876–1890	Yes	No	No
France – Norway	1867–1890	Yes	No	No
France – Italy	1863–1890	Yes	No	No
France – Russia	1885–1890	NA	NA	NA
France – Sweden	1863–1890	Yes	Yes	No
Germany and countries importing capital from it				
Existence of unit root in the time series of the German private bank money supply: yes				
Country pair	**Test period**	**Existence of unit root in current account of the capital importing country**	**Co-integration at 5 % level**	**Co-integration at 1 % level**
Germany – Denmark	1872–1890	Yes	No	No
Germany – Norway	1868–1890	Yes	No	No
Germany – Sweden	1863–1895	Yes	Yes	No

DOI: 10.2870/38202

Table 6. Co-integration of money supply by private banks in the core countries and balance-of–payments in periphery: the second period

Great Britain and the United States, and countries importing capital from them				
Existence of unit root in the time series of the British private bank money supply (CW): yes				
Country pair	**Test period**	**Existence of unit root in current account of the capital importing country**	**Co-integration at 5 % level**	**Co-integration at 1 % level**
Great Britain (C-W)–Australia	1890–1913	Yes	No	No
Great Britain (F-S) – Australia	1890–1913	Yes	No	No
Great Britain (C-W) – Canada	1890–1913	Yes	No	No
Great Britain (F-S) – Canada	1895–1913	Yes	Yes	No
Great Britain (C-W) – USA	1890–1913	Yes	No	No
Great Britain (F-S) – USA	1890–1913	Yes	No	No
USA (F-S) – Canada	1890–1913	Yes	No	No
France and countries importing capital from it				
Existence of unit root in the time series of the French private bank money supply: yes				
Country pair	**Test period**	**Existence of unit root in current account of the capital importing country**	**Co-integration at 5 % level**	**Co-integration at 1 % level**
France – Denmark	1890–1913	Yes	No	No
France – Norway	1890–1913	Yes	No	No
France – Russia	1888–1913	Yes	Yes	No
France – Sweden	1890–1913	Yes	No	No
Germany and countries importing capital from it				
Existence of unit root in the time series of the German private bank money supply: yes				
Country pair	**Test period**	**Existence of unit root in current account of the capital importing country**	**Co-integration at 5 % level**	**Co-integration at 1 % level**
Germany – Denmark	1890–1910	Yes	Yes	No
Germany – Norway	1890–1913	Yes	Yes	No
Germany – Italy	1890–1913	Yes	Yes	No
Germany – Sweden	1890–1913	Yes	No	No

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

6.3 The short-run relationship

Next I check if money supply in the core countries might have had a *short-term* impact on the current account of a capital importing country (ca_{ci}) in my sample. Tables 5–7 summarise the results of models reported in Appendix 4; the basic formulation in all of the models is:

$$ca_{ci} = \alpha + \beta_1 d_{ce1,t} + \beta_2 d_{ce1,t-1} + \beta_3 d_{ce1,t-2} + \beta_4 d_{ce2,t-1} + \beta_5 d_{ce2,t-1} + \beta_6 d_{ce2,t-2},$$
$$+ \beta_7 d_{ci,t} + \beta_8 d_{ci,t-1} + \beta_9 gdp_{ci,t} + \beta_{10} gdp_{ci,t-1} + \varepsilon \qquad (14)$$

where d_{ce1} is the logarithmic change of private sectors' bank deposits in the primary capital exporting country, d_{ce2} is the logarithmic change of private sector's bank deposits in the secondary capital exporting country, d_{ci} is the logarithmic change of the capital importer's own private sector bank deposits, gdp_{ci} is the gross domestic product of the capital importer, *t*, *t-1* and *t-2* are lag operators and ε is the residual of the model. The coefficients of the models mean the average percentage-point change of the current account per GDP (of the capital importing country) when private sector banks' deposit ratio of GDP increases one percentage point. The coefficients may be high: even small changes in the volume of banks deposits of a big country causes large changes in a small capital importing country.

The coefficients of a capital exporting country's bank deposits are negative and significant according to two criteria: (1) when the capital exporting country was in its industrialisation period and needed urgently foreign capital for building its industrial or transporting infrastructure, and (2) when the economy of the capital importing country was small compared to the economy and banking sector of the capital exporting countries. There is, nevertheless, a contradicting influence: if the money supply of a capital importer becomes endogenous, one would expect this to weaken the connection between its current account and capital exporters' money supply. Peripheral capital importing country's own money supply (change of private banking sector's deposits) should, at least to some extent, replace the influence of capital exporters' money supply. The coefficients should be negative also here: increase in domestic

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

money supply would be used for importing capital and consumer goods, thus deteriorating the current account.

According to the results reported in Appendix Tables 3.1–3.20 and in the summary Table 7, the impact of demand for credit in the developing countries was stronger than their own banking sectors ability to supply it. The first case was stronger than the last one. The countries where the change of current account was associated negatively with the change of the volume of core countries' bank deposits are Australia (importing capital from Great Britain), Canada (when importing from the United States), Denmark (when importing from Great Britain before 1890), Norway (when importing from Great Britain or Germany after 1890), Sweden (when importing from Germany), Italy (when importing from Germany after 1880) and Russia (when importing from France after 1890).

The countries where, and periods when, current accounts were not related statistically with the three core countries' bank deposits were the United States, Denmark (after 1890) and Norway (before 1890). The United States was already a large economy during the estimation period (1875–1913) and it created its own developed capital markets in the last decades of 19th century, although it also needed capital imports, specifically from Great Britain.[137] Its own considerably large money supply could suppress the impact of the British capital imports.

[137] Cassis (2006, p. 115) tells, citing Davis and Cull (1994), that between 1799 and 1914 foreign investment made less than a 5 % contribution to the huge domestic accumulation of capital in the United States.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Table 7. Summary of results from models explaining current account with private banking sector's money supply and GDP growth

Dependent variable: each country's current account				
	Before 1890		After 1890	
The country which current account is explained	Explanatory variable: private banks' money supply in …	Explanatory variable: country's own GDP growth	Explanatory variable: private banks' money supply in …	Explanatory variable: country's own GDP growth
Australia (See Appendix Tables 3.1–3.2)	Own: negative Great Britain: negative / positive	No	Own: negative Great Britain: negative	No
Canada (See Appendix Tables 3.3–3.4)	United States: negative	No	Own: negative United States: negative	Negative
United States (See Appendix Tables 3.5–3.6)	Own: negative	No	Own: negative Great Britain: positive	Positive (one-year lag)
Denmark (See Appendix Tables 3.7–3.8)	Own: negative France: positive	Yes	Own: negative	No
Norway (See Appendix Tables 3.9–3.10)	No	No	Great Britain: negative (two-year lag) Germany: negative (one to two-year lag)	No
Sweden (See Appendix Tables 3.11–3.13)	Germany: negative	No	Germany: negative	No
Italy (See Appendix Tables 3.14–3.15)	No	No	Germany: negative	No
Russia (See Appendix Table 3.16)	NA	NA	France: negative	Yes, positive
Great Britain (See Appendix Tables 3.17–3.18)	Own: negative	Positive (one-year lag)	Own: negative	Positive (one-year lag)
France (See Appendix Table 3.19)	Own: positive	No	Own: positive	No
Germany (See Appendix Table 3.20)	? (autocorrelated residuals in the model)		? (autocorrelated residuals in the model)	

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Norway, on the other hand, did not have a sophisticated financial sector before the First World War, thus its own money supply couldn't have a role in satisfying the demand for money. But, that demand appeared there only in the early 1890s when the country started to industrialize. Before the start of industrialization neither domestic or British and German money supply played a role in determining Norway's capital imports.[138] The demand for money appeared after 1890 when Norway started to industrialize. For that period the statistical models find a significant statistical relation among Norway's capital imports and changes in private sector banks' money supply in Germany and Great Britain: increase in money supply in the core contributed to increase of indebtedness the Norwegian economy.[139]

The case of Denmark is a bit of a puzzle, especially when compared to its neighbour Sweden. As a reaction to the crises of primary production of the 1870s and 1880s, both countries had developed or were developing advanced industrial production, food and chemical production in Denmark and metal industry in Sweden.[140] Industrialization took place to a great extent by using imported capital. As a consequence both countries got heavily indebted in the 1880s and 1890s. (See Figure 7.) Still, they seem to be different in their dependence on foreign capital in the 1890s and 1900s. The development of Denmark's current account is not any more related to changes in British, French or German money supply while the connection seems to continue with the Swedish current account until the end of the period. Sweden had to pay back part of its when money supply was scarce in the core and borrow more when it was abundant, but this didn't apply to Denmark.

Obviously, the need to get foreign capital in Denmark was not so urgent that it would borrow always when money supply was ample in the core. Denmark was able to finance part of its capital imports in the 1890s and 1900s by exporting high value-added food products to Great Britain, as Sweden was able to do by exporting metal, paper and machinery to Great Britain and Germany. A possible explanation for Denmark's early gained 'independence' is that its food exports were not as much tied to the busi-

[138] Norway's current account was in surplus most of the time between 1868 and 1890. See references in Appendix 1: Statistisk Sentralbyra (1953).

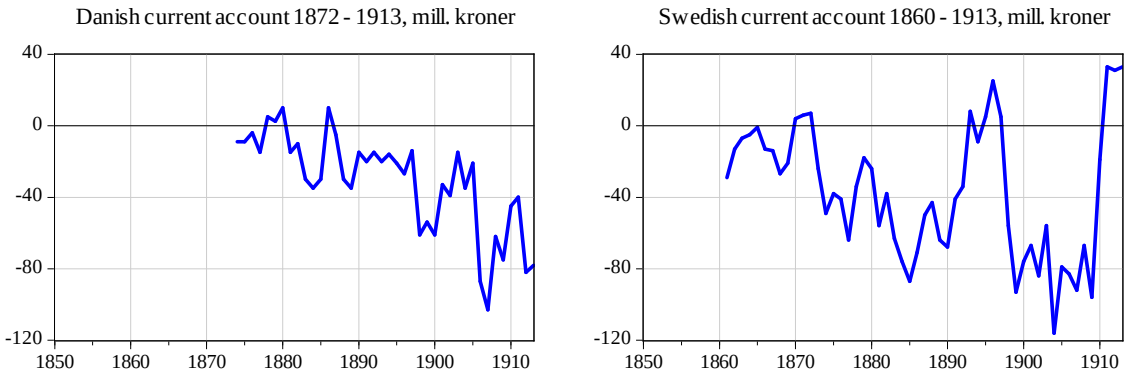
[139] See Appendix Table 4.10.

[140] Hansen (1972 and 1974) is a basic study of the Danish economic history and Schön (2000) tells about the structural changes in Sweden.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

ness cycles of the capital exporting countries as the more business-cycle bound exports of Sweden.

Figure 7. Danish and Swedish current account



Sources: See Data Appendix of the thesis.

Unlike Denmark, Australia, Canada, Norway and Russia were still in their initial period of industrialisation at the end of the estimation period in 1913. They depended on foreign financing even more than Sweden and imported capital always when it was available. This availability depended on the changes of money supply by private sector banks in Great Britain, France and Germany.

6.4 Changes of money supply in the core causing balance-of-payments problems in the periphery?

An almost conventional view in the literature of international capital flows is that investors in the capital exporting core countries are rationally behaving and risk averse, and the borrowers in the periphery are too often irresponsible, committing themselves to excess borrowing without sound fundamental to pay back. It is the money borrowers irresponsibility that leads to balance-of-payments problems, currency crises, and finally also to banking crises in the core.[141] Despite of investors' assumed rationality and the ample information about the financial state of borrowing countries, available

[141] As examples of this approach, see Bordo and Rockoff (1996), Bordo and Flandreau (2003), Flandreau and Zumer (2004).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

also in the 19th century, the problems have repeated themselves decade after decade and century after century.

This contradiction calls for another kind of understanding concerning the functioning of financial markets and international capital flows during the classical gold standard. The statistical evidence of the previous sections shows that money supply in the core countries was endogenous – that is demand-driven. It was suggested that the money was demanded by investors in the core countries willing to expand their business to developing countries. The statistical evidence also suggests that the indebtedness of the peripheral countries was indeed related to the volume of money supplied by private banks in the core. If the money supplied by the banks was demanded by investors in the core at first, and after that offered to the peripheral borrowers, the conclusion should be that it was the changes of money supply in the core that caused balance-of-payments problems in the periphery.

7. Summary and conclusions

I discussed an unconventional version of monetary theory in this paper, and I applied it to study the potential instability of the financial system during the classical gold standard period, the time when the system is conventionally supposed to have been very stable. I introduced two models which are contradicting to the conventional wisdom of banking, money supply, and international capital flows. The first model provides a stylized picture of the impact of banking evolution and financial regulation on money supply. I define financial systems to be functioning under three regimes: the Regime of Undeveloped Banking and Exogenous Money Supply, the Regime of Financial Innovation and Endogenous Money Supply, and the Regime of Regulated Banking under which money supply becomes exogenous again. The last two regimes keep swapping over in financially advanced economies.

The second model describes the interaction of money supply, interest rate and international capital flows under the Regime of Financial Innovation and Endogenous Money Supply. Money is supplied inside the financial sector of advanced core countries without the backing of gold or currency reserves in the central bank or credit

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

supplying commercial banks. Thus, the money supply process lacks the adjustment mechanism which would bring the economy back to equilibrium before an excessive and harmful credit boom – the scarcity of money, and thus, interest rate which rises steadily with increasing demand for money. The model also attempts to illustrate how the banking sector of a capital exporting country tends to "push" cheap money to peripheral countries. It suggests that this process continues until heavy contractions in money supply of the capital exporting country create adjustment problems in the periphery, and then, in the worst case, a banking crises in the very same capital exporting country where the chain of events started.

To evaluate the relevance of the models, I discussed the development of financial systems in a group of European countries, the United States, Canada and Australia in the late 19th century, and the consequences of this development on the mode of money supply and capital flows between these countries. The questions were (1) did money supply become determined inside the financing sectors of these countries, instead of having been controlled by central banks and backed by the gold stocks in the banking system, and (2) did private sector banks' money supply in the financially advanced Great Britain, France and Germany have an impact on the capital flows between them and peripheral, capital importing countries.

The statistical evidence of the paper suggests that money supply became, indeed, endogenous by the end of the 19th century in most of the European countries and the United States. Money was supplied by the private banking sectors independently of the gold stocks and independently of central banks' monetary policy. Great Britain and France were in the lead of the process. The period of endogenous money supply started in these two countries at least in the 1870s. Germany, Sweden, Denmark, Norway, Finland, Belgium, the Netherlands, the United States, Australia, India and possibly Russia shifted to the new financial regime by 1890s. The non-gold standard member Italy had endogenous money supply all of the period 1861–1913, and Canada never reached it before 1914.

Changes of private sector banks' money supply in the core countries was found to have an impact on the current accounts of the countries which imported capital from them: increase in the volume of private sector banks' deposits was associated with an

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

increase in capital imports of the peripheral countries, and correspondingly decrease of the deposits was followed by decrease of capital imports in periphery in the short-run. The changes of money supply of British private sector banks had a permanent, long-run impact on the capital imports of Australia and Canada especially in 1870s and 1880s, the behaviour of French banks had an impact on the capital imports of Sweden before 1890 and on the capital imports of Russia after 1888, and changes in the money supply of German banks contributed to the indebtedness of almost all countries which had trade deficits with Germany.

The results of the study have implications on economic theory of money, and the explanations of financial historians concerning the underlying causes of financial crises. At first, the conventional belief that money supply is *in general* exogenous doesn't hold in the light of the empirical results of the paper. During the period studied, money supply was exogenous only in the underdeveloped phase of financial development. Even the heyday of the classical gold standard didn't prevent money supply to become endogenous as the development of banking provided the means to endogeneity. Since the capacity of the central bank to influence money supply is weak under the regime of financial innovation, when banking is not regulated, its policy may not be blamed for inflation or business cycles – as is claimed by some influential monetarist and neo-Austrian economists.

Further, in the context on debt crises, the results are in contradiction with the literature which points an accusing finger on money borrowing countries for their irresponsible fiscal management, and which praises the investors in the capital exporting countries as rationally behaving and risk-averse agents, who evaluate carefully the risks of lending money in the light of available information.

There are at least five issues of further research for developing the arguments presented in this paper, but which were beyond its scope.

(1) The statistical experiments need to be extended to the periods 1918–1939, 1945–1975, and the period from 1975 to the present – the division of periods is based on whether financial markets were regulated or not. My presumption is that money supply was still endogenous until 1939, but became exogenous after the Second World War due to increased regulation. This period lasted until mid-1970s, after which financial liberalization

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

allowed money supply in developed economies to function in the same way as it did there in the late 19th century.

(2) The empirical study should be extended to a larger group of countries, including those Latin American and Asiatic countries which have been so often in the centre of financial turmoil in the 20th century.

(3) Two of the theoretical claims should be verified empirically: at first, the suggestion of the model that the relation between endogenous money supply and interest rate is non-linear, and second, that the interest rate starts to rise rapidly at full-employment equilibrium. The NAIRU (Non-Accelerating Inflation Rate of Unemployment) estimates would serve as approximations of equilibrium.

(4) How do changes in money supply coincide with individual banking crises, currency crises and sovereign debt crises?

(5) This study has dealt with aggregated financial data. It would be interesting to see how deposit-reserve ratios and credit-reserve ratios develop at the level of individual banks.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

References

Barro, R.J. (1979): Money and Price Level under the Gold Standard, *Economic Journal*, March.

Bordo, Michael D., Cavallo, Alberto F., and Meissner, Cristopher M. (2007): Sudden stops: determinants and output effects in the first era of globalization, 1880–1913, NBER Working Paper 13489.

Bordo, Michael D., Cavallo, Alberto F., and Meissner, Cristopher M. (2007): Foreign capital, financial crises and incomes in the first era of globalization, *European Review of Economic History*, Vol. 15, 61–91.

Bordo, Michael J. and Flandreau, Marc (2003): Core, Periphery, Exchange Rate Regimes, and Globalization, in *Globalization in Historical Perspective*, (ed. Bordo, Michael; Taylor, Alan; Williamson, Jeffrey G.), University of Chicago Press.

Bordo, M.D. and Jonung, L. (1987): The Long-run Behaviour of the Velocity of Circulation: The International Evidence, Harvard University Press.

Bordo, M.D. and Jonung, L. (1989): The long-run behaviour of the velocity of circulation: the institutional approach revisited, NBER Working Paper No. 3204.

Bordo, M. and Rockoff, H. (1996): The Gold Standard as a 'Good Housekeeping Seal of Approval', *Journal of Economic History*, Vol. 56, No 2, June, pp. 389–428.

Cassis, Youssef (2006): *Capitals of Capital, A History of International Financial Centres, 1780–2005*, Cambridge University Press.

Cassis, Youssef (2011): *Crises and Opportunities, 1890–2010: The Shaping of Modern Finance*, Oxford University Press.

Capie, Forrest and Webber, Alan (1985): *A Monetary History of the United Kingdom, 1870–1982*, George Allen & Unwin Ltd.

Chick, Victoria (1992): *On Money, Method and Keynes: Selected Essays by Victoria Chick*, edited by P. Arestis and S.C. Dow, New York: Macmillan/St Martin's Press.

Clemens, Michael A. and Williamson, Jeffrey G. (2004): Wealth bias in the first global capital market boom, 1870–1913, *The Economic Journal*, Vol. 114 (April), 304–337.

Craig, Lee A. and Fisher, Douglas (1997): *The Integration of the European Economy, 1850–1913*, Ipswich Book Company Ltd.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Davis, L.E. and Cull, R.J. (1994): *International Capital Markets and American Economic Growth 1820–1914*, Cambridge.

Eichengreen, Barry (1984): Central Bank Cooperation under the Interwar Gold Standard, *Explorations in Economic History* 21, 64–87.

Flandreau, Marc and Zumer, Frédérik (2004): *The Making of Global Finance 1880–1913*, OECD.

Friedman, Milton and Schwartz, Anna (1963): *A Monetary History of the United States 1867–1960*, Princeton University Press.

Friedman, Milton and Schwartz, Anna (1982): *Monetary Trends in the United States and the United Kingdom, Their Relation to Income, Prices and Interest Rates, 1867–1975*, University of Chicago Press.

Goodhart, Charles (1988): *The Evolution of Central Banks*, The MIT Press.

Goodhart, Charles (2004): A model to analyse financial fragility, *LSE Financial Markets Group discussion paper series*, no. 492.

Grossman, Richard (2010): *Unsettled Account: the evolution of banking in the industrialized world since 1800*, Princeton University Press.

Hansen, Svend Aage (1972): *Økonomisk vækst i Danmark*, Bind I: 1720–1914, Akademisk forlag.

Hansen, Svend Aage (1974): *Økonomisk vækst i Danmark*, Bind II, Akademisk forlag.

Huffman, Wallace E. and Lothian, James (1980): Money in the United Kingdom, 1833–80, *Journal of Money, Credit and Banking*, Vol. 12, No. 2, Part 1 (May, 1980, pp. 155–174.

Jones, Matthew T. and Obstfeld, Maurice (2001): Saving, Investment, and Gold: A Reassessment of Historical Current Account Data, in *Money, Capital Mobility, and Trade: Essays in Honor of Robert Mundell*, ed. Guillermo A. Calvo, Rudi Dornbusch and Maurice Obstfeld, MIT Press.

Jones, Matthew T. and Obstfeld, Maurice (2001), the database:
http://www.nber.org/databases/jones-obstfeld/

Kaldor, Nicolas (1970): The new monetarism, *Lloyds Bank Review*, 97, pp. 1 – 17.

Kaldor, Nicolas (1980): Monetarism and the UK monetary policy, *Cambridge Journal of Economics*, 4:4.

Kaldor, N. and Trevithick, J. (1981): A Keynesian perspective on money, *Lloyds Bank Review*, 108, January, pp. 1 – 19.

DOI: 10.2870/38202

Kaminsky, Graciela L. and Reinhart, Carmen M. (1999): The Twin Crises: The Causes of Banking and Balance-of-Payments Problems, *The American Economic Review*, Vol. 89, No. 3 (Jun., 1999), pp. 473–500.

Kindleberger, Charles P. (1971): *Manias, Panics and Crashes: A History of Financial Crises*, Basic Books.

Kindleberger, Charles P. (1993): *A Financial History of Western Europe*, 2nd ed., Oxford University Press.

Mauro, Paolo; Sussman, Nathan and Yasef, Yishay (2006): *Emerging Markets and Financial Globalization. Sovereign Bond Spreads in 1870–1913 and Today*, Oxford University Press.

Minsky, Hyman P. (1975): *John Maynard Keynes*, Columbia University Press.

Minsky, Hyman P. (1982): *Can "It" Happen Again? Essays on Instability and Finance*, M.E. Sharpe.

Niggle, Christopher J. (1990): The Evolution of Money, Financial Institutions, and Monetary Economics, *Journal of Economic Issues*, Vol. XXIV, No. 2, June.

Obstfeld, Maurice and Taylor, Alan M. (2004): *Global Capital Markets. Integration, Crises, and Growth*, Cambridge University Press.

Reinhart, Carmen R. and Rogoff, Kenneth (2009): *This time is different: eight centuries of financial folly*, Princeton University Press.

Russian Central Bank: http://www.cbr.ru/eng/today/history/empire_bank.asp.

Samuelson, Paul and Nordhaus, William D. (2001): *Economics*, McGraw-Hill.

Schön, Lennart (2000): *En modern svensk ekonomisk historia. Tillväxt och omvandling under två sekel*, SNS Förlag.

Taylor, Lance and O'Connell, Stephen (1985): A Minsky Crises, *The Quarterly Journal of Economics*, Vol. 100, Supplement.

DOI: 10.2870/38202

Appendix 1. Long-term analysis of endogeneity of money supply: results of co-integration tests

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Appendix Table 1.1. Long-term analysis of central bank and private bank money supply: co-integration of time series in 15 countries, varying years in 1850–1890

Country	Existence of a unit root in the time series of money supply		Co-integration of central bank and private bank money supply	Test period
	Central bank	Private banks		
Great Britain[142]	Yes	Yes	No	1873–1890
Great Britain[143]	Yes	Yes	No	1873–1890
Great Britain[144]	Yes	Yes	No	1853–1890
Great Britain[145]	Yes	Yes	No	1853–1875
France	Yes	Yes	No	1850–1890
France	Yes	Yes	Yes	1852–1875
Germany	Yes	Yes	Yes	1853–1890
Sweden	Yes	Yes	No	1852–1890
Sweden	Yes	Yes	No	1852–1875
Denmark	Yes	Yes	No	1852–1890
Denmark	Yes	Yes	No	1852–1875
Norway	Yes	Yes	Yes	1857–1890
Finland	Yes	Yes	No	1864–1890
Belgium	Yes	Yes	Yes	1867–1890
Netherlands	Yes	Yes	Yes	1852–1890
Italy	Yes	Yes	No	1864–1890
United States	Yes	Yes	No	1869–1890
Russia	Yes	Yes	No	1872–1890
India	Yes	Yes	No	1864–1890

The procedure for testing the existence of a unit root: see Table 3.
Co-integration: No = the test indicates no co-integration at 5 per cent level.
Co-integration: Yes* = the test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
Co-integration: Yes = the test indicates co-integration at 1 per cent level.

[142] The data of Capie and Webber (1985).
[143] The data of Friedman and Schwartz (1982).
[144] The data of Mitchell (2000).
[145] The data of Mitchell (2000).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Appendix Table 1.2. Long-term analysis of central bank and private bank money supply: co-integration of time series in 15 countries, 1891–1913

Country	Existence of a unit root in the time series of money supply		Co-integration of central bank and private bank money supply	Test period
	Central bank	Private banks		
Great Britain[146]	Yes	Yes	No	1891–1913
Great Britain[147]	Yes	Yes	No	1891–1913
France	Yes	Yes	No	1891–1913
Germany	Yes	Yes	No	1891–1913
Sweden	Yes	Yes	No	1891–1913
Denmark	Yes	Yes	No	1891–1913
Norway	Yes	Yes	No	1891–1913
Finland	Yes	Yes	No	1891–1913
Belgium	Yes	Yes	No	1891–1913
Netherlands	Yes	Yes	No	1891–1913
Italy	Yes	Yes	No	1891–1913
United States	Yes	Yes	No	1891–1913
Russia	Yes	Yes	No	1891–1913
India	Yes	Yes	No	1891–1913

Yes = fail to reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 1 per cent significance level.
Yes* = reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 1 per cent significance level but fail to reject it at 5 per cent level.
No = reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 5 per cent significance level.
Co-integration: No = the test indicates no co-integration at 5 per cent level.
Co-integration: Yes* = the test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
Co-integration: Yes = the test indicates co-integration at 1 per cent level.

[146] The data of Capie and Webber (1985).
[147] The data of Friedman and Schwartz (1982).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute
DOI: 10.2870/38202

Appendix Table 1.3. Long-term analysis of gold stock and private bank money supply: stationarity of time series and their co-integration in 17 countries, varying years in 1850–1890

Country	Existence of a unit root in the time series		Co-integration of gold stock and private bank money supply	Test period
	Gold stock	Private banks		
Great Britain[148]	Yes	Yes	No	1873–1890
Great Britain[149]		Yes	No	1873–1890
Great Britain[150]	Yes	Yes	No	1853–1890
Great Britain[151]	Yes	Yes	No	1853–1875
France	Yes	Yes	No	1852–1890
Germany	Yes	Yes	Yes	1853–1890
Sweden	Yes	Yes	Yes	1877–1890
Denmark	Yes*	Yes	No	1875–1890
Norway	Yes	Yes	Yes*	1865–1890
Finland	Yes	Yes	Yes*	1877–1890
Australia	Yes	Yes	Yes	1858–1890
Italy	Yes	Yes	No	1864–1890
Canada	Yes	Yes	Yes	1871–1890
United States	Yes	Yes	Yes*	1871–1890
Russia	Yes	Yes	–	–

The procedure for testing the existence of a unit root: see Table 3.
Co-integration: No = the test indicates no co-integration at 5 per cent level.
Co-integration: Yes* = the test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
Co-integration: Yes = the test indicates co-integration at 1 per cent level.

[148] The data of money supply is from Capie and Webber (1985).
[149] The data of money supply is from Friedman and Schwartz (1982).
[150] The data of money supply is from Mitchell (2000).
[151] The data of money supply is from Mitchell (2000).

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Appendix Table 1.4. Long-term analysis of gold stock and private bank money supply: stationarity of time series and their co-integration in 17 countries, 1891–1913

Country	Existence of a unit root in the time series		Co-integration of gold stock and private bank money supply	Test period
	Gold stock	Private banks		
Great Britain[152]	Yes*	Yes	No	1891–1913
Great Britain[153]		Yes	No	1891–1913
France	Yes	Yes	No	1891–1913
Germany	Yes	Yes	Yes*	1891–1913
Sweden	Yes	Yes	No	1891–1913
Denmark	Yes*	Yes	No	1891–1913
Norway	Yes	Yes	No	1891–1913
Finland	Yes	Yes	No	1891–1913
Australia	Yes	Yes	No	1891–1913
Italy	Yes	Yes	No	1891–1913
Canada	Yes	Yes	Yes	1891–1913
United States	Yes	Yes	No	1891–1913
Russia	Yes	Yes	Yes*	1891–1913

Yes = fail to reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 1 per cent significance level.
Yes* = reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 1 per cent significance level but fail to reject it at 5 per cent level.
No = reject the null hypothesis of H_0: $\rho = 1$ against the one-sided alternative of H_1: $\rho < 1$ at 5 per cent significance level.
Co-integration: No = the test indicates no co-integration at 5 per cent level.
Co-integration: Yes* = the test indicates co-integration at 5 per cent level but no co-integration at 1 per cent level.
Co-integration: Yes = the test indicates co-integration at 1 per cent level.

[152] The data of money supply is from Capie and Webber (1985).
[153] The data of money supply is from Friedman and Schwartz (1982).

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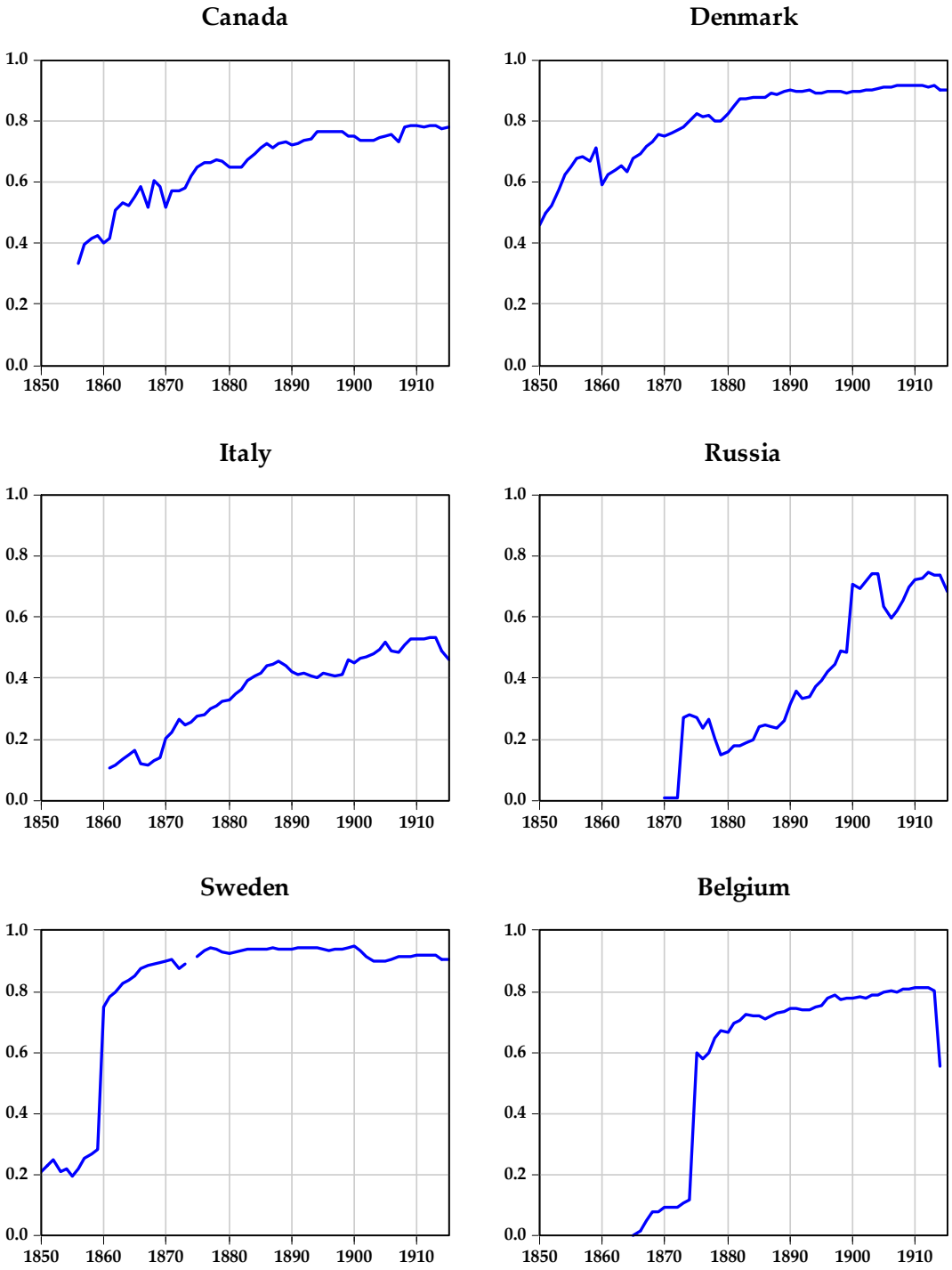
Appendix 2. The share of private sector banks' money supply of the total money supply in six peripheral countries



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Appendix 3. Statistical models for tracking the influence of the core countries' (Great Britain, France and Germany) private banking sector's money supply on the balance of payments of peripheral countries (Australia, Canada, United States, Denmark, Norway, Sweden, Italy and Russia) and their own balance-of-payments.

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Appendix Table 3.1: A model of Australia's current account and private banks' deposits

Variables:

AUS_DPCAO3 = relative change of current account[154]

AUS_DLPRIV = log. change of private bank deposits in Australia

UK_DLPRIVF_GDP = log. change of private bank deposits in Great Britain (data by Friedman and Schwartz)

AUS_DLGDPCU = log. change of Australian gross domestic product in current prices

Dependent Variable: AUS_DPCAO3
Method: Least Squares
Sample (adjusted): **1874 1890**
Included observations: 17 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.561743	0.630077	0.891547	0.3936
AUS_DLPRIV	-23.44316	5.866891	-3.995841	0.0025
AUS_DLPRIV(-1)	8.732394	5.130192	1.702157	0.1196
UK_DLPRIVF	33.06301	11.23622	2.942538	0.0147
UK_DLPRIVF(-1)	-46.63619	15.19932	-3.068308	0.0119
UK_DLPRIVF(-2)	25.59126	12.88643	1.985908	0.0751
AUS_DLGDPCU	-11.68293	8.818354	-1.324842	0.2147

R-squared	0.864910	Mean dependent var	-0.639154
Adjusted R-squared	0.783857	S.D. dependent var	2.442057
S.E. of regression	1.135342	Akaike info criterion	3.384647
Sum squared resid	12.89002	Schwarz criterion	3.727735
Log likelihood	-21.76950	Hannan-Quinn criter.	3.418750
F-statistic	10.67082	Durbin-Watson stat	2.026825
Prob(F-statistic)	0.000744	Prob. Chi-Square(2)	0.93

[154] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

DOI: 10.2870/38202

Appendix Table 3.2: A model of Australia's current account and private banks' deposits

Variables:

AUS_DPCAO3 = relative change of current account[155]

AUS_DLPRIV = log. change of private bank deposits in Australia

UK_DLPRIVF_GDP = log. change of private bank deposits in Great Britain (data by Friedman and Schwartz)

AUS_DLGDPCU = log. change of Australian gross domestic product in current prices

Dependent Variable: AUS_DPCAO3
Method: Least Squares
Sample: **1890 1913**
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.958838	1.687042	1.753862	0.0975
AUS_DLPRIV	-1.689678	16.78963	-0.100638	0.9210
AUS_DLPRIV(-1)	-30.68744	17.46376	-1.757208	0.0969
UK_DLPRIVF	-70.32731	35.09034	-2.004179	0.0612
UK_DLPRIVF(-1)	35.21841	36.81000	0.956762	0.3521
UK_DLPRIVF(-2)	-4.031531	34.91883	-0.115454	0.9094
AUS_DLGDPCU	4.745105	7.481124	0.634277	0.5343

R-squared	0.322009	Mean dependent var	-0.238490
Adjusted R-squared	0.082718	S.D. dependent var	2.579704
S.E. of regression	2.470708	Akaike info criterion	4.885379
Sum squared resid	103.7747	Schwarz criterion	5.228978
Log likelihood	-51.62455	Hannan-Quinn criter.	4.976536
F-statistic	1.345679	Durbin-Watson stat	2.276988
Prob(F-statistic)	0.291289	Prob. Chi-Square(2)	0.72

[155] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.3: A model of Canada's current account and private banks' deposits

Variables:

CA_DPCAO3 = relative change of current account[156]

CA_DLPRIV = log. change of private bank deposits in Canada

UK_DLPRIVC = log. change of private bank deposits in Great Britain (data by Capie and Webber)

US_DLPRIVF = log. change of private bank deposits in the United States (data by Friedman and Schwartz)

CA_DLGDPCU = log. change of Canadian gross domestic product in current prices

Dependent Variable: CA_DPCAO3
Method: Least Squares
Sample (adjusted): **1872 1890**
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.148454	0.052068	2.851159	0.0146
CA_DLPRIV	-0.962426	0.623818	-1.542799	0.1488
CA_DLPRIV(-1)	-0.614069	0.507169	-1.210778	0.2493
UK_DLPRIVC	1.832161	1.322578	1.385295	0.1912
US_DLPRIVF	-0.477037	0.575090	-0.829500	0.4230
US_DLPRIVF(-1)	-1.303939	0.492625	-2.646922	0.0213
CA_DLGDPCU	-0.445372	0.756404	-0.588803	0.5669

R-squared	0.759131	Mean dependent var	-0.053522
Adjusted R-squared	0.638696	S.D. dependent var	0.231706
S.E. of regression	0.139275	Akaike info criterion	-0.827423
Sum squared resid	0.232770	Schwarz criterion	-0.479472
Log likelihood	14.86052	Hannan-Quinn criter.	-0.768536
F-statistic	6.303254	Durbin-Watson stat	1.868431
Prob(F-statistic)	0.003448	Prob. Chi-Square(1)	0.99

[156] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

DOI: 10.2870/38202

Appendix Table 3.4: A model of Canada's current account and private banks' deposits

Variables:

CA_DPCAO3 = relative change of current account[157]

CA_DLPRIV = log. change of private bank deposits in Canada

UK_DLPRIVC = log. change of private bank deposits in Great Britain (data by Capie and Webber)

US_DLPRIVF = log. change of private bank deposits in the United States (data by Friedman and Schwartz)

CA_DLGDPCU = log. change of Canadian gross domestic product in current prices

Dependent Variable: CA_DPCAO3
Method: Least Squares
Date: 09/20/11 Time: 15:15
Sample: **1890 1913**
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.039071	0.102867	0.379822	0.7091
CA_DLPRIV	0.128686	0.612469	0.210111	0.8362
CA_DLPRIV(-1)	-1.514087	0.776280	-1.950438	0.0689
UK_DLPRIVC	3.581792	2.880276	1.243559	0.2316
UK_DLPRIVC(-1)	2.115402	2.698355	0.783960	0.4445
US_DLPRIVF	-1.551774	0.819429	-1.893726	0.0765
CA_DLGDPCU	1.566369	1.144189	1.368977	0.1899
CA_DLGDPCU(-1)	-3.347175	0.884422	-3.784590	0.0016

R-squared	0.688920	Mean dependent var	-0.125324
Adjusted R-squared	0.552823	S.D. dependent var	0.283116
S.E. of regression	0.189324	Akaike info criterion	-0.229518
Sum squared resid	0.573494	Schwarz criterion	0.163167
Log likelihood	10.75421	Hannan-Quinn criter.	-0.125338
F-statistic	5.061970	Durbin-Watson stat	1.748484
Prob(F-statistic)	0.003479	Prob. Chi-Square(1)	0.81

[157] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.5: A model of United States' current account and private banks' deposits

Variables:

US_DPCAO3 = relative change of current account[158]

US_DLPRIVF_GDP = log. change of private bank deposits in the United States (data by Friedman and Schwartz)

UK_DLPRIVF_GDP = log. change of private bank deposits in Great Britain (data by Friedman and Schwartz)

US_DLGDPCU = log. change of US gross domestic product in current prices

Dependent Variable: US_DPCAO3
Method: Least Squares
Sample (adjusted): **1873 1890**
Included observations: 18 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.412737	1.006722	1.403304	0.1881
US_DLPRIVF	-20.59414	10.74815	-1.916064	0.0817
US_DLPRIVF(-1)	-7.852885	10.54521	-0.744688	0.4721
UK_DLPRIVF	24.80600	32.57944	0.761400	0.4624
UK_DLPRIVF(-1)	-19.71838	30.12489	-0.654554	0.5262
US_DLGDPCU	0.732750	13.86066	0.052865	0.9588
US_DLGDPCU(-1)	15.63087	10.43751	1.497568	0.1624
R-squared	0.355004	Mean dependent var		0.152660
Adjusted R-squared	0.003188	S.D. dependent var		2.706837
F-statistic	1.009061	Durbin-Watson stat		1.921587
Prob(F-statistic)	0.466667	Prob. Chi-Square(1)		0.94

[158] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.6: A model of United States' current account and private banks' deposits

Variables:

US_DPCAO3 = relative change of current account[159]

US_DLPRIVF_GDP = log. change of private bank deposits in the United States (data by Friedman and Schwartz)

UK_DLPRIVF_GDP = log. change of private bank deposits in Great Britain (data by Friedman and Schwartz)

US_DLGDPCU = log. change of US gross domestic product in current prices

Dependent Variable: US_DPCAO3
Method: Least Squares
Sample: **1890 1913**
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.982854	1.463389	1.354973	0.1985
US_DLPRIVF	2.398195	7.871798	0.304657	0.7655
US_DLPRIVF(-1)	-16.93658	9.137977	-1.853428	0.0866
US_DLPRIVF(-2)	-11.27028	10.33985	-1.089986	0.2955
US_DLPRIVF(-3)	-20.61774	7.130865	-2.891338	0.0126
UK_DLPRIVF	-57.18702	35.20218	-1.624530	0.1282
UK_DLPRIVF(-1)	0.238091	33.71565	0.007062	0.9945
UK_DLPRIVF(-2)	63.95076	27.56707	2.319824	0.0373
US_DLGDPCU	8.557768	7.953268	1.076007	0.3015
US_DLGDPCU(-1)	21.62460	9.725395	2.223519	0.0445
US_DLGDPCU(-2)	9.343057	7.835136	1.192456	0.2544

R-squared	0.714825	Mean dependent var	0.399607
Adjusted R-squared	0.495460	S.D. dependent var	2.103843
F-statistic	3.258610	Durbin-Watson stat	2.033934
Prob(F-statistic)	0.024745	Prob. Chi-Square(3)	0.92

[159] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.7: A model of Denmark's current account and private banks' deposits

Variables:

DE_DPCAO3 = relative change of current account

FR_DLPRIV = log. change of private bank deposits in France

DE_DLGDPCU = log. change of Danish gross domestic product in current prices

Dependent Variable: DE_DPCAO3
Method: Least Squares
Sample (adjusted): **1875 1890**
Included observations: 16 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.843982	1.376698	-2.065799	0.0657
DE_DLPRIV	5.526454	5.635226	0.980698	0.3499
DE_DLPRIV(-1)	-13.41844	5.655184	-2.372768	0.0391
FR_DLPRIV	24.21516	8.823613	2.744359	0.0207
FR_DLPRIV(-1)	0.321111	7.683653	0.041791	0.9675
DE_DLGDPCU	21.60235	10.06632	2.146003	0.0575

R-squared	0.566333	Mean dependent var	-0.457093
Adjusted R-squared	0.349499	S.D. dependent var	1.920891
S.E. of regression	1.549268	Akaike info criterion	3.993439
Sum squared resid	24.00232	Schwarz criterion	4.283160
Log likelihood	-25.94751	Hannan-Quinn criter.	4.008275
F-statistic	2.611833	Durbin-Watson stat	1.881529
Prob(F-statistic)	0.092133	Prob. Chi-Square(1)	0.72

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Appendix Table 3.8: A model of Denmark's current account and private banks' deposits

Variables:

DE_DPCAO3 = relative change of current account

GE_DLPRIV = log. change of private bank deposits in Germany

FR_DLPRIV = log. change of private bank deposits in France

DE_DLGDPCU = log. change of Danish gross domestic product in current prices

de_cao3g_pri2b
Dependent Variable: DE_DPCAO3
Method: Least Squares
Sample: **1887 1913**
Included observations: 27

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.052162	1.487291	0.035072	0.9724
DE_DLPRIV	0.419491	6.363023	0.065926	0.9482
DE_DLPRIV(-1)	-12.64218	5.691641	-2.221183	0.0394
DE_DLPRIV(-2)	-3.044412	7.507506	-0.405516	0.6899
DE_DLPRIV(-3)	-1.095922	6.627733	-0.165354	0.8705
GE_DLPRIV	-2.958744	16.32656	-0.181223	0.8582
FR_DLPRIV	0.526085	10.34953	0.050832	0.9600
DE_DLGDPCU	0.995280	12.89228	0.077200	0.9393
DE_DLGDPCU(-1)	8.400625	14.18756	0.592112	0.5611

R-squared	0.255492	Mean dependent var	-0.498885
Adjusted R-squared	-0.075401	S.D. dependent var	1.342670
S.E. of regression	1.392369	Akaike info criterion	3.761092
Sum squared resid	34.89646	Schwarz criterion	4.193038
Log likelihood	-41.77475	Hannan-Quinn criter.	3.889532
F-statistic	0.772130	Durbin-Watson stat	2.437272
Prob(F-statistic)	0.631712	Prob. Chi-Square(1)	0.66

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DOI: 10.2870/38202

Appendix Table 3.9: A model of Norway's current account and private banks' deposits

Variables:

NO_DPCAO3 = relative change of current account

NO_DLPRIV = log. change of private bank deposits in Norway

GE_DLPRIV = log. change of private bank deposits in Germany

UK_DLPRIVC_GDP = log. change of private bank deposits in Great Britain (data by Capie and Webber)

SW_DLPRIV = log. change of private bank deposits in Sweden

DE_DLGDPCU = log. change of Danish gross domestic product in current prices

Dependent Variable: NO_DPCAO3
Method: Least Squares
Sample (adjusted): **1866 1889**
Included observations: 24 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1204345.	2114540.	0.569554	0.5760
SW_DLPRIV	-2608091.	20970298	-0.124371	0.9024
SW_DLPRIV(-1)	-12421848	18030448	-0.688937	0.4996
FR_DLPRIV	-6244241.	9062073.	-0.689052	0.4996
FR_DLPRIV(-1)	1204655.	9009510.	0.133709	0.8951
NO_DLGDPCU	925831.3	14662663	0.063142	0.9503

R-squared	0.043675	Mean dependent var	-41666.51
Adjusted R-squared	-0.221970	S.D. dependent var	2510485.
S.E. of regression	2775160.	Akaike info criterion	32.72263
Sum squared resid	1.39E+14	Schwarz criterion	33.01715
Log likelihood	-386.6716	Hannan-Quinn criter.	32.80077
F-statistic	0.164412	Durbin-Watson stat	2.028963
Prob(F-statistic)	0.972455	Prob. Chi-Square(1)	0.93

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Appendix Table 3.10: A model of Norway's current account and private banks' deposits

Variables:

NO_DPCAO3 = relative change of current account

NO_DLPRIV = log. change of private bank deposits in Norway

GE_DLPRIV = log. change of private bank deposits in Germany

UK_DLPRIVC_GDP = log. change of private bank deposits in Great Britain (data by Capie and Webber)

SW_DLPRIV = log. change of private bank deposits in Sweden

DE_DLGDPCU = log. change of Danish gross domestic product in current prices

Dependent Variable: NO_DPCAO3
Method: Least Squares
Sample: **1889 1913**
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.561508	0.829470	1.882536	0.0770
UK_DLPRIVC	-7.961498	9.887250	-0.805229	0.4318
UK_DLPRIVC(-1)	5.336356	11.74246	0.454450	0.6553
UK_DLPRIVC(-2)	-18.30419	10.22604	-1.789959	0.0913
GE_DLPRIV	2.038730	6.903253	0.295329	0.7713
GE_DLPRIV(-1)	-11.32981	6.827707	-1.659387	0.1154
GE_DLPRIV(-2)	-12.97232	6.363053	-2.038695	0.0573
NO_DLGDPCU	6.398540	4.864032	1.315481	0.2058

R-squared	0.443862	Mean dependent var	-0.210361
Adjusted R-squared	0.214864	S.D. dependent var	0.728938
S.E. of regression	0.645896	Akaike info criterion	2.217981
Sum squared resid	7.092089	Schwarz criterion	2.608021
Log likelihood	-19.72477	Hannan-Quinn criter.	2.326162
F-statistic	1.938282	Durbin-Watson stat	1.614910
Prob(F-statistic)	0.125522	Prob. Chi-Square(2)	0.43

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Appendix Table 3.11: A model of Sweden's current account and private banks' deposits

Variables:

SW_DPCAO3 = relative change of current account[160]

GE_DLPRIV = log. change of private bank deposits in Germany

UK_DLPRIVC = log. change of private bank deposits in Great Britain (data by Capie and Webber)

SW_DLGDPCU = log. change of Swedish gross domestic product in current prices

Dependent Variable: SW_DPCAO3
Method: Least Squares
Sample (adjusted): 1873 1885
Included observations: 13 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.520137	0.327273	1.589304	0.1631
GE_DLPRIV	-16.83081	5.754691	-2.924712	0.0265
GE_DLPRIV(-1)	5.760254	6.101002	0.944149	0.3815
UK_DLPRIVC	4.413535	4.921145	0.896851	0.4043
UK_DLPRIVC(-1)	1.947153	7.397135	0.263231	0.8012
SW_DLGDPCU	-9.196847	4.939819	-1.861778	0.1119
SW_DLGDPCU(-1)	-9.688657	5.187951	-1.867530	0.1111

R-squared	0.935079	Mean dependent var	-0.561581
Adjusted R-squared	0.870158	S.D. dependent var	1.287715
S.E. of regression	0.464011	Akaike info criterion	1.605915
Sum squared resid	1.291836	Schwarz criterion	1.910118
Log likelihood	-3.438447	Hannan-Quinn criter.	1.543387
F-statistic	14.40330	Durbin-Watson stat	1.830253
Prob(F-statistic)	0.002477	Prob. Chi-Square(1)	0.89

[160] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.12: A model of Sweden's current account and private banks' deposits

Variables:

SW_DPCAO3 = relative change of current account[161]

GE_DLPRIV = log. change of private bank deposits in Germany

UK_DLPRIV = log. change of private bank deposits in Great Britain (data by Capie and Webber)

SW_DLGDPCU = log. change of Swedish gross domestic product in current prices

Dependent Variable: SW_DPCAO3
Method: Least Squares
Date: 09/21/11 Time: 17:59
Sample: 1885 1913
Included observations: 29

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.791963	2.293552	1.217310	0.2358
GE_DLPRIV	-50.32277	24.24996	-2.075170	0.0493
GE_DLPRIV(-1)	17.15452	21.67922	0.791289	0.4369
UK_DLPRIVC	31.98407	35.65109	0.897141	0.3789
UK_DLPRIVC(-1)	-55.96492	37.72581	-1.483465	0.1515
SW_DLGDPCU	-7.814257	12.12505	-0.644472	0.5256

R-squared	0.203399	Mean dependent var	-0.194896
Adjusted R-squared	0.030225	S.D. dependent var	2.561787
S.E. of regression	2.522775	Akaike info criterion	4.870587
Sum squared resid	146.3810	Schwarz criterion	5.153476
Log likelihood	-64.62352	Hannan-Quinn criter.	4.959185
F-statistic	1.174534	Durbin-Watson stat	2.084099
Prob(F-statistic)	0.351764	Prob. Chi-Square(1)	0.82

[161] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.13: A model of Sweden's current account and private banks' deposits

Variables:

SW_DPCAO3 = relative change of current account[162]

SW_DLPRIV = log. change of private bank deposits in Sweden

GE_DLPRIV = log. change of private bank deposits in Germany

UK_DLPRIVC = log. change of private bank deposits in Great Britain (data by Capie and Webber)

SW_DLGDPCU = log. change of Swedish gross domestic product in current prices

Dependent Variable: SW_DPCAO3
Method: Least Squares
Sample (adjusted): **1873 1885**
Included observations: 13 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.320315	0.831733	0.385117	0.7198
SW_DLPRIV	8.289184	11.77325	0.704069	0.5202
SW_DLPRIV(-1)	-1.311108	8.975189	-0.146081	0.8909
GE_DLPRIV	-16.21720	6.597993	-2.457899	0.0698
GE_DLPRIV(-1)	3.984252	7.138751	0.558116	0.6065
UK_DLPRIVC	-0.676684	9.089751	-0.074445	0.9442
UK_DLPRIVC(-1)	1.309678	9.127079	0.143494	0.8928
SW_DLGDPCU	-12.84703	8.442948	-1.521628	0.2028
SW_DLGDPCU(-1)	-6.272807	7.624401	-0.822728	0.4569

R-squared	0.945562	Mean dependent var	-0.561581
Adjusted R-squared	0.836686	S.D. dependent var	1.287715
S.E. of regression	0.520393	Akaike info criterion	1.737494
Sum squared resid	1.083233	Schwarz criterion	2.128612
Log likelihood	-2.293708	Hannan-Quinn criter.	1.657101
F-statistic	8.684781	Durbin-Watson stat	1.937940
Prob(F-statistic)	0.026538	Prob. Chi-Square(1)	0.85

[162] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

DOI: 10.2870/38202

Appendix Table 3.14: A model of Italy's current account and private banks' deposits: the period when Italy imported capital from France, 1874–1885

Variables:

IT_DPCAG3 = relative change of the Italian current account[163]

IT_DLPRIV = log. change of private bank deposits in Italy

FR_DLPRIV = log. change of private bank deposits in France

IT_DLGDPCU = log. change of Italian gross domestic product in current prices

Dependent Variable: IT_DPCAO3
Method: Least Squares
Sample (adjusted): **1874 1885**
Included observations: 12 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.603614	8.014256	0.449650	0.6763
IT_DLPRIV	-73.47187	56.72291	-1.295277	0.2649
IT_DLPRIV(-1)	7.112251	48.21276	0.147518	0.8899
FR_DLPRIV	-8.329773	28.21474	-0.295228	0.7825
FR_DLPRIV(-1)	9.314733	20.30015	0.458850	0.6702
FR_DLPRIV(-2)	14.31508	18.37984	0.778847	0.4796
IT_DLGDPCU	-40.79609	29.97137	-1.361169	0.2451
IT_DLGDPCU(-1)	-22.15297	32.49297	-0.681777	0.5328

R-squared	0.485416	Mean dependent var	-0.193573
Adjusted R-squared	-0.415106	S.D. dependent var	2.625174
S.E. of regression	3.122861	Akaike info criterion	5.350097
Sum squared resid	39.00904	Schwarz criterion	5.673368
Log likelihood	-24.10058	Hannan-Quinn criter.	5.230411
F-statistic	0.539038	Durbin-Watson stat	2.137920
Prob(F-statistic)	0.776787	Prob. Chi-Square(2)	0.85

[163] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.15: A model of Italy's current account and private banks' deposits: the period when Italy imported capital from France, 1880–1913

Variables:

IT_DPCAG3 = relative change of the Italian current account[164]

IT_DLPRIV = log. change of private bank deposits in Italy

FR_DLPRIV = log. change of private bank deposits in France

IT_DLGDPCU = log. change of Italian gross domestic product in current prices

Dependent Variable: IT_DPCAO3
Method: Least Squares
Date: 09/21/11 Time: 15:43
Sample: **1880 1913**
Included observations: 34

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.973075	1.650817	1.195211	0.2420
IT_DLPRIV	-9.651032	12.74602	-0.757180	0.4553
GE_DLPRIV	14.13662	15.07872	0.937521	0.3565
GE_DLPRIV(-1)	-12.19541	14.25679	-0.855411	0.3996
GE_DLPRIV(-2)	-25.72006	14.22599	-1.807963	0.0814
IT_DLGDPCU	12.66838	13.47993	0.939796	0.3554

R-squared	0.161880	Mean dependent var	-0.019891
Adjusted R-squared	0.012215	S.D. dependent var	1.743839
S.E. of regression	1.733156	Akaike info criterion	4.096550
Sum squared resid	84.10721	Schwarz criterion	4.365908
Log likelihood	-63.64135	Hannan-Quinn criter.	4.188409
F-statistic	1.081618	Durbin-Watson stat	2.024912
Prob(F-statistic)	0.391919	Prob. Chi-Square(2)	0.76

[164] $\Delta CA = \frac{CA_t - CA_{t-1}}{|CA_{t-1}|}$

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Appendix Table 3.16: A model of Russia's current account and private banks' deposits

Variables:

RU_DPCAO3 = relative change of the Russian current account

FR_DLMS = log change of French money supply (total M3)

RU_DLGDPCU = log. change of Russian gross domestic product in current prices

Dependent Variable: RU_DPCAO3
Method: Least Squares
Sample: **1893 1913**
Included observations: 21

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.726806	1.293888	0.561723	0.5832
FR_DLMS	-7.740930	31.36755	-0.246781	0.8087
FR_DLMS(-1)	-86.73828	31.78506	-2.728901	0.0163
FR_DLMS(-2)	24.53688	29.98686	0.818254	0.4269
FR_DLMS(-3)	22.35948	27.49816	0.813126	0.4298
RU_DLGDPCU	-5.941272	7.883781	-0.753607	0.4636
RU_DLGDPCU(-1)	0.571845	7.658521	0.074668	0.9415

R-squared	0.389493	Mean dependent var	-0.528668
Adjusted R-squared	0.127847	S.D. dependent var	2.105607
S.E. of regression	1.966407	Akaike info criterion	4.451495
Sum squared resid	54.13461	Schwarz criterion	4.799669
Log likelihood	-39.74070	Hannan-Quinn criter.	4.527058
F-statistic	1.488627	Durbin-Watson stat	2.297156
Prob(F-statistic)	0.252070	Prob. Chi-Square(3)	0.81

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European University Institute
DOI: 10.2870/38202

Appendix Table 3.17: A model of Great Britain's current account and private banks' deposits, 1873–1890

Variables:

UK_DPCAO3 = relative change of the British current account
UK_DLPRIVC = log change of British private bank money supply (data by Capie and Weber)
UK_DLGDPCU = log. change of British gross domestic product in current prices

Dependent Variable: UK_DPCAO3
Method: Least Squares
Sample (adjusted): 1873 1890
Included observations: 18 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.319666	0.105764	3.022445	0.0098
UK_DLPRIVC	-6.743889	3.948477	-1.707972	0.1114
UK_DLPRIVC(-1)	-11.70678	3.362276	-3.481802	0.0041
UK_DLGDPCU	0.827757	2.038965	0.405969	0.6914
UK_DLGDPCU(-1)	8.261920	2.201352	3.753112	0.0024

R-squared	0.711888	Mean dependent var	0.138158
Adjusted R-squared	0.623238	S.D. dependent var	0.627641
S.E. of regression	0.385252	Akaike info criterion	1.160296
Sum squared resid	1.929451	Schwarz criterion	1.407622
Log likelihood	-5.442668	Hannan-Quinn criter.	1.194399
F-statistic	8.030330	Durbin-Watson stat	1.931553
Prob(F-statistic)	0.001728	Prob. Chi-Square(1)	0.98

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Appendix Table 3.18: A model of Great Britain's current account and private banks' deposits, 1890–1913

Variables:

UK_DPCAO3 = relative change of the British current account
UK_DLPRIVC = log change of British private bank money supply (data by Capie and Weber)
FR_DLPRIV = log change of French private bank money supply
UK_DLGDPCU = log. change of British gross domestic product in current prices

Dependent Variable: UK_DPCAO3
Method: Least Squares
Sample: 1890 1913
Included observations: 24

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.547115	0.224839	2.433364	0.0263
UK_DLPRIVF	2.912348	7.323759	0.397657	0.6958
UK_DLPRIVF(-1)	-4.908922	6.364637	-0.771281	0.4511
UK_DLPRIVF(-2)	-10.61714	5.946463	-1.785455	0.0920
FR_DLPRIV	-0.634338	3.162769	-0.200564	0.8434
FR_DLPRIV(-1)	-2.790330	3.755265	-0.743045	0.4676
UK_DLGDPCU	-0.457670	4.122608	-0.111015	0.9129

R-squared	0.327701	Mean dependent var	0.119541
Adjusted R-squared	0.090419	S.D. dependent var	0.465172
S.E. of regression	0.443643	Akaike info criterion	1.450902
Sum squared resid	3.345932	Schwarz criterion	1.794501
Log likelihood	-10.41082	Hannan-Quinn criter.	1.542059
F-statistic	1.381060	Durbin-Watson stat	2.490736
Prob(F-statistic)	0.277910	Prob. Chi-Square(1)	0.33

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DOI: 10.2870/38202

Appendix Table 3.19: A model of France's current account and private banks' deposits, 1873–1913

Variables:

FR_DPCAO3 = relative change of the British current account

FR_DLPRIV = log change of French private bank money supply

UK_DLPRIVF = log change of British private bank money supply (data by Freidman and Schwartz)

FR_DLGDPCU = log. change of French gross domestic product in current prices

Dependent Variable: FR_DPCAO3
Method: Least Squares
Sample (adjusted): **1873 1913**
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.304901	0.639451	-2.040658	0.0491
FR_DLPRIV	25.77778	6.505360	3.962545	0.0004
FR_DLPRIV(-1)	-19.43522	6.697457	-2.901880	0.0065
FR_DLPRIV(-2)	13.99908	6.187475	2.262487	0.0302
UK_DLPRIVF	28.69612	15.87061	1.808130	0.0794
UK_DLPRIVF(-1)	7.883892	12.81306	0.615301	0.5425
FR_DLGDPCU	-6.602710	7.257327	-0.909799	0.3693

R-squared	0.474452	Mean dependent var	0.519803
Adjusted R-squared	0.381708	S.D. dependent var	2.400245
S.E. of regression	1.887349	Akaike info criterion	4.262476
Sum squared resid	121.1110	Schwarz criterion	4.555037
Log likelihood	-80.38075	Hannan-Quinn criter.	4.369010
F-statistic	5.115730	Durbin-Watson stat	1.843640
Prob(F-statistic)	0.000774	Prob. Chi-Square(1)	0.89

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Appendix Table 3.20: A model of Germany's current account and private banks' deposits, 1873–1913

Variables:

GE_DPCAO3 = relative change of the German current account

GE_DLPRIV = log change of German private bank money supply

GE_DLGDPCU = log. change of German gross domestic product in current prices

Dependent Variable: GE_DPCAO3
Method: Least Squares
Sample (adjusted): 1861 1913
Included observations: 53 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.003934	0.219442	-0.017928	0.9858
GE_DLPRIV	3.375709	1.939048	1.740910	0.0882
GE_DLPRIV(-1)	0.895346	1.614553	0.554547	0.5818
GE_DLPRIV(-2)	-2.445134	1.549883	-1.577625	0.1214
GE_DLPRIV(-3)	1.230840	1.588287	0.774948	0.4423
GE_DLGDPCU	0.741050	2.334841	0.317388	0.7524

R-squared	0.116696	Mean dependent var	0.227184
Adjusted R-squared	0.022727	S.D. dependent var	0.601760
S.E. of regression	0.594883	Akaike info criterion	1.905366
Sum squared resid	16.63262	Schwarz criterion	2.128418
Log likelihood	-44.49220	Hannan-Quinn criter.	1.991141
F-statistic	1.241859	Durbin-Watson stat	2.710984
Prob(F-statistic)	0.304861	Prob. Chi-Square(3)	0.01

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Data Appendix of the whole thesis

Sources of historical national accounts series

Australia: **Butlin, N.G. (1962)**: Australian Domestic Product, Investment and Foreign Borrowing, 1861 - 1938/9, Cambridge

Canada: **Urquhart, M.C. (1993)**: Gross National Product, Canada, 1870 - 1926. The Derivation of the Estimates, McGill-Queen's University Press.

Belgium: **Maddison, Angus (1995)**: Monitoring the World Economy 1820–1992, OECD.

Denmark: **Christensen et. al**: Nordiske historiske nationalregnskaber - Workshop 3, Memo nr. 202 – Maj 1995. Koebenhavn Universitet, Oekonomisk Institut. Koebenhavn, 1998.

Finland: **Hjerppe, Riitta**: Finland's historical national accounts 1860-1994. Calculation methods and accounts, Suomen historian julkaisuja 24. University of Jyväskylä, Department of History, Jyväskylä 1996.

France: **Toutain, Jean-Claude (1997)**: 'Le produit intérieur brut de la France, 1789–1990', Economies et Sociétés, Histoire économique quantitative, Série HEQ nº1, nº 11/1997, pp. 5–136.

Toutain, Jean-Claude (1987): 'Le produit intérieur brut de la France, 1789–1982', Economies et Sociétés, no. 15, and

Levy-Leboyer, Maurice; Bourguignon, François (1990): *The French Economy in the Nineteenth Century*, Maisons des Sciences de l'Homme and Cambridge University Press.

Germany: **Burhop, Carsten; Wolff, Guntram B. (2005)**: A Compromise Estimate of German Net National Product, 1851–1913, and its Implications for Growth and Business Cycles, The Journal of Economic History, Vol. 65, No. 3.

Great Britain: **Feinstein, C.H. (1972)**: National Income, Expenditure and Output in the United Kingdom, 1855–1965, Cambridge University Press.

Italy: **Fenoaltea, Stefano (2005)**: The growth of the Italian economy, 1861–1913: Preliminary second-generation estimates, European Review of Economic History 9, 273–312.

The Netherlands: **Smits, Jan-Peter; Horlings, Edwin; van Zanden, Jan Luiten (2000)**: Dutch GNP and its components, 1800–1913, Groningen Growth and Development Centre, Monograph series no. 5.

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Norway: **Grytten, O.H. (2004)**: "The gross domestic product for Norway 1830-2003", 241-288, in Eitrheim, Ø., J.T. Klovland and J.F. Qvigstad (eds.), Historical Monetary Statistics for Norway 1819-2003, Norges Bank Occasional Papers no. 35, Oslo, 2004.

Portugal: **Valerio, Nuno (2001)**: National accounts, in Estatisticas Históricas Portuguesas (ed. Nuno Valerio) , Instituto Nacional de Estatística.

Russia: **Gregory, Paul, R. (1982)**: Russian National Income 1885–1913, Cambridge University Press.

Spain: **Prados de la Escosura, Leandro (1993)**: Spain's gross domestic product, 1850–1990 : a new series, Ministerio de Economía y Hacienda.

Sweden: **Krantz, Olle & Schön, Lennart (2007)**: Swedish Historical National Accounts 1800-2000, Lund.

United States: **Sutch, Richard (2006)**: National Income and Product, in Historical Statistics of the United States. Earliest Times to the Present, Millennium Edition, Volume Three, Cambridge University Press.

Sources of balance of payments series:

Australia: **Butlin, N. G. (1962)**, *Australian Domestic Product, Investment and Foreign Borrowing 1861-1938/39*, Cambridge University Press.

Canada: **Urquhart (1986)**, T. 2.4, pp. 20-25, rows 9 and 22)

Denmark: **Bjerke, Kjeld and Ussing, Niels (1958)**, *Studier over Danmarks nationalprodukt 1870-1950*, Copenhagen.

Finland: **Hjerppe, Riitta (1989)**, *The Finnish Economy 1860-1985. Growth and Structural Change*, Bank of Finland Government Printing Centre, Helsinki.

France: **Levy-Leboyer, Maurice and Bourguignon, François (1985)**, *l'Economie Française au XIXe siècle: Analyse macro-économique*, Economica, Paris.

Germany: **Hoffman, Walther G. (1965)**, *Das Wachstum der Deutschen Wirtschaft seit der mitte des 19 Jahrhunderts*, Springer Verlag, Berlin.

Great Britain: **Imlah, Albert H. (1958)**, *Economic Elements in the Pax Britannica, Studies in British Foreign Trade in the Nineteenth Century*, Harvard University Press, Cambridge Massachusetts. (until 1869), and **Feinstein, Charles H. (1988)**, "Stocks and Works in Progress, Overseas Assets, and Land", ch. 18 of Feinstein, Charles H. and Pollard, Sidney (eds) (1988), "*Studies in Capital Formation in the United Kingdom 1750-1920*", Clarendon Press, Oxford. (years 1870–1920).

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

Italy: **ISTAT (1957)**, *Indagine Statistica sullo sviluppo del reddito nazionale dell'italia dal 1861 al 1956*, Annali di Statistica, anno 86, Serie VIII, vol. 9, Istituto Centrale di Statistica, Roma.

Norway: **Mitchell, B. R. (1993)**, *International Historical Statistics Europe 1750-1988*, 3rd ed., Stockton Press, New York. (years 1861–1899), and **Statistisk Sentralbyra (1953)**, *Nasjonalregnskap 1900-1929, Norges Offisielle Statistikk XI 143*, Oslo. Central Bureau of Statistics of Norway, National Accounts, Norway's official statistics, series XI, no. 143, National Accounts 1900-1929, Oslo. (years 1900–1920)

Portugal: **Valerio, Nuno (2001)**: Foreign economic relations, in *Estatisticas Históricas Portuguesas* (ed. Nuno Valerio), Instituto Nacional de Estatística.

Russia: **Gregory, Paul R. (1982)**, *Russian national income, 1885-1913***,** Cambridge [Cambridgeshire] ; New York : Cambridge University Press.

Sweden: **Lindahl, Erik; Dahlgren, Einar; and Koch, Karin (1937)**, National Income of Sweden 1861-1930, vol. 3 of "*Wages, Cost of Living and National Income in Sweden 1860-1930*", Institute for Social Sciences, University of Stockholm, Stockholm.

United States: **US Bureau of the Census (1975)**, *Historical Statistics of the United States, Colonial Times to 1970*, Bicentennial Edition, US Government Printing Office, Washington DC.

Sources of money supply: notes and coins issued by the central bank + deposits in saving banks + deposits in commercial banks:

Australia:

- high-powered money and commercial bank deposits: **Vamplew, Vray (ed., 1987)**: *Australians, Historical Statistics*, Broadway, N.S.W.

Canada:

- all series: **Mitchell, B. R. (1993)**, *International Historical Statistics Europe 1750-1988*, 3rd ed., Stockton Press, New York.

Denmark:

- all series: **Mitchell, B. R. (1993.**

Finland:

- all series: *Bidrag till Finlands Officiella Statistik; Suomen Tilastollinen Vuosikirja.*

France:

- all series: *Annuaire Statistique de la France*.

DOI: 10.2870/38202

Germany:

- all series: **Hoffmann, Walther G. (1965)**: *Das Wachstum der Deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts*, Berlin.

Great Britain:

1) **Capie, Forrest & Webber, Alan (1985)**: *A Monetary History of the United Kingdom, 1870–1982*, London (The series are high-powered money and M3.)

2) **Friedman, Milton and Schwartz, Anna (1982)**: *Monetary Trends in the United States and the United Kingdom, Their Relation to Income, Prices and Interest Rates, 1867–1975*, p. 130. (The series are high-powered money and total money stock. Private sector banks' money supply was calculated by subtracting high-powered money from the total money stock.)

3) **Mitchell, Brian R. (1988)**: *British Historical Statistics*, Cambridge University Press (banknote circulation, commercial bank deposits); **Horne, H. Oliver (1947)**: *A History of Savings Banks*, Oxford (savings bank deposits).

Italy:

- all series: **Fratianni, Michele and Spinelli, Franco (1997)**, *A monetary history of Italy*, Cambridge University Press. (The series are high-powered money and M3.)

The Netherlands:

- all series: **Mitchell, B. R. (1993.**

Norway:

- all series: **Mitchell, B. R. (1993.**

Russia:

- all series: **Khromov, P.A. (1950)**: *Economic Development of Russia in the 19th and 20th Centuries, 1800–1917*, Moscow.

Sweden:

- high-powered money: **Jörgerg, Lars (1972)**: *A History of Prices in Sweden 1732–1914*, Lund; Statistisk Tidskrift.
- commercial and saving bank deposits: **Mitchell, B. R. (1993.**

United States:

- all series: **Friedman, Milton and Schwartz, Anna (1982)**: *Monetary Trends in the United States and the United Kingdom, Their Relation to Income, Prices and Interest Rates, 1867–1975*, University of Chicago Press., p. 122. (The series are high-powered money and total money stock. Private sector banks' money supply was calculated by subtracting high-powered money from the total money stock.)

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European University Institute
DOI: 10.2870/38202

Sources of gold stocks:

Australia: The database of **Jones and Obsfeld (2001)**. I created the time series of gold stock, using the data base on Australia, by adding up columns: "Sidney Mint Data: Gold coins in banks and private hands" and "Australian Trading Banks: Bullion holdings" until 1902 and at that year splicing with "Gold Stock Data: Gold coin stock RBA data".

Canada: The database of **Jones and Obsfeld (2001)**, column "Curtis (1931) and Yearbook data: Monetary gold stock".

Denmark: The database of **Jones and Obsfeld (2001)**, column "US Director of Mint Data: Stock of gold" until 1906 and at that year splicing with the data of "*Danmarks Statistik*: Nationalbanken Gold stock".

Finland: The database of **Jones and Obsfeld (2001)**, column "Monetary gold stock 1000 mk" divided by 1000.

France: The database of **Jones and Obsfeld (2001)**, column "Flandreau's data" until 1878, then spliced with the column "Predicted value of from regression Gold" using Sicsic's data until 1913, then spliced with the column "Annuaire Statistique data: Bank of France coin & bullion Gold".

Germany: The database of **Jones and Obsfeld (2001)**, column "Deutsche Bundesbank's data: Gold coin in circulation + Gold in bars and coins in Reichsbank".

Great Britain: The database of **Jones and Obsfeld (2001)**, column "Economist Data: Gold coin and bullion and silver coin in BOE".

Italy: Using the database of **Jones and Obsfeld (2001)**. To get the value of the gold stock for 1920: subtracting the value of the year 1920 in column "Di Mattia (1967) Data: Change in gold coin stock" from the value of the year 1921 in column "ISTAT (1968) Data: Official reserves in gold coin". The previous years were calculated in the same way.

Norway: The database of **Jones and Obsfeld (2001)**, column "Statistisk Sentralbyrå (1967) data: Metallic reserve at bank of Norway" until 1914n spliced with the column "Statistisk Sentralbyrå (1967) data: Gold stock at bank of Norway".

Russia: The database of **Jones and Obsfeld (2001)**, column "US Mint Report Data: Monetary gold stock".

Sweden: The database of **Jones and Obsfeld (2001)**, column "Historisk Statistik (1960): Gold in banks (incl. Riksbank)".

Lessig, Jyrki Johannes (2012), Essays on Stability of the Classical Gold Standard: Money supply, international capital mobility and symmetry of business cycles
European University Institute DOI: 10.2870/38202

United States: The database of **Jones and Obsfeld (2001)**, column "Monetary gold stock, annual average" x 1000.

The sources of foreign trade:

All countries: **Mitchell, B. R. (1993)**, *International Historical Statistics Europe 1750-1988*, 3rd ed., Stockton Press, New York.

The sources of interest rates series:

All countries: **Homer, Sidney (1977)**: *A History of Interest Rates:2000 BC to the present*, Rutgers University Press, 2nd ed., except Portugal.
Portugal: **Valerio, Nuno (2001)**: Money and credit, in *Estatisticas Históricas Portuguesas* (ed. Nuno Valerio), Instituto Nacional de Estatística.

The sources of central bank reserves:

All countries: **Flandreau, Marc and Zumer, Frédérik (2004)**: *The Making of Global Finance 1880–1913*, OECD.

The internet address of the database of **Jones and Obsfeld (2001)**:
http://www.nber.org/databases/jones-obstfeld/

DOI: 10.2870/38202