Adjustment under the Classical Gold Standard (1870s-1914):
How Costly did the External Constraint
Come to the European periphery?

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Abstract
Conventional wisdom has that peripheral economies had to ‘play by the rules of the game’ under the Classical Gold Standard (1870s – 1914), while core countries could get away with frequent violations. Drawing on the experience of three core economies (England, France, Germany) and seven peripheral economies (Austria-Hungary, Bulgaria, Greece, Italy, Norway Serbia, Sweden), my paper argues for a more nuanced perspective on the European periphery. While the conventional view might be true for some countries – most notably the Balkan economies -, our findings, based on a VAR model and impulse response functions, suggest that the average gold drain that a specific peripheral economy was exposed to differed substantially from country to country. We also show that some of the peripheral economies, most notably Austria-Hungary, always enjoyed enough “pulling power” via discount rate policy to reverse quickly any such gold outflow. In sum, while the experience of some peripheral economies under gold was poor and hence normally short-lived, the experience of other peripheral countries resembled more those of the core economies.

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JEL classification: E52, E58, N13
1. Introduction

1.1 Historical background: The Classical Gold Standard

The Classical Gold Standard (1870s – 1914) has attracted the interest of economists ever since its foundation. The exchange rate stability – which was the result of countries tying their currencies domestically to gold – among most countries of the world for some forty years was unprecedented and remained an inspiration for policy-makers after the demise of the Classical Gold Standard at the outbreak of World War I, leading to a short-lived resurrection in the interwar period and the Bretton Woods system of fixed exchange rates after World War II.

The literature on the Classical Gold Standard is vast and any categorisation necessarily involves some degree of simplification. Despite this caveat, it can be said that research has focused on assessing the costs and benefits of adherence to gold. While benefits might be seen in easier and cheaper access to foreign capital, it is less straightforward to define the ‘costs’ of adhering to gold. The gold standard as a system of (quasi) fixed exchange rates required the monetary authority to adopt measures so that the exchange rate would follow mint parity within the boundaries set by the gold points. In other words, continuous adjustment efforts were needed to maintain the gold link. In the case of a gold outflow, the necessary adjustment efforts would translate into raising the discount rate and/or reducing the monetary base – which is what Keynes famously called “playing by the rules of the game”. Partly intended, partly an undesired by-

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3. The “standard” exchange rate was determined by mint parity. For instance, the German gold standard legislation of 1871 stipulated that 2790 marks would be coined out of 1 kilogram of refined gold; the corresponding Austro-Hungarian law of 1892 established that 3280 crowns would be coined out of 1 kilogram of refined gold. This implies a mint ratio and, hence, a “standard” exchange rate of 1 mark = 3280 / 2790 crowns ≈ 1.1756 crowns.

4. As a large proportion of transactions under the Classical Gold Standard were not settled by gold coins, but by bills of exchange drawn on foreign countries, the price of the bills of exchange - in short, the exchange rate - could fluctuate within certain boundaries that are known as the gold export point and the gold import point. These gold points reflect the fact that paying in specie incurred substantially higher transactions costs than settling with bills of exchange. Only if the exchange rate moved beyond the gold points, did it make sense to switch from using bills of exchange to using gold coins.

product, both measures would typically reduce domestic economic activity. Thus, the gold standard carried with it the inherent policy conflict between external stability – i.e. to keep the exchange rate close to mint parity – and domestic stability. Negative repercussions of the necessary adjustment process on domestic economic activity can therefore be viewed as ‘costs’ of the gold standard.

Conventional wisdom has that the adjustment process to balance-of-payments disequilibria was very different in the case of the ‘core countries’ (UK, US, France, and Germany) as opposed to the ‘periphery’. Several studies have shown that the rich core countries could get away with frequent and sizeable violations of the “rules of the game”. By contrast, it is argued, peripheral countries had to play by the “rules of the game”, thereby exposing themselves to negative repercussions on domestic economic activity. In other words, the conflict between external stability and internal stability is said to have been much more pronounced in the periphery than in the core. Different authors have emphasised different factors in explaining the alleged advantages of the core countries in the adjustment process. Essentially drawing on the theory of optimum currency areas, one school of thought has argued that core countries were simply better suited for monetary integration than the periphery. Others have argued that central banks of core countries helped each other in times of crisis, but did not help peripheral economies for the lack of self-interest. The more recent literature has stressed the importance of credibility; Svensson, building on Krugman, has pointed out that a credible target zone can confer on a country a degree of independence in the operation of its monetary policy, even when the exchange rates are fixed. Applying this theoretical insight to economic history, the Classical Gold Standard has

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recently been interpreted as a target zone the limits of which were determined by the gold points.\textsuperscript{12} Consequently, as long as economic agents view a country’s commitment to gold as credible, such a country could violate the “rules of the game” in the short-run with a view to other policy goals.\textsuperscript{13}

1.2 Hypothesis and approach of this paper

The literature hence portrays peripheral economies as disadvantaged in the pre-World War I monetary order. A closer examination of the literature, however, reveals that most studies rely on the core countries only. In the few cases where a specific country in the periphery was investigated on its own, the room for manoeuvre in monetary matters turned out to be much larger than the stereotype wants us to believe.\textsuperscript{14}

We challenge this view and argue for a more nuanced perspective on the European periphery. While the conventional view might be true for some countries – most notably the Balkan economies -, our findings, based on a VAR model and impulse response functions, suggest that the average gold drain that a specific peripheral economy was exposed to differed substantially from country to country. We also show that some of the peripheral economies, most notably Austria-Hungary, always enjoyed enough “pulling power” via discount rate policy to reverse quickly any such gold outflow. In sum, while the experience of some peripheral economies under gold was poor and hence normally short-lived, the experience of other peripheral countries resembled more those of the core economies.

Austria-Hungary, Italy, Sweden and Norway followed the Classical Gold Standard for different periods. Austria-Hungary passed gold standard legislation in 1892, but exchange-rate stability to other gold standard countries was achieved only in 1896; the gold link was then

\textsuperscript{12} Eichengreen and Flandreau, eds., The Gold Standard in Theory and History.


maintained until the outbreak of World War I. Italy enacted gold convertibility in 1883, but was forced to suspend specie payment – i.e. conversion of bank notes into gold by the central bank – again in 1891. Mint parity was achieved again in 1903 and maintained until the outbreak of World War I. When estimating Italy, we will therefore differentiate between Italy’s earlier adherence to gold (1883-1891) and its later adherence (1903-1913). The Swedish and the Norwegian cases are less complicated. Both countries followed the Classical Gold Standard from 1873 until the outbreak of World War I.

The exchange-rate experience of the Balkan countries before World War I has so far been largely unknown, but the South-Eastern European Monetary History Network, founded in 2006, has produced first results on which this paper can draw. We classify Bulgaria, Greece, and Serbia as on gold from 1/1906 – 9/1912, 1/1910 – 7/1914 and 7/1905 – 9/1912, respectively.

England followed the gold standard from 1821 to World War I without interruption. France and Germany joined in 1873 and adhered to gold until 1914.

The estimation period is occasionally slightly more restricted due to data availability. Table 1 summarizes the periods of adherence to gold and the estimation periods.

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Table 1  
Countries studied

<table>
<thead>
<tr>
<th></th>
<th>Adherence to gold</th>
<th>Estimation period</th>
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</thead>
<tbody>
<tr>
<td>Austria-Hungary</td>
<td>1896 – 1914</td>
<td>1/1896 – 12/1913</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1906 – 1912</td>
<td>1/1906 – 9/1912</td>
</tr>
<tr>
<td>France</td>
<td>1873 – 1914</td>
<td>1/1889 – 12/1913</td>
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<tr>
<td>Germany</td>
<td>1873 – 1914</td>
<td>11/1875 – 7/1914</td>
</tr>
<tr>
<td>Italy I</td>
<td>1883 – 1891</td>
<td>1/1883 – 12/1891</td>
</tr>
<tr>
<td>Italy II</td>
<td>1903 – 1914</td>
<td>1/1903 – 12/1913</td>
</tr>
<tr>
<td>Norway</td>
<td>1873 – 1914</td>
<td>1/1873 – 7/1914</td>
</tr>
<tr>
<td>Serbia</td>
<td>1905 – 1912</td>
<td>7/1905 – 9/1912</td>
</tr>
<tr>
<td>Sweden</td>
<td>1873 – 1914</td>
<td>1/1878 – 12/1913</td>
</tr>
</tbody>
</table>

Source: Cf. main text.
2. Estimating the balance-of-payments adjustment mechanism

2.1 Adjustment under the Classical Gold Standard

Under a system fixed exchange rates such as the Classical Gold Standard, balance-of-payments adjustment can principally occur through two channels\(^\text{17}\): (a) via the so-called price-specie flow mechanism, and (b) via short-term capital flows. Adjustment can be accelerated by appropriate central bank behaviour, with the adjustment via the price-specie flow mechanism giving rise to the non-sterilisation-rule and the adjustment via short-term capital flows giving rise to the discount-rate-rule. As an understanding of both forms of adjustment is required for the set-up of our econometric model (and in particular the impulse-response functions), we need to explain them in some detail.

(a) Hume’s price-specie flow mechanism

The Scottish philosopher and economist David Hume (1711-1776) was the first person to reflect on how adjustment would take place under a specie standard such as the gold standard. In his “Of the Balance of Trade” (1752), Hume considers two economies operating a gold coin standard, i.e. gold coins circulate among economic agents in each country, and bank notes are unknown. Another feature of the Humean model is that there is only goods arbitrage available, but no capital arbitrage. Under such a scenario, metallic flows would increase the money supply of the country to which the metal went, and reduce the money supply of the country from which the metal came. Based on the quantity theory of money, the increased money supply would lead to higher prices in one country, while the decreased money supply would lead to lower prices in the other. The resulting price difference would give a comparative edge to the country that had lost metal in the first place, thus strengthening the balance of trade and, once again, leading to

external equilibrium. For Hume, arbitrage in the goods market, because of price differentials, would cause adjustment.\textsuperscript{18}

The key question in our context is how we can operationalise the price-specie flow mechanism under the conditions of the pre-WWI gold standard. Hume described the gold coin standard as a standard where only gold coin circulated among economic agents and where there was no monetary authority. Both these features changed over the course of the 19\textsuperscript{th} century. The gold coin standard became the gold bullion standard\textsuperscript{19}; gold coin was still in circulation in most of the countries adhering to the gold standard, but the bulk of the monetary base came to consist of bank notes. Bank notes were convertible against gold coin and/or gold bullion at the central bank. We have to ask ourselves how the Humean adjustment process would look within the framework of the late 19\textsuperscript{th} century central bank administered gold bullion standard.

From an economic point of view, however, there is little difference between the 18\textsuperscript{th} century gold coin standard and the 19\textsuperscript{th} century gold bullion standard: „Under any form of gold standard, gold is used for the settlement of discrepancies in the balance of payments. Under the “gold specie standard,” where the domestic circulation as well as the international means of settlement consisted largely of gold, the relationship between the domestic money supply and the balance of payments was direct and immediate; in fact, the very distinction between national and international currency became important only with the growing use of bank notes and deposits in circulation. Under the “gold bullion standard,” where bank notes and deposits formed the great bulk of domestic money, the relationship was less obvious but still generally operative, since any purchase of gold by the central bank could normally be expected to increase a country’s note circulation and bank deposits while any outflow of gold usually decreased them.”\textsuperscript{20}

We conclude as follows: Hume’s price specie flow model can be operationalised by a comparison of the effects of a gold outflow on the monetary base. Under late 19\textsuperscript{th} century conditions, the monetary base essentially consisted of bank notes in circulation (cf. section 2.2). If we witness a one-to-one relationship – i.e. if a gold flow of one unit translates into a one unit change in the monetary base – , then the central bank would help the balance-of-payments adjustment mechanism by not sterilizing gold flows. This rule became known as the non-


\textsuperscript{20} Ibid.
sterilization-rule in the gold standard literature. By contrast, if we witness less than a one-to-one relationship – i.e. if a gold flow of one unit translates into less than a one unit change in monetary base –, the monetary authority embarked on sterilisation policies. It is generally thought that sterilisation policies are followed in order to soften the impact of a currency peg on the domestic economy. The impulse response functions will allow us to estimate the impact of a gold flow on the monetary base.

(b) Adjustment via short-term capital flows
Hume’s price-specie flow mechanism was the first systematic attempt to explain the adjustment mechanism under a specie-standard. With time, economists became increasingly aware that adjustment via the goods market was not the only and perhaps not even the most important channel of adjustment. Any adjustment via price level differences is necessarily slow, while adjustment in the capital market tends to be much quicker. Increased financial integration in the 19th century brought the adjustment via short-term capital flows to centre-stage. In modern economics, epitomized by the still influential Mundell-Fleming open-economy models, it is usually adjustment via short-term capital flows that is seen as crucial in balance-of-payments adjustment.

Thus, if a central bank wants to accelerate the adjustment process, we would expect a gold outflow to be followed by an increase of the bank rate. This rationale became known as the bankrate-rule in the gold standard literature. Conversely, if a central bank attributed more importance to domestic policy goals, a central bank might leave the bank rate unchanged despite reserve drains. Again, a VEC model with impulse response functions will allow us to establish whether a central bank followed the bankrate-rule by estimating the impact of a gold flow on the bankrate.

(c) The “rules of the game” concept
The existence of these two main forms of adjustment, coupled with the 19th century belief that the central bank was responsible for maintaining the peg, culminated in the concept of the “rules of

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22 Bordo, "The Gold Standard: The traditional approach."
the game”: central banks were supposed to react to a gold outflow by two means: (1) raising the discount rate, and (2) reducing the monetary base.

The preceding description of the balance-of-payments adjustment mechanism has demonstrated that three time series are of crucial importance when determining whether a central bank played by the “rules of the game”: (1) the gold reserves, (2) the monetary base, and (3) the bank rate. The non-sterilisation-rule can be operationalised by establishing whether a one-unit gold outflow led to a monetary base reduction of similar size. The bankrate-rule can be verified by investigating whether the central bank reacted to a gold outflow by raising the bankrate.
2.2 The data employed in this paper

We will describe the Austro-Hungarian data in some detail and confine ourselves to some remarks regarding the other countries due to space constraints.

**Austria-Hungary**

Estimation was carried out for the years 1896 to 1913 (cf. table 1). Figure 1 shows the Austro-Hungarian raw data for gold reserves and monetary base.

![Figure 1: Austria-Hungary: Gold reserves and monetary base, 1896 – 1913.](image)

Source: Cf. data description in main text.
a. Gold reserves
Monthly data of the gold reserves were published in the annual reports of the Austro-Hungarian bank.\textsuperscript{24} Reserves consist of (1) gold bullion and gold coin, (2) silver coin, (3) gold bills, i.e. bills of exchange drawn on places located in gold standard countries (”Goldwechsel auf auswärtige Plätze”), (4) deposits on foreign banks, and (5) foreign bank notes.

b. Monetary base
The monetary base is the primary stock of money in an economy.\textsuperscript{25} As opposed to bank-created deposit money, the monetary base is the part of the money supply under the (almost) exclusive control of the monetary authority. This explains the economists’ interest in the monetary base when trying to establish a central bank’s policy. The monetary base essentially\textsuperscript{26} encompasses all liquid liabilities of the monetary authority. Under pre-1914 conditions, liquid liabilities were first and foremost the banknotes (ca. 90%), followed by commercial banks’ deposits at the central bank. Data were taken from the annual reports of the Austro-Hungarian bank.

c. Bankrate
Bank rates were taken from the \textit{Compass}\textsuperscript{27}, the leading financial yearbook in the dual monarchy.

\textsuperscript{24} Appendix 2 („Übersicht der Geschäftsbewegung“) of „Jahressitzung der General-versammlung der Österreichisch-Ungarischen Bank“, 1 (1879) – 36 (1914), Vienna.
\textsuperscript{26} Opinion differs as to whether coins should be counted as part of the monetary base. The question has both a theoretical and a practical dimension. On a theoretical level, two schools of thought can be distinguished: If the notion of “monetary base” is derived from the process of money creation, coins should clearly be included (cf. Begg, Fischer, and Dornbusch, \textit{Economics}, pp. 375-85.). By contrast, if the notion of “monetary base” is developed behind the background of what a central bank can control, coins should not be included as they do not constitute the liability of a central bank (but of the treasury); accordingly, the European Central Bank does not consider coins part of the monetary base (cf. F. Kissmer, \textit{Die Geldpolitik in der Europäischen Währungsunion} (Hagen: 2004), p. 109.). On a practical level, it is impossible to establish a time series for coin in circulation for Austria-Hungary at the frequency we are aiming for. Omitting coins, however, is unlikely to introduce any bias due the small size as opposed to the other two components of the monetary base; moreover, coin in circulation was certainly less volatile than the other two components.
Italy

Estimation was carried out for two sub-periods: 1883 – 1891 and 1903-1913. In the first period, Italy resumed specie convertibility only for a limited period of time, but the exchange rate continued to follow mint parity closely until 1891. The second period of gold adherence lasted from 1903 to 1913.

a. Gold reserves

Monthly data of the gold reserves have been collected by R. de Mattia in his 1967 data collection on the Italian banks of note issue.28 De Mattia has a very broad definition of reserves, and we felt the need not to include all of them into our study. In particular, de Mattia includes bonds of the Italian state or guaranted by the Italian state among reserves. For the purpose of this study, it seemed more appropriate to include only holdings of gold (## 1, 4, 6), silver (## 2, 3, 5), and foreign exchange (#13).

b. Monetary base

Monthly data of the note issue can be found in the same statistical reference work.29 We could not find data for commercial banks’ deposits at the bank of note issue. In the case of Austria-Hungary, we included them as they do technically constitute part of the monetary base. At the same time, they account for less than 10% of the monetary base in the case of Austria-Hungary. De Mattia’s 1967 collection of data, carried out under the auspices of the Bank of Italy, is of high quality and remains the standard source. As he does not provide such data, he himself was most likely either unable to establish such numbers, or, alternatively, the numbers he found were of negligible size which is why he did not include them. Either way, our time series for the monetary base consists entirely of bank notes in circulation.

c. Bankrate differential

Monthly data of the Italian bankrate can also be found in de Mattia 1967.30

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29 Ibid., table 5 (column 1 only), pp. 446-454.
30 Ibid., table 20, pp. 812-815.
Norway
Data were downloaded from www.norksebank.org

Sweden
Estimation was carried out for the years 1878 – 1900. While Sweden adhered to the Classical Gold Standard from 1871 to 1914, we are confined to the years 1878 – 1900 for two reasons. First, monthly data were published only in 1878. Second, after 1900 legislation was passed that allowed commercial banks to compete with the Swedish Riksbank, starting a process that moved the Swedish system slowly towards a system of free banking (rather than a system with a dominant central bank).31

a. Gold reserves
Monthly data of the gold reserves were published in the “Sammandrag af Bankernas Uppgifter” (Summary of Bank Reports) which were published at the end of each month.32 Reserves consist of (1) gold bullion and gold coin, (2) silver coin, (3) gold bills, (4) deposits on foreign banks, and (5) foreign bank notes.

b. Monetary base
As in the case of Italy, no information could be found on commercial banks’ deposits at the bank of note issue. We have therefore only relied on the amount of bank notes in circulation, which were taken from the same source as the gold reserves.

c. Bankrate differential
Monthly data of the Swedish bankrate can be found in an official publication of the Swedish Riksbank.33

**Bulgaria, Greece, Serbia**
Data were kindly communicated by the Bulgarian National Bank, the Bank of Greece, and the Serbian National Bank.

**Germany**
Data were taken from the “Verwaltungsberichte der REichsbank”, 1876 – 1914. Discount rate data were taken from Reichsbank (1925).

**France**
Data were taken from the Annual Reports of the Bank de France, 1890 – 1914. Discount rate data were taken from Hawtrey (1962).

**England**
Data were taken from Capie&Webber (1995). Discount rate data were taken from Hawtrey (1962).
2.3 The choice of a VAR model

The choice of the appropriate econometric model is largely determined by the nature of the problem under investigation. As the discussion on the “rules of the game” in 2.1 has demonstrated, the monetary authority was supposed to react to gold outflows by raising the discount rate and/or reducing the monetary base. Consequently, three time-series are important: gold reserves, monetary base, and the bank rate. As for the bank rate, it also seems appropriate to take – as an exogenous variable – the bank rate of the core countries (England, France, and Germany) into account.

Which of the three variables – gold reserves, monetary base or bank rate – can be treated as exogenous? Not the monetary base and the bank rate, for we are interested in how these two variables react to changes in gold reserves. This rationale implies that monetary base and bank rate differential are endogenous variables. The same is true for the gold reserves; a discount rate increase and/or a reduction of the monetary base aim at increasing gold holdings at the central bank. Thus, all three variables need to be treated as endogenous.

This rationale favours a vector autoregression approach (VAR). As the terminology suggests, a vector – rather than a scalar – is explained by its past values. As a VAR requires stationary time series, table 2 shows the results of the ADF-tests.

Table 2 shows that gold reserves and monetary base show up as I(1) in most cases. Only the interest rate time series come out usually as I(0), even though there are some outliers even here (Bulgaria, France, Serbia).  

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34 Bulgaria, France and Serbia are, incidentally, countries with relatively infrequent discount rate changes. As a result, the time series appear to have mean shifts which can give the appearance of I(1) non-stationarity.
Table 2
Results of Augmented Dickey-Fuller tests

<table>
<thead>
<tr>
<th>Source</th>
<th>Time series: levels</th>
<th>Time series: first differences</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ADF test with intercept</td>
<td>Levels at which H₀ of unit root cannot be rejected</td>
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<tr>
<td>Austria-Hungary</td>
<td>gold</td>
<td>-2.5316 10% 5% 1%</td>
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<td></td>
<td>mb</td>
<td>-1.2418 10% 5% 1%</td>
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<td>i</td>
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<td>Bulgaria</td>
<td>gold</td>
<td>-0.3384 10% 5% 1%</td>
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<tr>
<td></td>
<td>mb</td>
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<td></td>
<td>i</td>
<td>-0.3007 10% 5% 1%</td>
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<tr>
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<td>i</td>
<td>3.1227 1%</td>
</tr>
</tbody>
</table>

Source: Own calculations based on data as discussed in the main text.
The presence of I(1) time series raises the prospect of a vector error correction model (VEC model). A VEC model relies on I(1) time series that are related to each other by a so-called cointegrating relationship. A cointegrating relationship is a long-run relationship between different variables; this long-run relationship might be violated in the short-run, but forces inherent to the system will correct any such deviation in the long run. From an economic point of view, a system exhibiting such dynamics is an equilibrium: violations in the short-run may occur, but equilibrium will restore itself after some time.

This description fits the economic relationship between gold reserves and monetary base, which happen to be the two time series that show up as I(1) in most cases in table 2. In the long-run, the monetary base needs to be backed up by a certain amount of gold reserves.

For this reason we have tested for a cointegrating relationship between gold reserves and monetary base. Two test statistics are available for the Johansen cointegration rank test, which is the most commonly used cointegration test: the trace statistic and the max-eigenvalue statistic. In addition, two tests were carried out in each case, depending on the specific nature of the underlying time series (trend-stationary time series versus difference-stationary time series, cf. columns 7 and 8 in table 2). This makes for 4 different statistics in the case of each country which we have reproduced in table 3.

Table 3 shows that in some cases (England, Germany, Norway, Sweden), a cointegrating relationship is warranted under all four assumptions. In other cases (Greece, Serbia), by contrast, all four test statistics suggest the absence of a cointegrating relationship. In the remaining cases, some test statistics suggest a cointegrating relationship while others do not. Mixed results are certainly not unusual in cointegration analysis, and conflicting results are often settled with the help of economic theory: if there is enough reason to believe in an underlying relationship, cointegration analysis is often applied even if some of the statistics do not suggest the presence of a cointegrating relationship.

In our case, however, we have to bear in mind that for some countries none of the four test statistics suggest such a cointegrating relationship. We therefore decided against using a VEC model and to stick to the more conventional VAR approach.

---

### Table 3

#### Results of Johansen cointegration rank test

<table>
<thead>
<tr>
<th>Source</th>
<th>Trace statistic</th>
<th>5% critical value</th>
<th>Cointegrating relationship implied</th>
<th>Max-Eigenvalue statistic</th>
<th>5% critical value</th>
<th>Cointegrating relationship implied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria-Hungary</td>
<td>24.85</td>
<td>20.26</td>
<td>+</td>
<td>19.31</td>
<td>15.89</td>
<td>+</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>13.87</td>
<td>15.49</td>
<td>-</td>
<td>10.22</td>
<td>14.26</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>25.18</td>
<td>20.26</td>
<td>+</td>
<td>19.20</td>
<td>15.89</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>6.35</td>
<td>15.49</td>
<td>-</td>
<td>6.33</td>
<td>14.26</td>
<td>-</td>
</tr>
<tr>
<td>England</td>
<td>21.98</td>
<td>20.26</td>
<td>+</td>
<td>19.15</td>
<td>15.89</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>20.88</td>
<td>15.49</td>
<td>+</td>
<td>19.00</td>
<td>14.26</td>
<td>+</td>
</tr>
<tr>
<td>France</td>
<td>22.61</td>
<td>20.26</td>
<td>+</td>
<td>13.55</td>
<td>15.89</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>10.93</td>
<td>15.49</td>
<td>-</td>
<td>10.67</td>
<td>14.26</td>
<td>-</td>
</tr>
<tr>
<td>Germany</td>
<td>34.34</td>
<td>20.26</td>
<td>+</td>
<td>23.66</td>
<td>15.89</td>
<td>+</td>
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<tr>
<td></td>
<td>23.89</td>
<td>15.49</td>
<td>+</td>
<td>23.23</td>
<td>14.26</td>
<td>+</td>
</tr>
<tr>
<td>Greece</td>
<td>16.88</td>
<td>20.26</td>
<td>-</td>
<td>11.00</td>
<td>15.89</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>8.14</td>
<td>15.49</td>
<td>-</td>
<td>5.94</td>
<td>14.26</td>
<td>-</td>
</tr>
<tr>
<td>Italy I</td>
<td>26.87</td>
<td>20.26</td>
<td>+</td>
<td>18.72</td>
<td>15.89</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>20.37</td>
<td>15.49</td>
<td>+</td>
<td>12.77</td>
<td>14.26</td>
<td>-</td>
</tr>
<tr>
<td>Italy II</td>
<td>43.20</td>
<td>20.26</td>
<td>+</td>
<td>28.59</td>
<td>15.89</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>24.86</td>
<td>15.49</td>
<td>+</td>
<td>20.50</td>
<td>14.26</td>
<td>+</td>
</tr>
<tr>
<td>Norway</td>
<td>21.62</td>
<td>20.26</td>
<td>+</td>
<td>17.78</td>
<td>15.89</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>18.30</td>
<td>15.49</td>
<td>+</td>
<td>16.95</td>
<td>14.26</td>
<td>+</td>
</tr>
<tr>
<td>Serbia</td>
<td>7.12</td>
<td>20.26</td>
<td>-</td>
<td>5.38</td>
<td>15.89</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2.99</td>
<td>15.49</td>
<td>-</td>
<td>2.92</td>
<td>14.26</td>
<td>-</td>
</tr>
<tr>
<td>Sweden</td>
<td>53.44</td>
<td>20.26</td>
<td>+</td>
<td>46.45</td>
<td>15.89</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>30.79</td>
<td>15.49</td>
<td>+</td>
<td>30.79</td>
<td>14.26</td>
<td>+</td>
</tr>
</tbody>
</table>

Source: Own calculations based on data as discussed in the main text.

Returning to the results of the ADF-tests (table 2), we are confronted with a situation in which some time series are I(1) while others are I(0). Advice is conflicting in such situations: While some authors suggest estimating in first differences, others prefer running the VAR in levels despite some of the time series showing up as non-stationary. We have tried out both and found that, in most cases, results were surprisingly similar. Figure 2 shows, for instance, an impulse response function of the English bank rate, estimated both in levels and in first differences. While the overall shape of the impulse response functions tended to be very similar in most cases, the main difference was probably that impulse response functions in differences

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tended to return quicker to 0 (as one would expect). In the following, we have calculated all VARs in levels rather than in first differences.

Figure 2: Comparison of VAR estimation in levels and in first differences, illustrated by the response of the English bank rate to a (negative) one-standard deviation gold shock (Cholesky-decomposition).

Source: Own calculations based on data as discussed in the main text.
2.4 Estimating the VAR model

Estimating the VAR models
We have explained above that the main advantage of the VAR approach is that we can treat the three key time series in our context – gold reserves, monetary base, and interest rate – as endogenous. These three endogenous variables are complemented by one exogenous variable, i.e. the bank rate of the core countries (England, France, Germany).

As VAR estimations are widespread these days, there is no need to explain this technique in detail. Only two issues need to be addressed in this context: (a) the construction of the exogenous variable, i.e. the bank rate of the core countries (England, France, Germany); (b) the lag length of the VARs.

As for the exogenous variable, there was obviously the need to introduce some kind of “global” bank rate. As a matter of fact, the bank rate differential rather than the bank rate itself determines the “pulling power” of a given country. We experimented with a number of options, but finally chose to adopt the arithmetic average between the discount rates in London, Paris and Berlin. The reader may rest assured that the other options we tried out led to very similar results. In the case of England, France, and Germany, the exogenous discount rate only included the other two countries.

The appropriate lag length of each VAR model was determined by the standard lag length criteria. The most commonly used information criteria in this context – the sequential modified LR test statistic (LR), the final prediction error (FPE), the Akaike information criterion (AIC), the Schwartz criterion (SC) and the Hannan-Quinn criterion (HQ) – often suggested the same lag length, most usually one or two lags. If the information criteria suggested different lag lengths, we chose the Schwartz criterion over the others criteria for it most usually leads to shorter lag lengths.

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37 Ibid., p. 363.
Results
Space constraints prevent us from reporting the VAR estimates, but the rich interactions between the variables in the case of vector regressions (as opposed to scalar regressions) would inhibit us from attaching a straightforward interpretation to the given numbers anyway. The best way to interpret the results of a VAR model is to calculate the impulse response functions. Impulse response functions trace out how the different variables react in periods 1, 2, 3, … n to a specific shock to one of the variables in period 1. Similar to a natural science experiment in a laboratory, one specific cause and its effects can be isolated and studied on their own. This is precisely what we are interested in in our case: How does the bank rate respond in periods 1, 2, 3, … n to a sudden gold outflow in period 1? Vice versa, it is also interesting to see how much gold a given country can attract with a 1%-increase of the bank rate.

In other words, impulse response functions can be used to assess how difficult it was for a given country to maintain the gold link. As already indicated, two types of question seem to be the most relevant in this context. First, how does the bank rate respond to a sudden gold outflow? If country A needed to react much stronger than country B, we could argue that adherence to A came more costly than to B. If confronted with a gold outflow, it would then be important to determine the “pulling power” of country A as opposed to country B: If country A raises its discount rate by one percentage point, how many reserves will it attract?

Let us turn first to the first question outlined. Figure 3 shows the response of the English, German and Austro-Hungarian bank rates to a (negative) one-standard deviation gold shock (based on the Cholesky-decomposition with the Cholesky ordering gold reserves → interest rate → monetary base38). Interestingly enough, we see that the English discount rate actually responds much stronger to a gold outflow than the German discount rate, and the German discount rate reacts stronger than the Austro-Hungarian discount rate; which is certainly the opposite of what we expect.

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38 Cf. appendix 1.
Figure 3: Response of English, German and Austro-Hungarian bank rates to a (negative) one-standard deviation gold shock (Cholesky-decomposition).

Source: Own calculations based on data as discussed in the main text.

We do have to take into account, however, that the bank rate reacts to an “average gold shock” (a one-standard deviation gold shock in the words of the VAR terminology) which may obviously be very different from country to country. In other words, we need to establish the exact size of the average shock in each country which can also be inferred from the VAR estimate. Table 4 shows the average size of the gold shocks and scales them by the amount of reserves available to a specific central bank.
Table 4
Number of discount rate changes and size of average gold shock

<table>
<thead>
<tr>
<th></th>
<th>Total number of discount rate changes during estimation period</th>
<th>Discount rate changes per year during estimation period</th>
<th>Average size of gold shock, relative to average reserve level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria-Hungary</td>
<td>27</td>
<td>1.5</td>
<td>0.17%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>2</td>
<td>0.3</td>
<td>0.86%</td>
</tr>
<tr>
<td>England</td>
<td>226</td>
<td>5.8</td>
<td>2.38%</td>
</tr>
<tr>
<td>France</td>
<td>19</td>
<td>0.8</td>
<td>0.13%</td>
</tr>
<tr>
<td>Germany</td>
<td>137</td>
<td>3.6</td>
<td>0.40%</td>
</tr>
<tr>
<td>Greece</td>
<td>0</td>
<td>0.0</td>
<td>not applicable</td>
</tr>
<tr>
<td>Italy I</td>
<td>11</td>
<td>1.2</td>
<td>0.44%</td>
</tr>
<tr>
<td>Italy II</td>
<td>40</td>
<td>3.6</td>
<td>0.14%</td>
</tr>
<tr>
<td>Norway</td>
<td>83</td>
<td>2.0</td>
<td>0.88%</td>
</tr>
<tr>
<td>Serbia</td>
<td>4</td>
<td>0.6</td>
<td>1.50%</td>
</tr>
<tr>
<td>Sweden</td>
<td>65</td>
<td>1.8</td>
<td>1.48%</td>
</tr>
</tbody>
</table>

Source: Own calculations based on sources as discussed in the main text.

Table 4 is most illuminating in our context. In the English case, for instance, an average gold flow takes the size of 2.38% of the gold reserves of the Bank of England. By contrast, an average German shock is only 0.40% and an average shock to Austria-Hungary even less (0.17%), compared to their reserves.

What explains these differences, and how important are they in assessing figure 3? If we abstract from the English case for the moment, a certain pattern emerges when we try to rank countries by the size of the average shock. Serbia, Sweden, Norway and Bulgaria were all truly peripheral economies in the pre-World War I setting and all enjoy substantially higher average shocks than Germany, France, Austria-Hungary and Italy. Thus, a case could be made that, *cum grano salis*, the more peripheral an economy, the higher the average shock. But what then
explains that England had even higher average shocks? We admit that no easy answer is available to this question, but it might well have to do with London as the single most important financial centre and the most important money market before World War I. As a consequence, shocks were higher than anywhere else, as money could more easily be moved in and out of the country.

In figure 4 we have computed the response of the English, German and Austro-Hungarian bank rates to a (negative) gold shock of one percent compared to reserve levels. In other words, as opposed to figure 3, we control here for the size of the average shock. Figure 4 is much more in accordance with our expectations: London performs “best”, followed by Berlin and Vienna. Still, it is worth noting that there is little difference between Berlin and Vienna.

Figure 4: Response of English, German and Austro-Hungarian bank rates to a (negative) 1% per cent gold shock (relative to their respective gold reserves, based on Cholesky-decomposition).

Source: Own calculations based on data as discussed in the main text.
Is figure 3 more relevant for our question than figure 4 or vice versa? In our view, controlling for the size of the average shock (as done in figure 4) misses the point: If Serbia, for instance, is exposed to heavy shocks, it is little comfort to know that the country would have done better if shocks had only been on a level comparable to other countries. While the VAR technique does not allow to determine the – monetary and real-economic – factors driving the size of the average shock, VARs and impulse response functions do allow to establish their size and their importance. As a consequence, we think that figure 3 is actually more relevant to our question than figure 4.

Figure 5: Response of Austro-Hungarian and Norwegian bank rates to a (negative) one-standard deviation gold shock (Cholesky-decomposition).

Source: Own calculations based on data as discussed in the main text.

Figure 5 compares Austria-Hungary with Norway. It shows that the Austro-Hungarian response was consistently lower than the Norwegian one. This suggests that the gold link was, at all stages of the adjustment process, harder to bear for Norway than for Austria-Hungary.
While such a finding is certainly encouraging, two problems with this approach shall not be neglected. First, how do we judge the performance of two countries if country A has a higher response initially but than falls below B’s response (which is, for instance, the case for England and Germany in figure 3)? A metric would be needed to extract a single figure out of the impulse response function that would allow us to rank countries. Second, we have found it very difficult to implement this approach with countries that had infrequent discount rate changes. Figure 6 shows the cases of France and Bulgaria, both of which had, on average, less than one discount rate change per year.

Let us now turn to the second question: How much “pulling power” did each central bank have? This question asks for another impulse response function: How did the gold reserves react in periods 1, 2, 3 … n to a 1%-increase of the bank rate? Figures 7 and 8 show the cases of England, France, Germany, Austria-Hungary and Italy. Figure 7, for instance, shows that the Bank of England could attract 8% of additional reserves (compared to its current holdings), while the Reichsbank could only attract 3.5% of additional reserves. Taking figures 7 and 8 together, we see that England had, by far, the largest “pulling power”, almost twice as much as the second-best, the Bank of France. We believe that this finding needs to be taken into account when assessing what we said about the Bank of England earlier in this section. While England had, on average, higher gold shocks than any other country, it also had a substantially bigger pulling power to reverse any gold drain.
Again, it is interesting to see how well Austria-Hungary performs. A one-percent increase of the bank rate of the Austro-Hungarian bank would add an additional 4.2% of reserves which in fact is slightly more than we find for the Reichsbank. This contrasts quite significantly with Italy, another peripheral country, which had only half the pulling power.

Again, as in the case of the impulse response functions calculated above, results are not yet satisfactory for some of the other countries in our sample. The impulse response functions show virtually now – or even negative (!) – pulling power for the central banks. It does not seem to be coincidence that this problem is again more pronounced for those countries that had infrequent discount rate changes.
Figure 8: Increase of gold reserves due to a one percent increase of the discount rate, comparison between Austria-Hungary and Italy I.

Source: Own calculations based on data as discussed in the main text.
3. Conclusions

This paper was concerned with one particular aspect of the literature on the Classical Gold Standard, the pre-World War I system of fixed exchange rates. Conventional wisdom has that the adjustment process to balance-of-payments disequilibria was very different in the case of the ‘core countries’ (UK, US, France, and Germany) as opposed to the ‘periphery’. Several studies have shown that the rich core countries could get away with frequent and sizeable violations of the “rules of the game”. By contrast, it is alleged that peripheral countries had to play by the “rules of the game”, thereby exposing themselves to negative repercussions on domestic economic activity.

Drawing on the experience of three core economies (England, France, Germany) and seven peripheral economies (Austria-Hungary, Bulgaria, Greece, Italy, Norway Serbia, Sweden), this paper has argued for a more nuanced perspective on the European periphery. While the conventional view might be true for some countries – most notably the Balkan economies - , the experience of other peripheral countries, in particular Austria-Hungary, resembled more those of the core economies.

Three key points, all derived from a VAR model of monthly time series of gold reserves, monetary base, and interest rates for 10 European countries, stand out. First, the average gold drain (“gold shock” in VAR terminology) differed substantially across peripheral economies. Compared to average reserve levels, the shocks hitting the Serbian economy were, on average, almost ten times larger than the shocks hitting the Austro-Hungarian economy. As far as the average gold drain was concerned, we were able to show that Austria-Hungary and Italy were playing in a league with Germany and France rather than with the other peripheral economies. At the other end of the spectrum, Serbia, Sweden, Norway and Bulgaria were exposed to heavy shocks more in line with conventional wisdom.

In a second step, we estimated the impulse response of the bank rate to an average gold outflow. This would serve as an indication of how difficult it was to maintain the gold link. Again, we saw considerable differences between peripheral economies. We were able to show that Austria-Hungary not only had the lowest bank rate response of all peripheral economies, but even remained slightly below the German response.
In a third step, we estimated the “pulling power” of the different central banks: how many additional reserves could a specific central bank attract by raising the discount rate by one percent? Not surprisingly, we found that the Bank of England had the highest pulling power, almost twice as much as the second-best, the Bank of France, which, in turn, was followed closely by the Reichsbank. Again, Austria-Hungary followed with little distance. Italy, the next placed peripheral economy, only enjoyed half as strong a reaction as Austria-Hungary.

Last but not least, it is worth pointing out that a key question remains regarding those central banks that used the discount rate tool very infrequently. Bulgaria, Greece, Serbia, but also the Bank of France, had, on average, less than one discount rate change per year. Further research is needed to establish how exactly the gold standard operated in these countries.
Appendix: The calculation of impulse response functions

The calculation of impulse response functions differs only in how to determine the impact on the first period; henceforth, we will label the impact on the first period by the \((n \times 1)\) vector \(i_1\). For all subsequent periods \((i_2, i_3, i_4, \ldots)\), the calculation is identical; results obviously differ as they build on \(i_1\). Why does exactly the calculation of the impact in the first period differ? In order to say something about the first period, we need to know the patterns of contemporaneous causality between the variables (as opposed to intertemporal causality); eg, what is the impact of a bank rate increase on gold flows in the same month? Essentially, we are forced to make some assumptions about the patterns of contemporaneous causality, as impulse response functions cannot be calculated without them. Broadly speaking, there are two ways to solve this problem:

1) We assume there are no patterns of contemporaneous causality. In this case, the impact in period 1 is calculated as follows: As far as the variable to which the shock is supposed to happen is concerned, a one-standard-deviation shock is assumed; the size of a one-standard-deviation shock is taken from the diagonal elements of \(\Omega\), the covariance matrix of the estimated VEC model. The impact on all other variables equals 0.

2) The key objection to this procedure is that innovations in VAR/VEC models are, in general, not contemporaneously independent of one another. This is demonstrated by the fact that the off-diagonal elements of the variance-covariance matrix are usually different from zero. On reflection, such a structure of the variance-covariance matrix does not come unexpected; for we can only estimate the reduced form of the equation rather than the structural form. The structural form reads

\[
A \Delta Y_t = \Pi Y_{t-1} + \Pi_1 \Delta Y_{t-1} + \varepsilon_t
\]

where \(\varepsilon_t\) is a vector of i.i.d. error terms with a diagonal covariance matrix \(\Sigma = E(\varepsilon_t \varepsilon_t')\). The structural form contains patterns of contemporaneous causality, as off-diagonal elements of \(A\) can

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39 In our case of a VEC model including one extra differenced term, \(i_2, i_3, i_4, \ldots\) are calculated as follows: \(\Delta i_2 = \pi_1 i_1 + \pi_2 \Delta i_1\). Having established \(\Delta i_2, i_2\) can be calculated as \(\Delta i_3 + i_1\). Equally, \(\Delta i_3 = \pi_2 i_2 + \pi_3 \Delta i_2\) and \(i_3 = \Delta i_3 + i_2\).

40 In the case of one extra differenced term on the right hand side.
take values different from zero. The structural form, however, cannot be estimated by OLS in a consistent way due to the simultaneous equation bias. The only form that can be estimated is the reduced form, i.e. the form premultiplied by $A^{-1}$:

$$\Delta Y_t = A^{-1} \Pi Y_{t-1} + A^{-1} \Pi_1 \Delta Y_{t-1} + A^{-1} \varepsilon_t$$

If we set $\pi = A^{-1} \Pi$, $\pi_1 = A^{-1} \Pi_1$, and $U_t = A^{-1} \varepsilon_t$, we again obtain the form of the VEC model we have worked with so far:

$$\Delta Y_t = \pi Y_{t-1} + \pi_1 \Delta Y_{t-1} + U_t$$

The crucial thing in our context is the relationship between the covariance matrix of the reduced form and $A$: Can we recover an estimate $\hat{A}$ – which would allow us to establish patterns of contemporaneous causality – from $\Omega$?

$$\Omega = E(U_t U_t') = E(A^{-1} \varepsilon_t \varepsilon_t' A^{-1'}) = A^{-1} \Sigma A^{-1'} = A^{-1} I_n A^{-1'} = A^{-1} A^{-1'}$$

At first glance, it might seem that solving $\Omega = \hat{A}^{-1} \hat{A}^{-1'}$ for $\hat{A}$ yields a unique solution. This, however, is not the case since $\Omega$ is symmetric. Thus, we need to impose some restrictions on $\hat{A}$ before we can actually solve $\Omega = \hat{A}^{-1} \hat{A}^{-1'}$ for $\hat{A}$. How many restrictions need to be imposed? In our case with three time series, $\Omega$ is a symmetric (3 x 3) matrix, thus having 6 different elements. $\hat{A}$ is also a (3 x 3) matrix, which means we have to impose a minimum of 3 restrictions on $\hat{A}$.

What does imposing a restriction mean in economic terms? If a zero restriction is imposed, for example, this means that we rule out contemporaneous causality from one variable to another (the reverse causality is not affected).

Hence, the calculation of the impact on the first period is a two-step procedure. First, we need to establish $\hat{A}$ by imposing certain restrictions and then solving $\Omega = \hat{A}^{-1} \hat{A}^{-1'}$ for $\hat{A}$. Second, the impact on the first period is calculated as $i_1 = \hat{A}^{-1} (1, 0, 0)'$ (in case the shock is supposed to occur in the first structural equation).

What restriction can reasonably be made without offending economic sense? Standard econometric practice is to use a Cholesky-decomposition, where the upper triangle of $\hat{A}^{-1}$ is
constrained to contain zeros only. There is one variable that affects both other variables; there is another variable which has an impact only one other variable; finally, there is a variable that does not affect the other variables at all in period 1. Is there such an ordering – a so-called Cholesky ordering – that seems plausible in our case?

We could argue as follows: Gold flows can influence both the interest rate and the monetary base. An impact on the interest rate is possible as frequent meetings of the central bank ensured that the central bank react quickly and decisively to a gold outflow. Equally, any gold outflow goes, prima facie, hand-in-hand with a reduction of the monetary base; for the central bank wants to be paid for giving up gold which is equivalent to a reduction of the monetary base. Between the bank rate differential and the monetary base, we have assumed contemporaneous causality from the bank rate differential to the monetary base (and, hence, not vice versa). That the monetary base would react to a discount rate hike without too much delay is highly plausible; for the bank rate eases or tightens the credit conditions. Vice versa, we have had little evidence that the monetary base changes were of paramount importance to the central bank when setting the bank rate. Such a Cholesky decomposition – gold → i_d → mb – seems to be defensible in our case.

Even though the Cholesky decomposition gold → i_d → mb is the most convincing one, there is nothing that prevents us from trying out all possible Cholesky orderings; in our case, this yields 3! = 6 different cases. While such an approach might be considered arbitrary by some, it could also be seen as some kind of robustness check: If impulse-response functions do not differ too much regardless of the specific Cholesky-ordering, then we can have more confidence in our results than in cases where results depend to a large extent on the ordering.

Therefore, we have calculated seven different impulse response functions: six of them were based on different Cholesky-ordering, and the seventh was based on the approach that does not take contemporaneous causality into account at all (cf. above).
Bibliography

Published sources


Literature


