Business Cycle Synchronization in Europe: Evidence from the Scandinavian Currency Union

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Abstract

This paper studies business cycle synchronization in the three Scandinavian countries Denmark, Norway and Sweden prior to, during and after the Scandinavian Currency Union 1873–1913. We find that the degree of synchronization tended to increase during the currency union, thus supporting earlier empirical evidence. Estimates of factor models suggest that common Scandinavian shocks are important for these three countries. At the same time we find evidence suggesting that the importance of these shocks does not depend on the monetary regime.

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1 Introduction

A number of recent studies demonstrate that the adoption of a single currency increases trade among members of a monetary union, in this way leading to increased business cycle synchronization within the union. For example, Rose and Stanley (2005) show, using meta–analysis, that membership of a monetary union raises bilateral trade considerably (between 20 and 80 percent). López–Córdova and Meissner (2003) find that monetary integration and membership of currency unions raised trade substantially during the classical gold standard period; countries in a currency union traded 2.8 times more than countries that were not members of a union. The link from trade to business cycle synchronization is also strongly significant, see for example Frankel and Rose (1998), Clark

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and van Wincoop (2001) and Baxter and Kouparitsas (2005). An increase in bilateral trade thus feeds into increased business cycle synchronization.

To shed light on the question to what extent membership of a monetary union increases business cycle synchronization, it is promising to examine the historical record of monetary unions , taking into account observations before their creation, during their existence and, in case data permits, after their demise. The literature analyzing the properties of business cycles in a historical perspective usually focuses on comparisons across monetary regimes such as the pre-1914 gold standard (the classical gold standard), the interwar period and the post World War II period, commonly spilt into the Bretton Woods era and the years following with floating exchange rates without explicitly considering monetary unions, see for example Backus and Kehoe (1992), Bergman, Gerlach and Jonung (1992), Bergman, Bordo and Jonung (1998), A'Hearn and Woitek (2001), Chadha and Nolan (2002), Bordo and Helbling (2003). Exceptions are Bergman (1999) examining whether the three Scandinavian countries satisfied a set of optimum currency area criteria and Flandreau and Maurel (2005) studying business cycle synchronization and international trade during the classical gold standard.

In our opinion, the Scandinavian Currency Union (SCU), lasting from 1873 to 1921, is a most interesting episode in the monetary history of Europe.[1] Denmark, Norway and Sweden established the SCU in the 1870s when these three countries adopted the gold standard and as part of an agreement to introduce a new common currency unit.[2] The SCU lasted until World War I. Wartime shocks gradually undermined the foundations of the union. Eventually it was dissolved in the early 1920s.

The purpose of this paper is to examine whether business cycles in the three Scandinavian countries were more synchronized during the SCU era compared both to the period prior to the establishment of the union and after its abolishment. Given the strong and suggestive results cited above, we would expect that business cycles in the Scandinavian countries were more synchronized during the SCU compared to other periods. We document regularities of cyclical movements both across the three Scandinavian countries and across time. We also compare our findings for the Scandinavian with a select number of European countries. For these countries we expect to find increased business cycle synchronization during the post–World War II period. In order to examine regularities of business cycles and their interrelationships we make use of both simple correlation analysis and factor analysis. In particular, we use both a non–parametric and a parametric approach to measure the co-movement of business cycles in the Scandinavian countries as well as in the EU countries in our sample. First, we follow Lumsdaine and Prasad (2003) and compute measures of common Scandinavian and common European business cycles.

[1] Two other monetary unions emerged in Europe during the latter part of the seventeenth century, the Latin Union and the German Union. Bordo and Jonung (1997) offer a detailed description of these multinational monetary unions as well as of the SCU.

[2] For a discussion of why the SCU was formed and why it broke down, see Bordo and Jonung (1997) and Bergman, Gerlach and Jonung (1993).

Then we estimate and quantify the importance of these common factors for domestic business cycles. As an alternative we follow Stock and Watson (2005) and estimate a Factor–Structural VAR model allowing us also to study the importance of common international shocks as well as spillover effects since domestic shocks are allowed to affect other countries as well, a feature that the first method does not allow.

Our empirical study extends the existing literature in several directions. To our knowledge this is the first paper comparing the behavior of business cycles in the Scandinavian countries before, during and after the SCU era. Flandreau and Maurel (2005) study only the period 1880–1913 with a focus on trade and business cycle synchronization. We also extend the historical data backwards using recently published data for the Scandinavian countries allowing us to further explore changes in synchronization over time. We also compare our findings with the behavior of business cycles in eight EU countries and their relationships with Scandinavian business cycles.

Our main result is that business cycles in the three Scandinavian countries were more synchronized during the SCU compared to the post–World War II period but not more than during the period prior to the establishment of the union. For the European countries in our sample, we find an increase in average cross–correlations consistent with the view that increased economic integration leads to more synchronized business cycles.

The remainder of the paper is organized as follows. In the next section we give a short account of the rise and fall of the Scandinavian Currency Union In section 3 we discuss the data used and the methodology adopted to analyze business cycle synchronization. Section 4 contains the empirical analysis. Section 5 concludes.

2 The Scandinavian Currency Union 1873–1921

A number of attempts of creating monetary unions were made in Europe in the 19$^{\text{th}}$ century. Monetary unification took place *within* some nation states like Italy and Germany. These countries established national monetary unions defined as a union where political and monetary sovereignty went hand in hand. Following political unification in Italy in the 1860s and in Germany in the 1870s, coinage was unified and eventually a central bank was established.

Monetary unions were also created through cooperation between independent countries based on permanently fixed exchange rates between their currencies, although each member of the union maintained their own central bank and political independency. Such unions can be labeled as multinational monetary unions. In the extreme case the members of the union share the same currency.[3]

Two multinational monetary unions emerged in Europe prior to World War I. First, Belgium, France, Italy and Switzerland formed the Latin monetary union in 1865, with Greece joining in 1868. This union was based on gold and silver, and was thus a bimetallic

[3]See Bordo and Jonung (1997) on the distinction between national and multinational monetary unions.

union. In the late 1860s, Denmark and Sweden were considering joining the Latin monetary union. However, the French–Prussian war 1870–71 changed the scene completely. The surrender of the French army at Sedan on September 1, 1870 and the cease fire in the beginning of 1871 made a Scandinavian arrangement more attractive.[4] The outcome was the founding of a monetary union in Scandinavia, set up as a multinational monetary union.

The design of the SCU: The three Scandinavian countries were all on a silver standard prior to the establishment of the Scandinavian Currency Union in the beginning of the 1870s. At a meeting in Stockholm on 18 December, 1872, a currency treaty (*myntkonvention*) was signed.[5] It went into legal force in Denmark and Sweden in May, 1873. The parliament in Norway rejected, however, the treaty. Gradually the opposition in Norway subsided. Norway eventually joined the union on 16 October, 1875.

As part of the SCU treaty, the three countries introduced the decimal system and adopted a common unit of currency based on gold, the Scandinavian crown (*krona*), equivalent to the old Swedish *riksdaler*. One gold value of the *krona* (in Danish *krone*) was set to 1/2480 kilo of gold. Beside gold coins, each country was allowed to mint subsidiary (token) coins in silver and bronze with denomination and weight regulated by the treaty. The three Scandinavian countries also agreed to accept both gold and token coins issued in other member countries as legal tender. The stock of token coins was not regulated so that each country was allowed to issue the amount necessary but fixed rates between token and gold coins prohibited over issue of national currencies.[6] The circulation of national currencies in the Scandinavian countries was considerable even before the union was formed. This facilitated the introduction of the new common currency.[7]

With the establishment of the SCU, the Scandinavian countries left the silver standard and joined the international gold standard. They retained full control and sovereignty over monetary policy within the confines of the gold standard serving as the anchor of the monetary union. To monitor the monetary authorities in other member countries, they agreed to share information on all monetary activities including withdrawal of old coins and minting of new ones, once a year. Examinations of national coins with respect to the prescribed standards should also be accomplished regularly.

The monetary union evolved over time. Although the treaty of the SCU did not mention notes, the Swedish central bank accepted Danish and Norwegian notes at par when the SCU was founded in 1873. Formal agreements were signed in 1894 between Norway and Sweden, and Denmark joined the bilateral agreement in 1901. Furthermore, the three central banks agreed to permit each other the right to draw drafts in other

[4]Another option for the Scandinavian countries was to join the German monetary union. However, there was fear of being too closely tied to Germany. Besides, the Germans did not express an interest.

[5]For a detailed account of the debate leading to the establishment of SCU, see Øksendal (2006).

[6]See Alin (1900) on the treaty. The background and legal framework of the SCU is covered by among others Talia (2004), Øksendahl (2006,2007) and Jonung (2007).

[7]See Henriksen and Kærgård (1995).

Scandinavian currencies at par. This system of mutual drawing rights was agreed upon in 1885.[8]

Although the three Scandinavian countries had a common currency, the foreign exchange markets in Copenhagen, Christiania and Stockholm quoted separate exchange rates of their currencies. Heckscher (1926), for example, argued that the exchange rate bands should be smaller within a single currency area based on a gold standard than against other currencies also based on gold. The argument is that the gold standard by itself creates a currency union but a single currency that is legal tender in all member countries tends to move the gold points even closer to its parity. Full parity is, however, not necessarily guaranteed. Comparing the volatility of the nominal exchange rate among the Scandinavian countries and countries outside the single currency area, we find much lower volatility of intra–Scandinavian exchange rates compared to Scandinavian/non–Scandinavian exchange rates. For example, the Swedish/German mark exchange rate was twice as volatile as the Swedish/Danish exchange rate. This suggests closer gold points within the SCU compared with other gold standard countries.

The SCU treaty only concerned monetary aspects, the establishment of a common currency,leaving other international relationships such as trade outside the agreement.[9] This is surprising given the high degree of openness in these countries but intra–Scandinavian trade was relatively unimportant compared with the trade with England and Germany. Actually, intra–Scandinavian trade fell during the SCU; see Henriksen and Kærgård (1995).

After the breakdown of the political union between Norway and Sweden in 1905, the Swedish central bank revoked the agreements of 1885. However, acceptance of each other drafts continued, but no longer necessarily at par. The union functioned well up to the outbreak of war in 1914.

Macroeconomic developments during SCU. The SCU operated in a stable macroeconomic environment fostered by the classical gold standard. Nominal convergence within the SCU was substantial. The exchange rates between the three currencies remained 1:1:1, interest rates moved in close accord. The SCU contributed to financial integration within Scandinavia.

Economic growth was high in Scandinavia compared to many other gold standard countries. Relative per capita GDP levels remained almost constant during this period, see Krantz (1987). Labor force movements were relatively small between the Scandinavian countries throughout the pre–World War I period. While population growth in Denmark and Norway were stable during the SCU period, it fluctuated considerably in Sweden.

The economic structures in the three Scandinavian countries differed considerably dur-

[8]Heckscher (1926) and De Cecco (1992) suggest that this agreement tied the countries closer together than the gold standard did.

[9]Denmark differed from Sweden and Norway by maintaining free trade during the SCU period. Free trade of agricultural products was abandoned by Sweden in 1888 and in 1897 for industrial products when Norway also abandoned free trade.

ing the era of SCU, see Jörberg (1970). The agricultural sector dominated the Danish economy. In particular, this sector was the biggest earner of foreign income, the export share of agricultural products was about 80 percent during the SCU period. This sector was also important in Sweden, although not as important as the Swedish industrial sector, but relatively unimportant in Norway where the service sector played a major role for economic developments. The most important trading partners of the Scandinavian countries were Germany and the UK. Norwegian exports were dominated by gross freight earnings from ocean shipping (32 to 45 percent of total exports) and fish and whale products (15 to 20 percent of total exports). In Sweden, timber was the largest export sector, 26 to 40 percent of total export.

Although the Scandinavian countries managed to form a single currency area, it is noteworthy that economic developments differed among them, in particular concerning the structure of their economies, trade patterns, tariffs and population growth. In the light of these differences it is surprising that the SCU has been regarded as a successful European currency union.

The dissolution of the SCU: At the outbreak of World War I, all Scandinavian countries left the gold standard following the international response pattern. Divergent growth rates of money and prices in the three member countries during the period 1915–20 caused eventually the dissolution of the union. However, its decline was a lengthy process which occurred in roughly three steps.

First, at the outbreak of World War I, the Scandinavian countries suspended the gold convertibility of their currencies. Second, a gold embargo was established in all three countries in 1916 and 1917. The third step, finally, was taken in the early 1920's when Scandinavian token coins ceased to be accepted at fixed exchange rates in the three countries.

After the outbreak of war, Denmark and Norway experienced a sharp rise in foreign exports that was not shared by Sweden. As a result of this, monetary growth in Denmark and Norway as measured by notes in circulation was higher than in Sweden in 1914–16, causing an inflow of Danish and Norwegian notes into Sweden. As a result of this, the exchange rate of the Danish *krone* eventually declined. This decline was first publicly noticed in October 1915. In December, Norwegian notes were bought by the Swedish central bank (*Riksbank*) at the rate of 99. The exchange rates continued to fall and by 1920 the rates were 77.05 for the Danish *krona* and 80.75 for the Norwegian *krona*. These changes in exchange rates were caused by differential growth rates in money and prices in the three Scandinavian countries, see Bergman, Gerlach and Jonung (1993).

In February 1916 Sweden enforced an embargo on gold by restricting the trading of gold. This step signaled the second phase of the fall of the Currency Union. These restrictions, however, did not pertain to the inflow of gold minted in Denmark and Norway since, according to the statues of the Union, gold minted by one of the member countries was legal tender in the other countries. The Swedish Riksbank thus had to exchange such gold coins in notes on demand. The Swedish authorities wanted Denmark and Norway

to establish a gold embargo in order to curtail any inter–Scandinavian gold flows. In the summer of 1917 a prohibition on the export of gold had been enforced by all three countries. The gold embargo of the Swedish Riksbank was finally fully effective.

After these steps the notes and the gold coins of the individual members of the SCU were no longer traded at fixed rates and they were no longer legal tender in all of Scandinavia. There was still one remnant left from the original Union. Token coins were legal tender at the pre-war parity. One Norwegian or Danish *krona* in token coins was thus equal to one Swedish *krona*. However, the monetary development of Sweden had been quite different from that of Denmark and Norway — the exchange rates of the Danish and Norwegian currencies had, as discussed above, fallen far below the Swedish one by the beginning of the 1920s. Although the authorities had prohibited the export of token coins, the exchange rate differentials were so large that they induced a comprehensive smuggling of petty coins, which was organized on a large scale. Coins were collected within Denmark and Norway and brought illegally to Sweden. Eventually these events forced the authorities to abolish the last elements of the SCU in 1921, under pressure from Sweden.[10]

3 Data and Methodology

3.1 Data

The data set consists of annual observations on real GDP for 12 OECD countries, Denmark, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, the UK and the US. The sample period for the three Scandinavian countries is 1834–2008 whereas the sample for the other countries is 1880–2008. The data set we draw on is the same as used earlier by Bergman, Bordo, and Jonung (1998) and Bordo and Helbling (2003), see either of these papers for a complete description of the underlying sources. We have updated the GDP series to 2008 for most countries using the IMF's International Financial Statistics data base and historical GDP series for the three Scandinavian countries from 1873-1880 taken from Bergman, Gerlach and Jonung (1993). In order to extend our Scandinavian data back to 1834 we use Hansen (1974) for Denmark, Grytten (2004) for Norway, and Edvinsson (2005) for Sweden.

3.2 Measuring domestic business cycles

Prior to our empirical analysis we must extract the cyclical component from the macroeconomic time series, expressed as the natural logarithm of real GDP. We use the Christiano-Fitzgerald (2003) full sample asymmetric filter where the weights on the leads and lags

[10] After World War I there was discussion in Scandinavia of resurrecting the SCU, sparked by the return to gold after World War I. This discussion did not amount to new union. See Jonung (2007).

are allowed to differ. The asymmetric filter is time-varying with the weights both depending on the data and changing for each observation. We assume that the underlying series contain unit roots and we remove a linear trend prior to applying the filter following the adjustments suggested by Christiano and Fitzgerald (2003). In particular, we isolate cyclical components of the data with durations conforming to the Burns-Mitchell definition of the business cycle, i.e., we extract all fluctuations at frequencies between 2 and 8 years from the logarithm of real GDP in each country.

3.3 Measuring the international business cycle

There are several different approaches to measure international business cycles and their importance for domestic cycles, for example parametric dynamic factor models (Kose, Otrok and Whiteman (2003) and Kose, Prasad and Terrones (2003)), nonparametric methods to estimate dynamic factor models (Stock and Watson (2002) and Forni, Hallin, Lippi and Reichlin (2000)), and factor VAR models (Norrbin and Schlagenhauf (1996) and Stock and Watson (2005)). We adopt a nonparametric approach to estimate common dynamic factors representing international business cycles. In particular, we estimate a Scandinavian business cycle component and different measures of EU cycles and then use these international cycle components to estimate the importance of shocks to these common factors using structural VAR models.

We apply the method suggested by Lumsdaine and Prasad (2003). This method is based on the observation that large countries have low business cycle volatility whereas small countries have large volatility. Furthermore, large countries should be less influenced by the international business cycle as compared to small economies. The disadvantage of this approach is that we estimate a common business cycle component even if there is none. However, given that we are interested in measuring the importance of common cycles in the Scandinavian countries and its changing importance over time, we regard this disadvantage as not problematic. As an alternative, we also adopt the Factor–Structural VAR (FSVAR) framework suggested by Stock and Watson (2005) to estimate the importance of international shocks on domestic economies.

Following Lumsdaine and Prasad we suggest that the following GARCH(1,1) model for the domestic real GDP could be used to construct time–varying weights

$$y_{it} = c_i + \varepsilon_{it} \tag{1}$$

where $\varepsilon_{it} \sim N(0, h_{it})$, $h_{it} = w_i + \alpha\varepsilon_{it-1}^2 + \beta h_{it-1}$, y_{it} is the bandpass filtered component of the logarithm of GDP in country i, and c and $w > 0$ are constants. The parameters in the equation for the conditional variance, α and β, are constrained to be greater than zero and are assumed to satisfy $\alpha + \beta < 1$. The GARCH(1,1) model above is estimated for each country independently. The estimate of the conditional variance h_{it} can then be

used to construct the weights

$$W_{it} = \frac{(h_{it+1})^{-1/2}}{\sum_{i=1}^{n}(h_{it+1})^{-1/2}} \tag{2}$$

such that the common component can be constructed using

$$z_t = \sum_{i=1}^{n} W_{it} y_{it}. \tag{3}$$

Applying this method, we construct one common Scandinavian business cycle and a common European business cycles excluding the three Scandinavian countries. In the equations above, we let $n = 3$ when constructing the common Scandinavian business cycle component, z_t^{SCU} in real GDP in the three Scandinavian countries. Similarly, we let $n = 4$ (France, Germany, the Netherlands and Italy) when constructing a common business cycle component for the original EU member states, and finally we let $n = 8$ when estimating a common EU business cycle component.

The FSVAR model, suggested by Stock and Watson (2005), used as an alternative approach is based on the following VAR model

$$y_t = A(L)\, y_{t-1} + \varepsilon_t \tag{4}$$

where y_t is a vector of bandpass filtered output and where the residuals ε_t have the following factor structure

$$\varepsilon_t = \Gamma f_t + \xi_t \tag{5}$$

where f_t are common factors, Γ is a matrix containing factor loadings and ξ_t are idiosyncratic or country–specific shocks. It is assumed that $\mathrm{E}[f_t f_t']$ and $\mathrm{E}[\xi_t \xi_t']$ are both diagonal.

The common factors contained in f_t are identified as common shocks affecting more than one country simultaneously. In our application, we will estimate an FSVAR model consisting of both SCU and EU countries and identify two common shocks, one among the SCU countries and one among the EU countries. The estimated FSVAR model can then be used to compute the decompositions of forecast error variance of bandpass filtered GDP into four components, common shocks either originating in SCU countries or in EU countries, domestic shocks and spillover effects (defined as 1 minus the sum of the forecast error variance explained by the two common factors and domestic shocks).

4 Empirical Work

4.1 Business cycles in individual countries

In Figure 1, we show plots of the Danish, Norwegian and Swedish and business cycles and the two estimated international business cycles using the Lumsdaine and Prasad approach to be further examined below.[11] Looking at the three graphs in Figure 1, we find a positive relationship between domestic and common business cycles. However, the overall impression is that the Swedish economy seems to be somewhat more synchronized with the EU cycle than the Danish and Norwegian cycles. The recessions during the 1930s, in the late 1970s and early 1990s can clearly be seen. These recessions correspond to similar recessions in the common components. Also the great moderation of output fluctuations can be noted. There seems to be a lower volatility in the estimated cyclical components in all three countries as well as in the estimated common cycles.

In Table 1 we report average phase durations and measures of the volatility calculated using the bandpass filtered GDP data for the three Scandinavian countries. We compare three distinct samples, the Silver standard 1834–1872, the Gold standard and SCU period 1873–1913 and the postwar period 1951–2008. The Table reports for each series and for each subperiod, the average length of expansions ($\bar{\text{E}}$), the average length of contractions ($\bar{\text{C}}$), and the volatility (σ). The lower panel contains Wilcoxon rank–sum statistics (Diebold and Rudebusch (1992)) testing the null of no change in average phase durations. This test is standardized such that it can be interpreted as a standard t–statistic. Finally, we report the Brown and Forsythe (1974) test of equal variance of the business cycle in two subsamples. For expansions we find only one case when we reject the null of equal phase durations. For Denmark, the average length of expansions has increased from 1.6 years during the Silver standard to 2.7 years on average in the postwar period. There are three case when we reject equal average lengths of contractions, Denmark between the Silver and Gold standard periods where the average length increased from 1.8 years to 3.3 years during the Gold standard and for Sweden where the average length fell from 2.3 years to 1.6 years when comparing the Silver and Gold standard periods and then increased again to 2.6 years during the postwar period.

Comparing contractions and expansions we find no uniform results, for some countries and samples we find that the duration of expansions exceed the duration of contractions (five out of nine cases) but there are also cases when the opposite holds (four out of nine cases). There are also a few cases when the volatility has changed, for Norway the volatility fell during the postwar period compared to the Silver standard and for Sweden where fell considerably after the Silver standard. However, we fail to reject the null that

[11] The bandpass filtered GDP series are very persistent implying that the stationarity restriction that $\alpha + \beta < 1$ is violated quite frequently. When estimating the GARCH(1,1) models, we impose the restriction when necessary. We have also computed the common component using IGARCH(1,1) models and compared to the standard GARCH(1,1) model. The empirical results below are unaffected when using the IGARCH model.

the variance of the business cycle has changed in the postwar period compared to the classical Gold standard.

The results in Table 1 are also consistent with earlier empirical evidence where other detrending methods and filters have been used, see for example Bergman, Bordo and Jonung (1998) and Chadha and Nolan (2002). The average duration of business cycles peak to peak is 4 to 5 years and is fairly constant over time (when disregarding the interwar period). However, A'Hearn and Woitek (2001) examining data covering the period 1865–1913 find more evidence of a longer cycle in GDP with duration between 7 to 10 years for 13 countries.

4.2 Co–movements of business cycles

In order to learn more about the synchronization of business cycles in the Scandinavian countries we show, in Figure 2, the average correlation of business cycles during a rolling 20 year period. Each point in this graph represents the average cross–correlation over the last 20 years. As seen from this graph, the average cross–correlation fell during the 1840s and 1850s towards zero. In the early 1870s the cross-correlation tended to increase again, and increased during the SCU until early 1900. During the World War I, business cycle synchronization unsurprisingly fell but increased sharply during the interwar period. In the post–World War II period there has been a long swing, first up, then down and then finally up again. However, the average cross–correlation is fairly small, around 0.3 during the last 20 years.

As a comparison we have also included in the graph estimates of the average cross–correlations between the three Scandinavian countries and the UK and the original members of EU (France, Germany, Italy and the Netherlands). The average cross–correlation among the Scandinavian countries is not exceptionally high compared to the correlation with other countries. During the first part of the SCU period, the average correlation among SCU countries is about the same as the average correlation with the UK business cycle.

It is tempting to view the increase in cross–correlations during the SCU as a result of increased economic integration but when looking in detail at the cross–correlations and how they have changed from the SCU era until the post–World War II period we find no strong evidence supporting such conclusion, see Table 2. Here we report point estimates of the change in the cross–correlation between different periods for the three Scandinavian countries. A negative number implies that the cross–correlation has fallen during the later sample. Looking first at the change in the cross–correlations in the period prior to the SCU and the SCU era we find small and insignificant changes. The average change is in absolute value 0.06 and is not statistically significant at conventional levels. On average, there has been no increase in the cross–correlations.

We also find that the average cross–correlation has fallen significantly in the post–World War II period compared to both the period prior to the SCU and the SCU period.

The average change in the correlations is -0.30 and is significant at conventional levels. But at the same time, this holds only for Denmark and Norway when comparing SCU with the post–World War II period. The cross–correlation between Sweden and Norway remained almost constant.

Let us compare with EU countries. In Figure 3 we show rolling estimates of average cross-correlations for three different groups of EU countries; original member states: France, Germany, Italy and the Netherlands; EMU–countries: The four above plus Finland, Portugal and Spain; and EU countries: all above plus the UK. According to this graph there is a clear tendency of the average cross–correlation to increase over time regardless of how we combine the eight EU countries. The largest increase in the average cross–correlation is for the four original members of the EU. However, there seems to be a fall in the degree of synchronization among these countries recently. It is interesting to compare this graph with Figure 2 showing the rolling estimate for the Scandinavian countries. Recently the synchronization tended to increase in these countries to an average around 0.3. But we also note from Figure 3 that the synchronization fell recently in the four original members of EU to around 0.3.

It is difficult to draw any strong conclusions about the effects of economic integration on business cycle synchronization. It may be the case that there is a positive relation, supported by the estimates in Figure 3, or, alternatively, there is no such strong relation as indicated in Figure 2.

In Table 3 we show the change in cross–correlations between the period 1880–1913 and 1948–2008 for eight EU countries. The average change in the correlation is 0.24 with standard error equal to 0.06 (implying that there is a significant increase in correlation). Similarly, looking only at EMU countries we find that the average correlation has increased by 0.22, somewhat smaller than for all countries on average (this is also significant). However, focusing only on the original members of EU (France, Germany, Italy and the Netherlands), we find that the average cross–correlation has increased by 0.69 on average.

In order to test the null hypothesis of independence, we follow the suggestion by Harding and Pagan (2002) by regressing the binary business cycle indicator in one country on the binary variable for another country. The results from these regressions are shown in Table 4 for the Scandinavian countries during the same samples as was used above. The Table only reports p–values of the t–test statistic computed using Newey–West standard errors. As is evident from Table 4, we find no uniform result. The first impression one gets is that business cycles in the Scandinavian countries appear to be independent to a large degree. Also surprising is that all three business cycles are independent during the post–World War II period. However, one should keep in mind that we only measure the contemporaneous effects using the binary indicator, lagged dependencies are excluded. Looking more closely at the subsample estimates we find that Danish and Swedish business cycles are dependent whereas the Norwegian cycle is either related to the Danish cycle or independent.

In the next section we turn to the factor models. First we construct a Scandinavian and

an EU business cycle component using the Lumsdaine and Prasad approach and measure the importance of these common cycles on cycles in the three Scandinavian countries. Then we estimate an FSVAR model.

4.3 Importance of international and country–specific shocks

The two factor models discussed above allow us to examine the importance of international common shocks for output fluctuations in the Scandinavian countries. Using the Lumsdaine and Prasad approach, we obtain a measure of a common business cycle component in the Scandinavian countries, see Figure 1. This component represents a common SCU business cycle. Since this measure depends on three different output series implying that simple regressions or correlations only reflect the weights used to construct the measure, we set up a VAR model for each country comprised of domestic output, the common SCU cycle and our measure of the common European business cycle. This VAR model allows us to measure the relative importance of two common international shocks and one country–specific shock. Furthermore, estimating this model for different sub–samples we can explore potential changes in the relative importanceof shocks. We would expect, if monetary integration leads to increased business cycle synchronization, that shocks to the common SCU cycle should explain large parts of Scandinavian output during the SCU era whereas the EU cycle should be more important during the post-World War II period.

In Table 5 we report estimates of the forecast error variance of domestic output explained by each shock. All these estimates are based on trivariate VAR models with 2 lags. Below each estimate standard errors computed using bootstrap simulations with 1000 trials are shown. Results are provided for two different samples, the SCU era 1873–1913 and the post World War II period 1948-2008.

Looking first at the results for the SCU period in the left hand panel where we report results for three forecast horizons, 1, 2 and 5 years. A general result, which is consistent with our prior that the three Scandinavian countries were integrated which lead to a high degree of business cycle synchronization, is that shocks to the SCU cycle are more important than shocks to the EU cycle except for Sweden and horizons exceeding 5 years. Moreover, shocks to the EU cycle do not significantly affect Danish or Swedish GDP at short horizons, the one year horizon. Country–specific shocks explain large parts of output fluctuations in Sweden and lesser parts in Denmark and Norway.

For the postwar period we expect that the importance of the EU cycle should increase. This hypothesis is not supported by the estimates in Table 5. On the contrary, the importance of the EU cycle seems to be reduced considerably for all three Scandinavian countries. The importance of shocks to the SCU cycle is relatively unchanged while the importance of domestic shocks tends to increase. These results suggest that the three Scandinavian countries are integrated and that the degree of economic integration remains high even when there is no formal currency union. It is surprising that, in particular, Denmark is not more dependent on the EU cycle. On the other hand, when

estimating models using data covering the latter part of the postwar period (from 1973) we find that the importance of the EU cycle increases whereas the importance of the SCU cycle decreases.[12] We have also experimented with other model specifications where we also include the business cycle in the UK and a common business cycle component in the original members of EU. The main results reported in Table 5 are relatively unaffected. The common EU and the UK cycles explain small parts of the forecast error variance of Scandinavian business cycles.

There are some potential problems when using the Lumsdaine and Prasad approach. The main problem is that we obtain an estimate of a common business cycle component even in cases when there is none. Given that we only use three output series to construct our measure of the SCU cycle, it should not be a surprise that this measure is highly correlated to output fluctuations in individual countries. On the other hand, the weights used to construct the common cycle are time-varying implying that the correlation in principle measures the average weights used to construct the measure. This problem may not be severe in our estimations above since we are using the VAR approach focus on the effects of shocks to the common component instead of simple correlations between individual countries and the common factor. Another problem is that the method excludes the possibility of spillover effects. All co–movements stem from common shocks rather than from spillover effects.

The FSVAR method outlined above does not have these drawbacks. If there is no common shock and all co–movements stem from spillover effects, no common shock is estimated. On the other hand, a common shock is identified as a shock affecting all countries contemporaneously. We estimate the FSVAR model using maximum likelihood under the assumption that there are two common factors, one common Scandinavian and one common European.[13] Thus, we impose zero restrictions on the factor loadings associated to EU countries (SCU countries) in the first (second) column of Γ. The number of lags is 2 and the model consists of the three Scandinavian countries and the four original members of EU, France, Germany, Italy and the Netherlands.[14]

The forecast error variance of domestic output in the three Scandinavian countries is shown in Table 6 for the SCU era and the post-World War II period. The immediate impression is that the results confirm our earlier empirical evidence in Table 6. Common SCU shocks are still very important for the three Scandinavian countries while EU common shocks explain small parts of the forecast error variance of output. Comparing the two samples we find that the importance of EU shocks tends to decrease in all three countries. The most notable difference between the three Scandinavian countries is that

[12] These results are not reported here but are available upon request from the authors.

[13] The general approach is to test for the number of common factors prior to the estimation of the FSVAR model. We have, however, decided to impose a structure that allow us to estimate the relative importance of Scandinavian and European common shocks as this is our main purpose in the present setting.

[14] We have also extended this base model by also including the U.K. business cycle as a single factor. The results are very similar to the ones presented below.

Danish country–specific shocks are estimated to be unimportant whereas they are very important for the other two countries, where country-specific shocks explain more than half of the forecast error variance of domestic output. Furthermore, the common Scandinavian shock dominates Danish GDP in both periods (at shorter forecast horizons). Spillover effects are of less importance and explain output fluctuations to approximately the same degree as the common EU shocks.

These results can be compared to the variance decomposition of GDP in EU countries, see Table 7. As expected, the common Scandinavian shock explains small parts of domestic output whereas the EU common shock is considerably more important. We also find that spillover effects are somewhat more important for EU countries and that the fractions of output fluctuations explained by own shocks vary considerably across country and across time. For some countries and samples own shocks dominate (France during the post–World War II period) or have no explanatory power at all (the Netherlands during the post–World War II period).

How should these results be interpreted? Our interpretation is that common Scandinavian shocks are important for the three Scandinavian countries. At the same time we fail to find an increasing importance of common EU shocks. It may be that our use of annual data explains the absence of strong EU dependence during the post-World War II period. If we split the sample in the 1990s, results may be different. When examining the rolling estimates of average cross–correlations we do find evidence supporting the idea that EU wide shocks may become more important for the Scandinavian countries. At the same time we find no significant difference between the period prior to the establishment of SCU and the SCU era which questions the strong relationship between monetary integration and business cycle synchronization found in the literature.

5 Conclusions

This paper examines business cycle synchronization in the Scandinavian countries (Denmark, Norway and Sweden) prior to, during and after the Scandinavian Currency Union 1873–1913. Our focus is on the question whether business cycles are significantly more synchronized during a monetary union. In particular, we test, using simple cross–correlation analysis as well as estimates of two types of factor models, whether there are changes in the average degree of synchronization and how important common international shocks are for domestic output fluctuations. The analysis is based on bandpass filtered annual GDP data, using the Christiano–Fitzgerald filter.

Our empirical results are not fully consistent with the view that business cycles are more synchronized during monetary union. The estimates of changes in average co–movements of Scandinavian business cycles do suggest that business cycle synchronization tend to increase during the SCU era and decrease after the abolishment of the union. For EU countries we observe a similar behavior, business cycles in these countries seem to be more synchronized during the most recent 20 years.

Results from the two factor models we estimate (Lumsdaine and Prasad (2003) non-parametric method and Stock and Watson (2005) VAR based factor analysis) suggest that Scandinavian common shocks explain large parts of output fluctuations in the Scandinavian countries and that there is no uniform empirical evidence suggesting that common shocks originating in the Scandinavian countries become less important whereas common EU shocks become more important.

Why is not the behavior of business cycles within Scandinavia not more closely connected than our estimates suggests? One explanation may be that intra–Scandinavian trade decreased during the latter part of the nineteenth century. Instead, exports to the U.K. and Germany increased considerably. If the Scandinavian countries had adopted free trade within the union, one would anticipate that trade and financial ties should strengthen over time, in turn increasing the synchronization of domestic cycles.

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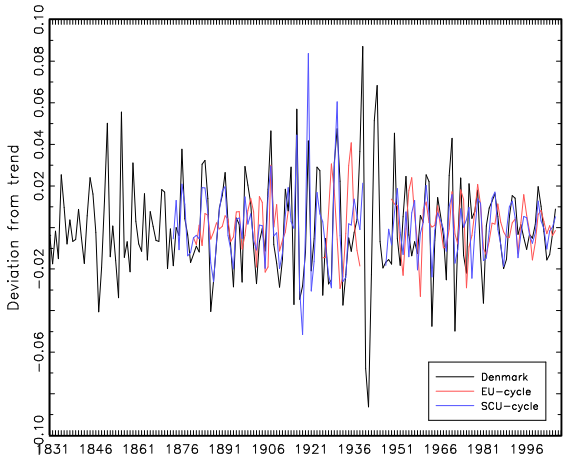
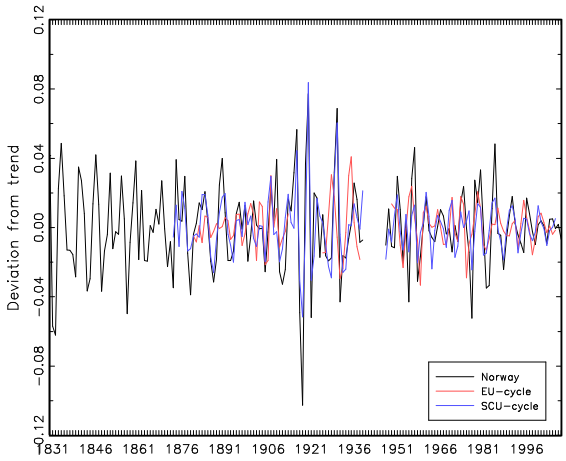
Figure 1: Bandpass filtered GDP in Scandinavian countries 1830–2008 and estimated EU and SCU business cycles.

(a) Denmark



(b) Norway



(c) Sweden

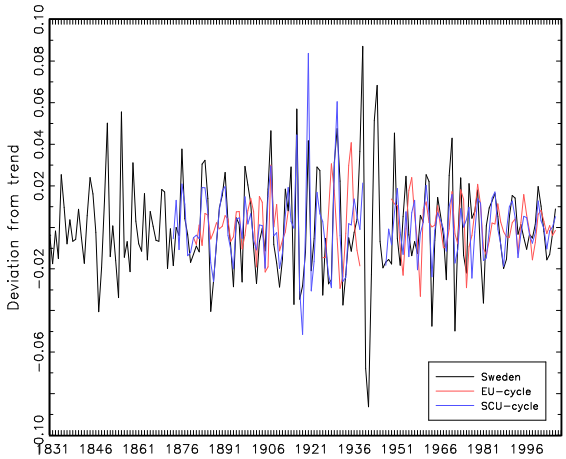


Figure 2: Rolling estimate of average cross–correlation between SCU countries and between SCU and EU countries 1834–2008, 20 period window.

Figure 3: Rolling estimate of average cross–correlation between EU countries 1880–2008, 20 period window.

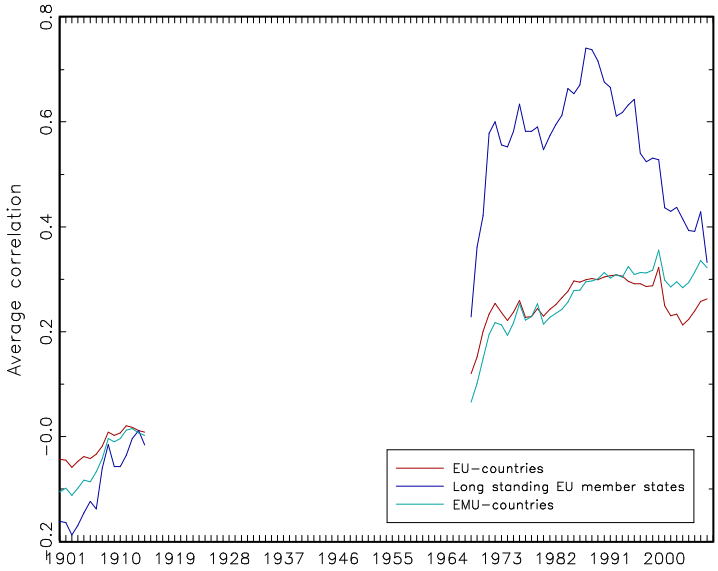


Table 1: Business cycle characteristics in the Scandinavian countries.

	Volatility and average phase duration								
	1834–1872			1873–1913			1951–2008		
	σ	$\bar{\text{C}}$	$\bar{\text{E}}$	σ	$\bar{\text{C}}$	$\bar{\text{E}}$	σ	$\bar{\text{C}}$	$\bar{\text{E}}$
Denmark	2.0	1.8	1.6	2.1	3.3	2.4	1.8	2.3	2.7
Norway	2.3	2.1	2.0	2.0	2.4	2.9	2.0	2.2	2.2
Sweden	3.2	2.3	2.4	1.5	1.6	2.2	1.4	2.6	2.1
	W_{C}^{12}	W_{C}^{13}	W_{C}^{23}	W_{E}^{12}	W_{E}^{13}	W_{E}^{23}	BF^{12}	BF^{13}	BF^{23}
Denmark	−1.9	−1.0	1.4	−1.7	−1.9	−0.3	0.66	0.58	0.27
Norway	−0.6	−0.1	0.5	−1.2	−0.3	1.1	0.44	0.05	0.23
Sweden	1.9	−0.9	−2.4	0.3	0.5	0.0	0.00	0.00	0.79

Note: In the upper panel we report the volatility of BP–filtered GDP (σ) and the average lengths of contractions ($\bar{\text{C}}$) and expansions ($\bar{\text{E}}$) measured in years. The lower panel reports standardized Wilcoxon rank–sum tests of the null hypothesis that the average lengths of contractions and expansions are unchanged across sub–samples. W_i^{12} denotes a test comparing sample 1: 1834–1872 and sample 2: 1873–1913. Finally, BF is the Brown–Forsythe test of equal variances in two sub–samples, only p–values are reported in the table.

Table 2: Changes in cross–correlations in SCU countries.

	1834-1872/1873-1913		1834-1872/1951-2008		1873-1913/1951-2008	
	Norway	Denmark	Norway	Denmark	Norway	Denmark
Denmark	0.08		-0.32		-0.39	
	(0.19)		(0.19)		(0.16)	
Sweden	0.06	-0.08	0.10	-0.08	0.04	-0.01
	(0.19)	(0.26)	(0.15)	(0.21)	(0.18)	(0.21)

Note: Newey-West standard errors are shown in parentheses below each estimate.

Table 3: Changes in cross–correlations in EU countries.

	Finland	France	Germany	Italy	Netherlands	Portugal	Spain
France	-0.04						
	(0.23)						
Germany	-0.03	0.08					
	(0.27)	(0.19)					
Italy	-0.48	0.68	0.56				
	(0.21)	(0.23)	(0.20)				
Netherlands	-0.08	0.68	0.95	0.92			
	(0.25)	(0.16)	(0.13)	(0.15)			
Portugal	0.11	0.90	0.69	0.53	-0.17		
	(0.19)	(0.16)	(0.14)	(0.19)	(0.14)		
Spain	0.19	0.31	0.69	-0.16	-0.33	0.07	
	(0.25)	(0.16)	(0.13)	(0.18)	(0.17)	(0.23)	
U.K.	-0.05	0.72	0.49	0.10	0.07	0.37	-0.04
	(0.18)	(0.17)	(0.25)	(0.17)	(0.28)	(0.24)	(0.17)

Note: Newey-West standard errors are shown in parentheses below each estimate.

Table 4: Tests of business cycle independence.

	1834–2008		1834–1872	
	Norway	Denmark	Norway	Denmark
Denmark	0.052		0.706	
Sweden	0.227	0.003	0.448	0.013
	1873–1913		1948–2008	
Denmark	0.019		0.897	
Sweden	0.374	0.001	0.300	0.906

Note: The table reports p–values of t–test statistics computed using Newey–West standard errors. All tests are based on binary indicators of business cycle recessions and expansions.

Table 5: Variance decompositions based on trivariate VAR models, fraction of forecast error variance of domestic GDP explained by international and domestic shocks.

	1873–1913			1951–2008		
	1	2	5	1	2	5
			Denmark			
EU	0.00	0.23	0.34	0.06	0.09	0.25
	(0.04)	(0.12)	(0.14)	(0.06)	(0.07)	(0.10)
SCU	0.69	0.56	0.45	0.46	0.44	0.39
	(0.10)	(0.12)	(0.13)	(0.09)	(0.09)	(0.10)
Domestic	0.31	0.21	0.21	0.48	0.47	0.36
	(0.09)	(0.08)	(0.09)	(0.09)	(0.09)	(0.08)
			Norway			
EU	0.27	0.21	0.19	0.03	0.12	0.18
	(0.13)	(0.11)	(0.11)	(0.05)	(0.08)	(0.09)
SCU	0.42	0.55	0.53	0.50	0.44	0.42
	(0.12)	(0.12)	(0.13)	(0.10)	(0.09)	(0.10)
Domestic	0.31	0.24	0.27	0.47	0.44	0.40
	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.09)
			Sweden			
EU	0.10	0.21	0.33	0.00	0.00	0.00
	(0.10)	(0.12)	(0.13)	(0.02)	(0.03)	(0.04)
SCU	0.35	0.32	0.24	0.46	0.44	0.55
	(0.13)	(0.12)	(0.11)	(0.10)	(0.10)	(0.10)
Domestic	0.55	0.47	0.43	0.54	0.56	0.46
	(0.13)	(0.12)	(0.12)	(0.10)	(0.10)	(0.11)

Note: EU include all EU countries in our sample. All estimates are based on trivariate VAR models with 2 lags. Bootstrap standard errors (1000 trials) are shown in parentheses below each estimate.

Table 6: Variance decompositions based on two–factor FSVAR models, fraction of forecast error variance of domestic GDP explained by international shocks, own shocks and spillover effects.

		1880–1913					1951–2008				
Country	Horizon	Int.	SCU	EU	Spillover	Own	Int.	SCU	EU	Spillover	Own
Denmark	1	0.95	0.95	0.00	0.00	0.05	0.92	0.92	0.00	0.00	0.08
	2	0.90	0.75	0.15	0.07	0.04	0.81	0.78	0.02	0.12	0.07
	5	0.81	0.41	0.40	0.17	0.02	0.77	0.63	0.13	0.18	0.05
Norway	1	0.33	0.33	0.00	0.00	0.67	0.04	0.04	0.00	0.00	0.96
	2	0.34	0.33	0.01	0.12	0.55	0.06	0.03	0.03	0.01	0.93
	5	0.44	0.36	0.08	0.13	0.43	0.14	0.04	0.10	0.11	0.75
Sweden	1	0.34	0.34	0.00	0.00	0.66	0.15	0.15	0.00	0.00	0.85
	2	0.37	0.29	0.07	0.13	0.51	0.18	0.15	0.03	0.01	0.81
	5	0.42	0.16	0.26	0.26	0.32	0.13	0.10	0.03	0.22	0.65

Note: The columns denoted int. (international shocks) is the sum of the forecast error variance of shocks from the common Scandinavian Currency Union factor and the common EU factor.

Table 7: Variance decompositions based on two–factor FSVAR models, fraction of forecast error variance of domestic GDP explained by international shocks, own shocks and spillover effects.

		1880–1913					1951–2008				
Country	Horizon	Int.	SCU	EU	Spillover	Own	Int.	SCU	EU	Spillover	Own
France	1	0.76	0.00	0.76	0.00	0.24	0.16	0.00	0.16	0.00	0.84
	2	0.69	0.08	0.61	0.17	0.14	0.19	0.00	0.19	0.07	0.73
	5	0.70	0.04	0.66	0.19	0.11	0.37	0.01	0.36	0.23	0.40
Germany	1	0.16	0.00	0.16	0.00	0.84	0.08	0.00	0.08	0.00	0.92
	2	0.26	0.01	0.25	0.11	0.62	0.19	0.03	0.16	0.12	0.69
	5	0.39	0.05	0.34	0.15	0.46	0.32	0.04	0.28	0.25	0.43
Italy	1	0.52	0.00	0.52	0.00	0.48	0.40	0.00	0.40	0.00	0.60
	2	0.56	0.04	0.52	0.06	0.38	0.44	0.05	0.39	0.05	0.51
	5	0.52	0.05	0.47	0.12	0.36	0.44	0.05	0.39	0.24	0.32
Netherlands	1	0.29	0.00	0.29	0.00	0.71	0.99	0.00	0.99	0.00	0.01
	2	0.43	0.01	0.41	0.16	0.42	0.96	0.03	0.93	0.03	0.01
	5	0.53	0.07	0.46	0.21	0.26	0.76	0.06	0.70	0.23	0.01

Note: The columns denoted int. (international shocks) is the sum of the forecast error variance of shocks from the common Scandinavian Currency Union factor and the common EU factor.