The Behaviour of Aggregate and Regional Business Cycles in the Nordic Countries*

Anna Larsson† Nevena Gaco Henrik Sikström
Stockholm University Stockholm University SIEPS

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Abstract

We study whether the business cycles in Denmark, Finland, Norway and Sweden show signs of convergence relative to each other, the EU-4 (France, Germany, Italy, Spain) and the euro area over the period 1970-2009, with particular emphasis on potential changes following the enactment of the Maastricht treaty in 1992. Despite important similarities between the Nordic countries, they are characterised by dramatically different levels of European integration and therefore constitute an interesting region of study. We find that Finland and Denmark, who have tied their currencies to the euro have become significantly more synchronous relative to the euro area and the EU-4 after 1992, while we do not find any such tendencies for Sweden or Norway. Using a previously unavailable dataset, we also study the behaviour of regional business cycles within these countries over the last fifteen years.

Keywords: Business Cycles, Convergence, Synchronisation, EMU, Asymmetric Shocks.

JEL-classification: E32, E42, F41, F44.

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†Corresponding author. Department of Economics, Stockholm University, SE 106 91 Stockholm. Phone: +46 8 16 38 65. Email: anna.larsson@ne.su.se.
1 Introduction

In this paper we study the behaviour of aggregate and regional business cycles in Denmark, Finland, Sweden and Norway in recent years. We are particularly interested in whether business cycles in this area are becoming increasingly synchronous, i.e. converging, to each other, the eurozone and its major member states. We investigate whether Finland and possibly Denmark, whose exchange rates have been tied to the euro in recent years, have become relatively more synchronous to the euro area than Sweden and Norway, who are maintaining floating exchange rates. In addition to studying aggregate business cycles, we analyse the behaviour of regional business cycles in the Nordic area, using previously unavailable data on regional GDP. To the best of our knowledge, our paper is the first to quantify the behaviour of regional cycles in the Nordic area.¹

Why should we care about aggregate business cycles in the Nordic countries? First, it is interesting to study how synchronous countries really are in the region. Due to well-known similarities between the countries, it has been suggested that the Nordic countries might be an Optimal Currency Area (OCA) as defined by Mundell (1961).² The common history of the countries implies great similarities in institutions, the geographical proximity and low language barriers are conducive to cross-country labour mobility, and the large trade flows within the area ensure a high level of economic integration. If these similarities imply that the area is more prone to symmetric than asymmetric shocks, this might cause the business cycles to co-vary. Another issue is whether the Nordic countries have become more or less synchronous over time. Despite the aforementioned common traits, the Nordic countries are at dramatically different stages of European integration. Norway, being the least integrated country of the four, is neither a member of the EU nor of the EMU. Sweden is a member of the EU since 1995 but remains outside the currency union. Denmark, the longest-standing EU-member of the four, opted out of the EMU in the referendum 2000 but has chosen to peg the krone to the euro through the ERM II system. Finland is the only country in the area to have reached the final stage of European integration after adopting the euro in 1999. If it is the case that having a common currency is conducive to synchronisation as has been suggested in the literature, we would then expect Finland, and possibly also Denmark, to display signs of aggregate convergence to the eurozone in recent years while we should expect no such tendencies for Sweden and Norway.³ While we do not claim to identify causal effects of monetary integration

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¹ Due to its geographical remoteness, Iceland is excluded from the sample. In what follows, the term the Nordic countries, somewhat incorrectly, refers to Denmark, Finland, Norway and Sweden.

² Indeed, Sweden, Denmark and Norway did constitute a currency union in 1873-1924. Jonung and Sjöholm (1997) argue that an OCA for Sweden would consist primarily of Finland, but possibly also Norway and Denmark.

³ Prior to the launch of the EMU, there was a heated debate about whether or not integration would make the business cycles of its future member states increasingly synchronous over time as suggested by Frankel and Rose (1997, 1998). The empirical evidence on monetary integration and synchronisation is mixed. De Haan et al. (2007) provide a survey of the literature and conclude that results differ greatly across methods and sample periods but
on convergence we argue that these opposing policy treatments are sufficiently interesting to merit studying the behaviour of business cycles in the area.

We complement the aggregate analysis with evidence on the behaviour of regional business cycles in the area. This adds another layer to the analysis by allowing us to consider heterogeneities within countries. Clark and van Wincoop (2001) find evidence of a border effect, suggesting that regional business cycles tend to be substantially more correlated within countries than across countries. Since the Nordic area is rich in adjustment mechanisms such as high labour mobility and low language barriers, it is interesting to study whether border effects are weak within the region. Given the contrasting monetary regimes maintained in the four countries, it is also of great interest to establish whether some regions are perhaps disconnected to their own country but synchronous to adjacent countries.  

Our paper is related to mainly two strands of literature. The first strand, reviewed by Clark and Shin (2000) seeks to explain the driving forces of aggregate business cycles by decomposing shocks to the economy. The approach typically rests on modelling a VAR and by performing variance-decomposition. The second strand is more closely related to our study and addresses business cycle synchronisation and convergence, see de Haan, Inklaar and Jong-A-Pin (2007) for an overview. Frankel and Rose (1997, 1998) argue that closer trade ties are conducive to synchronisation. Their hypothesis is supported by Baxter and Kouparitsas (2005) and Inklaar, Jong-A-Pin and de Haan (2008) who confirm that trade intensity affects synchronisation but that the effects are smaller than previously reported. While methods vary somewhat, the most common strategy in the literature is to use correlations to measure synchronisation. In order to study changes in synchronisation, i.e. convergence and divergence, the majority of studies divide the sample period into two or several sub-periods to see whether correlation coefficients change over time, see for instance Clark and van Wincoop (2001). Several studies split the sample into subperiods covering data before and after the implementation of the European Monetary System (EMS). Contributions include Artis and Zhang (1997, 1998), who conclude that European business cycles have become more synchronised after the implementation of the EMS. At the regional level, Fatás (1997) studies aggregate convergence and divergence, the majority of studies divide the sample period into two or several sub-periods to see whether correlation coefficients change over time, see for instance Clark and van Wincoop (2001). Several studies split the sample into subperiods covering data before and after the implementation of the European Monetary System (EMS). Contributions include Artis and Zhang (1997, 1998), who conclude that European business cycles have become more synchronised after the implementation of the EMS. At the regional level, Fatás (1997) studies aggregate and

4 For instance, it has been argued that households and firms in the southern Swedish region Skåne would benefit from adopting the euro due to its proximity to Denmark, see for instance Olshov (2009). The claim is that the euro has been conducive to favourable conditions in Denmark which has resulted in a competitive disadvantage for the Skåne area.

5 Instead of splitting samples, a couple of papers have studied rolling windows to track the evolution of correlation coefficients, see for instance Massamann and Mitchel (2004) and Montoya and De Haan (2008).
regional convergence before and after the creation of the EMS and finds that at the aggregate level, correlations have been increasing over time while at the regional level, correlations have gone down. Fatás argues that these findings are due to, first, European integration promoting trade and cross-border links rather than favouring specialisation at the country level and, second, higher cross-country correlations due to more coordinated economic policies. While many papers focus on documenting correlation patterns across time and space, there is a subset of this literature that explicitly addresses potential causes of correlations, see for instance Clark and van Wincoop (2001) who regress correlations on a set of explanatory variables. Darvas et al. (2005), study the effects of fiscal convergence on business cycle convergence and find evidence of a Maastricht Effect, i.e. evidence that the convergence criteria stipulated within the second stage of the EMU were conducive to synchronisation. Montoya and de Haan (2008) also find support for such an effect in a study of European regions.

In this paper, we initially follow the previous literature by computing cross-country correlations at both the aggregate and regional levels. Drawing on Hassler (2003), we then compute an asymmetry index in order to quantify convergence at the aggregate level. The main advantage of our method is that it allows us to look for statistically significant continuous trends in synchronisation rather than average correlations across subsamples as is common in the literature. To address the issue of a potential Maastricht effect as documented by Darvas et al. (2005) and Montoya and de Haan (2008), we also test whether there is any change in the convergence pattern of the Nordic countries relative to the eurozone after 1992. Due to lack of data at the regional level we focus on correlations in the regional analysis and refrain from addressing regional convergence. The regional time series are simply too short to generate reliable results on changes in asymmetries.

We find that Denmark and Finland, but neither Sweden nor Norway, have become significantly more similar to the eurozone after the implementation of the Maastricht Treaty. At the regional level we find evidence of large asymmetries within countries. Consistent with the aggregate analysis, the results suggest that the regions within the EU-members are positively correlated with the eurozone while the Norwegian regions are not. The regions that display the highest correlation relative to the euro area are, in turn, the Danish regions Hovedstaden and Jylland, the Finnish region Nyland and the Swedish region Skåne.

The rest of the paper is organised as follows. Section 2 describes the data and the method. Section 3 focuses on business cycle correlations at the aggregate and regional levels. Section 4 is devoted to business cycle convergence. Section 5 concludes.

However, as discussed by de Haan, Inklaar and Jong-A-Pin (2008), these types of cross-sectional regressions are not without problems. Moreover, many studies suffer from a low number of cross-sectional observations.
2 Data and method

2.1 Data

Throughout the analysis, our measure of economic activity is real GDP. Since we want to study business cycle synchronisation relative to other countries in the Nordic Region and different measures of the eurozone, we also include measures of these areas.\(^7\) As pointed out by Hassler (2003), it is often argued that the European Central Bank pays more attention to the larger EU economies than the smaller ones when setting monetary policy, and it is therefore of interest to analyse whether the Nordic countries have become more or less synchronous to the largest economies in the euro area. We therefore also study business cycle asymmetries relative to a group consisting of France, Germany, Italy and Spain, henceforth denoted the EU-4. Time series data at the country level are from the OECD and range from 1970 to 2009.\(^8\)

A major restriction when analysing regional convergence is the general lack of data at the disaggregate level. The availability of regional GDP is particularly poor. As discussed by Clark and Shin (2000), although there is some consensus that GDP is perhaps the preferred measure of business cycles movements, many studies must make due with alternative measures such as employment and value added. However, data on regional GDP have recently been made available in the Nordic countries and is therefore our chosen level of economic activity. Data on regional GDP are available for the period 1993–2008 for Denmark, 2000–2007 for Finland, 1995–2007 for Norway and 1993–2007 for Sweden. In the regional analysis, we divide the Nordic countries into key geographic regions for the sake of tractability. The classification is displayed in Table 1.

Due to space constraints, we focus on a select number of key regions. We thus take a stand on whether some regions may be considered more interesting than others based on their geographic location and industrial features. The capital regions Hovedstaden, Nyland, Oslo, and Stockholm are included as these are natural centers for economic activity and an obvious starting point for the analysis on within-country heterogeneity. We also include the regions at the maximum distance from the capital regions, typically the northern areas: the Finnish region Lappland, the Norwegian region Nordnorge and the Swedish region Norrland. While there is no obvious Danish equivalent to a remote northern area, we include Jylland for the sake of comparison. In addition to these

\(^7\) Comparisons with the Nordic aggregate are made excluding the country under study from the Nordic measure. When comparing, say, Norway with the Nordic Region, the measure of the latter comprises Denmark, Finland and Sweden. The same applies when comparing Finland to the euro area.

\(^8\) To increase the number of observations, it might be preferable to use quarterly data. However, quarterly data for the euro area are only available from 1995 onwards and since we want to study, first, convergence over a longer horizon, and second, whether the Maastricht Treaty of 1992 had any effect on synchronisation, we focus on annual data. Moreover, the regional data is annual and using quarterly aggregate data would make disaggregate comparisons difficult. As discussed by Clark and Shin (2000), quarterly data are also more prone to measurement error than annual data.
Table 1: Regional classification.

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<td>Norrland</td>
<td>Norrbotten, Västerbotten, Jämtland, Västernorrland, Gävleborg</td>
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polarised areas we include three more regions: the Danish region Syddanmark, directly adjacent to EMU-member Germany; the Norwegian region Rogaland, characterised by harbouring much of Norway’s oil production in the vicinity of Stavanger; and the Swedish region Skåne directly linked to Danish capital region Hovedstaden following the launch of the Öresund bridge in 2000.

2.2 Measuring business cycle asymmetry and synchronisation

We next describe how to detrend the GDP series and how to quantify correlations and tendencies toward synchronisation over time. Following Hassler (2003) we compute an asymmetry index and study how it has evolved over time.

2.2.1 The asymmetry index

First, we detrend the GDP series using the standard Hodrick–Prescott (HP) filter introduced by Hodrick and Prescott (1980, 1997). Although the HP-filter has been criticised and more sophisticated methods such as band-pass filters have been developed, the HP-filter remains a useful and accurate tool for detrending data.\(^9\) Hassler et al. (1992) provide a thorough discussion of different filters in a large study of Swedish business cycles over the period 1861–1988. They find that, with

\(^9\) A simple alternative to detrending by filtering is simply to remove the trend by taking first differences. However, taking first differences is equivalent to removing a linear trend from the data and this method does not allow for variations in the long-run trend of GDP.
some exceptions, their results are not sensitive to the filtering method. More recently, Montoya and de Haan (2008) find that using either the band-pass filter developed by Christiano and Fitzgerald (2003) or a standard HP-filter yields very similar results in a study of European regions. Clark and van Wincoop (2001) use annual growth rates in a cross-country study of business cycle correlations and state that using either the HP-filter or the Baxter-King filter produces the same results. Other studies reporting great similarities across different measures of the business cycle include Artis and Zhang (1997) and Massamann and Mitchell (2004). In our study we will therefore focus exclusively on HP-detrended series.

A key issue when detrending data using the HP-filter is how to set the smoothing parameter commonly denoted \( \lambda \). While most users would agree on setting the smoothing parameter to 1600 as originally suggested by Hodrick and Prescott (1980, 1997) when detrending quarterly data, there is less consensus on how to set the smoothing parameter when detrending annual data. Following Backus and Kehoe (1992), a smoothing parameter of 100 has been much used in the literature; however, Baxter and King (1999) show that a value of approximately 10 is a much better fit for annual data. Ravn and Uhlig (2002) show that setting the smoothing parameter to 6.25 produces almost exactly the same trend as when setting the smoothing parameter to 1600 for quarterly data. However, the accurate value is series-specific and depends on the dataset. Following Ravn and Uhlig (2002), we set the smoothing parameter in the HP filter to 6.25 but perform some sensitivity analysis by also setting the smoothing parameter to 100.

Once the series have been detrended, we compute a business cycle index. The business cycle index is based on the GDP gap, but we normalise the series so that they obtain a standard deviation of one.

To fix ideas, denote the (log) GDP series of country (region) \( i \) by \( y_i \) and denote the HP-filtered series, i.e. the non-linear trend, by \( y_i^* \). To obtain the business cycle index, \( c_{it} \), the detrended series, \( g_{it} = y_{it} - y_i^* \), is divided by its standard deviation, \( s_i \), i.e. \( c_{it} = g_{it}/s_i \). Let \( \bar{g}_i \) denote the mean of the detrended series. To see that the business cycle index has a standard deviation of one, note that the variance is given by:

\[
var(c_{it}) = \frac{1}{T-1} \sum_{t=1}^{T} \left( \frac{g_{it} - \bar{g}_i}{s_i} \right)^2 = \frac{1}{s_i^2 (T-1)} \sum_{t=1}^{T} (g_{it} - \bar{g}_i)^2 = 1
\]

Following Hassler (2003), we then compute an asymmetry index at the country level to quantify tendencies towards synchronisation over time. The value of the asymmetry index between countries \( i \) and \( j \) at time \( t \) is defined as

\[
A_{ijt} = |c_{it} - c_{jt}|
\]

Using the absolute value ensures that the asymmetry index always assumes positive values. If
the index assumes the value zero, the two countries are perfectly symmetric and booms and busts occur at the same time. Conversely, if the index is high, country \( i \) is in a boom when country \( j \) is experiencing a downturn and vice versa. If the asymmetry index is falling over time, this may thus be interpreted as evidence that countries \( i \) and \( j \) have become more synchronised over time.\(^{10}\)

When studying convergence it is common practice in the literature to merely look at whether trends are positively or negatively sloped; see for instance Hassler (2003) and EEAG (2009). We follow this convention throughout the analysis but we also provide a stricter test of synchronisation by fitting linear trends to the asymmetry indices by means of least-squares estimation and report the estimated slope coefficients and their associated t-values. To fix ideas, we estimate:

\[
A_{ijt} = \beta_0 + \beta_1 T_t + \epsilon_t
\]

where \( T_t \) denotes the linear trend, and look for significant estimates of \( \beta_1 \). \( \hat{\beta}_1 < 0 \) is interpreted as evidence of convergence between countries \( i \) and \( j \).

Following Montoya and de Haan (2008) and Darvas et al (2005), we also want to test for a Maastricht effect on convergence, i.e. investigate whether the Nordic countries have become increasingly synchronous relative to the EU-4 and the euro area, after the launch of the second stage of the EMU. To this end we report two sets of results. First, we estimate (1) for \( t > 1992 \). Second, we fit linear trends to the full sample but include a Maastricht dummy for the years after 1992, i.e. we estimate

\[
A_{ijt} = \beta_0 + \beta_1 T_t + (\beta_2 + \beta_3 T_t) MT_t + \epsilon_t
\]

where \( MT_t = 1 \ \forall t > 1992 \) and 0 otherwise. The formulation (2) allows for different intercepts and slopes post-Maastricht. Significant estimates of \( \beta_3 \) indicate that the slopes of the trends, and therefore the rates of convergence or divergence, have been different after 1992.

When testing for business cycle convergence we initially exclude the crisis years 2008-2009 from the sample to avoid results being driven by this large adverse shock. However, since shocks are what drive business cycles one could argue that these years should indeed be included. We therefore try both approaches and comment on how including the recent crisis affects the results.

### 2.2.2 The business cycles in the Nordic countries

The business cycle indices, i.e. the standardised GDP gaps for the Nordic countries are displayed in Figure A1 in the Appendix. The plots are consistent with conventional views of the evolution of the business cycle in the Nordic countries. Although the depth and length of the cycles vary across

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\(^{10}\) Our interest in the trend in the asymmetry index justifies our decision to standardise the business cycle indices. We want the asymmetry index to capture whether two countries are in a boom or bust at the same time. Neglecting to standardise the series would imply that extremely asymmetric GDP-gaps would cause large swings in the asymmetry index and have large effects on the slope of the trend we want to study.
countries, we see some familiar patterns: the global recession following the oil crisis in 1973, the recession following the 1979 energy crisis, the global crisis in the early 1990s, the worldwide slump in the tracks of the dotcom crisis at the turn of the century and, finally, the deep recession resulting from the massive financial crisis of 2007–2008. Focusing on events in recent years, the plots show that the downturns in the early 1990s were particularly severe in Finland and Sweden. In Sweden, the recession that followed the banking crisis was amplified by weak government finances. In Finland, the global recession was exacerbated by a huge drop in trade due to the collapse of the Soviet Union in 1991; see for instance Jonung et al. (2008).

3 Business cycle correlations

Table 2 displays the correlation coefficients of the business cycle indices for countries and regions over the period 1993–2008. The results suggest that the business cycles in Denmark, Finland and Sweden are positively correlated with the eurozone during the sample period with correlation coefficients of around .75. The finding that Sweden is positively correlated with the euro area during this period is consistent with Söderström (2008). Norway also displays positive correlation relative to the euro area, but it is much weaker with a coefficient of .16.

Turning to the regional business cycles, we address the following five questions: (i) whether

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Note: The following abbreviations are used. Hovedstaden (HS), Syddanmark (SD), Jylland (JY), Nyland (NY), Lappland (LA), Oslo (OS), Rogaland (RO), Nordnorge (NN), Stockholm (ST), Skåne (SK), Norrland (NL), Denmark (DE), Finland (FI), Norway (NO), Sweden (SW), Nordic Countries (NC), euro area (EA). The Euro area comprises Austria, Belgium, (Finland), France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain.
regions are positively correlated with their country aggregate; (ii) whether regions are correlated within each country; (iii) whether regional correlations are greater within countries or across borders; (iv) if regions adjacent to other countries are synchronous to neighbouring regions across national borders; and (v) which regions display the highest correlation relative to the eurozone.

While the first two points address within-country heterogeneity, points three and four address the importance of borders. The fifth point may provide some insight into which regions are best suited for participation in the EMU.

The results suggest that all regions are positively correlated to their country aggregate. The Danish regions are the most strongly correlated with their country aggregate. The weakest correlations with the country aggregate can be found within Norway, where the coefficients for Rogaland and Nordnorge are close to zero. This is likely to reflect the fact that the Danish regions included in our sample comprise a much larger share of the Danish economy than the Norwegian regions included. While Nordnorge, Rogaland and Oslo constitute key regions, important areas in western Norway are not represented and if the excluded regions have a great impact on the country aggregate this may account for why the regions in the sample display weak correlation with the country as a whole.

To further assess within-country asymmetries, the relevant measure is the correlation between regions in a given country. The results show that within Denmark, Finland and Norway, the regions we study are all positively correlated with each other. The highest correlation can be found within Norway, where all three regions appear to be highly synchronised. There is thus no indication that oil-capital Stavanger in the Rogaland area is out of sync with Nordnorge or Oslo. However, since the Norwegian regions display low correlation with the country aggregate, this finding indicates that there may still be some asymmetries within Norway due to the potentially low correlation between Nordnorge, Rogaland and Oslo and the regions omitted from our study.

The Danish regions are positively correlated with each other with coefficients exceeding .7. The Finnish regions Nyland and Lappland are also positively correlated with each other but much more weakly. The largest domestic asymmetries can be found within Sweden, where Skåne is positively correlated with Norrland while Stockholm is negatively correlated with both Skåne and Norrland.\footnote{The result that all regions are positively correlated with the Swedish aggregate but negatively correlated with each other can obtain since the correlation coefficients are small.}

Turning to the magnitude of correlations within and between countries, we are interested in whether the former are greater than the latter. If within-country correlations are higher than between-country correlations, this suggests that borders matter. The results indicate that the Danish regions are in general more correlated with each other and with the Danish aggregate than with the other Nordic countries. There are however, two notable exceptions: Hovedstaden is...
more correlated with Swedish region Skåne than with Syddanmark and Jylland is also marginally
more correlated with Skåne than with Hovedstaden. The strong interdependence between Skåne
and the Danish regions is addressed more in detail below. Turning to the Finnish regions, the
results suggest that both Nyland and Lappland are highly synchronous with the Danish regions
and the Danish aggregate. The two Finnish regions are also positively correlated with the Swedish
regions and, with the exception of Nyland and Stockholm, the Finnish regions are more correlated
with the Swedish regions than with each other. The Norwegian regions are much more positively
correlated with each other than with any other regions in the Nordic area. In fact, with some
exceptions, the Norwegian regions are negatively correlated with regions outside Norway and the
pattern is corroborated by the finding that the Norwegian regions are negatively correlated to the
Nordic Region as a whole. The Swedish regions show signs of within-country heterogeneity also
along this dimension. Stockholm is positively correlated with the Finnish regions and with Oslo,
but essentially uncorrelated with the Danish regions and the other Norwegian regions. Skåne is
positively correlated with the Finnish and the Danish regions but negatively correlated with the
Norwegian regions. In the case of Skåne, the correlations with Danish regions Hovedstaden and
Jylland are particularly strong, but we see that Skåne is more correlated with any of the Danish
and Finnish regions than with the other Swedish regions.

Turning to our fourth question, whether adjacent regions are correlated across national borders,
the results suggest that when studying the northern regions, the Swedish region Norrland and the
Finnish region Lappland are very synchronous. However, Norwegian region Nordnorge is negatively
correlated to the neighbouring northern regions in Finland and Sweden. As discussed above, we
also see strong indications that Skåne is more in sync with Denmark, but also with the Finnish
capital region Nyland than with the rest of Sweden.

Finally, we turn to regional synchronicity relative to the eurozone. The results in Table 2
suggest that all regions in the EU-members Denmark, Finland and Sweden display the highest
correlations with the eurozone. The Norwegian regions are negatively correlated with the euro
area during the sample period. The strongest positive correlations can be found for the Danish
regions, the Finnish capital region Nyland, and the Swedish region Skåne. Somewhat surprisingly,
we see that among the Danish regions, Syddanmark, i.e. the only region geographically adjacent
to Germany, displays the weakest correlation with the euro area.

4 Business cycle convergence

While correlation coefficients provide a descriptive statistic of average co-movements, it is of great
interest to study changes in asymmetries over time as this carries some information about where
each country is headed. In this section, we study whether the four Nordic countries have become more or less similar to each other, the Nordic aggregate, the EU-4 and the eurozone over time. Recalling that a decreasing trend in the asymmetry index suggests that the countries under comparison have become more synchronised over time, we also estimate linear trends by least squares and plot them alongside the data. We start by studying the evolution of the asymmetry indices and their estimated trends over the full sample period in Section 4.1 and proceed by studying the post-Maastricht period in Section 4.2.

4.1 The Nordic countries 1970–2009

Figure 1 displays asymmetry indices for Denmark relative to Finland, Norway, Sweden, the Nordic Region, the EU-4 and the euro area. The linear trends, fitted by least squares, are also plotted in each graph. The graphs indicate that Denmark has become increasingly synchronous to the other Nordic countries and somewhat more in sync with the EU-4 and the euro area, but the changes relative to the latter two seem negligible.

The slope coefficients of the estimated trends along with their t-values are reported in Table 3. The reported estimates are the slope coefficients for the trends in the asymmetry indices for each

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Note: t-values reported below each estimate.

***: significant at the 1 percent level; **: significant at the 5 percent level; *: significant at the 10 percent level.

The asymmetry indices for Finland are plotted in Figure 2. The pattern is similar to that of Denmark: Finland appears to have become more synchronous to its Nordic neighbours but not to the euro area. The results in Table 3 suggest that, from a statistical point of view, Finland has converged to Denmark, but not to Norway, Sweden or the eurozone.

Figure 3 displays asymmetry indices for Norway. The graphs disclose weak tendencies of Norwegian convergence relative to all areas of interest. However, the results in Table 3 show that it is only relative to Denmark that the decreasing trend is significant at the ten percent level.

Finally, Figure 4 displays the asymmetry indices for Sweden. As for Norway, Sweden shows signs of convergence across the board. Consistent with Hassler (2003), the plots suggest that Sweden has become more in sync with the euro area, and to some extent also with the EU-4. However, Table 3 reveals that the only statistically significant tendencies to convergence are relative to Denmark and the Nordic region as a whole.
As discussed in Section 2.2.1, we exclude the crisis years 2008-2009 when testing for convergence as in Table 3. However, the results are largely unaffected by this exclusion. Including 2008-2009 renders the slope coefficient of Finland’s asymmetry index relative to Norway statistically significant at the ten percent level but the other results still stand.

In sum, none of the Nordic countries show significant tendencies to convergence relative to the EU-4 or the eurozone over the period 1970-2009. The plots suggest such tendencies, but none of the changes are statistically significant. However, it does seem that these four Nordic countries have become increasingly synchronous to each other. In particular, all countries have become more synchronous to Denmark and Denmark and Sweden have converged to the Nordic aggregate.

4.2 A Maastricht effect?

As mentioned in the introduction, Montoya and de Haan (2008) and Darvas et al (2005) find that the enactment of the Maastricht Treaty has been conducive to synchronisation. In an attempt to investigate whether there is such a Maastricht effect for the Nordic countries, trends in synchronisation 1993-2007 are plotted in Figure 5. The plots indicate that the EU members Denmark, Finland and Sweden have become more symmetric relative to the EU-4 and the euro area since
1993. Norway, being the only non-EU country, seems to have become more asymmetric relative to the eurozone during the period.

Table 4 reports the estimates and t-values obtained when fitting linear trends to the asymmetry indices. Columns (1)-(4) display the results from estimating (1) over the sample period 1993-2007 and columns (5)-(8) display the results from estimating (2) on the full sample 1970-2007. The results in columns (1)-(4) suggest that Denmark and Finland have become significantly more synchronous relative to the EU-4 and the euro area at large. The effects for Sweden are statistically insignificant. The coefficients for Norway are negligible and statistically insignificant.

Turning to the results in columns (5)-(8), a significant negative coefficient for the interaction term, $T_{it} \cdot MT_{it}$, is indicative of convergence after 1993. We know from Table 3 that none of the Nordic countries display signs of convergence relative to the EU-4 or the eurozone when trends are estimated on the full sample 1970-2009. However, when allowing for different slopes before and after the Maastricht treaty as in Table 4, we see that all countries show signs of divergence relative to the euro area before the Maastricht treaty but more or less significant signs of convergence thereafter. As a consequence of the divergence prior to 1993, we see that the intercepts are significantly higher upon the enactment of the Maastricht treaty, indicating that all four countries...
were more asymmetric relative to the EU-4 and the eurozone in 1992 than in 1970. Consistent with the results in Table 3, Wald-tests of the null that the sum of $\beta_1$ and $\beta_3$ from (2) is zero, cannot be rejected. As shown in columns (5)-(8), the results for Denmark and Finland still obtain. However, using this method, the results suggest that also Sweden has become more synchronous relative to the EU-4 at the 10 percent level but not relative to the euro area at large. Given that the number of observations increases using the second method, it is not surprising that the slope for Sweden becomes significant. We also see that the coefficients are more precisely estimated across the board. The estimated coefficients for Norway are still insignificant and should not be interpreted. Regardless of the method used, we find the largest effects for Finland, the only full EMU-member of the four. The effects for Finland are also estimated with great precision.

When interpreting these findings as possible symptoms of a Maastricht effect, it is important to look at the economics behind the data to ensure that the results are not driven by extreme events. For instance, the results for Finland warrant some discussion as the sharply decreasing trend to some extent is driven by very high values of the asymmetry index in the early 1990s. As discussed in Section 2.2.2, Finland experienced a sharp drop in GDP due to the substantial decline in trade with the Soviet Union from 1991 onwards. Nevertheless, even if these initial observations were
excluded, the plot suggests that the asymmetry index would maintain its negative trend, which suggests that the sources of the synchronisation are not driven by one-time events.

Including the crisis years 2008-2009 changes the results somewhat by affecting the precision of the estimates. While qualitatively the same, including these years renders only the convergence of Denmark and Finland relative to the EU-4 statistically significant when estimating (1) for $t \in [1993, 2009]$. The estimated slope coefficients relative to the eurozone in columns (1)-(2) are not statistically different from zero when extending the sample. In columns (5)-(8) the results are largely unaffected but Denmark’s convergence relative to the eurozone in column (5) becomes statistically insignificant.

We perform some sensitivity analysis by setting the smoothing parameter in the HP filter to 100, as suggested in some of the previous literature. The main results were unaffected by this exercise. Increasing the smoothing parameter clearly affects the magnitude of the estimated slope coefficients and their associated t-values, but the majority of the results were robust to a change in $\lambda$.\textsuperscript{12}

\textsuperscript{12} The one thing that changes in a significant way is that when we set $\lambda$ to 100, we find that Norway is converging relative to the EU-4, but not relative to the euro area as a whole, during the period 1993-2007. Since it is difficult
Table 4: Business cycle convergence relative to the EU-4 and the eurozone 1993-2007.

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<td>-1.96</td>
<td>-2.93</td>
<td>-1.04</td>
<td>-1.85</td>
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</tbody>
</table>

| Euro area Intercept | 68.85** | 80.35** | -16.20 | 62.52 | -80.89** | -174.46*** | -86.23* | -58.81 |
|                    | 2.31   | 2.58   | -0.27 | 1.41  | -2.16  | -3.83  | -1.83  | -1.46  |
| $T_{it}$ | -0.03** | -0.04** | 0.01  | -0.03 | 0.04** | 0.09*** | 0.04*  | 0.03   |
|    | -2.30  | -2.57  | 0.28  | -1.40 | 2.18   | 3.85   | 1.85   | 1.48   |
| $MT_{it}$ | 149.73* | 254.81** | 70.03 | 121.33 | 1.85  | 2.58  | 0.69  | 1.39   |
| $T_{it} \cdot MT_{it}$ | -0.08* | -0.13*** | -0.04 | -0.06 | -1.86 | -2.60 | -0.70 | -1.40 |

Note: t-values reported below each estimate. ***: significant at the 1 percent level; **: significant at the 5 percent level; *: significant at the 10 percent level.

Columns (1)-(4) display the results from estimating (1) for $t \in [1993, 2007]$.
Columns (5)-(8) display the results from estimating (2) for $t \in [1970, 2007]$.

5 Concluding remarks

We study whether the business cycles in the Nordic countries Denmark, Finland, Norway and Sweden have become more synchronous relative to each other, the four largest economies in the EU and the euro area over different horizons. The four countries constitute an interesting region of study as they differ greatly with respect to the extent to which they have been integrated with the rest of Europe. We compute pairwise business cycle indices, based on HP-detrended real GDP, for countries and regions and study their correlations and, at the country level, tendencies to convergence over time. Due to data constraints, our study of regions is limited to the period 1993–2008 at best, but we also consider a longer sample at the aggregate country level and investigate to find a convincing rationale for why the choice of regime would make Norway converge relative to the EU-4 but not to the euro area as a whole, we do not interpret this result further.
whether the Nordic countries show signs of convergence after the enactment of the Maastricht treaty in 1992.

We find evidence that Denmark and Finland, with exchange rates tied to the euro within the ERM II and the EMU respectively, have become significantly more synchronous relative to the euro area and the EU-4 over the period 1993-2007. This result is consistent with the existence of a Maastricht effect as previously reported by Darvas et al. (2005) and Montoya and de Haan (2008). We find no convincing evidence of a Maastricht effect for Sweden - an EU-member maintaining a floating exchange rate. Norway, the only Nordic country remaining outside the EU, is the only country in the sample showing some signs of divergence from the euro area also in recent years.

At the regional level the results suggest that, within each country, regional business cycles are often out of sync and that some regions diverge greatly from the country aggregate. This suggests that shocks at the country level may have highly asymmetric effects regionally, and that the monetary policy that is optimal for one region may be unsuitable for another. The results from the regional analysis are largely consistent with the aggregate evidence of a Maastricht effect: the sample regions of the EU-members display positive correlation to the eurozone while the correlation is negative for the Norwegian regions. Consistent with our prior, the regions displaying the highest positive correlation relative to the euro area are, in turn, the Danish regions Hovedstaden and Jylland, the Finnish region Nyland and the Swedish region Skåne.

Except from referring to the different levels of monetary integration, we have said nothing about the potential causes for convergence or divergence in this paper. Since regional business cycles in this area are particularly poorly understood we wanted to start with a thorough description of their behaviour. The next step is to address factors that might be driving the patterns we observe. Due to data constraints, this is unfortunately not an easy task and left for future research. If one could compile a sufficiently rich dataset to link factors such as labour mobility, industry structure, trade, capital flows and economic policies to asymmetries at various levels, an empirical study seeking to identify sources of convergence or divergence in the area would be well worth pursuing.
References


Appendix

Figure A1: Business cycle indices of the Nordic Countries 1970-2009.