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Determinants of long-term interest rates in the Scandinavian countries

Abstract:
The financial markets in a small open economy like the Scandinavian countries are influenced by international economic developments, especially in their major trading partners. This paper investigates to which degree nominal long-term interest rates in Norway, Sweden and Denmark are determined by fundamental domestic macroeconomic variables and by international economic conditions. Relating the level of interest rates to international macroeconomic variables also sheds some light on the degree of financial marketintegration. In Norway the currency risk, exchange rate regime, international debt and unemployment in Europe are significant in explaining the interest rate differential. In Sweden domestic and US inflation are important, while for Denmark domestic debt, domestic and US money stock, and less significantly US inflation are determinants of the interest rate differential. In these three countries with quite different economies the expectations hypothesis, the effect of domestic growth and unemployment and of international growth are not supported as determinants of long-term interest rate differentials.

Keywords: long-term interst rates, expectation hypothesis, international macroeconomic influence, crowding out

JEL classification: E43, E44

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1 Introduction

Long-term interest rates play an important role in several economic decisions, such as firm's investment decisions and household's decision to buy durable goods. With inflation rates at a very low level in many countries, the short-term nominal rates have also fallen. This restricts the possibility to lower the short-term interest rate in order to stimulate the economy. It also increases the interest in long-term rates as a monetary policy instrument, though long-term rates are not affected directly by monetary policy in the same way as short-term interest rates are.

There exists a large literature that analyzes the yield curve and interest rates, using unobserved latent factors in no-arbitrage models to explain the yield of bonds. However, these no-arbitrage models offer no possibility to identify the economic forces that drive movements in interest rates. Interest rates could be thought of a being determined by financial flows and the exchange rate internationally, as they are financial variables that are determined by arbitrage between market participants. It is also plausible to assume that the risk premia associated with the term of a bond are linked to policy developments that have implications for the sustainability of fiscal policy in countries (Carporale, 2002). This suggests that macroeconomic development may be important to long-term interest rates. Researchers have begun to incorporate macroeconomic variables into interest rate models to shed some light on the fundamental determinants of interest rates (e.g. Diebold et al., 2005). The relationship between macroeconomic variables and the yield curve could provide more insight than some latent factors.

This paper analyzes the determinants of the long-term interest rate differential for Norway, Sweden and Denmark. Financial markets in such small open economies are affected by economic conditions in large countries, espe-

cially when they have large capital flows or trade much with these countries. Therefore both domestic and international macroeconomic developments are included to explain the interest rate. The term structure approach is more commonly used in the literature than long-term interest rate models, but the equations for long-term interest rates can be interpreted as a term-structure model. These three Scandinavian countries have close historical and economic relations, but are influenced by different developments in the last century. Norway has acquired a substantial amount of wealth through oil revenues, while Sweden has several large international companies that export a lot. These three countries have a small open economy and a different economic history and current economic situation providing additional tests in the literature to the hypotheses on what determines the long-term interest rate.

In related research, Carriero et al. (2006) assess the benefits from including macroeconomic variables for forecasting the short-term interest rate, while Ang and Piazzesi (2003) and Piazzesi (2005) have shown that term-structure models benefit from including macroeconomic fundamentals. In these papers, however, the effect of the integration of the international financial market on the interest rates has not been researched. The interest rates in the United States are less influenced from abroad than the Scandinavian countries, but one could also think of the effect of interest rates and transactions in Asia on the American long-term interest rates. Thus, this paper adds to the literature by analyzing the combined domestic and international effect of macroeconomic variables on the long-term interest rate differential.

The degree of capital mobility between financial markets has increased in the last decades. Financial deregulation, modern technology and development in financial instruments have made this possible (Hammersland et al.,

1997). Relating the level of interest rates to international macroeconomic variables also sheds some light on in which degree the financial markets are integrated. When only the domestic macroeconomic developments explain the interest rate, this indicates a low degree of integration.

In the next section I give a summary of the theories and empirical studies on long-term interest rates. In section 3 the data, empirical proxies for the theories and the estimation results are presented. Section 4 concludes and provides a summary of the main findings of this paper.

2 Literature survey on long-term interest rates theories and empirical studies

Interest rates are important for the workings of a whole economy and also at a business level. There exist several theories that explain the level of interest rates both in macroeconomics and finance. In this section I review the existing literature on the potential determinants of long-term nominal interest rates. This includes monetary, fiscal and other macroeconomic influences on long-term interest rates.

The loanable funds theory implies that the interest rate is determined by the supply and demand for loanable funds. The demand comes from business for investments, consumers for consumption and the government to cover their deficit, while funds are supplied by private and public domestic saving and increases in the money supply (Orr et al., 1995). The possible crowding out effect of government borrowing on private spending and the interest rate is subject of a long-standing debate. The direct and indirect effects of crowding out are documented in e.g. Blinder and Solow (1973), and Carlson and Spencer (1975). Most literature concentrates on

the short-run indirect crowding out (Hoelscher, 1986), in which increased government borrowing increases the (short-term) interest rates and thus can affect private spending negatively. Most empirical studies find no effect of federal borrowing on the nominal short-term rate, and explain that with the Richardian equivalence (Barro, 1974). However, several studies find this effect on the long-term interest rates (see e.g. Hoelscher 1986, Cebula 1988, Miller and Russek 1996 with 2 of 3 econometric models). Engen and Hubbard (2004) find that there exists a positive relation, in which an increase in government borrowing equal to one percent of the GDP could increase the long-term real interest rate by 3 basis points. Cebula et al.(1992) argue that the long-term interest rate transmits the impact of a deficit to the real sector of the economy, not the short-term interest rate. Barth et al. (1984) examined several empirical studies on the effect of federal deficit on interest rates. According to their results the empirical results appear to be sensitive to the time period, the choice of variables and how deficit is measured. Also the country in question that is researched affects the results. Linde (2001) tests the effect of budget deficits on Swedish data in the period of 1984 to 1996, but differs from this paper as it does not test for international influence of macroeconomic variables. Linde (2001) concludes that larger budget deficits in Sweden induced higher interest rates. Adding international evidence besides the United States which has had a large persistent trade deficit, tests the relevance of the Richardian equivalence in general. Ford et al.(1999) test the hypothesis of fiscal crowding out internationally. If international markets are integrated, then the national real interest rates depend on 'world' debt, instead of only national debt. This is a theoretical challenge of the Richardian equivalence, but empirical evidence on consumption suggests that public debt should partially crowd out private-sector activity.

Although the strict real interest rate parity is empirically rejected, it seems reasonable to suppose that capital markets are to a large extent integrated across advanced economies. International arbitrage between instruments in different currencies reduces deviations between country specific interest rates. Some evidence for this is found in Ford et al. (1991).

A liquidity effect is expected through the standard ISLM model, when an increase in the money supply decreases interest rates, both long–term and short-term (e.g. Gebauer et al., 1994). The liquidity effect is not often tested in the literature. Exceptions are Linde (2002) and Bernhardsen (1997).

In the expectations theory the long-term interest rate is a function of the current and expected future short-term interest rates. The terminology comes originally from Lutz (1940). Many papers have been written on this subject in the last decades. Several different versions of this hypothesis exist and are tested in the literature. Fuhrer (1996) argues that the stance of the monetary policy is important in explaining the expectations hypothesis. The current forward interest rates are determined by the anticipations in the market of future spot interest rates plus a constant risk premium according to the expectations hypothesis (Blanchard, 1984; Christiansen, 1997; Sarno, 2005). Tests of the expectations theory tend to generate paradoxical results. Campell and Shiller (1989) find support for the expectations hypothesis in that the yield spread forecasts the weighted average of the changes in short-term rates over the life of a long-term bond. The hypothesis is rejected for rates less than 2 years, while not rejected for longer maturity rates unless more powerful tests are used that e.g. include macroeconomic factors in Sarno (2005). The expectations hypothesis is rejected by Gerlach (2003). Lee (1994) models the long rate as a function of the distributed lag on realized short-term rates, which performs poorly after 1993 in the US.

Hammersland et al.(1997) have analyzed the relation between German and American long-term interest rates as an indication of integration of financial markets. In contrast with this paper, they use only the expectation hypothesis to explain long-term interest rates. They find a causal relation from US long-term interest rates and German short-term interest rates to German long-term interest rates, thus supporting the expectation hypothesis.

Monetary policy is also a relevant potential determinant as long-term inflations expectations are an important part of nominal long-term interest rates. An extension of the expectations theory adds a risk premium to the expected short-term rates, the Fisher effect (Fisher, 1907). Lucas (1978) extended this theory with a risk premium to compensate for uncertainty. The premium rewards the risk of unexpected inflation during the long period at which the bond is held. Fisher's theory of interest assumes that the movements in nominal yields originate from changes in real interest rates and changes in the expected inflation (Ireland, 1996). Inflation is added to show the influence of a monetary shock on the dynamics of nominal variables.

The uncovered interest rate parity posits that bonds in different currencies are at least partially substitutable, this is also true for long-term interest rates. Theories as the expectation and liquidity effect assume that the interest rate is an exogenous variable. However, macroeconomic theories might also explain the underlying economic factors that influence the interest rate. According to Diebold et al.(2005) a combined macro-finance modeling strategy will provide the best understanding of the term structure of interest rates. A constant difference between two international interest rates could represent a premium that investors require, which can reflect macroeconomic factors such as inflation differentials, debt levels or national

savings and investment levels (Eckhold, 1998). Also it can reflect the future behavior of the monetary policy in one country versus another and thus expected future real interest rate differences. According to economic theory, the natural interest rate is related to the output gap/potential GDP and growth. Laubach and Williams (2003) find a close relation between this interest rate and trend growth, as predicted by theory.

Bond yields are determined by domestic developments as well as by international capital flows. The global integration of capital markets appears to play a role in the relation between long-term interest rates between countries (Orr et al., 1995). For example, the tightening of monetary policy in the United States or other large countries have a significant influence on the world interest rates. It can be argued that due to international integration of financial markets, the Norwegian long-term interest rates are influenced also by foreign macroeconomic conditions. For countries with a fixed exchange rate, pursuit of an independent monetary and fiscal policy is limited. Flexible exchange rate and independent macroeconomic policy, however, give room for domestic developments to influence long-term nominal interest rates. Norway had a fixed interest rate until 1992, and a (managed) floating rate since then. Sweden had a fixed exchange rate during 1983 to November 1992, while Denmark still participates in the ERM-2 and thus has a fixed exchange rate to the euro. Mundaca et al.(1996) find a strong positive correlation between the changes in the Norwegian long-term interest rate and the Swedish and Danish long-term interest rates, without specifying a underlying fundamental variable that accounts for this.

Caporale and Williams (2002) investigate the information of domestic macroeconomic variables for the determination of nominal long-term inter-

est rates in the G7. They conclude that inflation uncertainty (monetary policy) and the quality of debt (fiscal policy) are important in the development of the long-term interest rates. Evans and Marshall (2001) find that macroeconomic factors as industrial production, personal consumption expenditure, an index of sensitive materials prices and the Federal funds rate have a substantial, persistent and statistically significant effect on the level of the interest rates with different maturities. Orr et al.(1995) also use macroeconomic variables to explain (real) long-term interest rates. Their results indicate that the rates are determined by the rate of return on business capital, portfolio risk, inflation uncertainty and indicators of future saving and investment balances, and monetary actions. Expected interest rates are assumed to influence the level of interest rates in Orr et al., but the impact is not clear cut. On the other hand, Ang and Piazzesi (2003) do not find a significant relation between macroeconomic factors and long-term interest rates. Thus, there is no unified conclusion in the literature regarding the effect of macroeconomic variables on long-term interest rates.

International macroeconomic factors are also expected to influence the interest rate. Brook (2003) finds evidence that US macroeconomic fundamentals have a greater influence on interest rate in Europe and Japan than vice versa. In Gurkaynak et al.(2005) long-term rates respond significantly to macroeconomic surprises. Barro and Sala-i-Martin (1990) analyzed short-term real interest rates in 10 OECD countries and concluded that each country's expected real interest rate depends primarily on world factors rather than own country factors. Gravelle et al. (2001) also include international macroeconomic variables. They discuss the effect of American macroeconomic announcement on the Canadian interest rate. This paper differs from Barro et al. (1990) as it analyzes long-term interest rate, and Gravelle et al.

(2001) as it looks at the interest rate differential, not only the reaction.

Orr et al. (1995) also include the current account as a percentage of GDP as a proxy for the currency risk on a country's bonds and the budget deficit/GDP ratio as long-run determinants of real bond rates. This variable is used to proxy the effects of external imbalances and/or currency risks on real bond yields.

Unemployment is used in several empirical studies as a reliable indicator for the stance of the economy. Unemployment is used a an explanatory variable in Lee (1994), Gravelle (2001), Sarno et al. (2005), Carriero et al. (2005).

Several financial theories as the portfolio and market segmentation theory are assumed to be smoothed out on a national level. The portfolio theory basically poses that interest rate changes happen because of shift in the portfolio composition of the actors in the financial markets. The market segmentation theory argues for a separate market for each maturity and the increasing liquidity premium where long-term bonds that are more volatile in price require higher yield to maturity to compensate.

To summarize, the nominal long-term rate of interest depends on the fiscal policy and government borrowing (Richardian equivalence), the money stock ('liquidity effect'), the domestic short-term interest rate (expectation hypothesis), inflationary expectations (the Fisher theory), the foreign short-term interest rates (according to the uncovered interest rate parity), the effects of macroeconomic developments fiscal and monetary in major trading partners (due to the integration of international financial markets), the real economic activity (strong real economy leads to a higher loan demand which increases the price of long-term loans), and the current account (currency

risk). The empirical evidence is not unanimous in their rejection or support of the different theories. I will test these theories on the interest rates of Norway, Sweden and Denmark, as far as the data allow, in the next section.

3 Empirical results

3.1 Data and hypotheses

The data used in this study are taken from several databases. The interest rate data are obtained from Norges Bank, the central bank in Norway. The macroeconomic data stem from EcoWin. Where necessary these are supplemented with data from national statistics agencies, central banks and the OECD statistical yearbook. The dependent variables are the annual long-term interest rate differentials of each Scandinavian country with Germany. Germany is used as a proxy for their largest trading partner, the European Union. The long-term interest rates are represented by quarterly series of the effective nominal yields on representative 10 year obligations issued by the government in each country.

I use quarterly series in order to incorporate the macroeconomic variables, most of which are available each quarter. In the literature most studies utilize quarterly frequency (see e.g. Cebula et al., 1992; Carporale et al., 2002; deWachter et al., 2004) as I do in this study, though the frequency ranges between daily to annual observations.

The interest rate data series begins in 1989 for Norway, in 1990 for Sweden and Denmark, and ends in 2005. Table 1 gives some descriptive statistics of the dependent series. The long-term interest rates are less volatile than the 3 month short-term interest rate. As a first indication whether the expectations theory is correct, the level of the 10 year and 3 month interest

rate is depicted for each country in figures 1 to 3. These figures show some common movement downwards in the last decade and a half, but no strong correlation otherwise. In all countries the 10 year interest rate is relatively high at the beginning of the 90's, while decreasing to lower levels through the 90's and the first years of the 2000's.

I test for unit roots in the data with the augmented Dickey Fuller (ADF) test and in some cases supplement this with the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Tables 5 and 6 in the appendix shows the ADF test statistics for all variables. The ADF has a null hypothesis of a unit root in the series, while the KPSS test has a null hypothesis of a stationary series. For the levels of the series the tests suggest non-stationary data with a few exceptions. The differenced series result in stationarity with a few exceptions. The ADF test shows that the 10 year interest rate differential is stationary for Norway and Denmark, while the null hypothesis of a unit root cannot be rejected for Sweden. Theoretically the relative interest rate should be stationary, and as this is the case for the other two Scandinavian countries, I assume that the relative difference between the Swedish 10 year interest rate and the German 10 year interest rate is also stationary. I will test the residuals of the estimates to ensure a stable equation. Similarly for the consumer price index series in Sweden, the ADF test rejects the null hypothesis of nonstationarity contrary to expectations, while the inflation in Germany and Denmark is not found to be stationary. However, when using the KPSS test this cannot be rejected either.[1] The KPSS gives a different result, and I assume that the CPI series is nonstationary and needs to be differenced which results in a stationary series. GDP are found to be stationary with a

[1] The KPSS test statistic for CPI in Sweden is 0.905, and for inflation in Germany is 0.459, in Denmark is 0.134. The critical value at 5 percent is 0.463, such that the null hypothesis of stationarity is rejected for CPI, and cannot be rejected for inflation in both countries.

trend in Norway and Danmark. Therefore, all other series are integrated in the first order I(1) in levels.

The debt for the OECD countries was only available annually. To obtain quarterly data I interpolated the series. Furthermore, the 12-month growth of the consumer price index is a common measurement for inflation. Therefore I took the fourth (annual) percentage change of these two variables. For the other variables the quarterly percentage change is taken. The largest international trading partners for the Scandinavian countries are here proxied by Germany (as a precedent for the European Union in the first part of the data series), and the United States. It is also assumed that this effect has a single direction from the large to the small countries, and not the other way around, similar to Hammersland et al.(1997).

	10 yr mean (std.dv)	3 mnth mean (std.dv.)
Norway	6.97 (2.14)	7.08 (3.31)
Sweden	7.15 (2.79)	6.28 (3.77)
Denmark	6.41 (2.00)	5.49 (3.17)

Table 1: Descriptive statistics for the 10 year and 3 month interest rate for Norway, Sweden and Finland. std.dv.= standard deviation

The loanable funds theory through the ISLM model, and the Richardian equivalence are tested by including the deficit or debt of the government. Following Ford et al. (1999) the debt as a percentage of GDP from OECD countries is added as a proxy for the world debt. If capital markets are integrated internationally, the interest rate of Norway, Sweden and Denmark should depend on the 'world' debt not only the national debt. A positive relation is expected with debt, as it increases the demand for money and could crowd out other investors. A negative effect on the long-term interest rates is expected from an increase in the money stock, as it increases the supply of money.

To test for the expectations theory, the domestic short-term interest rate is included for each country. According to the uncovered interest rate parity, interest rates from other countries could be added in this analysis. This theory expects a positive relation between short-term and long-term interest rates. No such interest rates are added as explanatory variables in the analysis here. Including these interest rates would give no fundamental explanation to why an interest rate changes, which is the purpose of this paper. The interest rate in Norway could change because of a change in the German interest rate. But why does the German interest rate change? Inflation is added to test the Fisher relation, and the effect of the monetary policy on the interest rates. Core inflation is expected to increase interest rates and interest rate expectations, and thus a positive relation with long-term interest rate is posed.

Exchange rate dummies are used filter the effect of a change in the exchange rate policy. For Norway this data set comprises three different exchange rate regimes. A fixed rate until December 1992, a managed float until March 2001, and free float afterwards[2]. For Sweden there are two regimes, a fixed exchange rate until November 1992 and free float afterwards. Finally, Denmark has had no change in its fixed exchange rate versus the German Mark and later the euro since 1987. These different exchange rate regimes can cause the influence of the macroeconomic variables from the European Union (Germany) to affect the Danish krone different from the Swedish and Norwegian krone. A fixed exchange rate decreases the possibility of having a large interest rate differential with large trading partners, thus a negative relation is expected.

[2]The exchange rate dummy for Norway is modelled as a step dummy, which increased with every change in the exchange rate regime. The dummy for Sweden has only two steps.

Gross domestic product is included as an explanatory variable to indicate the economic activity in each country. It also reflects the aggregate wealth available (Ingersoll, 1987). Growth in wealth should increase the demand for funds via an increase in borrowing, thus increasing the long-term interest rate. Real business cycle models imply that increased productivity growth increases real interest rates (Barro and Sala-i-Martin, 1990). An increased unemployment influences the interest expectations and thus the long-term interest rate negatively.

The current account of each country is added as a proxy for currency risk on a bond of that country. A higher currency risk should be compensated with a higher interest rate. For parsimony reasons, and because of the limited size of the time series with quarterly observations, only inflation, gross domestic product, a money aggregate and unemployment are included for the US and Germany. These are taken to be broad indicators of the welfare of the economy and affecting the interest rate in these countries in a similar way as domestic interest rates.

3.2 Estimates

The estimation results are presented in Table 2. The first striking result is that there is no common significant estimate that explains the interest rate differential towards Europe for the Scandinavian countries. Furthermore, in each country a combination of domestic and international macroeconomic variable(s) are significant in explaining the interest rate differentials implying a high level of integration in international financial markets. As proxy variables for many theories are included in the empirical analysis, Germany and the United States are selected to represent the rest of the world. All 3 models are well specified with good results for the Ramsey RESET test

and stationary residuals. Sweden has some problems with the ARCH test for autocorrelation, but this is not the case for Norway and Denmark. The t-statstics are corrected for possible heteroscedasticity. Compared to the studies on the effect of macroeconomic variables on macroeconomic data (see e.g. Cebula et al.,1992) few of the explanatory variables are significant.

The results for Norway and Sweden show no effect of increased national government debt on the interest rate differential. In Denmark the Richardian equivalence is rejected with a positive estimate that is significant. An increase in domestic government debt has a small but significant effect on the Danish differential. It increases the interest rate differential by around 0.08 basis points. The support for the Richardian equivalence for Norway and Sweden is in contrast with Hoelscher (1986), Cebula (1991), and Miller and Russek (1996) who find a significant effect of domestic government debt on long-term interest rates in their studies on US data. The support for Sweden is also in contrast with Linde (2002), who finds a positive significant effect of public deficit on a five to ten year government bond in Sweden on data from 1984 -1996. The rejection of the equivalence for Denmark is in contrast with Ford et al.(1999) who do not find a significant result of the domestic debt on the interest rate for Denmark. The support for the equivalence for Norway and Sweden is in line, however, with Bernhardsen (1997) who with a pooled parameter restricted regression finds no effect of debt on the interest rate differential at a 12 month maturity for all nine European countries tested, including the 3 Scandinavian countries over 1979 -1995. Testing the Richardian equivalence thus produces mixed results as usual in the previous literature.

Fiscal crowding out internationally, which depends on well functioning

international financial markets, is only supported for Norway. The effect of an increase in the international debt is much stronger on the Norwegian interest rate differential than the domestic debt on Denmark. The debt of governments across the OECD as a percentage of gross domestic product is not significant and has a sign contrary to theory for Sweden and Denmark. In Ford et al. (1999) the international crowding out is tested both with a single OLS regression and a system estimation. The results of the international fiscal crowding out for Denmark found in this analysis are in line with Ford et al. (1999) in their single OLS regression. In the system estimation they find a significant effect of the international debt. However, the system estimation restricts the coefficients to be equal across countries. This increases efficiency in the available degrees of freedom, however, it may introduce bias if the restrictions are incorrect.

The liquidity effect is supported in Denmark, but not for Norway and Sweden. Both a domestic increase in the money supply and increase in the money supply in the US has a significant negative effect on the Danish interest rate differential. Though based on a standard textbook ISLM model for the effect of money supply on the price of money, its effect is not often tested in the literature. Exceptions are Linde (2002) and Bernhardsen (1997). Linde finds similar results for Sweden, an insignificant negative effect on the interest rate differential. While Bernhardsen's results imply a insignificant negative result on the effect of the money stock for all 8 European countries, which is in contrast with the results for Norway in this analysis. The financial markets seem to be well integrated internationally, when an increase in the money supply in the United States has a significant effect on the interest rate differential in Denmark, and a significant effect on the Swedish differential at a significance level of 7,5 percent.

The short-term interest rate is not significant in explaining the interest rate differential in any of the Scandinavian countries. This is in line with for example studies as Gerlach (2002) and Sarno et al.(2005). However, test on the expectations theory tend to generate paradoxical results in the literature. For Denmark the estimate has a counter-intuitive sign. This is in contrast with Linde, who finds a positive significant effect of the short-term interest rate on the Swedish interest rate differential, and Orr et al. (1995) who test Sweden and Denmark. However, the short-term rate is lagged 24 quarters in Linde's analysis while I use the direct effect of the rate. Orr et al. include a lagged dependent variable in their analysis. In another analysis later in this paper, I will discuss the effect of several lagged short-term interest rates without using macroeconomic explanatory variables on the interest rate differential to compare with previous studies.

Inflation is added to show the influence of a monetary shock on the dynamics of nominal variables[3]. Only in Sweden the domestic and American inflation have a significant effect with a theoretically correct sign, thus supporting the Fisher theory. For Denmark the American inflation is significant at a 12 percent level, thus weakly affecting the interest rate differential. No effect was found of the inflation in Germany on all countries. These results are in line with the majority of the literature. For example, Orr et al. (1995) find a positive significant effect for several countries including Denmark and Sweden, and Bernhardsen (1997) the same effect on the pooled estimation. Furthermore, Cebula (1992), Diebold (2004) and Sarno (2006) find similar results for American data. Linde (2001) finds no significant effect on the interest rate on the Swedish differential, which is in contrast with the results in this paper.

[3]For Norway CPI-ATE was only available for a few years, thus shortening the time period of estimation too much to be included.

A dummy for a change in the exchange rate regime has a negative effect on the Norwegian interest rate differential, while it has no effect on the Swedish differential. The possibility of having a larger interest rate difference with the major trading partner and largest neighbor country is only supported for Norway. A possible explanation is that Norway is the only of the Scandinavian countries that is not member of the European Union or previous the European Exchange Rate Mechanism (ERM).

According to economic theory, the natural interest rate is related to the output gap/potential GDP and growth. None of the domestic or international growth in GDP have a significant effect on the interest rate differentials, with the exception of the US GDP growth on the Danish differential which has an incorrect sign. This theory is also not included in the estimates of the determinants of long-term interest rates in studies on the Scandinavian countries (Linde, 2001; Hammersland, 1997; Orr et al., 1995). The results are in line with the findings of Miller et al. (1996) and deWachter et al. (2004), who also do not find a positive significant effect, but in contrast with Cebula (1992).

The estimates for Norway support the expected positive effect of the current account as a percentage of GDP on the interest rate differential. Thus a higher currency risk on a country's bonds as proxied by the current account is rewarded by a higher interest rate in Norway. This is not the case for the other Scandinavian countries. It has a very weak positive effect on the Swedish interest rate differential, while the hypothesis is rejected for Denmark. These results are in contrast with Orr et al. (1995) who find a significant negative effect for two countries, but do not include the variable for Sweden and Denmark. Also Bernhardsen (1997) find a negative significant relation for the pooled estimates.

Finally, a change in unemployment in Germany is only found to influence the interest rate differential significantly for Norway. An increase in the domestic unemployment is not significant. Also the change of unemployment in the United States is significant, but has a theoretically incorrect sign. For Sweden and Denmark, the unemployment rate has no explanatory power. Bernhardsen (1997) neither finds a significant effect of the domestic unemployment on the pooled estimates. In Gravelle (2001) and Sarno et al. (2005) a significant effect is estimated.

To obtain a more parsimonious model, all determinants with incorrect sign or with less significance than 15 percent are taken out of the model. The results are very similar to the results described above, see table 3.

To relate to the literature on term-structure, the same model is tested for shorter maturities. The domestic and international macroeconomic proxy variables for the theories are tested with the 5 year interest rates for all three countries. The Swedish data set end in 2001, while it continues to 2005 for Denmark and Norway. The time series for interest rates with an even shorter maturity, 3 years, where too short to test all the theories. The support for the effect of the exchange rate regime and volatility are weakened with insignificant estimates for the 5 year Norwegian interest rate differential. The international crowding out hypothesis and unemployment as an indicator for the welfare of the economy, however, have nearly the same size and significance. These two indicators are thus important determinants in for the interest rate differential for Norway. The international Fisher hypothesis is no longer supported in Sweden for the shorter series of the 5 year interest rate differential. The support for the national Fisher hypothesis drops under the 5 percent level of significance, while the support for the liquidity effect increase above the 5 percent level. Obviously, excluding the

	10yr No	10 yr Swe	10 yr Dk
Domestic			
Δdebtgdp	0.72 (0.66)	-0.13 (-0.86)	0.08* (1.78)
ΔM2[a]	8.85 (1.25)	-4.73 (-0.41)	-7.97*** (-3.04)
Δ3 mnth r	0.03 (0.04)	0.64 (0.45)	-0.42 (-0.79)
ΔCPI	NA	31.67** (2.01)	-3.65 (-0.34)
Dum xrate	-0.31** (-2.00)	0.02 (0.02)	NA
ΔGDP	3.78 (1.20)	1.00 (0.28)	-8.05 (-1.37)
Δcagdp	0.06*** (3.26)	-0.56 (0.49)	NA
Δunemp	-0.30 (-0.35)	3.19 (1.09)	-0.32 (-1.37)
International			
ΔOECD debtgdp	4.19** (2.57)	-0.65 (-0.18)	-0.87 (-0.77)
ΔM2 DL	-3.21 (-0.83)	7.97 (1.33)	1.77 (0.50)
ΔCPI DL	-1.86 (-0.21)	-27.60* (-1.64)	6.06 (0.79)
ΔGDP DL	-1.22 (-0.32)	-5.76 (-0.89)	-1.98 (-0.71)
Δunemp DL	-2.45** (-2.14)	-0.92 (-0.33)	2.03 (0.86)
ΔM2 US	7.47 (0.52)	-52.59 (-1.51)	-20.52* (-1.82)
ΔCPI US	2.13 (0.14)	47.31* (1.74)	17.89 (1.59)
ΔGDP US	0.17 (1.52)	-0.30 (-1.23)	-0.17* (-1.98)
Δunemp US	6.22** (2.63)	-3.53 (-0.65)	-0.50 (-0.29)
R^2	0.59	0.64	0.55
ADF ε	-4.95**	-3.67**	-4.59**

Table 2: Estimated results for the 10 year interest rate differentials for Norway, Sweden and Denmark versus Germany. Heteroscedasticy corrected t-values in brackets. 10 yr No = interest rate differential between the 10 year rate in Norway and Germany, 10 yr Swe = similar variable for Sweden, 10 yr Dk = similar variable for Denmark, debtgpd = debt or deficit as a percentage of gross domestic product (GDP), M2 is the money stock M2, 3 mnth r = the short-term 3 month interest rate, unemp = unemployment rate, cagdp = current account as a percentage of GDP, CPI = consumer price index, Dl = Germany, US = United States of America. a) M3 for Sweden. */**/*** significant at 10/5/1 percent level.

	10yr No	10 yr Swe	10 yr Dk
Domestic			
Δdebtgdp			0.02 (1.07)
ΔM2			-6.19** (-2.15)
ΔCPI		20.20*** (3.03)	
Dum xrate	-0.27** (-2.55)		
Δcagdp	0.06*** (4.49)		
International			
ΔOECD debtgdp	3.35*** (2.77)		
Δunemp DL	-1.09 (-1.36)		
ΔM2 US		-48.94*** (-3.00)	-23.22*** (-3.59)
ΔCPI US		28.83** (1.85)	15.53* (1.94)
ΔGDP US	0.16** (2.46)		
R^2	0.52	0.53	0.35
ADF ε	-3.53**	-2.94**	-3.46**

Table 3: Estimated results for the 10 year interest rate differentials for Norway, Sweden and Denmark versus Germany. Heteroscedasticy corrected t-values in brackets. 10 yr No = interest rate differential between the 10 year rate in Norway and Germany, 10 yr Swe = similar variable for Sweden, 10 yr Dk = similar variable for Denmark, debtgpd = debt or deficit as a percentage of gross domestic product (GDP), M2 is the money stock M2, unemp = unemployment rate, cagdp = current account as a percentage of GDP, CPI = consumer price index, Dl = Germany, US = United States of America. */**/*** significant at 10/5/1 percent level.

last four years in the series influences the results compared to the main analysis. Finally, for Denmark the support for the liquidity effect remains strong with circa the same estimates, while the support for national crowding out falls away.

	5yr No	5 yr Swe	5 yr Dk
Domestic			
Δdebtgdp	0.92 (0.61)	-0.11 (-0.44)	0.10 (0.84)
ΔM2[a]	9.71 (0.79)	-4.03 (-0.28)	-11.43*** (-3.75)
Δ3 mnth r	0.01 (0.01)	2.84 (1.25)	-0.81 (-1.19)
ΔCPI	NA	43.45 (1.39)	-2.15 (-0.16)
Dum xrate	-0.20 (-0.98)	-0.12 (-0.09)	NA
ΔGDP	4.12 (1.17)	2.22 (0.43)	-11.48 (-1.27)
Δcagdp	0.06 (0.88)	-0.75** (-2.02)	NA
Δunemp	-0.30 (-0.35)	8.08 (1.59)	-0.32 (-0.96)
International			
ΔOECD debtgdp	4.31* (1.65)	-0.26 (-0.06)	-0.41 (-0.26)
ΔM2 DL	-2.63 (-0.52)	10.56 (1.45)	1.83 (0.36)
ΔCPI DL	-9.92 (-0.96)	-79.84*** (-4.37)	7.73 (0.77)
ΔGDP DL	-2.96 (-0.51)	-6.52 (-0.87)	-1.64 (-0.42)
Δunemp DL	-2.81* (-1.71)	-0.67 (-0.23)	1.50 (0.48)
ΔM2 US	12.08 (0.70)	-95.08* (-1.86)	-21.96 (-1.54)
ΔCPI US	2.16 (0.09)	-2.37 (-0.06)	21.01 (1.45)
ΔGDP US	0.10 (0.65)	0.04 (0.12)	-0.11 (-0.98)
Δunemp US	7.02** (2.47)	-0.55 (-0.06)	-0.70 (-0.31)
R^2	0.42	0.70	0.49
ADF ε	-3.95**	-3.84**	-3.78**

Table 4: Estimated results for the 5 year interest rate differentials for Norway, Sweden and Denmark versus Germany. Heteroscedasticy corrected t-values in brackets. 5 yr No = interest rate differential between the 5 year rate in Norway and Germany, 5 yr Swe = similar variable for Sweden, 5 yr Dk = similar variable for Denmark, debtgpd = debt or deficit as a percentage of gross domestic product (GDP), M2 is the money stock M2, 3 mnth r = the short-term 3 month interest rate, unemp = unemployment rate, cagdp = current account as a percentage of GDP, CPI = consumer price index, Dl = Germany, US = United States of America. a) M3 for Sweden. */**/*** significant at 10/5/1 percent level.

4 Conclusion

In this paper I have tested the effect of theories that explain long-term interest rates for Norway, Sweden and Denmark. These theories included both domestic and international factors to test the degree of integration of the financial markets. No theory is common in explaining the interest rate differential for these three countries. The international factors are significant in explaining the interest rate differentials in the Scandinavian countries. The effect of these factors are transferred through well-connected international financial markets. In line with the literature I find that macroeconomic developments can partly explain the interest rate differential in these countries. A large part of the variation of the differentials can be captured, around fifty percent.

In Norway the currency risk, exchange rate regime, international debt, unemployment in Europe (Germany) are significant in explaining the interest rate differential. In Sweden domestic and US inflation are important, while for Denmark domestic debt, domestic and US money stock, and less significantly US inflation (just below 10 percent) are determinants of the interest rate differential. In these three countries with a quite different economy the expectations hypothesis, the effect of domestic growth and unemployment and of international growth are not supported as determinants of long-term interest rate differentials. This model gives a new impulse to the explanation of long-term interest rates, which are important to many economic decisions and also monetary policy effects.

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Appendix

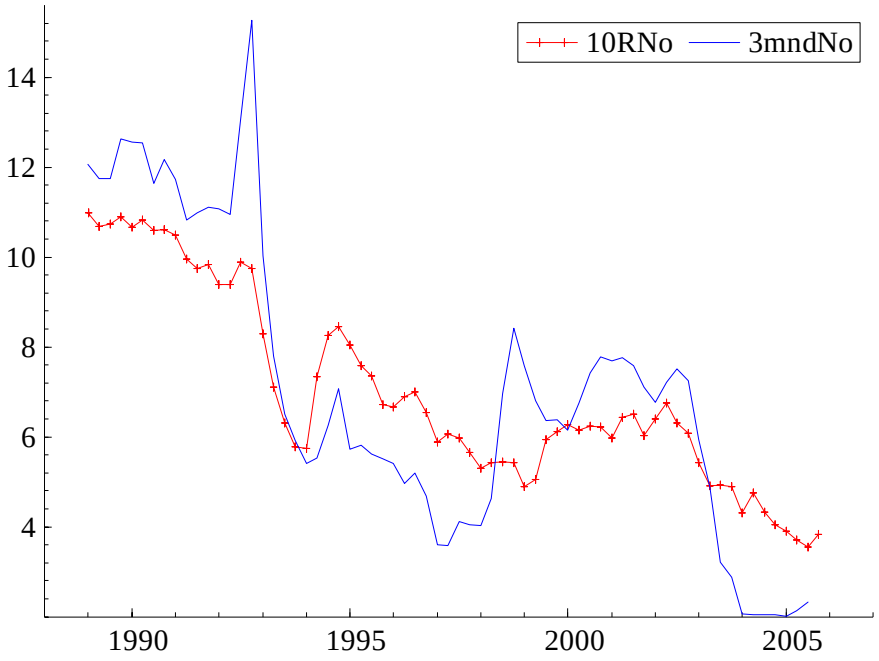

Figure 1: 10-year yield and 3 month interest rate in Norway.

ADF test	Norway	Sweden	Denmark	OECD	Germany	USA
10 yr int r	-1.29	-1.89	-1.49	-	-	-
10 yr diff	-3.53*	-2.45	-2.98*	-	-	-
3 mnth	-1.30	-0.92	-1.16	-	-	-
CA/GDP	-1.42	-2.02	NA	-	-	-
unempl	-2.41	-1.10	-1.20	-	-1.78	-1.24
GDP (trend)	-4.72*	-12.33*	-2.03	-	-3.30	NA
debt/GDP	-3.86*	-3.99*	0.48	-0.86	-	-
CPI (trend)	NA	-5.02*	-2.67	-	-1.65	-1.87
M2	2.93	1.66	1.96	-	-0.92	5.09

Table 5: Unit root test for the level of the data used. The critical value at 5 percent is -2.91 (constant) or -3.48 (constant and trend). CPI is either core or harmonized.

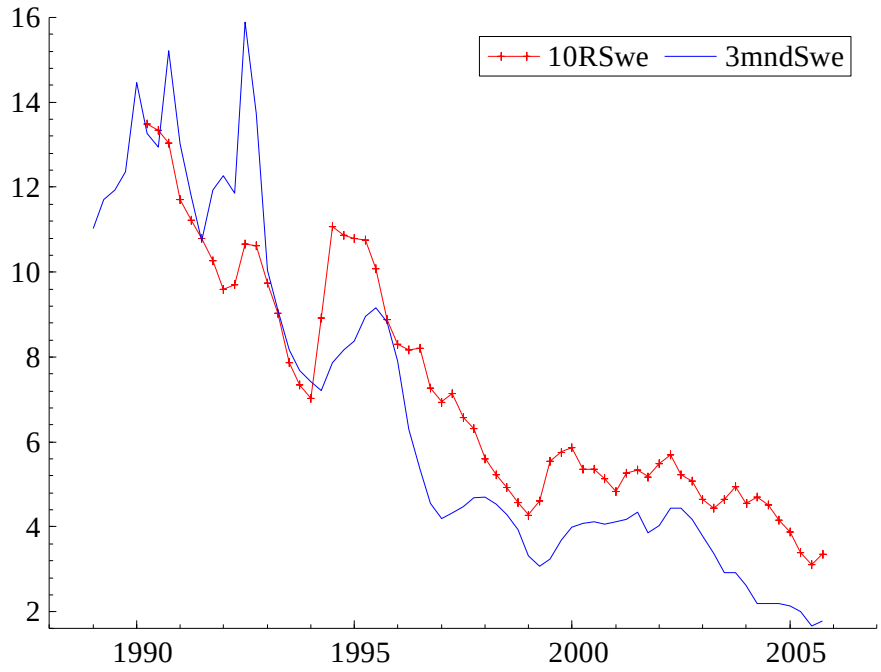

Figure 2: 10-year yield and 3 month interest rate in Sweden.

ADF test	Norway	Sweden	Denmark	OECD	Germany	USA
Δ3 mnth	-5.35*	-5.49*	-7.17*	-	-	-
ΔCA	-7.62*	-8.12*	NA	-	-	-
Δunempl	-11.83*	-3.09*	-12.42*	-	-10.82*	-4.60*
ΔGDP	-11.13*	-28.79*	-9.49*	-	-9.33*	-5.38*
Δdeficit, debt	-19.71*	-7.73*	-7.24*	-2.77	-	-
ΔCPI	NA	-3.48*	-1.49	-	-2.55	-1.78
ΔM2	-8.96*	-8.23*	-5.89*	-	-6.51*	-4.25*

Table 6: Unit root test for the first difference of the data. The critical value at 5 percent is -2.91.

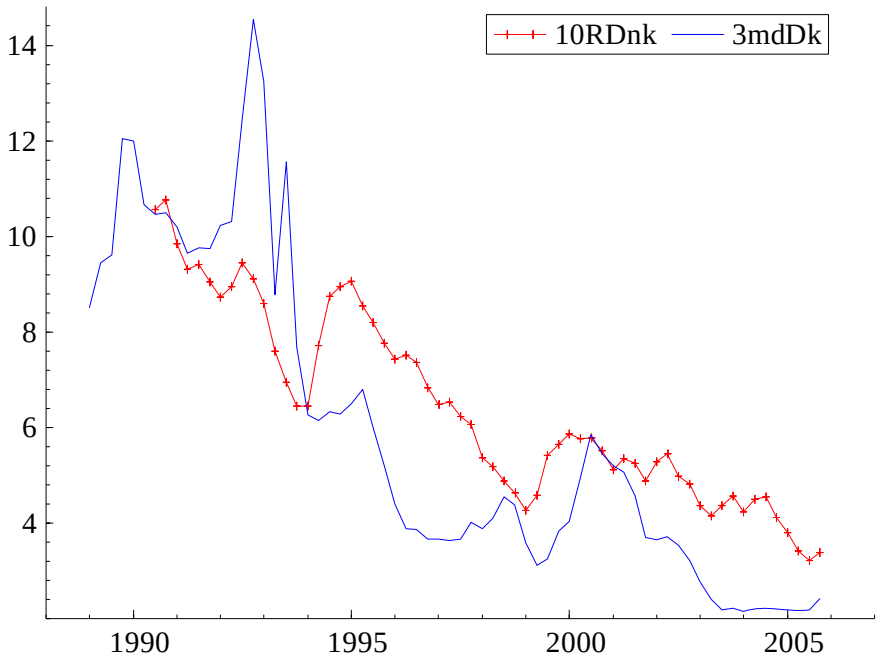

Figure 3: 10-year yield and 3 month interest rate in Denmark.

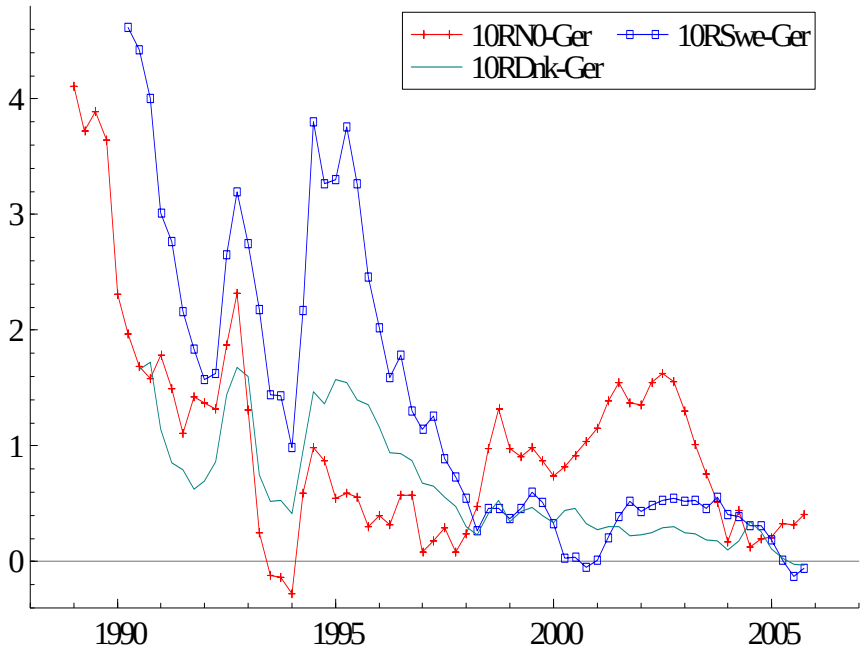

Figure 4: Interest rate differentials between 10 year interest rate in Norway, Sweden and Denmark versus Germany.

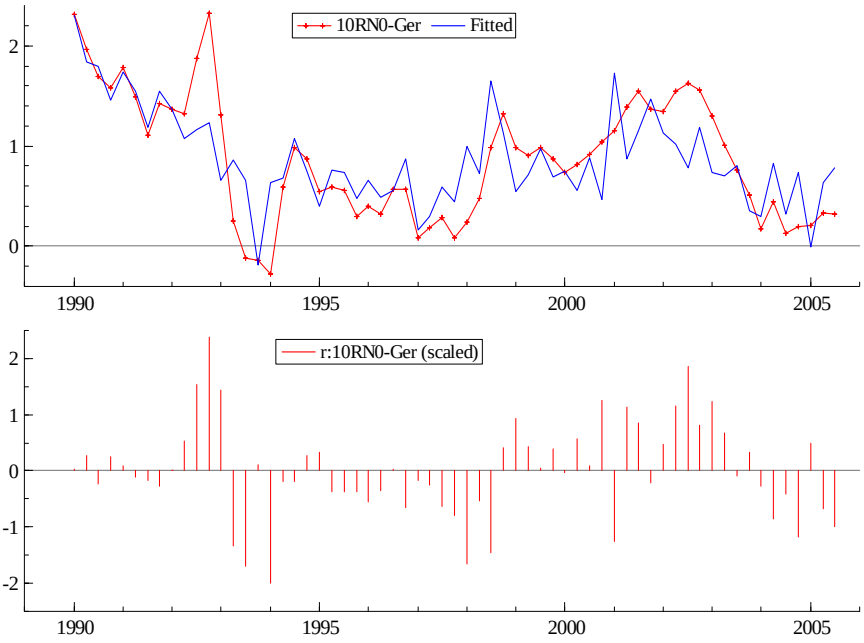

Figure 5: The actual and fitted series of the 10 year interest rate differential between Norway and Germany. The residuals of the estimated series are depicted in the bottom of the figure.

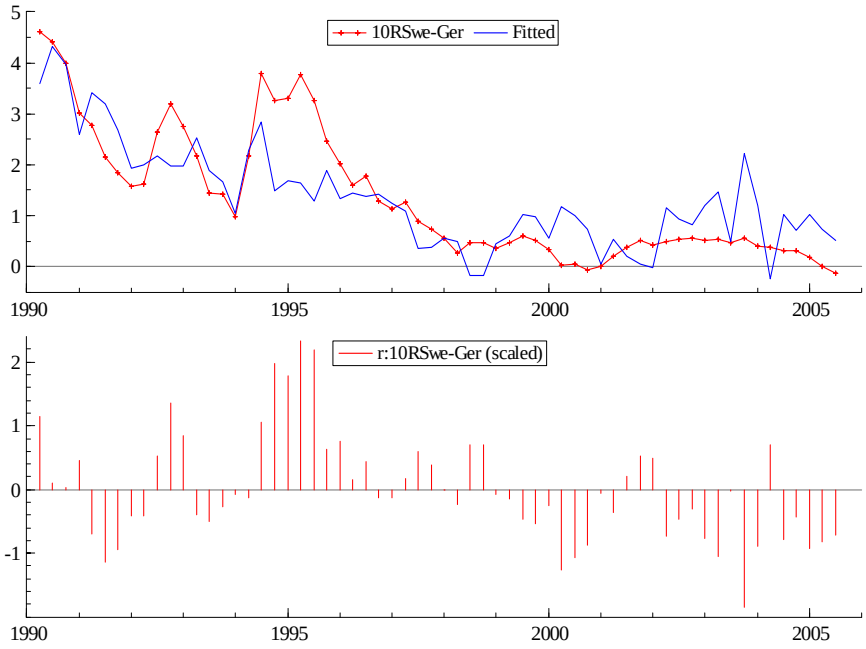

Figure 6: The actual and fitted series of the 10 year interest rate differential between Sweden and Germany. The residuals of the estimated series are depicted in the bottom of the figure.

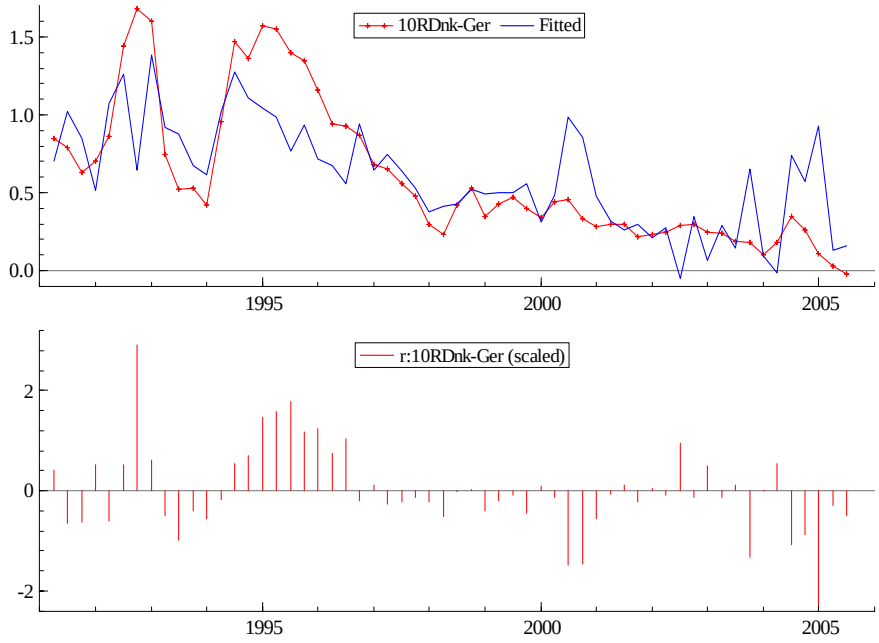

Figure 7: The actual and fitted series of the 10 year interest rate differential between Denmark and Germany. The residuals of the estimated series are depicted in the bottom of the figure.

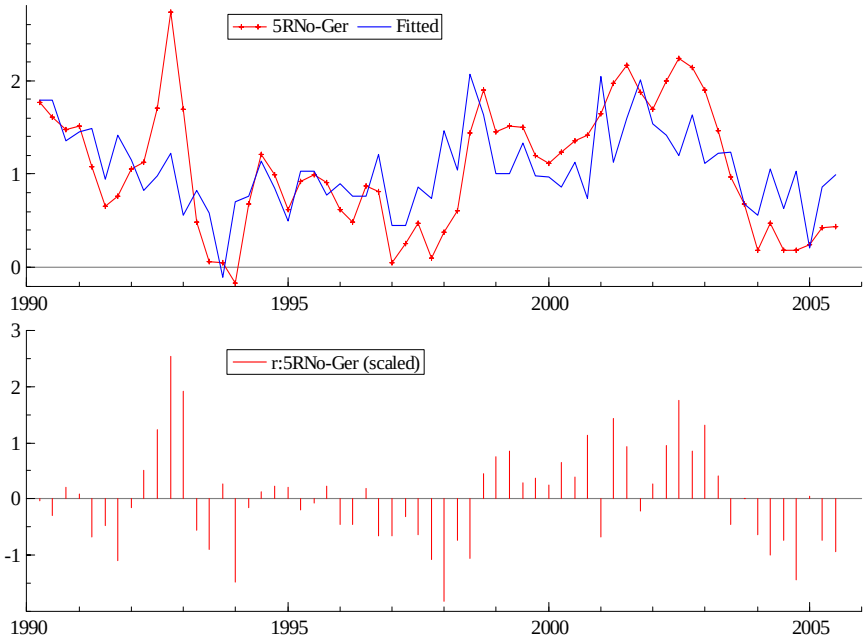

Figure 8: The actual and fitted series of the 5 year interest rate differential between Norway and Germany. The residuals of the estimated series are depicted in the bottom of the figure.

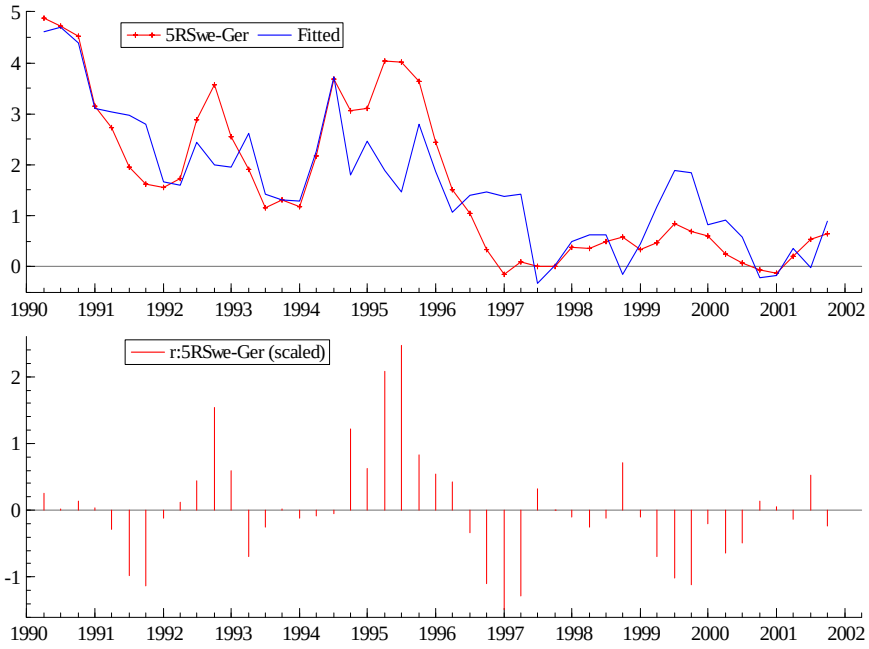

Figure 9: The actual and fitted series of the 5 year interest rate differential between Sweden and Germany. The residuals of the estimated series are depicted in the bottom of the figure.

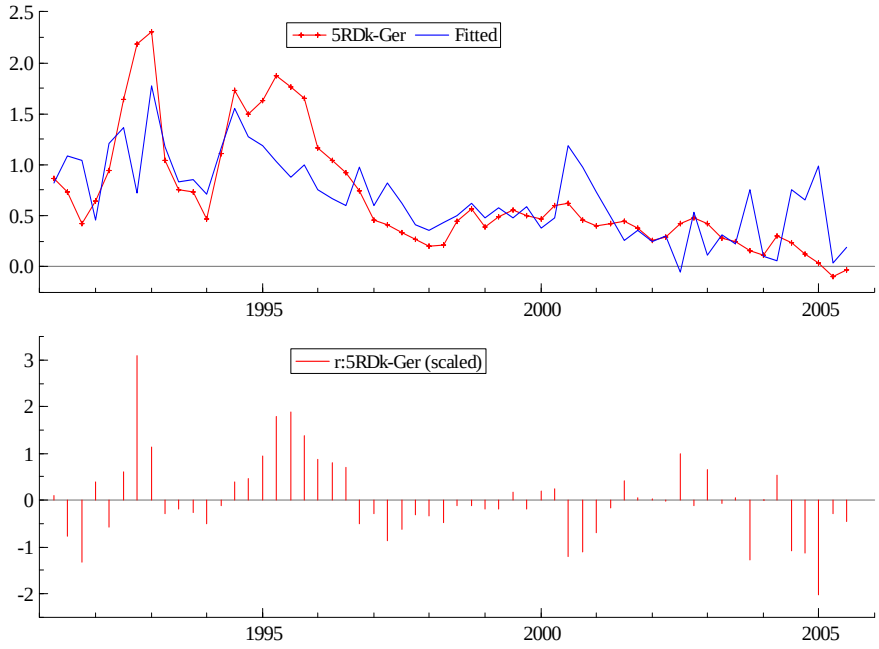

Figure 10: The actual and fitted series of the 5 year interest rate differential between Denmark and Germany. The residuals of the estimated series are depicted in the bottom of the figure.

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