Yield spreads and the exchange rate system: Denmark and the ERM II

Christoph Wegener*†, Tobias Basse‡, Frederik Kunze§
and Hans-Jörg von Mettenheim¶

Abstract

The uncovered interest rate parity is a common theoretical framework to analyze the relationships between bond yields and exchange rates. In this study, we consider theoretically the conditions for a cointegration relation among interest rates in a target zone. First, there must be – under realistic assumptions – a long run equilibrium between the interest rates because exchange rate risk is almost absent. Second, by using methodology rooted in the field of fractional integration and cointegration we find evidence for (a) a long run relationship between the interest rates from Denmark and Germany and (b) fractional cointegration between a risk aversion proxy and the government bond yield spreads.

JEL classification:

Keywords: Uncovered Interest Rate Parity, Fixed Exchange Rate Regimes, Sovereign Risk Premium, Fractional Cointegration

*Corresponding Author. E-Mail: cw@kvw-hannover.de and c.wegener@ipag.fr, +491743400924

†IPAG Business School, 184 Boulevard Saint-Germain, 75006 Paris, France, and Center for Risk and Insurance, Otto-Brenner-Straße 1, 30159 Hannover, Germany

‡Norddeutsche Landesbank Girozentrale, Friedrichswall 10, 30159 Hannover, Germany, and Touro College Berlin, Am Rupenhorn 5, 14055 Berlin, Germany

§Norddeutsche Landesbank Girozentrale, Friedrichswall 10, 30159 Hannover, Germany, and Faculty of Economic Sciences, Chair of Economic Policy and SME Research, University of Goettingen, Platz der Goettinger Sieben 3, 37073, Goettingen, Germany

¶Institut für Wirtschaftsinformatik Leibniz Universität Hannover, Königsworther Platz 1, 30167 Hannover

1. Introduction

The implications of the European sovereign debt crisis (which even caused some fears about the future of the Euro) for bond markets meanwhile have been analyzed quite intensively using the uncovered interest rate parity condition as theoretical foundation (see, for example, Basse, 2006; Sibbertsen, Wegener, and Basse, 2014). In this study, we plan to examine target zone fixed exchange rate regimes from exactly the same perspective (see, most importantly, Svensson, 1993) by focusing on Denmark. As already stressed by Kim et al. (2016), Denmark is an interesting example because it is one of the very few countries that have participated in the two exchange rate systems ERM and ERM II without noteworthy difficulties.

The Exchange Rate Mechanism (ERM) of the European Monetary System was created in 1979 to reduce exchange rate volatility after the end of the Bretton Woods system of fixed exchange rates. The ERM II (which has superseded the ERM) allows its member countries to let their currencies float against the Euro in a broad range of $+/-15\%$ towards the central rate (see, for example, Jupille and Leblang, 2007; Redo, 2016). Denmark has participated in the ERM II since its start in January 1999 (see, for example, Fatum and Pedersen, 2009; Abad, Chuliá, and Gómez-Puig, 2010). At the moment the country is the only member of the ERM II. It is important to note that the Danish krone has been pegged more closely to the Euro within an official band of only $+/-2.25\%$ (see, for example, Jupille and Leblang, 2007; Kim et al., 2016). Thus, the exchange rate between the Danish krone and the Euro is not considered to be very volatile. While the possibility of some movements of the exchange rate allows a certain (but quite limited) degree of monetary policy discretion this currency regime still forces the Danish central bank to regularly intervene in foreign exchange markets. Thus, there are obvious limits to the ability of the central bank in Copenhagen to freely decide about monetary policy issues.

At this point it is important to stress that currency regimes have implications for interest rates differentials. Abad, Chuliá, and Gómez-Puig (2010), for example, argued convincingly that the close ties of the Danish currency to the Euro seem to be the main reason for the rather low integration of the Danish with the US bond market. Given that the existence of the ERM II regime reduces exchange rate risk for Danish investors in the Euro Zone (and vice versa) there should be a close relationship between the interest rates in both currency areas. Put simply, yield spreads between risk free interest rates in Denmark and the Euro Zone ought to compensate investors for an expected devaluation. At this point it should be stressed again that the target zone ERM II limits exchange rate risk. More formally (and as will be discussed in some detail later on), the uncovered interest rate parity predicts that disregarding risk premia the discounted yield differential between two currency areas should equal the expected change of the exchange rate. This would have implications for the properties of the yield spread time series. In fact under certain conditions, the uncovered interest rate parity predicts cointegration among the interest rates in two countries (respectively currency areas). In this context it is important to note that in the case of Denmark the nominal exchange rate of the Danish krone relative to the Euro ought to be stationary because of the target band.

This paper is structured as follows: The 2nd section discusses the relationship between exchange rate regimes and interest rates and also provides a brief survey of the relevant literature. Section 3 introduces the data that is examined and also addresses a number of important methodological issues. Before concluding in Section 5, Section 4 empirically analyses the data and evaluates the reported evidence in some detail.

2. Exchange rate systems and interest rates

2.1. Exchange rates systems and the end of Bretton Woods

The exchange rate system chosen by a country clearly has major implications for the level of interest rates in this currency area. This is especially true for short-term interest rates. In fact, the trilemma of international financial economics (also called the impossible trinity) states that a country cannot have a fixed exchange rate, free capital movements and an independent monetary policy (see, for example, Bluedorn and Bowdler, 2010; Aizenman, Chinn, and Ito, 2013). Furthermore, Cooper et al. (1999) and Wagner (2000) have argued convincingly that there are still major uncertainties in the literature discussing what type of currency regime is appropriate for specific countries.

However, there are definitely no doubts about the fact that the choice for an exchange rate regime that a country makes has major implications for the monetary policy options of its central bank (see, for example, Cooper et al., 1999; Frankel, Schmukler, and Serven, 2004). With the introduction of absolutely fixed exchange rates, for example all but one central bank participating in this currency regime have to loose the possibility to freely use the tools of monetary policy. This can be quite problematic. In the 1970s, for instance, economists and politicians in West Germany hoped that the end of the Bretton Woods exchange rate system and the subsequent introduction of floating exchange rates would give central bankers the ability to fight more effectively against inflationary pressures by an appreciation of the home currency against the US dollar. Compared to the US the German experiences with the higher inflation rates of the 1970s were definitely more favorable; still floating exchange rates were not able to fully isolate Germany and other countries from inflation generated abroad (see, for example, Bordo, 1993; Basse, 2006).

In the United Kingdom, on the other hand, monetary policymakers back then seemed to be quite happy about the opportunity to depreciate the pound against the US dollar (most importantly, see Rowan, 1969). Consequently, the new exchange rate system clearly was one cause of elevated inflation rates relative to the United States. In sum, Helbling (1974) argued that the end of the Bretton Woods system resulted in an increase of the international price of the currencies of Japan, Switzerland and West Germany and a devaluation of the currencies of the United Kingdom and Italy relative to the US dollar. In spite of some problems floating exchange rates in general were quite popular among politicians and economists in the 1980s and 1990s. The negative experiences with the Bretton Woods system of fixed exchange rates clearly might be an explanation for this fact.

Meanwhile, there is less optimism. In fact, recently a fear of floating has been diagnosed in international finance (see Calvo and Reinhart, 2002). Some observers seem to believe that there are alternatives to freely floating exchange rates that could help to combine the advantages of absolutely flexible and rigidly fixed exchange rates (see, for example, Cooper et al., 1999; Masson, 2001). A target zone arrangement is one possible intermediate currency system that is neither based on freely floating exchange rates nor on purely fixed exchange rates. This exchange rate regime allows the price of the currency of one country to fluctuate within a pre-specified band relative to another currency (or a basket of currencies). Target zones therefore can help a country to reduce exchange rate volatility and still maintain a limited degree of monetary policy autonomy by not always forcing its central bank to intervene in currency markets to stabilize a rigidly fixed exchange rate (see, for example, Svensson, 1994; Jansen, 2008).

2.2. Uncovered interest rate parity in target zones

Based on the uncovered interest rate parity condition, Svensson (1993) argued convincingly that the yields of interest rate differential between fixed income securities of the same maturity denominated in two different currencies that both are members of an exchange rate target zone should reflect the expected rate of depreciation of the weaker currency relative to the stronger currency because exchange rate risk (and consequently also the premium compensating for this risk) in a target zone is likely to be small:

$$\frac{ip_t - i_t^*}{1 + i_t^*} = \frac{E\left(\Delta S_{t+1}\right)}{S_t}. \tag{1}$$

Thus, following Svensson (1993) the exchange rate risk premium is negligible in Equation (1). As almost always, it is assumed that the default risk of the two fixed income securities examined is identical (see, for example, Svensson, 1993; Sibbertsen, Wegener, and Basse, 2014). The two nominal interest rates might, for example, be government bond yields. To further simplify matters sovereign credit risk could be ignored for the moment. Moreover, it might also be assumed that there are no differences with regard to the liquidity of the two fixed income securities. In Equation (1) S_t is the spot exchange rate between the currencies of the two countries. The risk free interest rate at home is ip_t and the risk free rate abroad is i_t^*.

We examine one period bonds. Therefore, there are no coupon payments (see Alexius, 2001). Consequently, $E\left(\Delta S_{t+1}\right)$ is the expected change of the exchange rate during the lifetime of the two bonds. Rearranging leads to Equation (2) with the yield spread among the two fixed income securities on the left hand side:

$$ip_t - i_t^* = \frac{E\left(\Delta S_{t+1}\right)}{S_t}\left(1 + i_t^*\right). \tag{2}$$

If foreign exchange rate risk is not negligible the interest rate differential ought to not only reflect the devaluation expectations of market participants but also the currency risk premium (see, most importantly, Svensson, 1993). Svensson (1992) has argued that in a target zone the currency risk premium consist of two separate risk premia – one to compensate investors for exchange rate movements inside the band and a second one due to realignment risk. In a creditable target zone system realignment risk should be low or even negligible .

Moreover, relaxing the assumptions that the foreign fixed income securities might be seen as a highly liquid benchmark issue for the target zone which is free of default risk. Then ip_t is the risk adjusted interest rate at home (which means $ip_t = i_t - RP_t$ with i_t as nominal interest rate priced in the bond market). The risk premium RP_t should compensate investors for different types of relevant risks (most importantly sovereign credit risk, liquidity risk and currency risk). Substitution leads to:

$$i_t - RP_t - i_t^* = \frac{E\left(\Delta S_{t+1}\right)}{S_t}\left(1 + i_t^*\right) \tag{3}$$

respectively to

$$i_t - i_t^* = \frac{E\left(\Delta S_{t+1}\right)}{S_t}\left(1 + i_t^*\right) + RP_t. \tag{4}$$

At this point it could be assumed that RP_t is a function of the target zones benchmark interest rate i_t^* and one additional variable σ_t (measuring risk aversion) with CP as constant:

$$RP_t = CP + r_1 i_t^* + r_2 \sigma_t. \tag{5}$$

Substituting Equation (5) in Equation (4) yields to

$$i_t - i_t^* \left(1 - r_1 - \frac{E\left(\Delta S_{t+1}\right)}{S_t}\right) = \frac{E\left(\Delta S_{t+1}\right)}{S_t} + CP + r_2\sigma_t. \tag{6}$$

2.3. Target zone exchange rate systems in Europe

As already indicated, Denmark has participated in the exchange rate systems ERM and ERM II without major difficulties (see, most importantly, Kim et al., 2016). The Exchange Rate Mechanism (ERM) of the European Monetary System was created in 1979. This currency regime was based on the idea to define the exchange rates of the currencies of the member countries relative to the European Currency Unit (a predecessor of the Euro).

Vlaar and Palm (1993), for example, noted that these central rates determined a grid of bilateral central rates around which fluctuation margins were established. Countries participating in the ERM in general were obliged to intervene in foreign exchange markets when bilateral exchange rates reached the boundaries of one of these bands. Realignments of the parities were also possible (see, for example, Vlaar and Palm, 1993; Favero and Giavazzi, 2002).

However, realignments required the agreement of all ERM members. Quite clearly, the ERM helped to reduce exchange rate risk for investors. Therefore, this exchange rate system already should have caused tendencies to convergence of interest rates in Europe. While the ERM in theory was a symmetric system it has always been argued that Germany had a special role in the ERM and that Bundesbank more or less independently made monetary policy decisions de facto fixing the reference level of ECU interest rates relative to the US dollar thereby forcing the other central banks in the ERM countries to stabilize the parity against the German currency (most importantly, see Hassapis, Pittis, and Prodromidis, 1999). This point of view is called German Dominance Hypothesis. Consequently, German government bond yields should have played a special role for the European bond markets "causing" interest rate movements in other ERM member countries. Testing this hypothesis has not produced clear empirical findings. While the results reported by Hassapis, Pittis, and Prodromidis (1999) seem to indicate that the currency regime did not strongly increase the linkages between interest rates in Germany and the rates of other ERM countries with only one exception (the Netherlands) there also is empirical evidence that speaks for the validity of the German Dominance Hypothesis.

In fact, for example, Baum and Barkoulas (2006) using techniques of fractional cointegration analysis have provided some empirical support. With regard to the Danish experiences in the ERM period Svensson (1993) has provided an interesting empirical analysis examining devaluation expectations against the German currency. Speculative attacks in 1992 caused a crisis that resulted in a near-collapse of the ERM. As a consequence, the margins of the exchange rate bands were increased considerably. In fact, Zurlinden (1993) argued that the new widened margins came close to a suspesion of the system. With the introduction of the Euro the ECU basket of the ERM was no longer an adequate solution.

After the end of the ERM the ERM II was created. As already noted, this currency regime allows its member countries to let their currencies float against the Euro in a broad range of $+/-15\%$ towards the central rate (see, for example, Jupille and Leblang, 2007; Redo, 2016). Denmark has participated in the ERM II since its start in 1999 and has decided to peg its currency more closely to the Euro within an official band of only $+/-2.25\%$. At the moment it is the only member of the ERM II.

3. Data and methodological issues

3.1. Data

We examine German and Danish bond yields with the maturities of two, five and ten years with a weekly periodicity. All six time series are generic government bond yields calculated from bid market prices. Additionally, we analyze the spot exchange rate between the Euro and the Danish krone (also weekly data) and the S&P Volatility Index (VIX). All time series are taken from Bloomberg. Our sample starts 01/07/2000 and ends 03/24/2017 and consists out of 899 observations for each time series.

3.2. Testing the theoretical implications of the stochastic trending behavior

In this section we focus on the analysis of the system in Equation (6). First, we examine the conditions which might force a cointegration relationship among the interest rates. In this context we draw conclusions about the theoretical cointegrating vector. Second, we analyze the long run relationship between the resulting equilibrium between the interest rates and the risk premium.

We start with the empirical counterpart of Equation (6)

$$\underbrace{i_t}_{I(1)} - \underbrace{i_t^*}_{I(1)} \left(1 - r_1 - \underbrace{\frac{E\left(\Delta S_{t+1}\right)}{S_t}}_{I(-0.5<d_{FX}<0)} \right) = CP + \underbrace{\frac{E\left(\Delta S_{t+1}\right)}{S_t}}_{I(-0.5<d_{FX}<0)} + r_2 \times \underbrace{\sigma_t}_{I(0\leq d_{VIX}<1)} + \underbrace{\varepsilon_t}_{I(d_\varepsilon)}. \quad (7)$$

In addition to Equation (6) we add an error term ε_t. We assume that ε_t follows stationary

Fractional White Noise

$$(1-L)^{d_\varepsilon}\varepsilon_t = u_t \tag{8}$$

with $(1-L)$ as the back shift operator, $d_\varepsilon \in [0, 0.5)$ as the degree of persistence of ε_t and u_t as White Noise. This allows to draw inference about the system in (8) even if ε_t captures additional effects (e.g. omitted variables). Furthermore, we assume that interest rates are integrated of order one $I(1)$ (see, for example, Sibbertsen, Wegener, and Basse, 2014).

Moreover, the exchange rate between two currencies in a target zone should be mean reverting by definition (see, for example, Vlaar and Palm, 1993). As a consequence, the change (Δ) of the exchange rate should be an integrated process with an order less than zero ($I(-1 \leq d_{FX} < 0)$) as we assume that the spot rate is $I(d_S)$ with $0 \leq d_S < 1$. Note, that there is an important strand of the literature which shows that (real) exchange rates can be best explained by nonlinearly mean-reverting models (see, for example Taylor, Peel, and Sarno, 2001). The assumption that S_t is driven by long memory processes might be violated and ESTAR (see, for example, Kilian and Taylor, 2003) or Markov Switching dynamics (see Kruse, Frömmel, Menkhoff, and Sibbertsen, 2012) might be more appropriate. However, also in this case, S_t is a nonlinear mean-reverting process. Thus, the expected change of the exchange rates is less persistent than the interest rates which are characterized by unit root processes. From this point of view, the conclusions about the existence of cointegration among the interest rates are not violated. Thus, we assume here that $d_{FX} \in (-0.5, 0)$ because this assumption facilitates tremendously the following analysis without violating the generality of our results concerning cointegration in the system.

The measure of risk aversion σ_t could be volatility in equity markets (for example the VIX or the VDAX). Volatility measures might be integrated with an order less than one – thus, mean reverting. Bandi and Perron (2006) estimated values for the degree of persistence of implied volatility (d_{VIX}) around 0.5 and 0.7. For the moment, we assume $d_{VIX} \in [0, 1)$.

Because all terms of the sum of the right side are assumed to be $I(d)$ with $d \in (-0.5, 1)$ or constant (CP), the two interest rates must be cointegrated with an equilibrium error of $I(1-b)$. Moreover, when there are devaluation expectations or signs of at least some interest rate sensitivity of the risk premium the cointegration vector should read $\left(1, -\left(1 - r_1 - \frac{E(\Delta S_{t+1})}{S_t}\right)\right)$. The estimation of this vector then might be difficult because of its time variation.

If a cointegrating vector exists for the two interest rates, if $d_{VIX} \in [0.5, 1)$ and if all other variables are mean and variance stationary or constant, the risk measure and the equilibrium error must have the same degree of persistence and must be fractionally cointegrated as long as ε_t is less persistent than the volatility measure and the interest rate equilibrium.

To illustrate this, assume that a cointegration relation among the interest rates exists with $b = 0.3$, which leads to $I(0.7)$ for the equilibrium error. Furthermore, assume that the exchange rate movements are $I(-0.2)$, ε_t is by definition mean and variance stationary – for the purpose of illustration assumed to be $I(0.1)$. CP is constant and the cointegrating vector is assumend to be also constant $(1, -1)$ which is the simple spread between the interest rates. This examples come quite close to the estimated real world parameters in the following section.

$$\underbrace{i_t - i_t^*}_{I(0.7)} = \underbrace{CP}_{\text{constant}} + \underbrace{\frac{E\left(\Delta S_{t+1}\right)}{S_t}}_{I(-0.2)} + r_2 \times \underbrace{\sigma_t}_{I(0.7)} + \underbrace{\varepsilon_t}_{I(0.1)}. \tag{9}$$

Because the right hand side and the left hand side must have the same degree of persistence, d_{VIX} must be integrated of the same order as the spread. Furthermore, they must be fractionally cointegrated with the vector $(1, -r_2)$ because both sides of Equation (10) must have the same degree of integration

$$\underbrace{spread_t}_{I(0.7)} - r_2 \times \underbrace{\sigma_t}_{I(0.7)} = \underbrace{CP}_{\text{constant}} + \underbrace{\frac{E\left(\Delta S_{t+1}\right)}{S_t}}_{I(-0.2)} + \underbrace{\varepsilon_t}_{I(0.1)} \tag{10}$$

with $spread_t = i_t - i_t^*$.

Our empirical modeling strategy works in two steps:

1. We estimate the degree of persistence of the underlying time series using the procedure by Shimotsu and Phillips (2005) respectively Shimotsu (2010) to allow an unknown mean.
2. We investigate the cointegration among the interest rates and the risk measure by applying the test by Nielsen and Shimotsu (2007). First, the test is applied to investigate cointegration among the interest rates. Second, we apply the test to investigate a long run relationship between the equilibrium error between the interest rates and the volatility measure. Note that we assume a constant cointegrating vector in this case. Furthermore, if the assumption about the exchange rate changes is violated and the process is characterized by another nonlinear mean reverting process than long memory, the inference about parameters – using for example the test by Shimotsu (2012) – in the cointegrating system might be biased.

4. Empirical Analysis

This section reports the results of estimated persistence parameters (d) for the spot rate (S_t), the change of the spot rate (ΔS_t), the VIX (σ_t), the spreads and the underlying interest rates from Germany and Denmark (see table 1). Furthermore, we test for cointegration between the interest rates (see table 2) and the spreads and the VIX (see table 3).

	$m = T^{0.55}$	$m = T^{0.60}$	$m = T^{0.65}$	$m = T^{0.70}$	$m = T^{0.75}$
Spot Rate	0.852	0.883	0.891	0.948	0.927
Change of the Spot Rate	-0.150	-0.118	-0.108	-0.052	-0.072
VIX	0.672	0.627	0.724	0.838	0.848
2 Years					
Denmark	1.188	1.131	1.135	1.186	1.114
Germany	1.186	1.218	1.154	1.189	1.158
Spread	0.718	0.726	0.745	0.872	0.899
5 Years					
Denmark	1.021	0.949	0.992	1.038	1.016
Germany	1.038	1.037	1.018	1.080	1.077
Spread	0.786	0.783	0.801	0.888	0.955
10 Years					
Denmark	0.923	0.933	0.972	1.034	1.058
Germany	0.951	0.936	0.974	1.029	1.023
Spread	0.767	0.807	0.891	0.980	0.995

Table 1: Estimated persistence parameters for several bandwidths for the spot rate (S_t), the change of the spot rate (ΔS_t), the VIX (σ_t) and the interest rates for maturities of two, five and ten years of Denmark and Germany and its spreads.

	$v(n) = m_1^{-0.45}$	$v(n) = m_1^{-0.35}$	$v(n) = m_1^{-0.25}$	$v(n) = m_1^{-0.15}$	$v(n) = m_1^{-0.05}$
2 Years					
$m_1 = 29$, $m = 21$					
$L(0)$	-1.492	-1.311	-1.066	-0.733	-0.282
$L(1)$	-1.699	-1.609	-1.486	-1.320	-1.095
r	1	1	1	1	1
5 Years					
$m_1 = 29$, $m = 21$					
$L(0)$	-1.492	-1.311	-1.066	-0.733	-0.282
$L(1)$	-1.620	-1.529	-1.407	-1.240	-1.015
r	1	1	1	1	1
10 Years					
$m_1 = 29$, $m = 21$					
$L(0)$	-1.492	-1.311	-1.066	-0.733	-0.282
$L(1)$	-1.625	-1.534	-1.412	-1.246	-1.020
r	1	1	1	1	1

Table 2: Test results of (fractional) cointegration among the government bond yields of Denmark and Germany. The first line ($L(0)$) refers to the hypothesis of $H_0 : r = 0$, the second line ($L(1)$) refers to the hypothesis of $H_0 : r = 1$. We consider the test for several values of $v(n)$ and for cointegration between two, five and ten year government bond yields of both countries.

In table 1 we report the results of procedure by Shimotsu (2010). We see that the Spot rate is less persistent for the most of the bandwidths than a random walk and the change of the spot rate shows even estimated values for the persistence smaller than 0. Thus, the driver of the persistence of the spread – which is in the region between 0.7 and 0.9 – cannot be the expected change of the exchange rate. However, the VIX shows also estimated persistences in this region.

From the results reported by table 1, we further consider cointegration among the interest rates. Here, we see that we find cointegration for all bandwidths and all maturities between Denmark and Germany – which supports the first part of our theory in the forgone section. Note that we assume a constant cointegrating vector in this case.

	$v(n) = m_1^{-0.45}$	$v(n) = m_1^{-0.35}$	$v(n) = m_1^{-0.25}$	$v(n) = m_1^{-0.15}$	$v(n) = m_1^{-0.05}$
2 Years					
$m_1 = 29$, $m = 21$					
$L(0)$	-1.492	-1.311	-1.066	-0.733	-0.282
$L(1)$	-1.373	-1.283	-1.160	-0.994	-0.768
r	0	0	1	1	1
5 Years					
$m_1 = 29$, $m = 21$					
$L(0)$	-1.492	-1.311	-1.066	-0.733	-0.282
$L(1)$	-1.250	-1.160	-1.037	-0.871	-0.646
r	0	0	0	1	1
10 Years					
$m_1 = 29$, $m = 21$					
$L(0)$	-1.492	-1.311	-1.066	-0.733	-0.282
$L(1)$	-1.427	-1.336	-1.214	-1.048	-0.822
r	0	1	1	1	1

Table 3: Test results of (fractional) cointegration among the government bond yield spreads and the VIX. The first line ($L(0)$) refers to the hypothesis of $H_0 : r = 0$, the second line ($L(1)$) refers to the hypothesis of $H_0 : r = 1$. We consider the test for several values of $v(n)$ and for cointegration between VIX and two, five and ten year government bond yield spreads.

Applying also the methodology of Nielsen and Shimotsu (2007) to the VIX and the spreads – which is the same like a constant cointegrating vector of $(1, -1)$ shows also some evidence for cointegration between both variables – this supports the second part of our theory, that VIX and spread should be cointegrated for a constant cointegrating vector.

5. Conclusion

The empirical evidence presented above suggests that the exchange rate between the Euro and the Danish krone seems to be mean reverting. This is no surprise because Denmark has adopted a target zone exchange rate regime with a peg to the Euro. In fact, Denmark has participated in this target zone regime ERM II since its start in 1999 and at the moment is the only member of this system of partly fixed exchange rates. Consequently, there are limits to the volatility of the exchange rate between the Danish krone and the Euro as long as this arrangement is considered to be credible.

Interestingly, Denmark is one of the very few countries that have participated in the two exchange rate systems ERM II and its predecessor ERM without noteworthy difficulties. Therefore, the target zone regime could be considered to be quite credible. Thus, given that the exchange rate between the two currencies seems to be stationary the change of the exchange rate should be an $I(d)$ process with $d \in [-1, 0)$.

As discussed above, this empirical finding has some implications for bond yields in the two currency areas. While the interest rate differentials (two, five and ten years) all seem to have a lower persistence then the change of the exchange rate.

This empirical finding should be a consequence of the risk premia. Moreover, economic theory does suggest that the cointegration vector between the interest rates in the two currency areas is not necessarily $(1, -1)$. This could also help to explain our empirical findings.

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