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Jakob Lage Hansen

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A risk index for euro-denominated assets

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Please direct any enquiries to
Danmarks Nationalbank, Information Desk, Havnegade 5, DK-1093 Copenhagen K
Denmark
Tel.: +45 33 63 70 00 (direct) or +45 33 63 63 63
Fax : +45 33 63 71 03
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A risk index for euro-denominated assets[1]

Jakob Lage Hansen

Danmarks Nationalbank

Havnegade 5

1093 Copenhagen K

Denmark

+45 33 63 63 63

jlh@nationalbanken.dk

May 2006

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Abstract

This paper introduces an index that captures risk premiums of euro denominated assets based on sub-indices reflecting various credit spreads, implicit volatilities and bonds' excess return over stocks. The index reflects one common factor that accounts for general shifts in risk premiums across all markets. The development in the index is related to the business cycle, macroeconomic uncertainty and monetary policy. The risk index helps understand underlying market developments and can be applied in investment decisions – when the risk index rises (reflecting higher risk premiums), the level of the German yield curve falls, it becomes more flat and the curvature is reduced. The index also has use in the evaluation of financial stability. For instance, there is a tendency for the risk index to have more extreme tops than troughs, which indicates an asymmetry in investors' returns. Also, the covariation between sub-indices has risen since 1999, thereby indicating an increase in investors' vulnerability.

Resumé

Papiret introducerer et indeks, der afspejler risikopræmierne på euro-denominerede aktiver. Det beregnes på baggrund af en række underindeks, der bygger på kreditspænd, implicitte volatiliteter, samt obligationers merafkast i forhold til aktier. Indekset afspejler én fælles faktor, der fanger generelle skift i risikopræmierne på tværs af markederne. Indekset varierer med konjunkturudsving, makroøkonomisk usikkerhed samt det pengepolitiske renteniveau. Indekset kan bidrage til forståelsen af den underliggende markedsudvikling og kan anvendes i investeringsbeslutninger – når indekset stiger (svarende til højere risikopræmier), falder niveauet for den tyske rentekurve, der samtidig bliver fladere og mindre krum. Indekset kan ligeledes anvendes i analysen af den finansielle stabilitet. Fx er der en tendens til, at indeksets toppe er mere ekstreme end dets bunde, hvilket tyder på en asymmetri i investorers afkast. Derudover er samvariationen i underindeksene steget siden 1999, hvilket indikerer øget sårbarhed for investorer.

1. Introduction and summary

Investors' assessment of risk is an important factor in determining asset prices, and in periods it can dominate the developments in financial markets. The working paper develops a risk index for assets denominated in euros that reflects a general risk premium on risky assets. The index is applied to investment decisions and the assessment of financial stability.

A number of investment banks maintain risk indices similar to the one proposed here. However, few of these are specifically targeted to the euro market or focused on investment decisions concerning government bonds, as in this analysis. Also, the use of a risk index to draw out implications for financial stability is not common.

The index is based on sub-indices reflecting four credit spreads (reflecting both government, corporate and bank debt), three implicit volatilities (on government bonds and stocks), and the performance of bond markets relative to stock markets. A higher value of the index (i.e. higher risk premiums) can either reflect a rise in investors' assessment of the risk associated with euro-denominated assets, or that investors demand a larger premium for holding a given risk. As the index is based on market prices it can be calculated in "real-time", and both a short-term and long-term index is calculated.

Since 1999 the index has had a number of spikes, which can be associated with large shocks to the market. Lately, the index has fallen to a very low level. A rise in the index coincides with lower GDP-growth, higher macroeconomic uncertainty and higher monetary policy rates by the ECB. It is shown that the index mirrors one principal component that affects the eight sub-indices in a similar fashion which corroborates that the index reflects a common risk-factor that influences all markets.

The index can be used to understand underlying developments in the market. The analysis suggests that the development in the yield curve of German government debt is related to the development in the risk index. When the risk index rises, the level of the yield curve falls, it becomes more flat and the curvature is reduced. Overall the effects suggest "safe haven" demand effects, some substitution of more risky longer maturities for less risky shorter maturities, and short-term rates being anchored due to monetary policy.

The index can be applied in investment decisions in different ways. By relating the development in the index to recent market developments, it might enhance the understanding of current market conditions. As many investment decisions are based on level, slope and curvature of the yield curve, the relations between these and the risk index can be helpful, if one can form an opinion on the development in the risk index going forward. This opinion could be based on macroeconomic fundamentals and/or an assessment of the markets vulnerability and focus. One can also take a contrarian view based on the risk index's tendency to mean revert.

Four observations are made, that have relevance for financial stability. Firstly, the index's tops are more extreme than the troughs. This suggests that markets are more vulnerable to negative shocks (that increase risk premiums) than positive, which exposes investors more to downside movements in prices than upside. This

might be related to investors being risk averse, the use of "stop-loss" and "stop-profit", a natural lower bound on i.a. credit spreads, and the general use of market-based risk management. Secondly, the covariations between the sub-indices rise when the overall index rises. As a consequence diversification benefits dries up, when investors need it most. Thirdly, the covariance between sub-indices has trended up since 1999 – i.e. the changes in the risk premiums demanded in different markets increasingly behave in a similar fashion. This could be due to more synchronized business cycles in a globalized world, the move towards common risk-management practices, benchmarking and more "perfect" markets. The implication for investors is reduced opportunities for diversification. Fourthly, the index has a tendency to mean revert, which can be due to the cyclical nature of the macroeconomy and the limits of exposure imposed on investors by risk management. This fact can be used to evaluate the investor community's vulnerability at a given point in time.

The paper follows the outline of the introduction. Section 2 describes the calculation of the index, section 3 analyzes the development in index and sub-indices, section 4 relates developments in the index to the German yield curve and to investment decisions while section 5 explains implications for financial stability.

2. The calculation of the index

The objective is an index that quantifies a general (or market) risk premium investors demand for holding risky assets denominated in euro. This risk premium should rise if either the general market risk is perceived higher or if investors demand a bigger premium for holding a given risk. Risk premiums of individual assets are also influenced by idiosyncratic risks. By basing the index on several broad indices, idiosyncratic shocks have a more limited effect on the index.

The index is based on eight sub-indices with a daily frequency, and can be calculated back to 1999 when the euro was introduced. As it is based on market prices, it can be updated in "real-time". The aim has been to use sub-indices based on markets “in the vicinity” of the investment universe of Danmarks Nationalbank, which is restricted to bonds with high credit quality. Therefore the majority of the sub-indices are related to the bond market, while also taking the stock market into account. Four sub-indices are based on credit spreads, which reflect the risk premium for holding bonds with credit risk. Both government, corporate and bank risk is included in this way. Three sub-indices reflect implicit volatilities derived from options. In this way uncertainty over developments in both short-term and long-term government bonds is included, as is uncertainty in the stock market. Options give the right to buy or sell an asset at a predetermined price and thus provide security against movements in asset prices. The value of options (and therefore the implicit volatility) rises if investors become more uncertain about future market developments (risk increases) or if investors are less willing to be exposed to risk (and thus value the protection of options higher). Lastly, one sub-index reflects the accumulated daily excess return of government bonds over stocks. It is based on the idea that stocks are more risky than government bonds, and an increase in the equity risk premium on a given day will decrease the return of stocks relative to bonds on that given day. A rise in the sub-index thus indicates a higher equity risk premium.

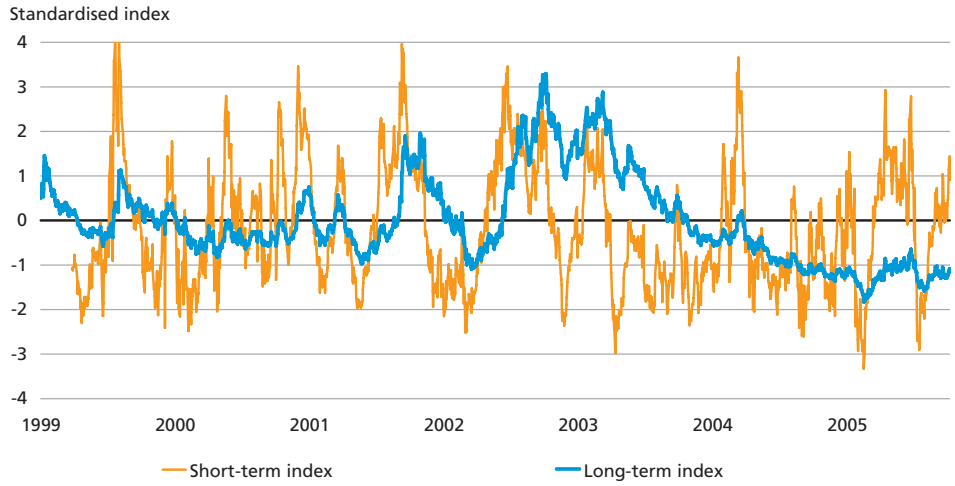
Specifically, the eight sub-indices are:

- *Emerging market spread:* The spread between government debt issued in euro by emerging markets and government debt issued in euro by countries in the euro area (J.P. Morgan index).
- *Corporate spread I:* The spread between AA-rated corporate debt issued in euro and government debt issued in euro by countries in the euro area (J.P. Morgan index).
- *Corporate spread II:* The spread between BBB-rated and AAA- corporate debt issued in euro (derived from J.P. Morgan indices).
- *Swapspread:* The difference between a 10-year euro swap and a 10-year German government bond. The swap yields a fixed rate with the obligation to pay a variable rate and the spread is, inter alia, due to credit risk in the inter-bank market (Bloomberg series).
- *Bond implicit volatility I:* The implicit volatility derived from a 1 year/1 year swaption – that is, the option on a 1 year swap in 1 year (Bloomberg series).
- *Bond implicit volatility II:* The implicit volatility derived from a 1 year/10 year swaption – that is, the option on a 10 year swap in 1 year (Bloomberg series).
- *Stock implicit volatility:* The implicit volatility of options on the German stock index DAX (VDAX – Bloomberg series).
- *Excess return of government bonds over stocks:* The accumulated difference between the return from government debt issued by countries in the euro area in euro (price gains and coupons) and the return on the Euro Stoxx 50 equity index (price gains and dividends) (derived from a J.P. Morgan index and Bloomberg series).

All series are standardized over the whole period (from 1999 to the last observation) by subtracting the mean and dividing by the standard deviation. That is, $\hat{I}^S_t = (I^S_t - \mu^S) / \sigma^S$, where $\hat{I}^S_t$ is the observation at time t in sub-index S, I^S_t is the observation at time t in the underlying series of sub-index S, μ^S is the average of the observations in the underlying series of sub-index S and σ^S is the standard deviation of the underlying series of sub-index S. As a result $\hat{I}^S$ has a mean of 0 and a standard deviation of 1. An underlying series for the aggregate index is then calculated as the average of the 8 sub-indices, that is $I^A_t = \Sigma^8_{S=1}(\hat{I}^S_t / 8)$, where I^A_t is the observation at time t in the underlying aggregate index and the eight sub-indices are labelled 1, 2, … , 8. This method ensures that each sub-index has a similar impact on the underlying aggregate index, both with respect to level and changes. Finally, the underlying aggregated index is standardized to create the aggregate index (same methodology as the sub-indices – that is, $\hat{I}^A_t = (I^A_t - \mu^A) / \sigma^A$ with parallel notation). A level of the aggregate index ($\hat{I}^A_t$) above 0 indicates a larger risk than average (and vice versa). Also, 95 pct. of the observations can be expected to lie between -2 and 2, when the distribution is normal.

To visualize short-term fluctuations in the risk index, a short-term index is also calculated. The calculation is similar except that a given observation in the aggregate index is standardized with respect to the observations in the underlying index during the 3 months prior to the given observation (that is, when calculating $\hat{I}^A_t$, μ^A and σ^A are calculated from observation t-61 to observation t). In a similar fashion short-term sub-indices can be calculated (not shown, but used in the analysis below).

RISK INDEX FOR EURO-DENOMINATED ASSETS Chart 1



Note: Calculation as described in section 2.
Source: Bloomberg, J.P. Morgan and own calculations.

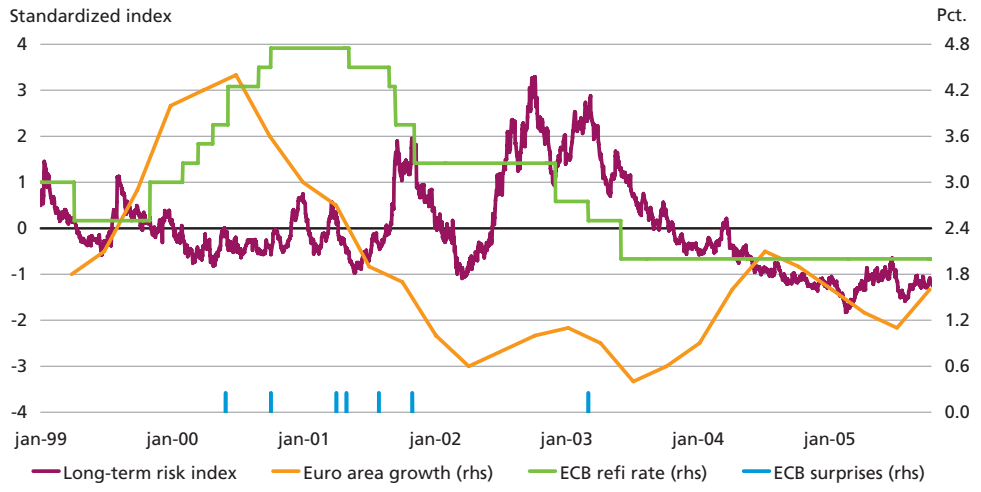
3. Analysis of the risk index

3.1. The risk index and macroeconomic factors

The long-term index fluctuated around 0 in the beginning of the period, cf. chart 1. The index rose in connection with September 11 2001, during the American accounting scandals in 2002, and in the run-up to the Iraq-war in 2003. Subsequently the index has fallen to a low level.

The index thus seems to reflect large shocks that have been in the focus of market participants in the later years. Various macroeconomic factors can also be expected to affect the risk index (causality can, however, be ambiguous). These are laid out in the following and then tested econometrically.

THE RISK INDEX, GROWTH AND MONETARY POLICY Chart 2

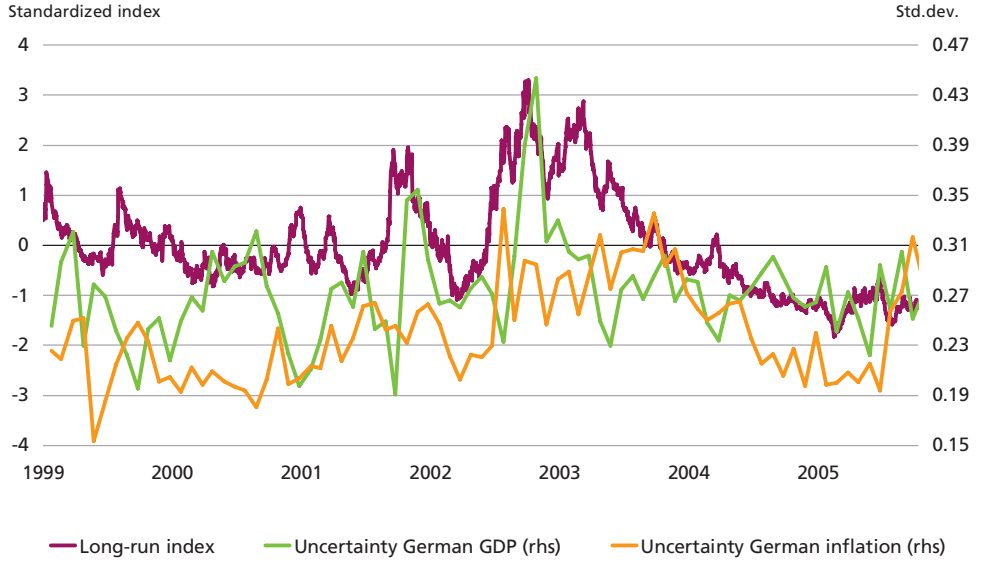


Note: Euro area growth is quarterly year-year figures. ECB surprises is the absolute difference between ECBs interest rate decision and the median of economists forecasts collected by Bloomberg.
Source: Bloomberg, J.P. Morgan and own calculations.

The level of economic activity can affect risk premiums for several reasons. Since risk averse investors are less willing to be exposed to risk in periods where their income is low, the price of risk can be expected to rise in economic downturns; while investors at the peak of business cycles have a healthy income, and thus are more willing to take on risk, which depresses the price of risk. In addition the amount of risk varies with the business cycle as investors can be expected to asses the probability of default higher when demand for corporate products and tax revenue is low (and vice versa). In chart 2 the growth of the euro area is shown along with the risk index. The risk index was depressed during the economic expansion in 2000, while the subsequent drop in economic activity coincided with a period of elevated risk. The subsequent drop in the risk index coincided with improving growth – however, the risk index's low level at the end of the period does not seem to reflect the economic growth of the euro area, which has remained subdued. In this period worldwide growth has been healthy, though.

Monetary policy can also affect the risk index as ECB determines the cost of financing investments in risky assets. Many view the present low risk premiums as a result of loose monetary policy as the low yield has "forced" investors into more risky assets to get a high return. Other investors have used the opportunity to increase their gearing, also creating demand for risky assets. A related factor, that could influence the risk premiums of euro assets, is uncertainty over future ECB policy. ECB was a new player in 1999, and since that time investors have become more familiar with ECB policy and communication, which might have reduced the uncertainty. The interest rate decisions of ECB surprised investors on several occasions in the beginning of the period, while the decisions during the last three years all have been expected, cf. chart 2.

THE RISK INDEX AND MACROECONOMIC UNCERTAINTY — Chart 3

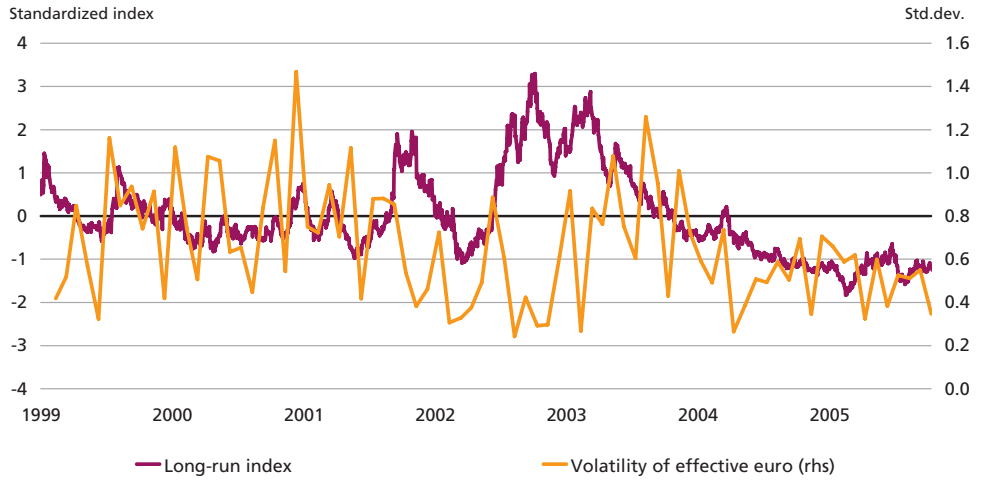


Note: The uncertainty regarding German GDP/inflation is calculated as the standard deviation on economists' forecasts of German growth/inflation collected by Consensus Economics. Consensus Economics collects a forecast for current and coming year. To keep the forecast horizon constant, the standard deviations are weighed to create a rolling forecast one year ahead (for instance in March (April) the forecast for current year is given the weight 9 (8) and coming year is given weight 3 (4)). There are no apparant seasonal effects in the resulting time series.
Source: Bloomberg, J.P. Morgan, Consensus Economics and own calculations.

Uncertainty over the macroeconomic outlook can also influence the risk associated with assets. Uncertainty over real growth makes profits of corporates and governments less predictable, while uncertainty over inflation raises the ambiguity of ECBs future monetary policy. One way to ascertain the macroeconomic uncertainty is by the dispersion in economist forecasts on economic activity and inflation – a large dispersion indicates more uncertainty. In chart 3 the uncertainty regarding the German economy one year ahead is shown. Germany is used as forecasts on the euro area are unavailable for the whole period. However, Germany should be a good proxy since it is the largest economy of the euro area and is particularly dependent on external trade (and hence on developments in other euro area countries). The spikes in the risk index seem to coincide with increased macroeconomic uncertainty, while the uncertainty has been fairly low in the major part of 2005.

Lastly, since an inherent risk associated with euro assets is the currency risk, the volatility of the euro might influence the risk premiums. Investors were unfamiliar with the euro in 1999, and there has since been a (weak) downward trend in the volatility of the currency, cf. chart 4. Also, fluctuations in the risk index and euro volatility periodically coincide.

THE RISK INDEX AND VOLATILITY OF THE EURO — Chart 4



Note: The volatility of the effective euro is calculated as the standard deviation on daily observations within in each month. The effective euro is a trade-weighted average of 22 currencies calculated by ECB.
Source: Bloomberg, J.P. Morgan and own calculations.

A regression of the risk index on the mentioned factors is shown in table 1. PMI is used instead of GDP-growth to allow for a monthly frequency (the correlation between the two is 0.87 at quarterly frequency). All signs are as expected, except for ECB surprises. The latter is also insignificant, along with euro volatility. The factors explain 41 percent of the variation in the risk index. The theoretical links between the risk index and macroeconomic factors seem to be confirmed empirically, while the same is not true for ECB surprises and euro volatility. It should be noted, that the results are based on a relatively short period and a simple methodology. However, the results are in line with studies of the US market based on longer periods and more sophisticated econometric methods that find a

negative relationship between credit spreads and economic activity and a positive relationship between credit spreads and the risk-free rate (Amato and Luisi (2006) and references therein).

RISK INDEX REGRESSED ON MACROECONOMIC FACTORS Table 1

Variable	Coefficient	P-value
PMI for the euro area	-0,07	0,02*
ECBs refi-rate	0,36	0,00*
ECB surprises	-1,62	0,22
GDP uncertainty	6,91	0,01*
Inflation uncertainty	8,88	0,00*
Volatility of the effective euro	0,59	0,15
Explanatory power	0,41	

* Significant at the 5 pct. level

Note.: Monthly observations from January 1999 to October 2005. The long-run index is used in the calculations. For the calculations behind the explanatory variables, refer to the notes in chart 2-4. PMI is calculated as the average of the index for service and the index for manufacturing. The reported P-values are two-sided. A constant of -1,70 is not reported above (p-value 0,42).
Source: Bloomberg, J.P. Morgan, Consensus Economics and own calculations.

The result gives an indication of some factors that influence risk premiums in the euro market, which can be useful in investment decisions and when evaluating financial stability (explained in detail below).

However, it is also clear that other factors account for a large part of the variation in the risk index. Thereby the risk index adds value by containing information in addition to that contained in (this specific) macroeconomic data. Also, the index has the advantage of being available on a daily frequency without a lag.

3.2. Analysis of the sub-indices

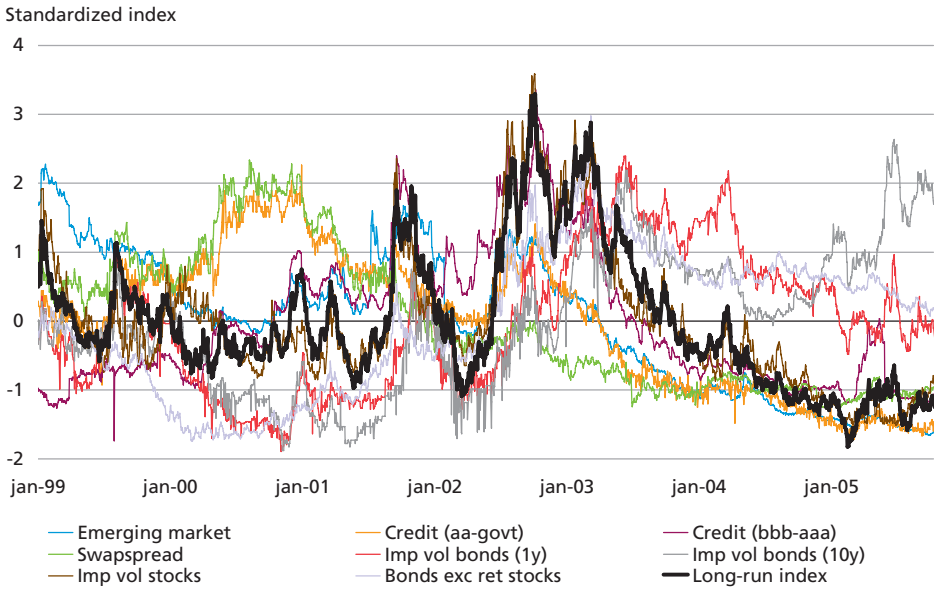
The main goal of this subsection is to establish to what degree a common risk factor drives the sub-indices and to ascertain whether the aggregate index reflects such a common factor.

In chart 5 it is clear, that the development in the level of the eight sub-indices have differed to some degree over the period. However, it is usually a matter of one or two indices diverging for short periods at different times. Generally the changes in the sub-indices are fairly similar.

This is confirmed by the cross-correlations between the daily changes in the sub-indices, which are all positive, cf. table 2. Correlations between each sub-index and an aggregate index of the seven other indices are 0.25 on average. If a similar analysis is made on the levels of the short-term sub-indices the correlations rise to 0.44 on average. This presumably reflects a certain degree of "noise" in the daily data (i.a. due to different markets closing at different times or occasional flawed observations).

The analysis suggests that a common factor does indeed drive a fair share of all markets. The correlations are not perfect, though, reflecting that individual markets are also hit by idiosyncratic shocks that do not reflect a general shift in the amount of risk and/or investors' willingness to take risk. By basing the index on a range of sub-indices such idiosyncratic shocks are marginalized and the result is an index that reflects general shifts in risk premiums.

SUB-INDICES OF THE RISK INDEX — Chart 5



Note: Calculations as explained in section 2.
Source: Bloomberg, J.P. Morgan and own calculations.

CORRELATIONS BETWEEN DAILY CHANGES IN SUB-INDICES — Table 2

	EM	C1	C2	S	IVB1	IVB2	IVS	BERS	Remaining
Emerging market	1,00	0,21	0,20	0,08	0,08	0,02	0,17	0,18	0,24
Credit (aa – govt)	0,21	1,00	0,11	0,07	0,03	0,03	0,14	0,22	0,18
Credit (bbb – aaa)	0,20	0,11	1,00	0,03	0,07	0,00	0,20	0,26	0,20
Swapspread	0,08	0,07	0,03	1,00	0,05	0,05	0,12	0,05	0,12
Imp vol bonds (1y)	0,08	0,03	0,07	0,05	1,00	0,48	0,05	0,09	0,31
Imp vol bonds (10y)	0,02	0,03	0,00	0,05	0,48	1,00	0,02	0,02	0,22
Implicit vol stocks	0,17	0,14	0,20	0,12	0,05	0,02	1,00	0,71	0,31
Bond exc return stock	0,18	0,22	0,26	0,05	0,09	0,02	0,71	1,00	0,45

Note: The period is January 1999 – October 2005. The column "remaining" reports the correlation between a given sub-index and an aggregate index of the seven remaining sub-indices. Correlations between 0,1 and 0,2 are yellow, between 0,2 and 0,3 are orange, and above 0,3 are brown.
Source: Bloomberg, J.P. Morgan and own calculations.

Principal component analysis can be used to substantiate this proposition. By this method the variation in the daily changes of the sub-indices can be summarized in eight components that are orthogonal (uncorrelated) by construction. The changes in each index can subsequently be created by weighing the eight components. If a large part of the variation can be summarized in one component that affects all sub-indices positively it reflects that one common factor drives a large part of the variation in all sub-indices. If the risk index mirrors this component, the risk index reflects general shifts in risk premiums.

In table 3 the components with largest explanatory power are shown. The first component explains 26 pct. of the variation in all eight sub-indices and has a positive weight in each index. That is, when this component is positive (meaning the amount of risk and/or the price of risk rises) all sub-indices gain. This

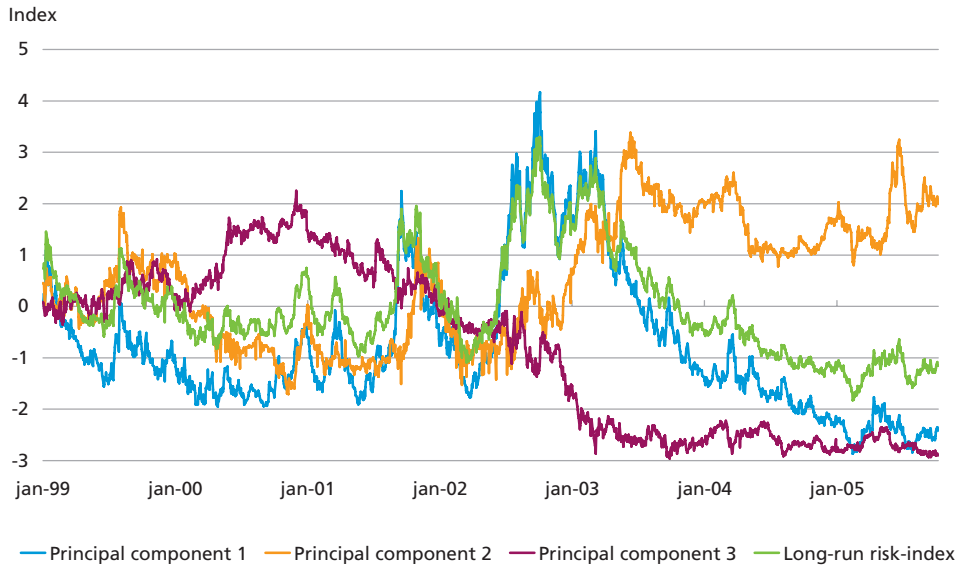
corroborates that a common risk factor drives a fairly large share of the movements in all markets. If the first component is accumulated over the period the development mirrors the long-run risk index, cf. chart 6. In other words, the calculated index to a large extend reflects this first component and thus general shifts in risk premiums. As suggested earlier, the data on daily changes can be prone to "noise" resulting in an underestimation of the explanatory power. If the principal component analysis is made on the level of the short-term sub-indices, the first component accounts for 38 pct. of the variation in all the sub-indices, suggesting a larger role for general shifts in risk premiums than the analysis on daily changes.

PRINCIPAL COMPONENT ANALYSIS OF SUB-INDICES — Table 3

	Component 1	Component 2	Component 3	Correlation with component 1	Coefficient
	----------	Weights	----------		
Emerging market	0,32	-0,01	0,58	0,36	0,13
Credit (aa – govt)	0,30	-0,05	0,50	0,43	0,35
Credit (bbb – aaa)	0,33	-0,07	0,17	0,41	0,21
Swapsspread	0,15	0,07	0,31	0,20	0,11
Imp vol bonds (1y)	0,19	0,67	-0,07	0,33	0,31
Imp vol bonds (10y)	0,12	0,69	-0,08	0,26	0,30
Imp vol stocks	0,55	-0,17	-0,39	0,84	0,81
Bonds exc ret stocks	0,57	-0,15	-0,35	0,80	0,40
Explanatory power	0,26	0,18	0,13		

Note: The period is January 1999 – October 2005. The column "Correlation with component 1" is a simple correlation analysis between changes in each sub-index and the first component. The column "Coefficient" is the result of a regression of changes in each sub-index on the first component. All coefficients are significant at the 1 pct. level.
Source: Bloomberg, J.P. Morgan and own calculations.

PRINCIPAL COMPONENTS OF SUB-INDICES — Chart 6



Note: The three principal components are illustrated by accumulating each components of the principal component analysis of daily changes. The initial value of the first component is set equal to the initial value of the long-run risk index.
Source: Bloomberg, J.P. Morgan and own calculations.

Another finding with relevance for market analysts can be made on basis of the principal component analysis. The amount of correlation between each sub-index and the first components differs, cf. table 3. While the correlation is high for the stock-related sub-indices, it is low when it comes to the sub-indices based on swapspread and 10-year implicit volatility. Also, the coefficient from regressing each sub-index on the first component differs (the coefficients should be comparable due to each sub-index being standardized). The sub-indices based on swapspread and emerging markets have a relatively low coefficient, while the opposite is true for the sub-index based on the implicit volatility of stocks. The combination of these facts suggests that changes in the VDAX index (the underlying series for the sub-index on the implicit volatility of stocks) to a large extent can be expected to reflect changes in the general risk premium in the markets. This is useful for analysts who need a readily available index for their market analysis. If this finding carries over to the US market it gives credibility to the wide use of VIX (implicit volatility on the broad US stock index S&P500) as a general gauge of investor "fear".

Lastly, a few insights can be gained from looking at the second and third component. The second component indicates that a large share of the variation in changes in the two sub-indices related to the implicit volatility of bonds can be explained by a factor that does not affect the other sub-indices to the same degree. This is primarily due to the development in the middle of the period, though. The second component might also capture that these two sub-indices seem more prone to "noise" on a day-day basis than other sub-indices.

The third component affects the risk premiums in the bond markets in the opposite direction than in the stock market (the four sub-indices related to credit spreads have positive weight, while the two stock-related sub-indices have negative weight). The development in the component indicates that the risk premiums on stocks fell relative to bonds from the beginning of the period until the end of 2000, while the opposite was true from that point until the beginning of 2003.

The main conclusion of this sub-section is that the risk index does indeed reflect a general risk premium that in turn accounts for a fair share of the developments in the individual markets.

4. The risk index and developments in government bond yields

The objective of this section is to establish empirical relationships between developments in the risk index and changes in the shape of the German yield curve, ultimately to aid in shaping investment decisions. The focus reflects that the investment universe of Danmarks Nationalbank is largely limited to government bonds.

4.1. The risk index and the German yield curve

A priori, one would expect a negative relationship between changes in the risk index and changes in yields on German government bonds due to "safe-haven" effects – if risk rises, the demand for less risky assets such as government bonds increases. This pushes up prices of bonds resulting in lower yields. A simple regression confirms this relationship, cf. table 4. About 20 pct. of the variation in

daily changes in yields can be explained by the risk index, which is not bad considering the many factors that affect yields. The effect (simply evaluated by the numerical coefficient) and explanatory power is largest for the 5-year bond, where an increase in the risk index of 1 reduces the yield by 19 basispoints. The effect is slightly smaller for 2-year and 10-year bonds.

CHANGES IN GERMAN GOVERNMENT BOND YIELDS EXPLAINED BY CHANGES IN THE RISK INDEX — Table 4

	2-year	5-year	10-year
Coefficient	-17	-19	-16
Explanatory power	0,19	0,21	0,20
P-value	0,00*	0,00*	0,00*

* Significant at the 5 pct. level

Notes: Three separate OLS-regressions on daily changes from January 1999 to October 2005. Yield changes are measured in basispoints. Benchmark German government bonds are used. Changes in the risk index are changes in the long-run index. P-values are two-sided
Source: Bloomberg, J.P. Morgan and own calculations.

Many investment strategies are based on the shape of the yield curve which is traditionally characterized by level, slope and curvature. By use of principal components almost the entire variation in yields can be explained by three components related to these concepts, cf. table 5.

PRINCIPAL COMPONENTS OF THE GERMAN YIELD CURVE — Table 5

	Component 1	Component 2	Component 3
		Weights	
3 month	0,26	0,66	0,60
1 year	0,29	0,45	-0,15
2 year	0,30	0,23	-0,40
3 year	0,31	0,08	-0,35
4 year	0,31	-0,02	-0,24
5 year	0,31	-0,09	-0,15
6 year	0,31	-0,16	-0,09
7 year	0,31	-0,20	0,05
8 year	0,31	-0,24	0,20
9 year	0,30	-0,28	0,28
10 year	0,30	-0,30	0,34
Explanatory power	0,94	0,05	0,01

Note: The period is January 1999 – October 2005. The results are from a principal component analysis of the level of the reported benchmark German government bond yields measured in percentagepoints.
Source: Bloomberg and own calculations.

The first component has a similar, positive weight at each maturity. This means that an increase in this component increases yields at all maturities with the same magnitude and the first component can thus be interpreted as representing the level of the yield curve. The second component has a positive weight at the short maturity while the weights gradually decline as the maturity increases. An increase in this component thus increases short yields relative to long yields and hence captures the slope of the yield curve – a higher value reduces the slope of the

generally upward sloping yield curve. Lastly, the third component has positive weights at short and long maturities, and negative weights at the middle of the yield curve. When this component rises, the result is that the generally concave yield curve becomes less curved. It turns out that changes in the risk index are related to changes in all three components.

CHANGES IN THE PRINCIPAL COMPONENTS OF THE GERMAN YIELD CURVE EXPLAINED BY CHANGES IN THE RISK INDEX — Table 6

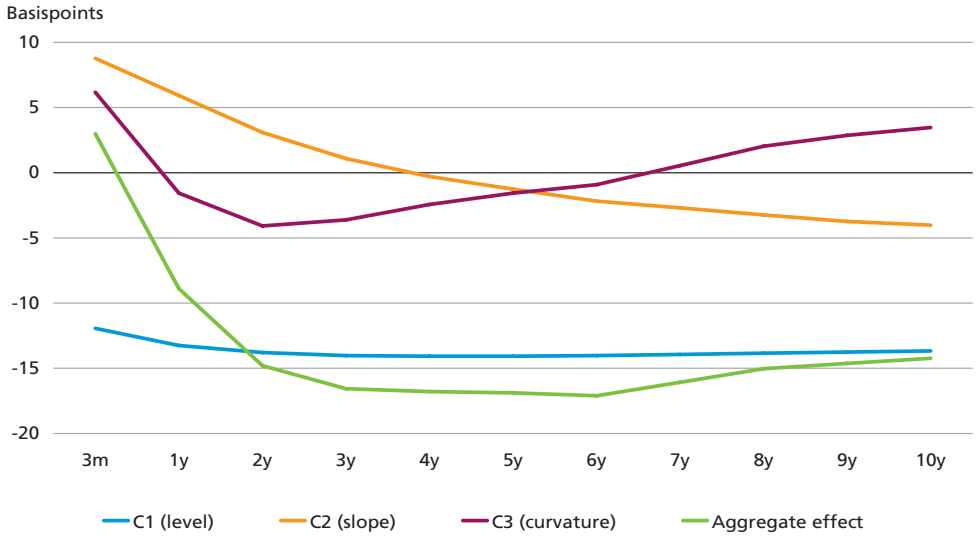
	Component 1	Component 2	Component 3
Coefficient	-0,45 (lower level)	0,13 (more flat)	0,10 (less curvature)
Explanatory power	0,20	0,05	0,04
P-value	0,00*	0,00*	0,00*

* Significant at the 5 pct. level

Notes: Three separate OLS-regressions on daily changes from January 1999 to October 2005. Changes in the risk index are changes in the long-run index. Components are those represented in table 5. P-values are two-sided
Source: Bloomberg, J.P. Morgan and own calculations.

An increase in the risk index reduces the level of the yield, cf. table 6 and chart 7, and the risk index explains 20 pct. of the variation in the level of the yield curve. The likely explanation is that an increase in risk results in a general demand for German government bonds. Another possible explanation is that both the level of the yield curve and the risk index is related to the business cycle.

THE EFFECT OF AN INCREASE IN THE RISK INDEX ON THE GERMAN YIELD CURVE — Chart 7



Note: The chart illustrates the effect of an increase in the long-term index of 1. The effects along the yield curve for a given component is found by multiplying the coefficient from table 6 (how much the component rises when the risk index rises) with the weights from table 5 (how much the yields rise when the component rises). The aggregate effect is the sum of effects from the three components.
Source: Bloomberg, J.P. Morgan and own calculations.

At the same time an increase in the index results in a more flat yield curve, although the explanatory power is lower at 5 pct. This might seem puzzling at first glance as longer maturities are generally viewed as more risky than shorter maturities and a flattening of the curve entails that the prices of longer maturities rise relative to shorter maturities. The finding can be due to longer maturities having higher convexity – the convex relationship between prices and yields results in larger price gains from a drop in yields than price losses from a similar rise in yields. Higher uncertainty over the outlook for yields increases the value of this asymmetry in returns and thus increases the value of longer maturities relative to shorter maturities.[1] A second possible explanation is that short-term rates are fairly anchored on a day-day basis due to the persistence of monetary policy, while demand and supply effects to a larger degree can impact the longer end of the curve. The slope effect to some extend neutralizes the level effect at short maturities. Also, the relationship can be due to a more negative outlook for growth affecting expectations of future monetary policy, thereby reducing the slope of the yield curve, as well as the amount and price of risk.

Lastly, a higher risk index entails less curvature, with an explanatory power of 4 pct. This finding can be due to substitution from (more risky) long maturities to (less risky) short maturities while short rates are fairly anchored due to monetary policy.

The net effect on yields is small at short maturities and largest at the middle of the curve. This suggests general "safe haven" buying, anchored short-term rates and substitution from longer to shorter maturities. As the relationship between all three characteristics of the yield curve and the risk index is significant, it points to the potential use of this knowledge in investment decisions.

4.2. Using the risk index in investment decisions

The risk index can help understanding current market developments, which should be a first step in any investment decision. By relating recent developments in the risk index to market developments in the euro bond market, it can be judged to what degree changes in risk drive the markets. If risk is an important factor, more emphasis can be given to forming an opinion on future prospects for risk. If one has a view on the macroeconomic outlook, this can transformed into a view on risk based on the relationships mentioned in section 3. If a view on risk is formed, positions can be taken based on the analysis of the yield curve in the previous section – for instance, if one expects an increase in risk, one could position oneself for a fall in the level of yields or for a reduction in either the slope or the curvature. On the other hand, if risk does not seem to be at the focus of market participants, it signals that it has less relevance for the decisions at hand.

If one has a clear view on either how changes in risk "should" have impacted markets or how news "should" have impacted risk, this can be related to how the reaction has been, and discrepancies can be pursued. For instance, if markets are judged to have under-reacted to negative news, one could position oneself for an increase in risk.

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[1] For more on these subjects, see Andersen and Hansen (2006).

The risk index can also demonstrate to which degree the market is vulnerable to shocks. If substantial news has been released or a large event has taken place without a notable reaction in the risk index, it implies that the market is fairly "robust". One possible conclusion could be that a fall in yields is unlikely if negative news is released. On the other hand, if there has been a large reaction to minor news, it indicates edgy investors and a more vulnerable market.

Lastly, the index can be used in a contrarian manner. An extreme value of the index indicates a larger potential for a mean-reverting correction (a potential explanation is given in section 5). This can be used as an input to forming a view on the likely future path of the risk index. Depending on the investment horizon, either the short-term or long-term risk index (or a risk index calculated at an intermediate horizon) can be used as the contrarian indicator.

5. Observations with relevance for financial stability

Four observations based on the risk-index have relevance for financial stability. This section describes the observations, offers explanations for them and hints at the implications for financial stability. Most of the themes in this section are not novel, but point to the potential use of the risk index in connection with financial stability.

The *first observation* is that the index has more extreme observations to the upside than the downside, cf. chart 1. This is true for both the short-run and long-run index. This indicates that market participants react more forcefully to negative news than positive and the implication for investors with risky assets is more exposure to negative shocks than positive.

Several reasons can be forwarded for the finding. One reason for the observation can be that investors are risk-averse and therefore demand a bigger compensation for a rise in risk than they will give up for a similar fall in risk. That means that the markets will react asymmetrically to a stream of "symmetric news". Another reason can be the use of "stop-loss" and "stop-profit" orders by market participants. In the former an asset is automatically sold when the price drops to a certain level thereby reinforcing the price movement. In the latter an asset is sold when the price has risen to a certain level, thereby dampening the price movement. However, for investors that are "short" the effect is opposite – if the price rises, the investor loses money, and has to buy the asset to stop the loss. Long investors outnumber short investors, though. A third reason can be that most of the sub-indices have a natural lower bound of 0 (that goes for credit spreads and implicit volatility), which can restrict downward movements.

Lastly, the wide use of similar market-based risk management systems (where risk is measure by Value-at-Risk or VaR) can have an effect[2]. Essentially investors' VaR rises when either volatility of asset returns or correlations between asset returns in the portfolio rise. As investors typically operate with an upper bound on their allowed risk, higher volatility may force them to sell more risky assets. Hence a negative market development that increases the volatility in a market can force

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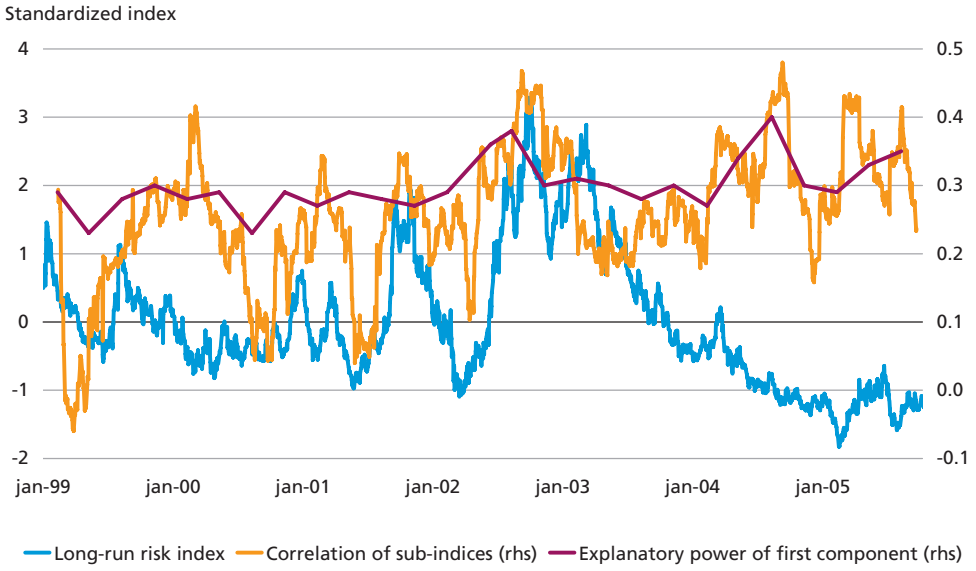
[2] For more on this subject, see Persaud (2003).

market participants to sell assets in that market. (A positive market development that creates volatility might also force investors to sell assets – but this will dampen the price movement).

The bottom line of the first observation is an asymmetry in returns that is detrimental to financial stability.

The second and third observations are related to the degree of covariation between the sub-indices. One way to calculate this is by the explanatory power of the first component of the sub-indices as the first component reflects general shits in risk premiums. An alternative way is by taking an average of the correlations between each sub-index and an index based on the seven other sub-indices. Both are shown in chart 8.

COVARIATION IN SUB-INDICES Chart 8



Note: "Correlation of sub-indices" is the average correlation between changes in each sub-index and changes in an aggregate index of the remaining seven sub-indices over a 3 month rolling window. In the graph the observations are centered in the rolling window. "Explanatory power of first component" is calculated on daily changes during each quarter of all 8 sub-indices. In the graph the observations are centered in each quarter.
Source: Bloomberg, J.P. Morgan and own calculations.

A visual inspection of chart 8 suggests that the covariation rises when the risk-index rises. A correlation analysis between changes in the index and changes in the correlation of sub-indices confirms a weak positive relationship. This *second observation* is interlinked with the first observations – if risk premiums behave more synchronously when risk rises, an index based on an average of these risk premiums will be asymmetric to the upside. The second observation could also be due to risk management practices – if investors typically sell a range of risky assets when their VaR rises, a negative movement that increases volatility in one market can spill over into other markets. The effect is self-reinforcing as the resulting increase in correlations between risky assets only increases the VaR further. The observation thus implies that the detrimental effects to financial stability due to the

first observation is reinforced – but not only is the return asymmetry in each market strengthened; also the diversification benefit from being in different markets dries up just when investors need it most.

The *third observation* that can be forwarded is that the covariation has trended up during the period and has kept a high level despite the fall in the risk index in the later years. One explanation can be that increased globalization has resulted in more synchronic business cycles, thus creating similar global developments in the amount of risk (as businesses and countries face similar cycles in profits) and the price of risk (as investors face similar cycles in income). The move towards similar risk management practices among investors can have supported this trend. Another factor behind similar investment practices might be benchmarking of market participants against each other, as this can discourage individual investors from deviating from the "pack".

Another set of explanations revolve around markets becoming more "perfect" (in the text-book sense). One driver of this development can be reduced informational asymmetries due to a fall in information costs as the internet and other information sources has eased access to business and economic news. Another is the growth of hedge funds and other investors with ample funds that base investment strategies on mis-pricings in the market – if large enough investors exploit these opportunities, they end up driving them away. A "perfect" pricing entails that changes in the amount of risk or investors attitude towards risk will impact all markets instantaneously.

The implication of the third observation is a general reduction in the diversification investors receive from investing in different markets which increases the volatility of investors' aggregate returns, which is potentially negative for financial stability. As higher correlations increase investors' VaR, another implication can be that investors are forced to reduce their exposure to more risky assets, which might impact the price of risk.

The *fourth observation* that can be made is that there is a tendency for the risk index to mean revert, cf. chart 1. This entails that extreme values of the risk index increases the likelihood of a mean-reverting correction. Part of the reason can be the cyclical nature of the factors that are associated with developments in the risk index, as laid out in section 3. However, risk management practices can also be a partial explanation. For example, a low level of the index can be associated with large investor demand for more risky assets in the wake of some positive economic news. As investors operate with limits for their exposure, a continuation of the positive news stream might not have a large market impact, as the investors cannot buy more risky assets. On the other hand, if negative news results in a change of sentiment, the market impact is potentially larger, as investors have a large exposure to reduce. Therefore, if the risk index is very low, it indicates an increased risk of an upward correction (and vice versa). A low level of the risk index can in this way be seen as a warning that investors with exposure to more risky markets are vulnerable. This analysis can be combined with the outlook for macroeconomic variables. For instance, if the euro area is simultaneously facing macroeconomic conditions, that typically increases the risk index, i.e. tighter monetary policy or slower macroeconomic growth, it only heightens the hazard.

To sum up, the analysis has shown that the development in the risk index points to some general characteristics that are relevant for the evaluation of financial stability, as well as to the potential use of the index in an ongoing analysis of financial stability.

6. References

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