D MEASURING INVESTORS' RISK APPETITE

The willingness of investors to bear financial risk, commonly referred to as investors' risk appetite, has been a subject of growing interest among market participants and observers alike not least on account of the buoyancy of financial markets over the past three to four years. Many different indicators of risk appetite have been developed but patterns in them are not always the same even though they are supposed to capture the same phenomenon. This Special Feature aims at unearthing a common component between several commonly followed indicators and it develops a composite measure of risk appetite. The resulting composite measure appears to capture well several periods when markets underwent episodes of stress.

INTRODUCTION

Risk appetite is frequently cited in the media and elsewhere as a factor explaining asset price movements. The term risk appetite is generally understood to be the willingness of investors to bear financial risk with the expectation of generating a potential profit. Gauging the degree of risk appetite at any given point in time is highly relevant from a financial stability perspective because past episodes of sudden rises in risk premiums, declines in market liquidity and sharp asset price declines have often been associated with the loss of risk appetite on the part of investors. Recent studies and surveys have focused on several different measures of risk appetite. They are variously referred to as indexes of "risk aversion", "risk appetite", "investor confidence" and "investor sentiment". Although they have different titles, they are usually constructed with the objective of measuring the same phenomenon. However, the patterns in them are not always the same even during episodes of extreme investor pessimism. This Special Feature aims at clarifying concepts of risk appetite and it develops a summary indicator by extracting the common information provided by some of the measures commonly followed.

CLARIFYING RISK CONCEPTS AND TERMS

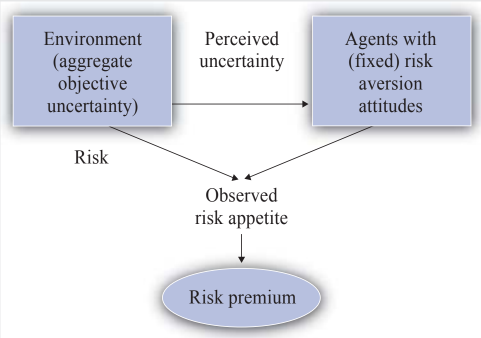
As discussed in Gai and Vause (2004), the terms "risk aversion", "risk appetite" and "risk premium" are often thought of as synonyms for one another.[1] Although there are links between them, each of these terms refers to a concept quite distinct from the other two. Fundamentally, investors prefer to avoid risk. In this vein, risk aversion measures the (subjective) attitude of investors towards uncertainty. As the degree of risk aversion of investors reflects deep-seated preferences, it is usually assumed to be constant in asset pricing models. Risk appetite encompasses the notion of risk aversion but it is a somewhat broader concept as it is also influenced by the amount of (objective) uncertainty which exists about asset price movements at any given point in time (see Figure D.1). In other words, risk appetite depends not only on the degree to which investors dislike uncertainty but also on the overall level of uncertainty about the fundamental factors which drive asset prices and by their perception thereof. Neither of these factors is directly observable from asset prices, only the combination of them. However, since the degree of risk aversion is usually thought to be fairly stable, risk appetite indices are usually considered to be tracking changes in investor uncertainty with risk appetite declining when uncertainty increases. The risk premiums embedded in asset prices are influenced by the degree of risk appetite as well as by the riskiness of the asset in question.

UNDERLYING RISK APPETITE INDICATORS

The pool of available indicators of risk appetite can be grouped on the basis of two fundamental approaches used for measurement and

1 See P. Gai and N. Vause (2004), "Risk Appetite: Concept and Measurement", *Bank of England Financial Stability Review*, December.

Figure D.1 Uncertainty and risk appetite



monitoring.[2] The first group of risk appetite indicators denoted here as market-based indicators are largely atheoretical measures which are constructed using simple statistical methods that aggregate information extracted from market prices. They are typically based on implied volatility and spreads of different asset classes, and are broken down by financial instrument (fixed income, equity, credit and commodities) and geographical location (emerging vs. developed markets) (see Table D.1). This group of indicators includes CBOE's Volatility Index (VIX), JP Morgan's Risk Tolerance indices – one global (JPM G-10 RTI) and one for the emerging markets (JPM EM RTI), UBS's FX Risk Index, Westpac's Risk Appetite Index (WP), Dresdner Kleinwort's Aggregate Risk Perception Index (ARPI), Merrill Lynch's Risk Aversion Indicator (ML RAI), Lehman Brothers' Market Risk Sentiment Index (MARS), and Bank of America's Risk Appetite Monitor (RAM).

The second group of indicators, referred to here as model-based measures, includes the Bank of England Index developed by Gai and Vause (FSI),[3] the State Street Investor Confidence Index (ICI), the Goldman Sachs Risk Aversion Index (GS), the Tarashev, Tsatsaronis and Karampatos Risk-Appetite Index (BIS),[4] and the Credit Suisse Global Risk Appetite Index (CS). These indices are typically based on a financial or economic model applied to a single financial market (see Table D.2). There are three main approaches: a more structured market-based method looking at the correlation between volatility and returns; a method based on the implied probability density function of prices, providing information on investors' expectations and their degree of uncertainty and permitting a separation between different individuals' attitude towards risk; and finally a pool of models which take a traditional structure, e.g. the capital asset pricing model (CAPM), and add a new element designed to capture the time-varying nature of investors' perceptions.[5]

METHODOLOGY

The indices described in the last section measure different facets of investors' risk appetite. However, being constructed using different approaches and focusing on different markets, they also have important idiosyncratic elements. One way of separating the idiosyncratic components of these indices from the unobservable component that is common to all of them, if it exists, is to analyse the data with principal components analysis (PCA).[6] PCA is a dimension reduction method which produces an orthogonal linear transformation of correlated variables, projecting a multidimensional space into a coordinate system with fewer dimensions. These coordinates, which are called components, are orthogonal to each other and retain the characteristics of the dataset that contribute

2 See M. Illing and M. Aaron (2005), "A Brief Survey of Risk-appetite Indexes", *Bank of Canada Financial Stability Review*, June. For data availability reasons, only some of the indicators currently available in the market are considered. Sources: Bloomberg, JP Morgan, UBS, Bank of America, Merrill Lynch, Dresdner Bank, Lehman Brothers, Goldman Sachs, Credit Suisse.
3 See P. Gai and N. Vause (2004), op. cit.
4 See N. Tarashev, K. Tsatsaronis and D. Karampatos (2003), "Investors' Attitude towards Risk: What Can We Learn from Options?", *BIS Quarterly Review*, June.
5 See W. F. Sharpe (1964), "Capital asset prices: A theory of market equilibrium under conditions of risk", *Journal of Finance*, Vol. 19 No. 3.
6 The PCA approach is supported by the arbitrage pricing theory advanced by S. Ross (1976) "The arbitrage theory of capital pricing", *Journal of Economic Theory*, December.

Table D.1 Market-based indicators

Index	Components	Method
VIX (+)[1]	• Implied volatility of S&P500 Index	Based on a weighted average of the implied volatility from eight calls and puts on the index.
JPM G-10 RTI (+)	• US swap spread (liquidity risk) • VIX (equity market risk) • EMBI+ (credit risk in emerging markets) • Trade-weighted Swiss franc (risk appetite in currency markets)	Constructed as an equally weighted average after having standardised the four components.
JPM EM RTI (+)	• VIX • EMBI+	A weighted average after standardising the two components (weights: 30% VIX, 70% EMBI+).
UBS FX Risk Index (+)	• US Treasury relative to the U.S. stocks • Three-month foreign exchange option implied volatility (USD/JPY and EUR/USD) • Gold in EUR and USD • VIX • EMBI+ • US Treasury spread • Differences in stock returns between the S&P financials and utilities • High-yield corporate spreads relative to the US Treasury	An arithmetic average of the normalised values of market variables.
WP (+)	• An average of the three-month implied volatility for six major currencies • VIX index • US ten-year bond-swap spread • JP Morgan emerging markets bond spread • US BB1 industrial bond spread	A 60-day z-score[2] of a base index calculated in three steps: the first step calculates the daily percentage change of each variable, then the figures obtained are averaged, and finally the index values are indexed to 100 on 1 January 1998.
RAM (-)	• EMBI spread • Carry AUD/JPY • Corporate bond spread BB • Carry EUR/CHF • Spread MSCI EM Lccy	The correlation (over a rolling six-week period) among a large sample of emerging economies for each of the three asset classes, multiplying them by a market direction measure (in order to distinguish between bullish or bearish periods). Finally, the correlation coefficients are aggregated with an equally weighted average.
ML RAI (+)	• US high-yield spreads (US higher yield spread over Treasuries, expressed as % yield) • VIX implied volatility • TED spreads (three-month euro-dollar deposits minus three-month T-bills) • US ten-year swap spreads, emerging market bond spreads (ML USD Emerging Markets Sovereign 'Plus' Index yield) • The trade-weighted Swiss franc, and emerging market equities (USD) • US small cap stock	For each item, this takes the standard deviations from 52-week moving averages. Then it sums the standard deviations of US high-yield spreads, VIX implied volatility, TED spreads, US ten-year swap spreads, emerging market bond spreads and the trade-weighted Swiss franc, while it subtracts those of EM equities and US small cap stock.
ARPI (+)	Based on high-frequency data (mainly spreads and implied volatilities) from five asset classes: • Fixed income basket (global and political risk) • Equity basket (equity investment risk) • Liquidity basket (liquidity risk) • Commodity basket (energy risk) • Credit basket (credit risk)	Based on a two-step principal component analysis (PCA), firstly within the baskets, and secondly between the principal components of these baskets.
MARS (-)	• Market volatility (one-year FX implied volatility and equity implied volatility), • EM event risk (EM CDS spreads and EM equities), • Market liquidity (G3 swap spread) • Risk appetite ratios (equity to bond returns, gold price to gold equity returns, and US equity P/E ratio).	Built on a four-step process: input transformation (a rank transformation of each risk input relative to its past 20 day values), data aggregation (a simple equally weighted average), transformation of the average rank into a score between 0 and 1, and finally a computation of the two-day moving average of the aggregate index.

1) "+/-" stands for the degree of correlation with investors' level of risk appetite.
2) The X-day z-score is defined as the value of a base index, net of its X-day mean, and divided by its X-day standard deviation.

Table D.2 Model-based indicators

Index	Components	Method
GS (+)[1]	• Real US per-capita consumption growth • The returns on real rate on three-month US Treasury bills • The returns on inflation-adjusted S&P 500 Index	This introduces a time-varying risk aversion coefficient within the CAPM. The discount factors are computed recursively with a fixed-range for the risk aversion coefficient. The obtained quadratic equation is used to obtain the risk aversion coefficient.
ICI (+)	The model is based on international holdings of sophisticated investors (large institutional investors), whose activities involve 22 million security transactions annually, across 45 countries.	The model calculates percentage changes in international holdings, given the country and the day, as the dollar flow for that day divided by the dollar holdings of the previous day. This measure is then expressed as a share of market capitalisation in each country over time using the MSCI measure of market capitalisation.
BIS (+)	The model is applied to the: • S&P 500 • DAX 30 • FTSE100	This indicator is obtained by comparing the statistical likelihood of future asset returns, which is estimated on the basis of historical patterns in spot prices, with an assessment of the same likelihood filtered through market participants' effective risk preferences, which are driven by options prices. The value of the index is the ratio of the left tails of the two distributions.
FSI (BoE) (-)	• S&P500 Index • Three-month options prices • US Treasury bills	Based on the CAPM, this model considers expected returns as a function of the probabilities of the state of the world assigned by investors. Different levels of risk aversion correspond to different probabilities. The difference between the mean risk-neutral probability density function and the mean of the investors' subjective probability density function captures investors' risk appetite. The approach is very similar to that of the BIS, but considers the ratio of the whole distribution rather than just the tails.
CS (+)	• A pool of safe assets (proxied by seven to ten-year government bonds) • A pool of risky assets (including equities and emerging market bonds)	This is based on the cross-sectional linear regression of excess returns and past risks (volatility). For each asset, the six-month excess return over cash and 12-month volatility are calculated; the slope of the regression line represents the risk appetite index.

1) "+/-" stands for the degree of correlation with investors' level of risk aversion.

most to its variance.[7] The principal components derived from PCA are natural summary measures capturing the co-movements of a variety of indicators. Put simply, principal components are linear combinations of the set of variables studied that show (decreasingly) the largest variance. Accordingly, the first principal component would capture the latent "commonality" of the underlying risk appetite indicators, explaining the largest share of their joint variation. Therefore, this component could be interpreted as a composite risk appetite measure.

The two criteria often used to decide upon the number of the components that have to be considered are known as the Kaiser and the Joliffe criteria.[8] The latter considers the last significant component with the explained cumulative variance reaching a certain threshold (for example 90%). By contrast, the Kaiser criterion considers all components whose eigenvalues are greater than 1. If the series taken into consideration follow a common pattern, the first principal component should be able to explain most of the variance, and

7 The first principal component is computed as a linear combination of the series in the group with weights given by the first eigenvector. The second principal component is the linear combination with weights given by the second eigenvector, and so on. These eigenvectors are the correlation coefficients between variable and components, namely the factor loadings.

8 See, for instance, G. H. Dunteman, (1989), *Principal Components Analysis, Series: Quantitative Applications in the Social Sciences,* Sage Publications, Inc., California.

consequently would be a satisfactory summary of all the series making it a useful measure of risk appetite.

RESULTS

Applying the PCA approach to all 14 risk appetite measures considered – market-based and model-based – over the period from February 1999 to July 2004,[9] it is found that the first principal component explains just 38% of the overall variance while the second explains 18%. The low proportion of the total variance explained by the first two components together may reflect the considerable variety of methodologies underlying the different indices. Both criteria for selecting statistically significant principal components produce a high number of them – five with the Kaiser criterion, and six with the Joliffe criterion. The factor loadings show that there is no systematic pattern in the way the original variables contribute to the various components. In other words, it is difficult to choose a criterion on the basis of which movements in a given component can be attributed to movements in a given subset of the original series.

It is of interest to consider whether the reason for the low degree of commonality between each of the indices is due to the method used to construct them, i.e. model or market-based. Regarding the five model-based indicators, application of the PCA technique over the sample from February 1999 to July 2004 finds that the number of relevant components is two with the Kaiser criterion and three with the Joliffe criterion. However, the first component explains 35% of the total variance while the second explains 30%. Again, this may reflect the variety of methodologies underlying the different model-based measures. The factor loading uncovers two main groups: the Goldman Sachs Index (GS) and the Credit Suisse Indicator (CS) show a high degree of correlation with the first component, while the BIS and the Bank of England indices have higher factor loadings related to the second component.[10] Overall, there does not appear to be a single model-based risk appetite measure.

Turning to the market-based indicators, the contribution of the first principal component rises to 47% of the overall explained variance, and the number of significant principal components decreases to two with the second explaining 26% of the variance. Hence, as with the model-based group, two distinct clusters stand out.

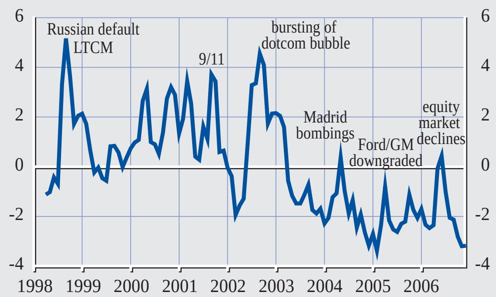
An examination of the standardisation process reveals that these indicators, even if they do use analogous variables, data frequencies and methods, differ in the assumed time they are expected to return to the series mean value once they have moved away from it. This affects data standardisation, as means and variances are across the different indicators are calculated based on periods of different length.

9 Due to data availability reasons of the model-based indicators, the sample has been restricted in the first two Principal Component Analysis estimations.

10 The last two measures are based on similar methodologies, which underlines the importance of the method used in the final outcome. The State Street indicator plays a stand-alone role as it is highly related to the third principal component, possibly because of the very specific methodology upon which it is based.

Chart D.1 Composite risk appetite indicator

(index value)



Sources: Bank of Canada, Merrill Lynch, UBS, JP Morgan, Lehman Brothers, Westpac, Dresdner Bank, Bank of America, Goldman Sachs, Credit Suisse, State Street Corporation and ECB calculations.
Note: The index is constructed as the first principal component of the market-based indicators. A rise in the index denotes a decline of risk appetite.

As it produces the greatest variance among possible composite measures, a deeper analysis of the first market-based component is warranted. To this end, the consistency of this composite risk appetite measure is mapped against some critical historical episodes. The highlighted peaks in Chart D.1 correspond to known episodes of market stress between April 1998 and December 2006 where investor pessimism was extreme and are closely matched by this summary measure. Moreover, the indicator has a desirable quality of smoothness.

CONCLUDING REMARKS

Central banks, investment banks and academics have developed measures of risk appetite in a variety of different ways. However, these measures are not always accordant with one another even during periods of extreme investor pessimism. Given differences in methodologies and underlying data, it is challenging to unearth a common component between several commonly followed indicators which explain large proportions of their variance. Nevertheless, an indicator can be derived from commonly followed market-based indicators and it appears to capture well several periods when markets underwent episodes of stress.