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UBS Investment Research

PAS User Guide: Risk Models

An introduction to PAS Risk Models

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UBS PAS: The UBS Portfolio Analysis System

The UBS Portfolio Analysis System (PAS) is a long established and comprehensive portfolio risk system. It is used to analyse both 'long-only' and 'long-short' equity portfolios to help explain the risks against a chosen equity or cash benchmark. PAS can also be used to construct and optimise portfolios.

PAS Risk Models

PAS risk models have been developed and refined over many years, incorporating UBS's leading quantitative research. The aim is to provide accurate, robust and transparent risk models with best in class flexibility. A form of hybrid risk model has been added recently. PAS enables the user to customise the risk model and loop through different iterations to compare the results.

Why the flexibility?

We believe that it is important to observe a range of possible risk statistics resulting from different risk models rather than searching for the elusive 'best' risk model.

Documentation

This document describes the structure of PAS risk models, the estimation techniques used, how to setup and customise the models, and how to loop over multiple risk models. For further technical detail on the PAS risk model see our research monograph: UBS Hybrid Risk Model, 17 December 2010. For a complete list of PAS documentation, see the monthly PAS newsletter.

Sample risk breakdown with a cash benchmark

	Initial Portfolio Total Risk	Contribution to Variance	Percentage Contribution to Variance
Benchmark Risk	7.78	60.53	49.50
MacroFactors=CHF	2.66	7.09	5.80
Sector Risk	5.96	35.54	29.07
Regional/Country Risk	2.09	4.38	3.58
Cross-Sectional Risk	3.10	9.60	7.85
Factor Risk	**10.82**	**117.14**	**95.79**
Stock Specific Risk	2.27	5.14	4.21
Total	**11.06**	**122.28**	**100.00**

Source: UBS PAS

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Introduction

This document is an introductory guide to the risk models available in PAS.

We begin by giving an overview of equity risk models in general and the considerations involved in structuring a model. We then go on to discuss the various risk models available in PAS, describing the approach we have taken and why.

The middle part of the document focuses on how to set up and customise the risk models within PAS for your funds.

Finally, we look at some of the time-saving features available in PAS, including macros to automate the process.

The document is not necessarily intended to be read cover-to-cover so do feel free to skip around to the sections that interest you. However if you are not familiar with equity risk models, we would suggest that you start with the first two sections.

Further information can be found in the following documents:

- **UBS Hybrid Risk Model**, 17 December 2010 for a technical description of the new hybrid risk models.
- **PAS User Guide: GEM Risk Model**, August 2011 and similar user guides on risk models for Taiwan, Thailand, South Korea and India.
- **PAS User Guide: PAS Macros** (forthcoming) describes how to set up risk models in PAS with macros.
- **Understanding Factor Models**, January 2006 on the structure of risk models.
- **Understanding Risk: A New Global Country-Sector Model** January 2002 which describes the 'Global' risk model added into PAS at that time to complement the original 'Local' risk model.

Overview of equity risk models

Equity risk models have three basic functions:

- Estimating the volatility of a portfolio against a benchmark (the 'tracking error') or cash (the 'total risk').
- Decomposing the risk of a portfolio.
- Influencing the construction of a portfolio, perhaps using an optimiser.

Structuring a risk model

Key considerations are:

- Accuracy.
- Robustness over time when used out of sample.
- Parsimony (reducing the complexity of the model).
- Ease of interpretation, so the factors used have an intuitive economic interpretation.

There are numerous approaches that can be taken to structuring a risk model, each of which can give quite different results.

The central task involved in building a risk model is to estimate the covariance matrix of stock returns. This task is hard as there are normally many more assets than observations of returns, so some structure for the model is required.

Need to estimate the volatility of each stock and the correlation between each pair of stocks

The most common solution is to use factor indices to capture common risks and to estimate the covariance matrix using a Linear Factor Model.

Covariance(X,Y)=Correlation(X,Y)* Volatility(X)*Volatility(Y)

Linear Factor Model

A Linear Factor Model expresses the return for each stock as the sum of 'betas' times the return on a number of factors plus some stock specific risk. For each stock there is a beta to each factor.

r_t = sum over k factors($\beta_k * f_{k,t}$)+ε_t

Within the Linear Factor Model framework, there are three basic approaches that can be taken:

- Time-series modelling, where the time-series of the factors are 'given' (or 'known') and the betas estimated.
- Cross-sectional modelling, where the betas are 'known' and the time-series of each factor is estimated.
- Statistical modelling, where both the betas and time-series are estimated.

These differ in the assumptions that they make - primarily the choice of factors and the observed/estimated parameters.

In choosing between these approaches, the first task is to decide how much structure to impose. This involves a trade-off between sampling error and structural error.

Sampling versus Structural Error - how much structure should be imposed?

Statistical modelling

First let's assume that one imposes very little structure. A statistical model is an example of this where the only assumption is that there are a certain number of factors. These factors are identified from the matrix of stock returns. In this case all of the estimation error is due to sampling error and structural error is negligible.

One draw back of statistical models is that it can be hard to know what the factors represent. Another is that the sampling error can be very large as there are so many parameters to be estimated, with the result that only the first few factors are really significant.

Time-series and cross-sectional modelling

Alternatively, one can impose more structure by identifying the factors in advance (for example, assuming that the main sources of risk are due to regional, sector and style exposures). Imposing structure will introduce some structural error, as the assumptions about the structure will be prone to error. However it will reduce the sampling error as there are fewer parameters to estimate. Both time-series and cross-sectional models are examples of this approach.

For equity risk models, our research finds that it is better to impose almost as much structure as reasonably practicable.

Time-series or cross-sectional modelling?

These two approaches differ primarily in their choice of observed and estimated parameters.

Time-series modelling is very good at capturing sector and region risk but less successful with style risk

Time-series modelling assumes that the factor returns are observed and then estimates the stock betas to these factors. The assumption is that the stock betas are constant over time. This approach is very good at capturing sector and region risk, as it easily allows a stock to have exposure to more than one sector and more than one region. However it is less successful at capturing style risk since a stock can frequently switch between styles over time and so to assume a constant beta for a stock against a style is not optimal.

Cross-sectional modelling is better suited to capturing style risk

Cross-sectional modelling assumes that the stock betas are observed and estimates the risk factors. This means that the stock betas can vary over time which makes this approach much better suited to capturing style risk. However sector risk, for example, is not captured as well as with time-series models unless a large number of factors is used. However, having perhaps seventy sector factors conflicts with the parsimony objective.

For macro factors, use a time-series model

To investigate sensitivity to macro-economic factors, a time-series approach is required. Macro factors cannot be used with cross-sectional models.

Hybrid risk models

It is possible to combine two or more of the three basic approaches - time-series, cross-sectional and statistical modelling – in one risk model. The result is a hybrid risk model.

Hybrid models combine modelling techniques. For example, adding statistical factors after time-series factors to see if there is missing factor risk

PAS can calculate hybrid risk models, with the option to combine both time-series and cross-sectional regressions in a single estimation procedure. We'll look at the PAS hybrid model in more detail in the next section.

Other considerations

Once the structure and estimation technique have been decided on, there are other aspects of the model that can significantly affect the results. These include: the length of estimation period to use; the sampling frequency; how to weight the data; the number and selection of factors to include; how factors are orthogonalised and the order of the factors. All of these aspects are customisable in the PAS risk models.

Length of estimation period, sampling frequency, weighting data, number and order of factors, orthogonalisation of factor blocks

This flexibility allows risk models to be constructed for particular investment strategies. For instance if a portfolio is taking large country positions and small sector positions, it is best to have the country factors before the sector factors.

Practical implementation

Equity universes often contain so many stocks that complete stock by stock covariance matrices are very unwieldy. Also, these matrices hide the factor structure behind the risk model.

$V = BFB^T + D$

For these reasons, the stock by stock matrix is normally held in component form. These components are:

V is the stock by stock covariance matrix
F is the factor covariance matrix;
B is a matrix of n stocks by f factors;
D is a diagonal matrix with stock specific variances down the main diagonal and zero elsewhere

A factor-by-factor covariance matrix

A matrix of betas for each stock against each factor

The stock specific risk for each stock

Portfolio volatility=sqrt(hVh')

Conceptually these can then be combined into a stock-by-stock covariance matrix which is used to calculate the tracking error and risk breakdown for a portfolio, the marginal contributions to active risk for each stock, and so on.

h are the portfolio weights

UBS PAS risk models

Based on UBS's leading quantitative research, PAS has been developed and refined over many years to provide accurate, robust and transparent risk models.

Risk models calculated as required, not pre-calculated

PAS does not use pre-calculated risk models but calculates them as required. This enables an enormous range of risk models to be used, and this range is increasing all the time.

Default risk models

A default risk model can be selected with either *Fund, Edit* **or** *Fund, Risk Model*

All the flexibility available can make it hard to decide right risk model to use for a fund and make it hard to specify the risk model. For these reasons, PAS has the concept of 'default' risk models. There are various possible system defaults which vary by market. In addition users can set up their own defaults to make it easy to select the same risk model for several funds.

The old defaults were all based on monthly data and were:

- 'Local' for markets such as Japan, with sector time-series calculated for the market concerned.
- 'Local, Countries First' for Emerging Markets with regional factors before the country factors and sector time-series calculated for the market concerned.
- Otherwise the 'Global' country-sector risk model.

PAS is gradually moving towards new defaults with weekly data and cross-sectional styles.

Weekly, daily, hybrid and macro models

PAS risk models can now be calculated with daily, weekly or monthly data. Any time-series required are calculated using the current constituents of the benchmark (or 'Wider Universe'). This gives more flexibility over the choice of say sector factors in the models, so that either level 1 or level 2 sectors, or a combination of them, can be used.

Hybrid model offers both time-series and cross-sectional modelling

Hybrid risk models in PAS incorporate both time-series and cross-sectional regression techniques. This has been one of the more recent developments as previously all estimation was done using time-series modelling.

We believe that cross-sectional regressions have more explanatory power than time-series methods for style factor risk, but that a time-series approach is best for sector and country risk as these risks are less transient than style risk. The option to use time-series regressions for style risk remains as it can be interesting to run a comparison with cross-sectional styles.

The hybrid risk model uses Bayesian estimation within the time-series regressions, which shrinks betas towards values such as one or zero, as opposed to setting non-significant values to zero.

A stochastic volatility model replaces exponential weighting. We believe it is a better way to adjust for periods of high and low volatility.

It is possible to incorporate a block of macro factors such as commodity prices.

PAS risk models can also incorporate a user's own factors, either as time-series macro factors or as cross-sectional style factors.

Before estimating the betas for stocks against the factors, the time-series factor returns are orthogonalised within blocks. This means that, for each block of factors, only that part of their return that is independent of the previous factors is used. This process will impose a block diagonal structure on the factor covariance matrix and eliminate any covariance terms between factors in different blocks.

In keeping with the PAS aim of providing as much flexibility as possible, it is possible to customise the sampling period, sampling frequency and factor time-series used amongst other parameters which we will see in the next section.

Flexibility over window length, sampling frequency and method of calculation of factor time-series

The original monthly models, using stored time-series

'Global' or 'Local' models based on 60 months data

Traditionally PAS risk models use sixty months' data for sector, country and style factors, and time-series regression. Users can choose between the 'Global' model, which had region-neutral sectors and sector-neutral regions and 'Local' models, calculated with time-series based on the market selected for a fund.

Normally Sector, Region and Style factor blocks, with ability to change the order

The time-series used are retrieved from the PAS database and converted into the currency for the selected fund.

'Countries First' (ie Region, Sector, Style) better in emerging markets

The betas calculated are tested for significance with a particular t-statistic level, and non-significant betas were dropped unless they were for a stock's own sector or country. The significant betas were then re-estimated.

Future volatility is estimated using exponential weights on the time-series returns. This means that volatility shocks will enter the calculation quickly and gradually fade away.

Extra risk models and the risk model loop

Each fund in PAS has a main risk model defined
Extra risk models can also be defined

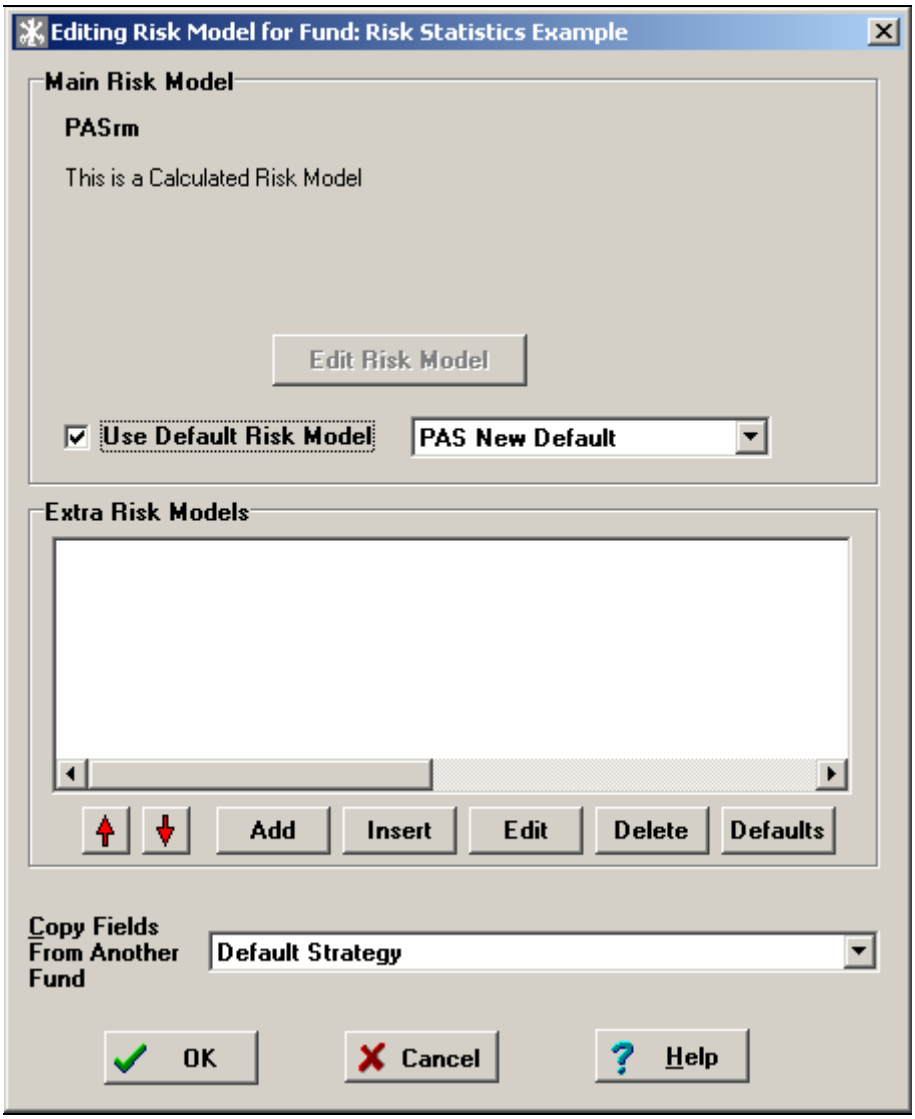
It is often interesting to see a fund's risk statistics from several risk models. This is done within PAS by setting up the fund's main risk model and a list of 'Extra Risk Models'. The **Risk Model Loop** view displays the risk statistics for all the defined risk models, but the main risk model is used for the headline tracking errors and marginal contributions to risk and so on.

Choosing risk models for a fund

We now discuss how to set up risk models in PAS.

Selecting the Main Risk Model and Extra Risk Models for a Fund

Select **Risk Model** from the **Fund** menu. This displays the following dialog box.



Source: UBS PAS

To edit the main risk model for the fund, uncheck *Use Default Risk Model*, and press *Edit Risk Model*. This will display the dialog on the next page

The dropdown allows the user to specify which Default Risk Model to use. In time there will be PAS long-term, medium-term and short-term default risk models. For now use *PAS Default* or *PAS New Default*. The user can also define default models, as described in the next section, which will appear in this dropdown

To define Extra Risk Models, the *Add*, *Insert* and *Edit* buttons will display the dialog on page 11

The *Defaults* button displays a number of different risk models in the *Extra Risk Models* box

Click on a fund name from the *Copy Fields From Another Fund* dropdown to copy the risk model settings from that fund to the current fund

Specifying a risk model in PAS

The next few pages are for users who want to go beyond the PAS default risk models, and for users who want to understand the settings behind the default risk models. The dialog on the next page shows all the settings needed. This page has a series of questions that need considering and an overview of the recommended default settings.

Settings on the Fund, Edit dialog

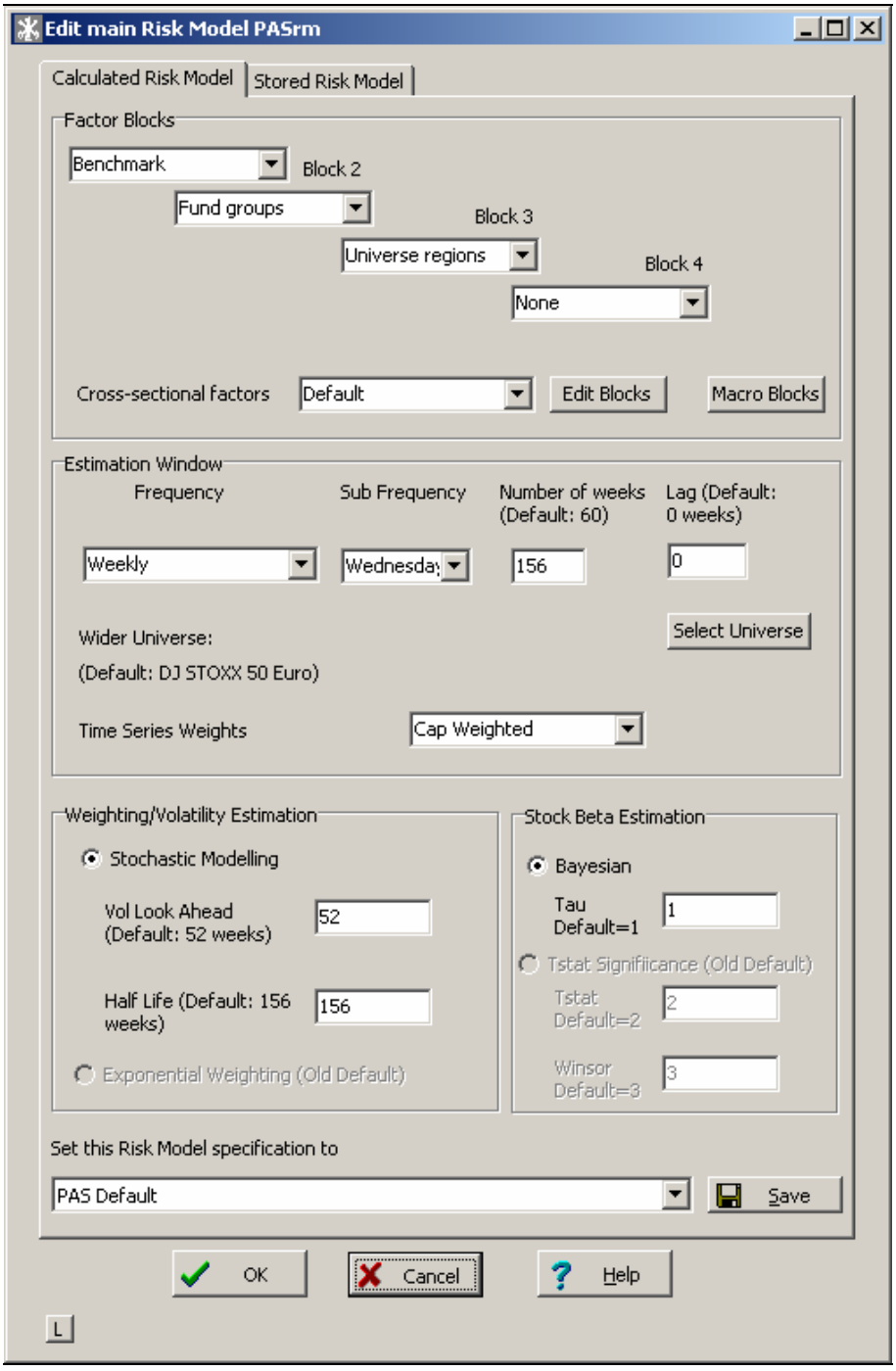
■ Market and Benchmark?	The benchmark determines the first factor
■ Currency?	All stock time-series are translated into the fund's currency
■ Sector definitions?	For 'Fund groups' or 'Fund sectors'
■ Regions selected?	For 'Fund regions'
■ Styles selected?	Only if 'Selected styles' chosen
■ Wider Universe?	With narrow benchmarks, define a wider universe for calculating factor time-series

Risk model specification dialog (see next page)

Selecting and ordering the factor blocks	Defaults
■ Add a Universe factor?	Only for Sector funds
■ Sector, regional and macro time-series factors?	'Benchmark, Fund groups, Universe regions' unless regions are more important than sectors as in Asia, or a sector fund
■ Cross-sectional or time-series style factors?	'Default' block of cross-sectional styles
Setting the estimation window and frequency	
■ Monthly, weekly or daily observations?	Depends on investment horizon
■ Monthly to which day of the month? Weekly to which day of the week?	Last day of month Wednesday
■ How many observations?	156 weeks for long term
■ Lag the window?	No, use 0
How the time-series factors are calculated	
■ Cap weighted, Equally weighted, Square Root weighted?	Cap weighted, unless concentrated factors
■ Based on Benchmark or a Wider Universe?	Winder Universe if < about 100 stocks in benchmark
■ Or use pre-calculated monthly time-series from the database?	No (unless using an 'old' style risk model)
Weighting/Volatility and Stock Beta Estimation	
■ How to adjust for changing volatility? New models: Vol Look ahead (for Stochastic Volatility), Half Life Old models: Half Life (for exponential weighting)	Vol Look Ahead and Half Life depend on investment horizon (in different ways)
■ How to estimate stock betas? New models: Tau for shrinkage to Bayesian priors Old models: Tstat and Winsor	Vol Look Ahead=52 weeks? Half Life=number of observations? Tau=1

The Edit Risk Model dialog

This dialog can be accessed as described in the previous section or directly by selecting **Edit Main Risk Model** from the **Fund** menu.



Source: UBS PAS

For more details, see the next few pages

Choose the factor blocks and their order for time-series factors

Choose the cross sectional styles. Also set up blocks of macro time-series

Specify the estimation window, data frequency and method of calculating the time-series

Specify data weighting, volatility look ahead and estimation procedure

Set this Risk Model specification to **another risk model**

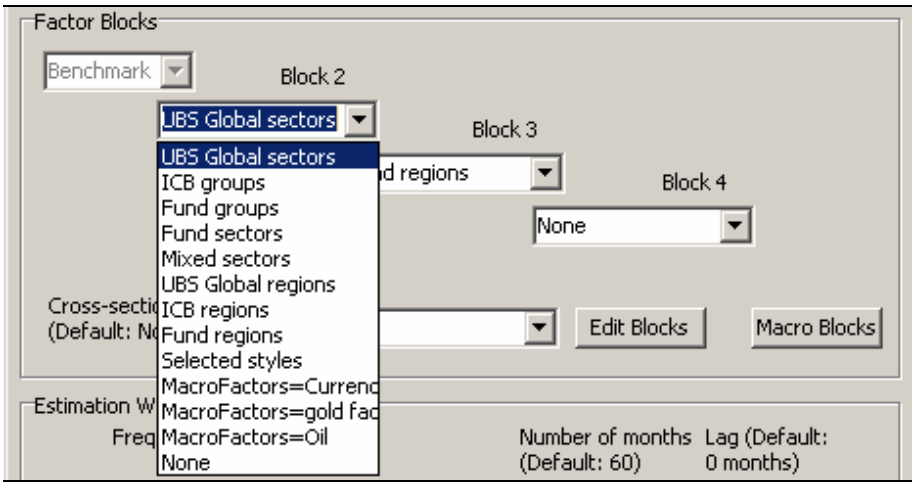
Save **will save the current risk model as a** *Default* **risk model which will appear in the** *Default Risk Model* **dropdown in the previous dialog box**

If this dialog is displayed with **Fund**, **Edit Main Risk Model**, it has an extra option at the bottom to draw the Risk Statistics view automatically after the dialog is closed.

Source: UBS PAS

The **L** button in the bottom left corner shows the current risk model as text.

Selecting and ordering the factor blocks



Source: UBS PAS

The first factor is always the benchmark; the subsequent factor blocks can be specified by the user

UBS Global sectors and **UBS Global regions** are monthly time-series that are pre-calculated outside PAS so that the sector factors are region-neutral and the region factors are sector-neutral. UBS Global sectors consist of ten ICB country-neutral sector indices. UBS Global regions consist of eight ICB sector-neutral regional indices. These time-series are only available for monthly models and are stored in the PAS database. See **Understanding Risk: A New Global Country-Sector Model,** January 2002.

The sector and regional factors from the 'Global' risk model

Fund groups and **Fund sectors** calculate the time-series as needed based on the groups or sectors that are selected when creating a fund, for example GICS 1/2, ICB 1/2 etc. (Note that PAS groups are a higher level than PAS sectors and each group might contain several sectors).

Fund groups correspond to the level one sectors displayed on the Summary tab of the PAS output under *Group Weights*

Mixed sectors are for sector funds. It uses a mixture of groups and sectors. If there are no stocks from the benchmark in a group, it will use that group, otherwise it uses the sectors in that group.

Fund regions calculates the time-series as needed based on the regions selected for the fund. The fund regions can be edited by choosing **Select Regions** from the **Fund** menu.

Fund regions correspond to the regions displayed on the Summary tab of the PAS output under *Market Weights*

ICB groups and **ICB regions** are pre-calculated monthly time-series for the old 'Local' models. ICB groups consist of the ten UBS 'level one' sector indices for the selected market. ICB regions consist of the ICB indices for the selected market. For monthly models the time-series will be stored in the database, otherwise they will be calculated as required.

Sector and regional factors from the old 'Local' risk model

Selected styles is a block of styles selected for the fund. The selected styles can be edited by choosing **Select Styles** from the **Fund** menu. For monthly models the time-series will be stored in the database, otherwise they will be calculated as required.

Selected styles correspond to the styles displayed on the Summary tab of the PAS output under *Style Weights*

MacroFactors= selects a block of macro factors that have been set up with the **Macro Blocks** button.

Hints: The new defaults will be based on **Fund groups** and **Fund regions** as Blocks 2 and 3, and cross-sectional styles. **Mixed sectors** are intended for sector risk models. If a block of macro factors is used, this should be Block 2.

Cross-sectional factors

Source: PAS

To use cross-sectional style factors select **Default** from the dropdown and ensure **Selected styles** is not selected in any of the other factor blocks.

A user can read in his own cross-sectional style factors via PAS macros, but this requires a value for each stock for each month in the estimation window, so requires a significant amount of data.

Edit Blocks enables the user to edit the block of default style factors and create new blocks of factors.

Macro Blocks will edit the blocks of macro factors available.

Ordering the factor blocks

The first factor is always the benchmark time-series; the order of the remaining factors can be specified by the user with the exception of the cross-sectional styles.

If a block of macro factors is selected, this is normally placed as block 2.

Hint: hold down the shift key when selecting the factor block to 'insert' it and move the current blocks across

If **Selected styles** are used, we recommend placing these after the sector and country factors. The betas of stocks to styles will be less stable as, unlike its sector or country, a stock can readily move from value to growth and back again and so it makes sense to place the time-series styles last.

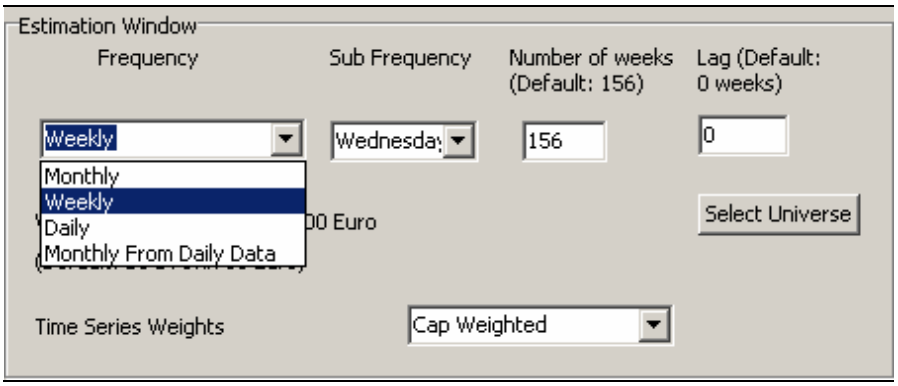
The time-series factor returns are orthogonalised within blocks. This means that for each block of factors, only that part of their return that is independent of the preceding factors is used. These are referred to as the 'residual factor returns'. This process imposes a block diagonal structure on the factor covariance matrix and eliminates any covariance terms between factors in different blocks.

Orthogonalising factor blocks prevents any covariance between factors in different blocks

Setting the estimation window and frequency

This flexibility in sampling period and frequency allows the risk models to be customised to suit different investment horizons. For example increasing the sampling frequency and fitting the model over a shorter period will mean that recent market movements will have a much bigger impact.

Sampling period and frequency can be customised as required to suit different investment strategies



Source: UBS PAS

Sampling frequency

Previously all PAS risk models were based on monthly data, however it is now possible to calculate risk models based on weekly and daily data. If **Daily** or **Weekly** is chosen then some inputs such as the risk free rates and cross-sectional style data are held constant over several observations; this is because they are stored monthly in the PAS database.

Monthly, weekly or daily data available

Warning: Daily models for global portfolios are not reliable due to end of day prices from different time zones

Monthly from Daily Data uses data from the daily price dataset. In this case, the **Sub Frequency** lets the user specify the last working day of the month, or a number of days from the start of the month (positive sub-frequency) or a number of days before the end of the month (negative sub-frequency).

For *Weekly* and *Monthly* from daily data frequencies changing the *Sub Frequency* can have a surprisingly large impact.

Sampling period

Six years of daily returns for the selected currency are available in PAS. The sampling period (or estimation window) and sampling frequency are customisable, within the six years for which data is available. However if stored monthly time-series are used, this window can go back to around 1997.

The units for the sampling period and lag are the based on the sampling frequency selected i.e. daily = days etc. At least thirty more periods should be used than the number of factors. For a long term risk model we suggest 156 weeks.

A **Lag** of 1 will calculate the risk model from the previous period. Care is needed when adding a lag as there is a maximum of six years of data in the database with which to calculate the time-series. This restricts the length of **Lag**, especially when **Monthly From Daily Data** is selected.

A Lag can be added to move the sampling period back in time

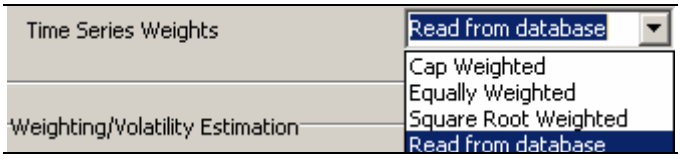
The suggested settings for various different investment strategies will be discussed further in the PAS risk model defaults section.

Factor time-series calculation

Factor time-series are calculated as required giving greater flexibility for sector and region selection

PAS normally calculates the benchmark, sector and regional time-series as part of the risk model calculation, which gives greater flexibility for sector and region selection. All time-series are calculated using current constituents, assuming a constant number of shares are held.

The weighting scheme used in calculation of time-series is chosen by the user.



Source: UBS PAS

Cap Weighted is the most common, and uses the benchmark weights. **Square Root Weighted** should be used when one or two stocks dominate the benchmark.

Read from database will read monthly time-series from the database. However, if this is selected, and the time-series for the relevant factors are not stored in the database, say for a weekly risk model, then the time-series will be calculated with **Cap Weighted**.

Wider Universe

Source: UBS PAS

The Benchmark factor proxies market risk; this poses problems in cases of a narrow benchmark

The first factor in PAS is always the benchmark time-series. The risk from this factor is considered a blend of 'benchmark' and 'market' (or 'universe') risk. The constituents from the benchmark index are used in calculating the time-series' for the remaining factors.

This works well for broad benchmarks however for narrow benchmarks, such as sector benchmarks, it is less satisfactory for the following two reasons.

First, a narrow benchmark is likely to lead to unreliable factor time-series due to their containing very few stocks.

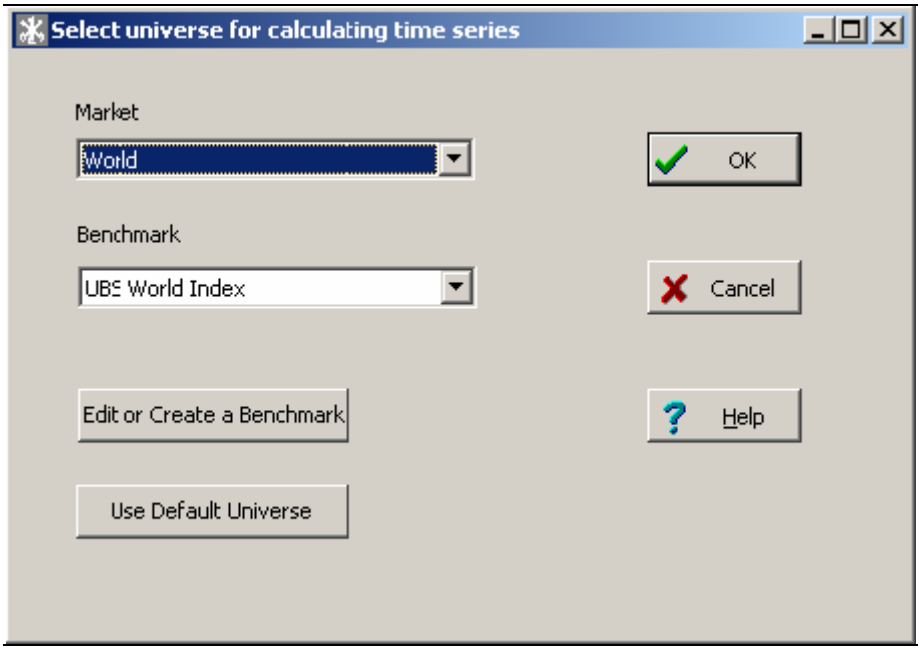
Narrow benchmarks can lead to spuriously high factor correlations and unreliable factor time-series'

Second, suppose the benchmark is a sector; orthogonalising the factor returns will only remove the sector benchmark risk from the subsequent factors and not the market risk as intended. This will result in a spuriously high correlation of factors and make the risk attribution rather arbitrary. This is especially true for benchmarks with very low or very high betas to the market.

The best way to set up a Wider Universe is with Edit on the Fund menu

To overcome these problems, the user should select a **Wider Universe**. The constituents from this index are used in calculating the time-series for the remaining factors thereby avoiding unreliable time-series. This can also be done with **Fund**, **Edit** to save doing it for several risk models.

Click **Select Universe** to display this dialog box



Source: UBS PAS

For a sector benchmark, choose the wider benchmark that the sector benchmark is based on

For a narrow general benchmark, pick a wider benchmark in the same market, or in a larger market

Click *Use Default Universe* to revert back from the Wider Universe to the benchmark

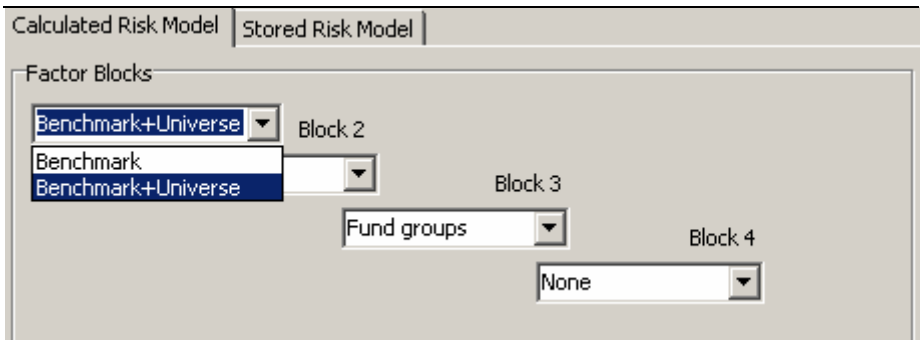
If a factor has fewer than ten stocks in it a warning will be displayed on the first tab of the **Risk Statistics** view. If a factor has fewer than six stocks in it, the factor will be left out of the risk model. If too many factors are dropped, use a **Wider Universe**.

Benchmark + Universe (for sector funds)

PAS also has the option to include an additional factor block, the Universe factor, which is placed directly after the Benchmark factor. Risk is first measured relative to the narrow or sector benchmark and residual market risk is picked up by the Universe factor. This option should only be chosen for sector risk models.

For sector funds a Universe factor will prevent too much correlation between the regional factors.

Selecting a Universe factor after the benchmark factor

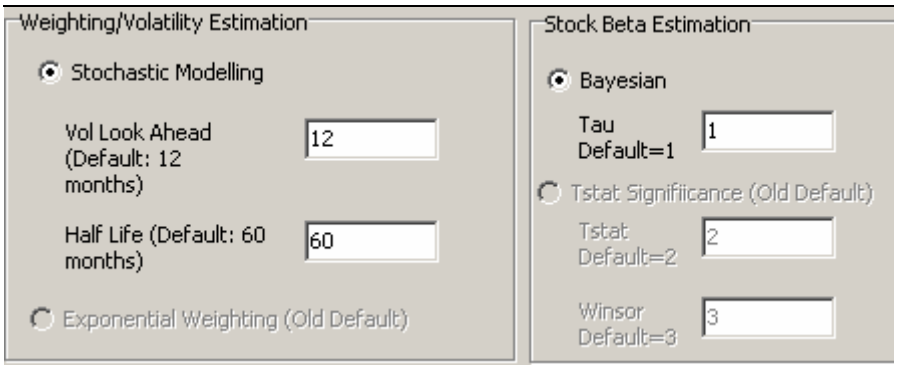


The Universe factor can be inserted after the benchmark factor to proxy market risk

***Warning*: The Universe factor should only be used for funds with sector benchmarks as it can otherwise lead to difficulty in interpreting the risk**

Source: UBS PAS

Estimation



Source: UBS PAS

The original monthly models use *Exponential Weighting*, *Half Life*, *Tstat* and *Winsor*
New models use *Stochastic Modelling*, *Vol Look Ahead*, *Half Life* and *Tau*

The units in which the *Vol Look Ahead* and the *Half Life* are expressed are based on the sampling frequency i.e. either months, days or weeks.

Weighting/Volatility

The original monthly risk models use exponential weighting on the time-series of returns means that shocks enter the system quickly, and eventually drop out of the sixty month window gracefully. Also, if correlations gradually drift over time, more weight is put on the most recent correlations.

A **Half Life** of sixty means that the most recent return is given twice the weight of the return sixty months ago.

A very large half life will approximate to a uniform weighting. Short half lives put more weight on recent observations. Half lives of less than eighteen periods are not recommended.

The high volatility during the financial crisis means this period has an excessive impact on the estimation of betas when using exponential weighting

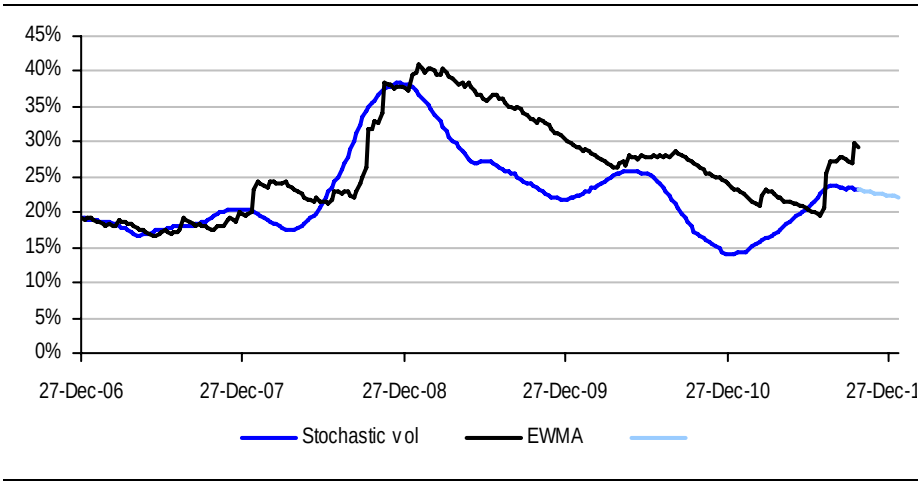
A drawback of this approach is that the value of betas is driven by periods of high volatility. To avoid this we have introduced Stochastic Volatility Modelling. This involves modelling the market volatility over the estimation window, then using this volatility time-series to deflate each return. The risk numbers then have to be scaled up for the volatility at the end of the calculation.

How they are scaled up is crucial. Possible multipliers vary between the volatility at the end of the period and some long-term 'natural' volatility. The former might be used for a very short term model and the latter for an extremely long-term model.

The **Vol Look Ahead** indicates the horizon over which the risk model will forecast volatility. The same units are used as for the estimation. For a long-term weekly risk model we would recommend 52 weeks. For a one month forecast, we would use 4 weeks.

The new risk models use exponential weighting as well as Stochastic Volatility Modelling. This allows the user to vary the weight between the most recent observations and the earliest observations. The default is a half life equal to the estimation window.

Stochastic Volatility



The dark blue line shows the fitted volatility. The light blue line shows the forecast trend towards an ultimate level of volatility

The Vol Look Ahead parameter decides what value to take along the light blue line. It has its highest impact during periods of very high or very low volatility

The black line is an exponentially weighted moving average

Source: UBS Estimates

Stock Beta Estimation and the new models

The new approach shrinks the betas back towards a Bayesian prior. If a stock lies in the factor (country or sector), then the prior is set to '1', otherwise it is set to '0'. The extent to which the betas are shrunk back is regulated by the parameter **Tau**.

The value of **Tau** is set by the user; smaller values of **Tau** indicate greater confidence in priors (and lower confidence in estimated betas) and shrink the betas closer to their respective priors, tending to lower the estimated tracking error. Bigger values of **Tau** shrink the estimated betas less, tending to increase the tracking errors.

Tau **indicates the level of confidence in the priors and regulates the extent of the beta shrinkage**

If Tau is very close to zero, the model approximates to a cross-sectional model, especially if weighting set to 'Equally Weighted'

This approach means many stock betas against factors other than the benchmark are very close to 0. Before, these would have been set to zero. The negligible betas will not change any of the risk statistics significantly.

Stock Beta Estimation and the original Global and Local models

To calculate the betas for each stock against each factor the stock returns are regressed against the factor returns twice. The t-statistics from the first regression are used to test whether each beta is significant (although it is assumed that the betas against a stock's own sector and region are significant). The significant betas are then estimated again.

The default critical Tstat value is 2, which some would say is rather strict

These betas are then winsorised. If the stock beta is outside the range of plus or minus the **Winsor** parameter times the standard deviation of the stock betas for that factor, it is trimmed to that value.

Identify and trim outliers

The disadvantage of this approach is that a stock with a big active position in a fund could switch from a significant beta to zero over the course of a month, and cause a change in the risk statistics. To overcome this disadvantage, we now prefer an approach based on Bayesian estimation for all the factors.

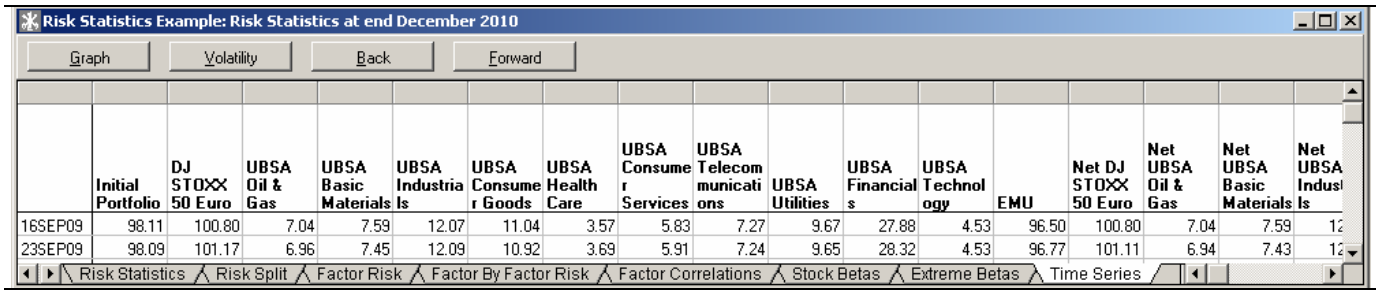
This can mean the risk changes very slightly when the order of the factor blocks is changed

The betas against the first factor, the benchmark, are treated differently. These are shrunk back towards 1, as in the new model.

Risk Statistics view

Once the risk model has been specified it can be used to analyse a portfolio with the **Risk Statistics** view. This has several tabs, although only the first three are shown as part of a composite view by default. Use **Fund**, **Output Settings**, **Concise Output**, **Detailed Risk Statistics tabs** to change this default.

The top left of the Time-series tab



	Initial Portfolio	DJ STOXX 50 Euro	UBSA Oil & Gas	UBSA Basic Materials	UBSA Industrials	UBSA Consumer Goods	UBSA Health Care	UBSA Consumer Services	UBSA Telecommunications	UBSA Utilities	UBSA Financials	UBSA Technology	EMU	Net DJ STOXX 50 Euro	Net UBSA Oil & Gas	Net UBSA Basic Materials	Net UBSA Indust
16SEP09	98.11	100.80	7.04	7.59	12.07	11.04	3.57	5.83	7.27	9.67	27.88	4.53	96.50	100.80	7.04	7.59	12
23SEP09	98.09	101.17	6.96	7.45	12.09	10.92	3.69	5.91	7.24	9.65	28.32	4.53	96.77	101.11	6.94	7.43	12

Source: UBS PAS

The main features of each tab are as follows:

Risk Statistics shows the risk broken down by factor block.

Risk Split shows the risk split by each stock's weighted MCAR and then aggregated by sector and region. It does not split the risk between factor risk and stock specific risk, unlike the rest of the tabs.

Factor Risk splits the risk by factor.

Factor by Factor Risk shows how the risk from a factor is derived from the covariance between the different factors.

Factor Correlations has a heat map of the correlations between factors and the factor covariances.

Stock Betas shows the betas for each stock against each factor. Numbers in bold indicate that the stock is in that sector or region, so that with Bayesian Shrinkage, the beta is shrunk towards 1, not 0.

Extreme Betas highlights which stocks are responsible for the tilts in overall beta position for each factor. It also shows which stocks contribute the most to the stock specific risk.

Time-series has two time-series for each factor. The first time-series for each factor is the one that is input to the risk model calculation. The second time-series (labelled **Net**) shows the orthogonalised time-series, after taking out the impact of factors from the previous factor blocks.

Volatility will be available soon and shows the relationship between forecast tracking error and the historic returns of the current holdings and benchmark. It also shows the stochastic volatility that was fitted by the risk model.

Risk Model Loop

This PAS feature allows the user to get summary risk statistics for several risk models, to compare these with the statistics from the main risk model.

To set up **Extra Risk Models**, select **Risk Model** on the **Fund** menu. Then either use the **Add**, **Insert** or **Edit** buttons or the **Defaults** button. The latter is a quick way to get several risk models.

To calculate the risk statistics for the Extra Risk Models selected for a fund, use **Risk Model Loop** on the **Analysis** or **Trial** menus, or on the **Composite View** dialog.

Risk Model Loop example

Risk Statistics Example: Initial Portfolio Risk Model Loop at end December 2010

UBS Portfolio Analysis System

Risk Model	Beta	Tracking Error	Active Specific Risk Proportion	Active Factor Risk Proportion	Active Market Risk Proportion	Active Sector Risk Proportion	Active Country Risk Proportion	Active Style Risk Proportion	Total Risk	Benchmark Total Risk
Global	0.68	9.49	18.7	81.3	42.7	23.6	8.7	6.4	15.94	21.27
Global, Tau=1	0.53	11.64	16.2	83.8	70.7	9.8	2.1	1.1	12.73	21.25
Global, Vol Look Ahead=12	0.71	9.25	28.3	71.7	42.7	14.4	8.8	5.7	17.05	22.19
Global, Tau=1, Vol Look Ahead=	0.57	11.75	22.5	77.5	63.6	11.4	1.5	0.9	14.43	22.19
Global, XsFactors=Default	0.57	11.83	19.3	80.7	62.5	11.4	1.4	5.5	14.36	22.10
PASrm, NumPeriods=60, Frequer	0.56	11.03	21.7	78.3	64.3	9.7	1.6	2.8	13.22	20.51
PASrm, NumPeriods=260	0.65	8.38	22.9	77.1	52.6	21.1	1.9	1.5	12.87	17.60
PASrm	0.62	8.85	18.0	82.0	61.3	18.2	1.3	1.2	12.40	18.12
PASrm, Vol Look Ahead=4	0.62	8.30	18.0	82.0	61.3	18.2	1.3	1.2	11.64	17.00
PASrm, Vol Look Ahead=1	0.62	8.26	18.0	82.0	61.3	18.2	1.3	1.2	11.58	16.92
UBS Global sectors, UBS Global	0.67	6.41	16.0	84.0	66.4	14.5	0.0	3.1	11.26	15.86

Risk Model Loop | Betas and MCARs | Factor Risk 1

Source: UBS PAS

The first tab shows the tracking error, beta and risk decomposition for each risk model. The second tab shows the betas and marginal contributions to active risk for each stock in the portfolio and benchmark for each of the risk models. Only the first tab is shown if the view is constructed as part of a composite view.

The headings on the first tab are fixed and do not currently allow for blocks of macro factors. For now this risk is included with the Market Risk.

Each risk model in the loop is calculated, adding to the time taken to run an analysis. If necessary, it should be possible to exit the loop prematurely by pressing the panic button in the bottom right of the PAS window. In this case the PAS will attempt to rerun the main risk model for a fund so the tracking error, MCARs and other risk statistics for a fund are up to date. However care must be taken, as it is possible these values will be corrupted. If in doubt, rerun **Risk Statistics**.

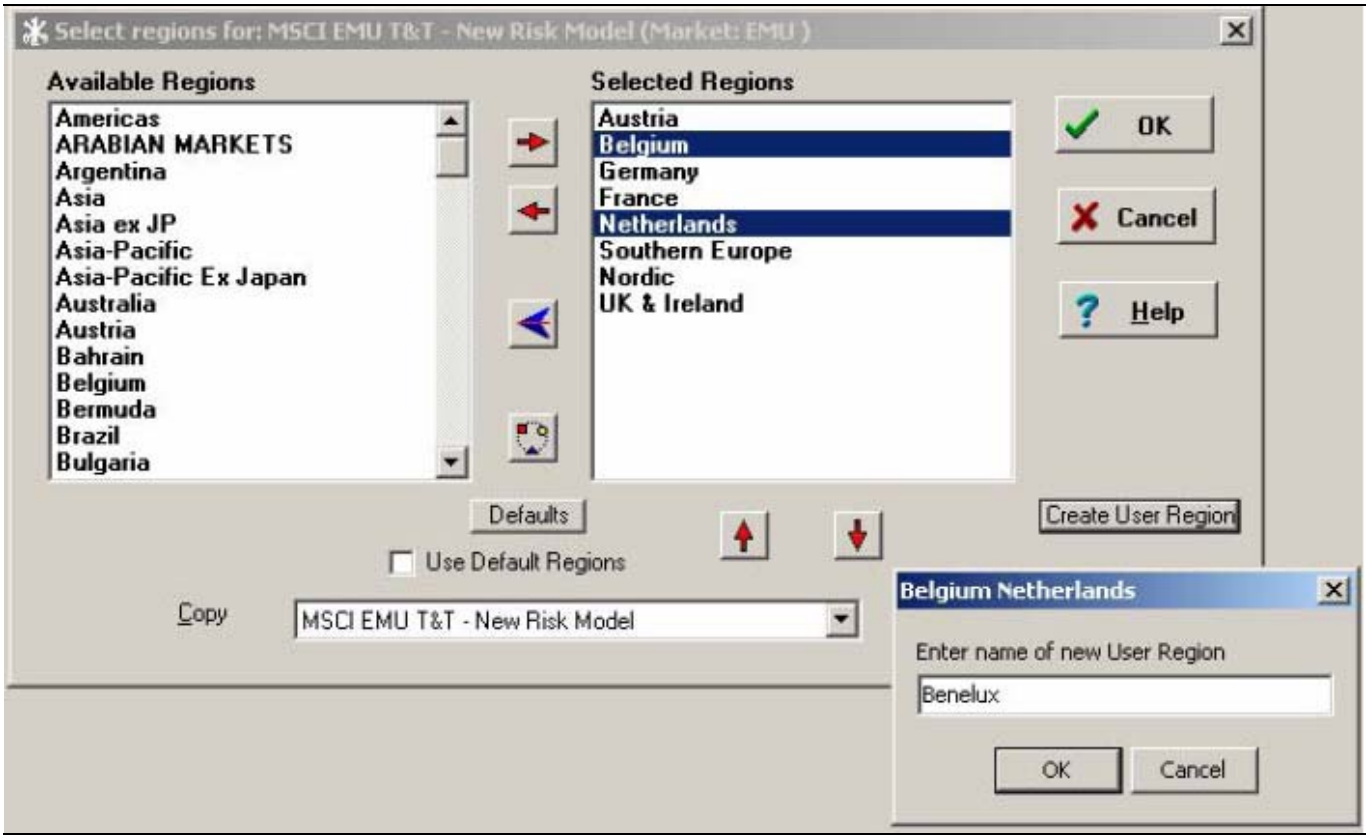
User Markets

User Markets are a way of setting up new markets in PAS.

This can be useful for grouping countries together for use as factors in risk models. If a country has too few stocks to appear as a factor, or if a country's time-series is very volatile, it is best to group it with one or more similar countries as a user factor. For instance one might combine Ireland with the UK or Sri Lanka with India.

To create a **User Market**, use **Select Regions** on the **Fund** menu. Then in the **Selected Regions** list box, select the countries or regions to combine, and press **Create User Region**, and give the new market a name in the next dialog box.

Select constituent regions, then press Create User Region



Source: UBS PAS

Risk models for sector funds

The flexibility in PAS setting up risk models means it is possible to set up much better sector risk models than before. However, some care is needed to set up the risk model.

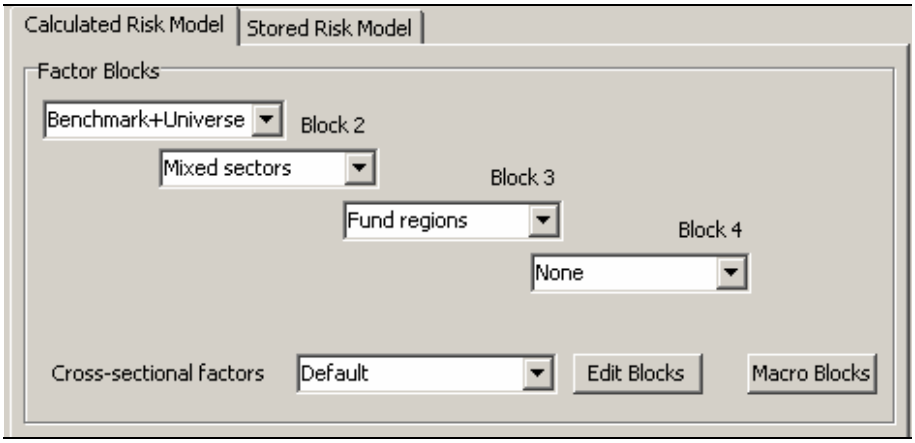
A wide universe should be selected on **Fund**, **Edit**. This can be set at the risk model level, but it is better to do it once at the fund level. For say a MSCI Europe Financials fund, select MSCI Europe as the Wider Universe.

Benchmark+Universe should be selected as the first block to reduce the correlation between the other sector factors.

Mixed sectors should be used for sector factors. If there are no stocks in the Wider Universe in a top level sector, then this top level sector is used as a factor. Otherwise each lower level sector in the top level sector is selected as a factor. It may be sensible to select ICB 1/3 or GICS 2/3 as the sectors for the fund with **Fund**, **Edit**.

Having a **Wider Universe** is important to ensure that the regional factors are based on all sectors, not just the sectors in the benchmark.

Possible Factor Block settings



Source: UBS PAS

Setting up risk models for several sector funds at once

It may be possible to set up the risk models for several sector funds at once with **Multi-Fund**, **Risk Model**.

However if the risk models are not identical, it will be necessary to edit the risk models for each fund individually as well with **Fund**, **Risk Model** or **Fund**, **Edit Main Risk Model.** This would be the case for sectors with no sub sectors where it is better to leave out the block for sector risk.

Remember that **Fund**, **Split into Sub-Funds** is a quick way to create sector funds with sector benchmarks. It can also be used to set up sector benchmarks on a Wider Universe.

Risk models and PAS macros

It is sometimes easier to set up lots of extra risk models with PAS macros rather than using the dialog boxes. Macros can reduce the number of keystrokes needed and make repetitive tasks much easier.

See the **PAS User Guide: PAS Macros** for more details.

To capture the current risk model and extra risk models for a fund, do: **Macro**, **Copy to Clipboard**, **Risk Models** and paste this into your macro file. Alternatively **Fund**, **Risk Model Status** will display this information in Notepad.

For copying risk model settings from one database to another **Data**, **Save User Data** can be useful to generate the required macros.

As an example rather than going into the dialog boxes to change Tau several times, the following macros could be used:

```
Main Risk Model, PASrm, Tau=1.5

Analysis menu, Risk Statistics


Blank Additional Risk Models

Additional Risk Model, PASrm, Tau=3

Additional Risk Model, PASrm, Tau=2

Analysis menu, Risk Model Loop
```

Risk models with the very latest PAS data

Some clients receive a file with the daily stock returns each week as well as the standard monthly update. To use the very latest returns data in risk models, you need to be working in the **Extra Month**. The **PAS User Guide: PAS Macros** describes how to do this, but two key macros are:

`Fund, EMU Long Portfolio, Extra Month`

> Selects a fund in the Extra Month. The second string is the fund name to be selected

`Benchmarks to Extra Month`

> This copies all benchmark weights to the Extra Month from the last full month in the database, and rescales them using the most recent daily price data This is the bulk version of `Benchmark,, Copy Last` but can take several minutes to execute. It is very useful if a fund contains Futures which are mapped as Benchmark User Identifiers

PAS risk model defaults

The idea behind default risk models in PAS is to save the user from having to decide and enter lots of parameters.

A default risk model can be selected for each fund with **Fund**, **Edit**.

There are standard defaults in PAS which all users have, and users can also set up their own default risk models. The former can vary by market, the latter cannot.

To see a list of all the default risk models in PAS select **Data**, **Default Risk Models**.

The regional factors selected for a fund do not form part of the risk model specification. These regional factors may have to be changed to get the best possible risk model.

Testing risk models

As can be seen in this PAS User Guide, there are many settings that go into the specification of a risk model and it can be very hard to know what is a 'good' risk model or even the 'best' risk model.

There is no simple test of how good a risk model is. One approach might be to generate many random portfolios and see how they perform out of sample. However this can be very period specific and it is hard to know what a random portfolio is. The set of 'random' portfolios should correspond to the actual portfolios held by a fund manager, but these are probably based on a limited set of forecasts.

Ideally we would like to be able test risk models within PAS.

- The risk model loop can be used to see the impact of changing the settings.
- The risk model view can show if some factors are highly correlated.
- We are working or views to see if the residual stock returns are correlated and to examine the historic tracking error.

However PAS cannot see if statistical factors would reduce the residual stock returns. For this reason, much of our risk model testing is done with the statistical language R, outside PAS. This testing has produced research documents on Risk models for GEM, Taiwan, Thailand, South Korea and India. Any of these documents are a good introduction to testing risk models.

We do not know how to test whether the risk breakdown from a risk model is accurate. This is a very difficult problem.

A useful document is **Understanding Factor Models** from January 2006.

Selecting the defaults (and selecting good risk models)

We prefer not to have too many risk models as defaults. Having the same risk model structure for several similar markets makes comparisons easier.

Here are some general questions to be considered:

- Are the number of observations and the forecast look ahead appropriate for the time scale of the risk analysis?
- Are regions or sectors dominated by one or two stocks and very concentrated? If so calculate the time-series with square root weights or aggregate countries.
- Sectors before or after regions? For emerging markets regions should come first as they are more important.
- Use level 1 or level 2 sectors? The latter might be more sensible if the benchmark (or universe is skewed towards one or two level 1 sectors).
- Combine some countries/markets? This should be done if there are small and volatile countries.
- Which are the right cross-sectional style factors to use? The PAS defaults use the same general set of factors which we think often explain risk. Some of the factors are not needed in some markets, but it does little harm to leave them in and always use the same set. If the manager uses quant signals to construct his portfolio these **must** be used to ensure the risk is picked up.

Frequently Asked Questions

How are the new risk models estimated in PAS?

Unlike the original monthly risk models which are estimated via regressions, the new risk models are estimated with an Expectation Maximisation (EM) algorithm and incorporates Bayesian priors which tend to reduce the sampling error and speed up the estimation. For details see *UBS Hybrid Risk Model*, 17 December 2010.

Why can adding extra factors increase the risk?

In a large portfolio with many names, the stock specific risk will be diversified away. If risk is transferred from stock specific to factor risk by adding extra factors, the risk will not be diversified away.

Why does my other risk model have much higher factor risk?

Statistical risk models will have the highest factor risk, but will not necessarily be good at explaining the risk in meaningful ways. Also, models that do not test betas for significance or do not shrink the betas will have higher factor risk. We do not think that high factor risk is always a good thing, it can be due to over fitting and lead to poor predictions. There is a trade-off between in-sample accuracy and out-of-sample accuracy.

Why does my other risk model have much lower factor risk?

In some cross-sectional models stocks only have one non-zero country beta and one non-zero sector beta. This can lead to underestimating the factor risk. Also we have found that the special factors in our global model can pick up more sector risk.

Why does my other risk model predict different tracking errors?

The volatility forecast is probably the most important element.

The length of the time period used as has an impact. The longer the data period the more observations, therefore the greater the likely statistical accuracy. However, the longer the data period, the stronger the assumption of market stability.

Finally, the tracking error from cross-sectional models can vary substantially from month to month as a result of the way the stock specific risk is calculated.

What should we do if we do not trust risk models?

Try to understand why different models give different answers and why the predicted tracking errors do not always agree with the realised tracking errors.

Also, look at as many other views of a portfolio as possible. For instance, compare the aggregate statistics for a fund with those of its benchmarks. Another possibility is to use a stress testing approach for style, size, sectors, countries etc. The skew and kurtosis of the historic returns is also important.

What are the pros and cons of Time-Series versus Cross-Sectional Models?

Time-Series Models, eg, PAS

- It is easier to identify factor returns and estimate betas.
- It is easier to include tests for parsimony.
- However, the model assumes more structural stability. It assumes betas are constant over the data sample. This is a reasonable assumption for sectors and countries but more questionable for styles when the classification changes.

Cross-sectional Models

- Some heroic assumptions are needed to 'know' the betas. The model is only as good as these assumptions.
- It is difficult to include tests of statistical significance.
- However, the model allows for more structural flexibility as the betas can change over data sample.
- Fewer assumptions are required to include new stocks. One needs only a set of betas, not a time-series of returns.

What happens in PAS to stocks with only a short time-series available?

The stock price return will be extended with an appropriate sector time-series. The stock specific risk will be taken as the average stock specific risk of stocks in that sector, or the calculated number if greater.

Why does PAS not use currency returns as factors?

We have often found spurious correlations between currency returns and the other factors, resulting in very strange risk breakdowns. See page 32 of 'Understanding Risk: A New Global Country-Sector Model – January 2002' for further details.

Can I create hedged risk models in PAS?

This can be done on an experimental basis with PAS macros. For example:

Main Risk Model, PASrm, Hedged

The keyed word **Hedged** on a risk model specification string tells PAS to use stock prices in their own currencies. Normally the stock prices are translated into the currency of the current fund, so holdings are treated as unhedged

Is it possible to include other asset types such as bonds, convertibles or options in PAS?

No, it is an equities-only risk model although it is possible to include cash holdings in a fund's reporting currency.

How accurate are the stock betas against each factor?

In very rough terms the standard error is around 0.3. With Bayesian estimation, this should improve a little. (In tech speak: 0.3: is approximately the confidence in the priors when Tau=1, and when these priors are updated with real data, the standard error will decrease).

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UBS 12-Month Rating	Rating Category	Coverage[1]	IB Services[2]
Buy	**Buy**	59%	35%
Neutral	**Hold/Neutral**	35%	33%
Sell	**Sell**	6%	14%
UBS Short-Term Rating	**Rating Category**	**Coverage[3]**	**IB Services[4]**
Buy	**Buy**	less than 1%	0%
Sell	**Sell**	less than 1%	20%

1:Percentage of companies under coverage globally within the 12-month rating category.
2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.
3:Percentage of companies under coverage globally within the Short-Term rating category.
4:Percentage of companies within the Short-Term rating category for which investment banking (IB) services were provided within the past 12 months.

Source: UBS. Rating allocations are as of 30 September 2011.

UBS Investment Research: Global Equity Rating Definitions

UBS 12-Month Rating	Definition
Buy	FSR is > 6% above the MRA.
Neutral	FSR is between -6% and 6% of the MRA.
Sell	FSR is > 6% below the MRA.
UBS Short-Term Rating	**Definition**
Buy	Buy: Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.
Sell	Sell: Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.

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Market Return Assumption (MRA) is defined as the one-year local market interest rate plus 5% (a proxy for, and not a forecast of, the equity risk premium).

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