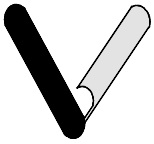
OCCAM Financial Technology



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OCCAM Application Note 2

Currency Factor Models in POW!

A Types of Currency Model

POW! allows a model including currencies to be handled as a:

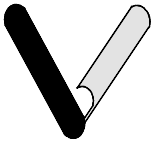
1. **Full Covariance Model**. In this case the returns, risks and correlations/covariances of all assets with foreign currency exposure must be converted[1] to some one currency, which acts both as the universe currency and the portfolio base currency[2]. Foreign assets are treated in exactly the same way as domestic assets, and the user has less flexibility than if he uses either of the other two methods; on the other hand, the Full Covariance Model is simpler and quite adequate for many purposes. For more guidance on it, please consult the user manual.

2. **Currency Factor Model**. This approach, which is the main subject of the present note, is suitable for international asset allocation problems where each asset is exposed to two factors only, the asset itself (usually) in local currency terms, and the relevant exchange rate. This approach also lends itself to currency hedging, although the latter will be covered in a separate note.

3. **Custom Factor Model**. This approach is suitable for domestic and international allocation problems where currencies are only one of a number of factors to be taken into consideration. For more guidance on this approach, please consult the user manual.

[1] But not necessarily *hedged* into the base currency of the universe. Indeed one way in which currency hedging can be implemented (although it is not recommended) is by specifying the model type as Full Covariance and then for each asset entering two sets of data, one hedged, the other unhedged.

[2] In Full Covariance Models, the user may enter the name of the currency as a memo item in U.Main cell G4, where it will be picked up by Pf.Holdings cell D5, but not otherwise processed.



B Currency Factor Models

B1. What does currency exposure mean in the context of portfolio optimisation?

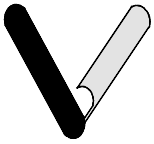
Currencies are typically a feature of international asset allocation problems where the portfolio is to be divided between different asset classes in different countries e.g. German equities, Japanese equities, US government bonds, UK index linked gilts etc. In the absence of hedging, a Canadian holding German equities is exposed to (a) German equities (measured in DM say by the DAX) and (c) to the DM/Canadian dollar exchange rate; holding Japanese equities would give him exposure to (a) Japanese equities measured in Yen and (c) the Yen/Canadian Dollar exchange rate; and so on. In each case (a) is an *asset factor* and (c) is a *currency factor*.

Currency returns and risks can only be expressed relative to some other currency and so currency exposure is a relative concept too. Usually currency exposures will be relative to the domestic currency of the investor owning the portfolio, and an investor who invests entirely in domestic assets will have no currency exposure. The investor's domestic currency is called the (portfolio) *base currency*.

However not all portfolios looked after by the same manager will necessarily have the same base currency. For this reason, POW! allows the user to set up a universe based in some single currency, called the *universe currency*, which may be different from the base currencies of some or all of the portfolios he manages.

Returns on assets will normally be expressed in their *local currency* ie the currency in which their prices are quoted. If an asset's local currency is the same as the universe currency, the return and risk on its associated universe currency factor will necessarily be zero because they are measured relative to themselves.

In principle, there is no reason why the asset factor for some or all assets should not be expressed in some currency other than their local currency, for example, if this is the only form in which the data is available. This will inevitably be the case when a multi-currency composite index such as EAFE is used. However, unless care is taken, this is likely to lead to considerable confusion, especially where currency hedging is involved, and should be avoided where possible. For the purposes of the remainder of this note, it will be assumed that an asset's asset factor is indeed expressed in local currency.



B2. Putting returns and risks together

The return on the Nikkei, local currency the Yen (JPY), when the universe currency is the US$ (USD) and the investor's base currency is the Swiss Franc (CHF) is normally expressed as:

$$A_A = \left(1 + F_{Nikkei\ /Yen}\right)\frac{\left(1 + F_{JPY\ /USD}\right)}{\left(1 + F_{CHF\ /USD}\right)} - 1$$

If the return on the Nikkei is 20% in Yen, and the return to a US$-based holder of Yen is 10%, the return on the Nikkei in US$, the universe base currency, will be 1.2 x 1.1 -1 =0.32 = 32%; and if the return on the Swiss Franc to a US$-based holder is 8%, then the return on the Nikkei to a Swiss Franc-based investor will be 1.2 x 1.1 / 1.08 -1 = 22.2%.

The variance of the Nikkei returns, based in Swiss Francs is:

$$\begin{aligned}\sigma^2_{Nikkei/CHF} &= \sigma^2_{Nikkei/JPY} + \sigma^2_{JPY/USD} + \sigma^2_{CHF/USD} \\ &+ 2\sigma_{Nikkei/JPY}\sigma_{JPY/USD}\rho_{Nikkei/JPY,JPY/USD} \\ &- 2\sigma_{Nikkei/JPY}\sigma_{CHF/USD}\rho_{Nikkei/JPY,CHF/USD} \\ &- 2\sigma_{JPY/USD}\sigma_{CHF/USD}\rho_{JPY/USD,CHF/USD}\end{aligned}$$

Notice that although the elements of the return are multiplied or divided, the elements of the risk are added or subtracted. This is because the returns are expressed as conventional percentages, while the risks are estimated in log space. This is what is called in POW! a multiplicative (or divisive) factor. If returns are expressed in log terms, as may sometimes be necessary or preferable, then an additive or subtractive factor should be used instead[3].

The portfolio currency can be changed in both the risk and return expression by substituting some other currency factor for CHF/USD.

The asset and currency returns are not orthogonal (i.e. they are correlated to some degree) and, because of this, asset local currency returns and risks need to be treated as factors not as asset-specific items; you will note that there is no provision for a separate U.Specific worksheet in Currency Factor Models. One asset factor is needed for each asset in the portfolio.

B3. Take care with the signs of Exchange Rates

Exchange rates can be quoted either in the form of local currency to universe/base currency or the other way round, and conventions vary from country to country. For instance, sterling exchange rates are usually quoted as dollars to the pound whereas French Franc exchange rates normally appear as francs to the dollar. Thus a foreign holder of sterling is like an investor in a stock market, pleased at an increase in the price quoted, whereas for a foreign investor in the French Franc an increase in the exchange rate is a bad thing.

If currency returns are estimated from exchange rate time series then care needs to be taken that the base currency is consistently either the numerator or the denominator. Alternatively, if the sense of one currency factor is inverted then it can be corrected in POW! by being used with a beta of -1.

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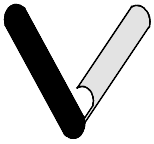
[3] Currency poses a problem to all asset allocation models. On the one hand it is clear that the conventional percentage approach gives the correct result, so both risks and returns should in principle be treated in percentage space; however the mathematics of handling risk in such space are intractable, especially if the returns are log-normally distributed. If on the other hand both are handled in log form, the portfolio return optimised will be the *arithmetic average log return*, equivalent to the *geometric average percentage return*, which will not necessarily be optimal in true percentage terms. So some compromise is necessary.



C Setting up Currencies in POW!

This section explains how to use POW! to set up a currency factor model to the extent that it differs from other factor models in POW! If you are not familiar with factor models in general in POW! you may find it helpful refer to the user manual first.

C1. Set up model in Dialog Box 2

Currencies are treated as factors in POW! and asset local currency returns are entered as factors in the U.Factors sheet, and not as asset specific returns. Use the POW! Wizard to create a factor model as follows.

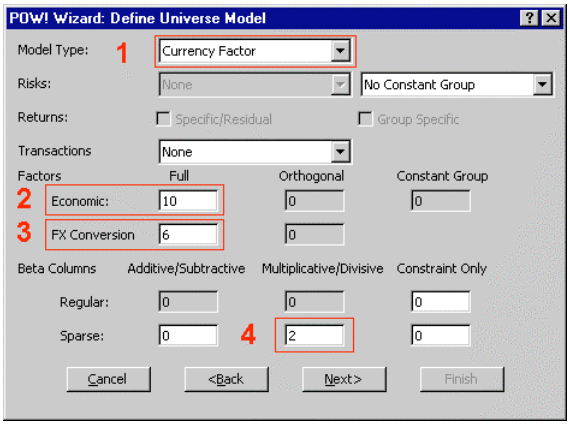


Figure 1 - The POW! Wizard Define Universe dialog

In Dialog Box 2 set:

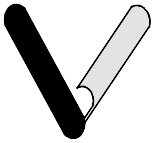
- the model type to 'Currency Factor' (item 1).
- the number of Economic factors equal to the number of *assets* in the universe (item 2)
- the number of FX Conversion factors to the number of different currencies in the universe, including the universe currency itself. You should also include any other currencies that are used as portfolio base currencies, even if no assets in the universe are denominated in them (item 3).
- the number of multiplicative[4] sparse beta columns to 2 (item 4).

Set the other options offered by the POW! Wizard according to your requirements in the usual way; see C7 for what you need to do at this stage to make it possible to apply constraints later on.

C2. Enter the factor names, returns and risk matrix in U.Factor

POW! will create a U.Factor worksheet in the new optimisation workbook in which you should enter the names of the factors, their returns and the risk matrix. The currency factors will appear at the bottom.

[4] Or additive if desired - see section B2 above and footnote 3.



The return, standard deviations and correlations of the universe currency factor should always be zero.

C3. Enter the name of the Universe Currency in U.Main

Skip U.Groups for the moment, and go direct to U.Main, where you should enter the name of the universe currency in cell G4. This can be in any convenient form, and does not have to reproduce exactly the relevant factor name in whole or part.

C4. Define groups for the currency and local return factors in U.Groups

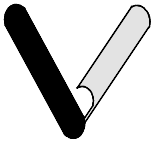
Now go to U.Groups, where you will see the POW! Wizard has provided for two sparse groups as illustrated in Figure 2 below.

Column D is a special group for the currency factors. Double-click on a cell in column D below row 8 and use the Helper dialog to select all the currency factors. These will then be displayed in the column as shown.

Use the Helper again in column E to enter the names of the asset local return factors. You should also assign an appropriate name to the factor group like 'Assets in LC'.

	D	E
3	Report:	Sparse Groups
4	Date:	September 1998
5		
6		
7	FX Factor vs. US$	Assets in LC
8	(Factor Group)	(Factor Group)
9	Guilder/US$	Dutch Eqs
10	FrFranc/US$	French Eqs
11	DM/US$	German Eqs
12	Lire/US$	Italian Eqs
13	UK£/US$	UK Eqs
14	US$/US$	US Eqs
15		French Bonds
16		German Bonds
17		FrFranc Deposits
18		DM Deposits
19		Lire Deposits (proxy)

Figure 2 - The U.Groups sheet



C5. Associate each asset with its local factor and currency factor in U.Main

Now return to U.Main, which will resemble Figure 3 below. There are two sets of sparse factors: the one on the left (cols. E-F) is for the currency factor names and their betas, and the one on the right (cols. G-H) is for local return factor names and their betas. The title of the currency factor column is preset (note the red font) and its position is fixed by the Wizard; but you should double click on cell G7 to set the title of the local factor column to match the name of the local factor group set in U. Groups.

	A	B	C	D	E	F	G	H	I	J
1	POW! Universe:	Private Client				File:	FXModDM.xls			
2										
3	Report:	Assets								
4	Date:	September 1998				Currency:	US$			
5										
6										
7		Specific	Specific	All	FX Factor vs. US$		Assets in LC		Euro-members	
8		Return	Risk	Factors						
9					SPARSE		SPARSE		G.CONSTR	
10	OPERATOR	+	+		*		*		N/A	
14										
15					Factor	Beta	Factor	Beta	Factor	Beta
16	Dutch Equities	1.00	1.00		Guilder/US$	1.0	Dutch Eqs	1.0	Euro-me	1.0
17	French Equities	1.00	1.00		FrFranc/US$	1.0	French Eqs	1.0	Euro-me	1.0
18	German Equities	1.00	1.00		DM/US$	1.0	German Eqs	1.0	Euro-me	1.0
19	Italian Equities	1.00	1.00		Lire/US$	1.0	Italian Eqs	1.0	Euro-me	1.0
20	UK Equities	1.00	1.00		UK£/US$	1.0	UK Eqs	1.0	Euro-me	0.0
21	US Equities	1.00	1.00		US$/US$	1.0	US Eqs	1.0	Euro-me	0.0
22	French Govt Bonds	1.00	1.00		FrFranc/US$	1.0	French Bonds	1.0	Euro-me	1.0
23	German Govt Bonds	1.00	1.00		DM/US$	1.0	German Bonds	1.0	Euro-me	1.0
24	French Franc Deposits	1.00	1.00		FrFranc/US$	1.0	FrFranc Deposit	1.0	Euro-me	1.0
25	DM Deposits	1.00	1.00		DM/US$	1.0	DM Deposits	1.0	Euro-me	1.0
26	Lire Deposits	1.00	1.00		Lire/US$	1.0	Lire Deposits (pr	1.0	Euro-me	1.0

Figure 3 - The U.Main sheet

Each asset needs to have the right currency and local return factor allocated to it. The easiest way to do this is to invoke the Helper by double-clicking in the pink factor cell and then selecting the correct factor from the list that will be presented.

Note the pink *s in row 10 which show that the factors are multiplicative. (If you have elected to use additive factors, you will need to double click on both of them to change them)

For most purposes, all the betas in this model should be left at one except when they are minus one because the data is inverted (see section B3).

C6. Set the Portfolio Base Currency in Pf.Holdings

Initially the base currency *factor* will appear in cell C8 of the Pf.Holdings sheet as None, with a blank in the base currency *name* Cell D5. Subsequently it may appear as in Figure 4, where you will see the factor cell C8 has been set to Guilder/US$, and the name cell D5 to Guilder.

To set or change the base currency, double-click on the currency factor cell C8 to bring up the Base

Currency helper shown in the foreground of the illustration, then select the factor corresponding to the new base currency (the DM in this case). Providing the factor name is reasonably well-formed, the Helper will work out the name of the Base Currency from the factor description and enter it in cell D5; otherwise you will need to type it in yourself.

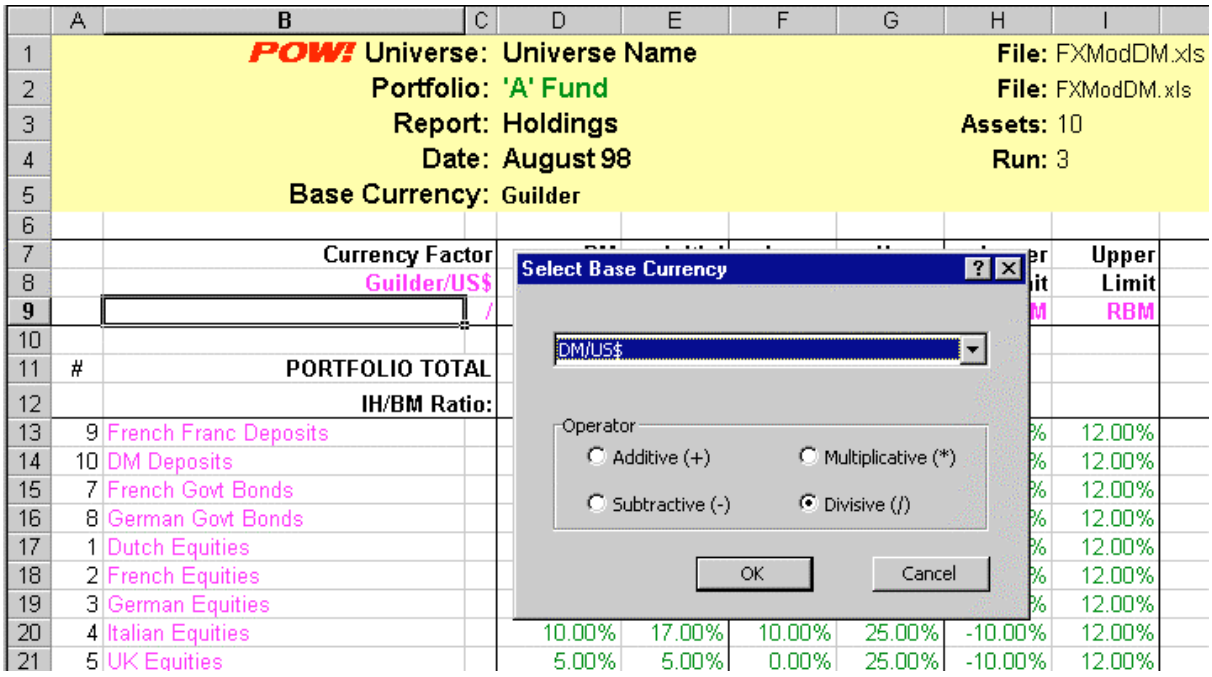


Figure 4 - The Pf.Holdings sheet

Cell C9 shows the operator of the factor, which in this case it is divisive. The currency factor operator should be the *inverse* of the currency factor operator in the U.Main sheet; so if it is multiplicative in U.Main, it should be divisive here; if it is additive in U.Main, it should be subtractive here.

C7. Set Constraints in Pf.Constraints

Factor and other general constraints are set in the usual way in Pf.Constraints. You may find the currency factors useful for purposes such as limiting your overall exposure to the Yen, and they are indispensable for many hedging applications. Apart from entering the actual constraints required in Pf.Constraints, no further action is needed.

However, groups such as equities, bonds etc., unlike currencies, will not be already set up, unless you have specified them. To do so, you should have specified one or more suitable sparse constraint columns in Dialog Box 2, and then made the appropriate entries in U.Groups and U.Main.