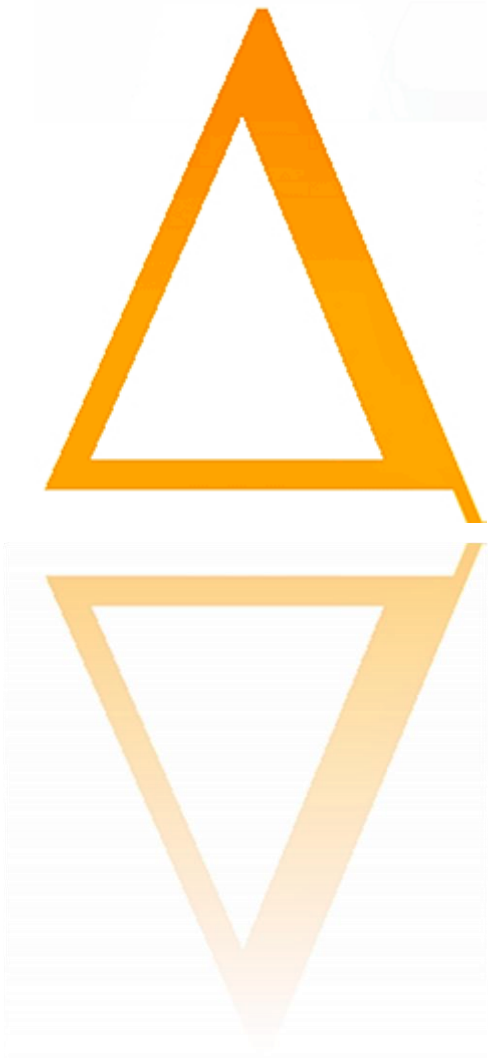

ArbMakerFX / Plus / Pro

Arbitrage software

Documentation

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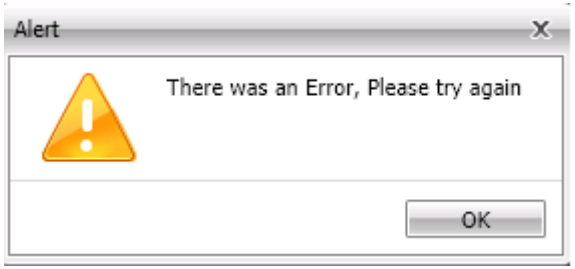
Setting it up

Install requirements

1. Download the ArbMakerSetup.msi
2. **Microsoft SQL Server Express Edition should already be installed**. This is free, available here and is the version we have tested with. It is worth selecting a "With tools" version for download that will include SQL Server Management Studio.
3. The most common install error message is this:



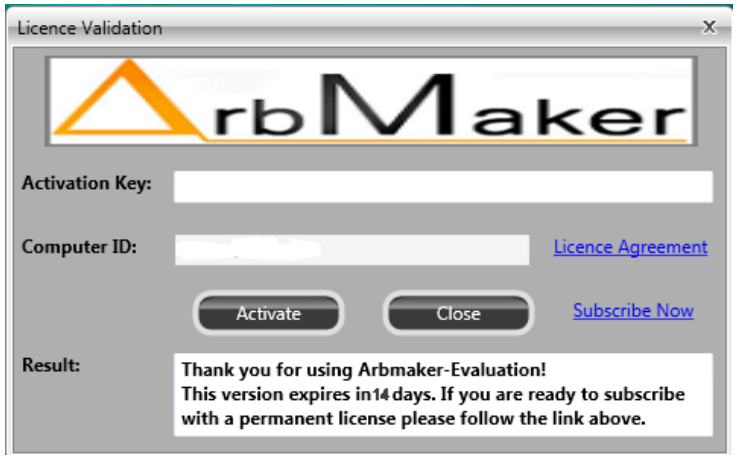
and relates in nearly all cases to one of these things:

- Not taking the default name "SQLEXPRESS" during install of MS SQL Server Express
- Two of the Windows Services entries for SQL Server Express failing to start. The two are "SQL Server (SQLEXPRESS)" and "SQL Server VSS Writer". This is remedied by going to Control Panel->System and Maintenance->Administrative Tools->Services and scrolling down to the two entries. Right click and take "Properties". Under the "General" tab set "Startup type:" to 'Automatic' and then exit.
- The Windows operating system has not been kept current via its "Windows Update" function.

4. If you are using IQFeed data and Windows Vista we do support the latest **version 4.8.1.7** of their client. However, we have not tested as extensively under Vista as under Windows 7. If you prefer using the old IQ client 4.7.2.0 this can be downloaded here.

Installing

1. Ensure Microsoft SQL is installed. **Run the ArbMakerSetup.msi file**.
2. When the licensing screen appears copy and paste the License Key you received via email in the box and click on "Close"
3. If you are using an evaluation version there is no need for a key. You will see the box below on startup – just click 'Close' to continue.



Setting expectations: limitations of this software

Technical limitations

In a perfect world we could ask ArbMaker to look back 25 years at the entire universe of equities at our disposal and deliver the best trading opportunities globally.

In this less than perfect world ArbMaker has been optimized to perform very large scans over a three to five year horizon. There are different reasons for this:

- Just 3 years' worth of price data is 750 observations per symbol. 330 symbols generate a possible 54,285 different pair combinations. That is over 40 million observations to run. Stretch it back to ten years and it becomes over 134 million. Technically it is not feasible with even the best off-the-shelf computers and an optimized database to handle several hundred million data points and return results fast enough to keep users satisfied. Grass grows faster.
- For the purposes of trading the vast majority of results are fails. It depends on the precise scan criteria but our own methods exclude well over 90% of the combinations run. ArbMaker therefore takes advantage of this by not using a database as part of the scanning method. The SQL database only holds and tracks the results users wish to keep. This permits the software to process all calculations in cache memory at very, very high speed.

This all means that most users will be able to run combinations of at least 50,000 over 5 years and, unless the criteria selected in the Options screen (see the Quick Start section below for details) are particularly loose, a great many more than that. A typical scan of this size will last between 30 and 40 minutes.

The software will handle 10 years scans of 10,000 combinations with the same provisos referred to above. A scan this size will last 18 to 21 minutes.

Speeds depend on data connection, data vendor and asset class. FX and futures tend to be slower than equities. Intra-day is slower than end-of-day.

Strategic limitations

ArbMaker software is a tool-set to help strategy implementation. It is **not** the strategy or black box itself. Its strength is scanning for cointegration, analyzing the returns and back testing them all at the pair level.

Known issues & Miscellany

1. IQ's latest client, version 4.8.1.7 is not fully supported under Vista. Vista users should continue to use version 4.7.2.0 which can be downloaded here.
2. Charts are sharper than in the prior version because out-of-market days and times have been removed. At the daily level this was not previously noticeable. But the introduction of intra-day charts makes this a necessity.
3. On the Results screen if the first character used in the filter function in columns "Beta", "R squared", "Axis Crossings", or "MRC" is the "." the software will crash. Please begin with a number (eg "0.5" rather than ".5"). This bug comes from a fault in the third party software driving ArbMaker's graphics functions and has been reported.
4. The zoom controls of the graphs, as well as their resizing, can provoke random crashes. We believe this bug also comes from a fault in the third party software driving ArbMaker's graphing features. We intend to move to an upgraded suite of graphics as a result.
5. It is possible to find and save pairs under Yahoo that move from cointegrated to not cointegrated (and therefore blank on the Watchlist). This is not an ArbMaker bug; Yahoo can produce what seem to be random changes to its data, particularly non-US data.
6. When opening certain features such as the Back Tester the new window will sometimes open behind the main screen. This bug is the subject of an ongoing fix process.

Caution: Important Information

ArbMaker offers some flexibility on settings because this may free computer and internet resources - thus affecting performance. You must exercise care in dealing with settings.

1. Inside the 'Data Sources' screen, "UTC" is specific to the intra-day feed: checking it in the data feeds converts transaction times to Coordinated Universal Time which allows cross time zone, like-for-like comparisons. If you are only scanning within the same time zone you may unclick this.
2. Inside the 'Data Source' screen, "Open H" applies to intra-day feeds only: when checked only data recorded during market hours will be pulled. Pre-open and post-close data will be ignored.
3. The 'Trading Hours' screen: controls for the opening hours of the exchanges and their time zones are set here. **You should not change the time zone defaults without good reason and without a thorough understanding of the logic behind it.** There is no need to worry about Daylight Saving Time changes as they are taken into account automatically.

Quick start

This section covers the basics of setting up and running a test. For greater detail and information on using the Watchlist (where signals can be set) please also consult the "ArbMaker: a how-to-use-it example" section.

Choose a default currency

Set your default base currency after install, Go->Symbols Management->Currencies->Select Currency by Clicking on the Currency's Row->Set Default

Load symbols

Head to the symbol management screen, Go->Symbols Management->Symbols

Uploading our files

Go->Symbols Management->Symbols->Import Symbols

If you are uploading one of our files, navigate to its location and select it. There is no need in this case to add countries or exchanges - we have preloaded over 20 Countries and Exchanges that match our symbol files to avoid that.

Uploading your own files

First you must ensure the Country and Exchange you plan to load symbols for exists. If these are not amongst the preloads we ship with then:

Go->Symbols Management->Countries->Add New Country

And complete the Country Code you are using as well as the Country Name.

Then:

Go->Symbols Management->Exchanges->Add New Exchange

and fill in the Exchange Code you have chosen. The Country box will be a pull down from which you match the country to the exchange you are creating. The description is user defined.

The Provider box is a choice between MT4, Google, Yahoo! and IQ. If you are an IQ subscriber choose IQ for the US and Canadian exchanges you have paid for.

The Default box behaves like a backup to the provider exchange. For example, if IQ's connection is lost ArbMaker will switch over in mid-scan to Google or Yahoo. The only impact will be that the pair IQ was scanning at the moment the connection was broken will not be returned.

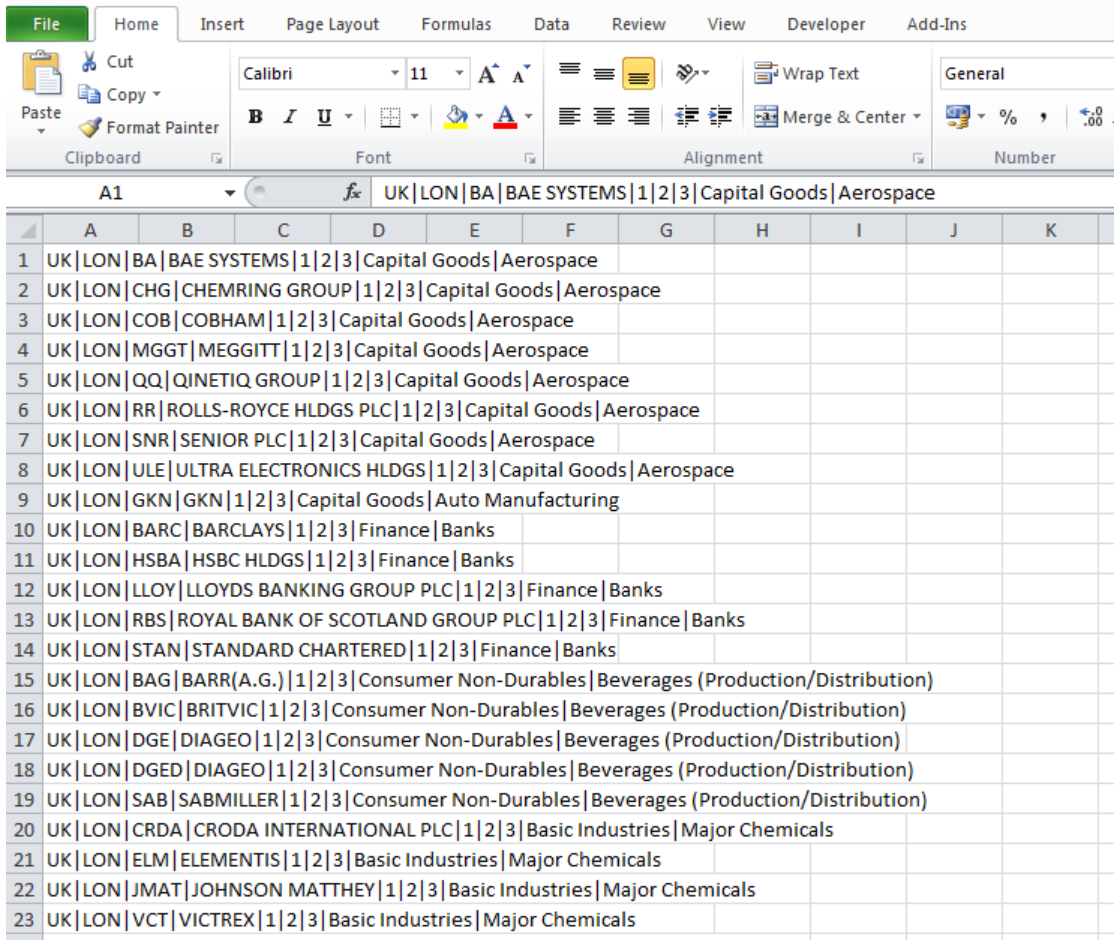
The CSV or TXT Format to follow

If you create your own upload files they must be laid out like this <u>without headings:</u>

Country Code|Exchange Code|Symbol|Company Name|dummy value 1|dummy value 2|dummy value 3|Sector|Industry

ArbMaker uses the pipe delimiter "|" to separate fields. This can be produced by pressing and holding the "Alt" key followed by "1" then "2" and then "4".

An example in .csv format:



	A
1	UK|LON|BA|BAE SYSTEMS|1|2|3|Capital Goods|Aerospace
2	UK|LON|CHG|CHEMRING GROUP|1|2|3|Capital Goods|Aerospace
3	UK|LON|COB|COBHAM|1|2|3|Capital Goods|Aerospace
4	UK|LON|MGGT|MEGGITT|1|2|3|Capital Goods|Aerospace
5	UK|LON|QQ|QINETIQ GROUP|1|2|3|Capital Goods|Aerospace
6	UK|LON|RR|ROLLS-ROYCE HLDGS PLC|1|2|3|Capital Goods|Aerospace
7	UK|LON|SNR|SENIOR PLC|1|2|3|Capital Goods|Aerospace
8	UK|LON|ULE|ULTRA ELECTRONICS HLDGS|1|2|3|Capital Goods|Aerospace
9	UK|LON|GKN|GKN|1|2|3|Capital Goods|Auto Manufacturing
10	UK|LON|BARC|BARCLAYS|1|2|3|Finance|Banks
11	UK|LON|HSBA|HSBC HLDGS|1|2|3|Finance|Banks
12	UK|LON|LLOY|LLOYDS BANKING GROUP PLC|1|2|3|Finance|Banks
13	UK|LON|RBS|ROYAL BANK OF SCOTLAND GROUP PLC|1|2|3|Finance|Banks
14	UK|LON|STAN|STANDARD CHARTERED|1|2|3|Finance|Banks
15	UK|LON|BAG|BARR(A.G.)|1|2|3|Consumer Non-Durables|Beverages (Production/Distribution)
16	UK|LON|BVIC|BRITVIC|1|2|3|Consumer Non-Durables|Beverages (Production/Distribution)
17	UK|LON|DGE|DIAGEO|1|2|3|Consumer Non-Durables|Beverages (Production/Distribution)
18	UK|LON|DGED|DIAGEO|1|2|3|Consumer Non-Durables|Beverages (Production/Distribution)
19	UK|LON|SAB|SABMILLER|1|2|3|Consumer Non-Durables|Beverages (Production/Distribution)
20	UK|LON|CRDA|CRODA INTERNATIONAL PLC|1|2|3|Basic Industries|Major Chemicals
21	UK|LON|ELM|ELEMENTIS|1|2|3|Basic Industries|Major Chemicals
22	UK|LON|JMAT|JOHNSON MATTHEY|1|2|3|Basic Industries|Major Chemicals
23	UK|LON|VCT|VICTREX|1|2|3|Basic Industries|Major Chemicals

And, on the next page, in .txt format:

Aus ASX 50 - Notepad

File Edit Format View Help

```
AU|ASX|AGK|AGL Energy Ltd|1|2|3|Public Utilities|Power Generation
AU|ASX|AMP|AMP Ltd|1|2|3|Finance|Investment Managers
AU|ASX|ANZ|ANZ Banking Group|1|2|3|Finance|Major Banks
AU|ASX|ASX|ASX Limited|1|2|3|Finance|Investment Bankers/Brokers/Service
AU|ASX|AWC|Alumina Ltd|1|2|3|Basic Industries|Aluminum
AU|ASX|AMC|Amcor Ltd|1|2|3|Basic Industries|Containers/Packaging
AU|ASX|AIO|Asciano Ltd|1|2|3|Transportation|Railroads
AU|ASX|BHP|BHP Billiton Ltd|1|2|3|Basic Industries|Mining & Quarrying of Nonmetallic Minerals (No Fuels)
AU|ASX|BXB|Brambles Industries Ltd|1|2|3|Basic Industries|Containers/Packaging
AU|ASX|CFX|CFS Retail Property Trust|1|2|3|Consumer Services|Real Estate Investment Trusts
AU|ASX|CSL|CSL Ltd|1|2|3|Health Care|Biotechnology: Biological Products (No Diagnostic Substances)
AU|ASX|CCL|Coca-Cola Amatil Ltd|1|2|3|Consumer Non-Durables|Beverages (Production/Distribution)
AU|ASX|CBA|Commonwealth Bank Australia|1|2|3|Finance|Major Banks
AU|ASX|CPU|Computershare Ltd|1|2|3|Technology|Computer Software: Programming, Data Processing
AU|ASX|CWN|Crown Limited|1|2|3|Consumer Services|Hotels/Resorts
AU|ASX|FMG|Fortescue Metals Group|1|2|3|Basic Industries|Steel/Iron Ore
AU|ASX|FGL|Foster's Group Ltd|1|2|3|Consumer Non-Durables|Beverages (Production/Distribution)
AU|ASX|GPT|GPT Group|1|2|3|Consumer Services|Real Estate Investment Trusts
AU|ASX|ILU|Iluka Resources Ltd|1|2|3|Basic Industries|Mining & Quarrying of Nonmetallic Minerals (No Fuels)
AU|ASX|IPL|Incitec Pivot|1|2|3|Basic Industries|Agricultural Chemicals
AU|ASX|IAG|Insurance Australia Group Ltd|1|2|3|Finance|Accident &Health Insurance
AU|ASX|LEI|Leighton Hldgs Ltd|1|2|3|Energy|Oil & Gas Production
AU|ASX|LLC|Lend Lease Group|1|2|3|Finance|Real Estate
AU|ASX|MAP|MAP Airports International Ltd|1|2|3|Transportation|Transportation Services
AU|ASX|MQG|Macquarie Group Ltd|1|2|3|Finance|Finance/Investors Services
AU|ASX|MGR|Mirvac Group|1|2|3|Consumer Services|Real Estate Investment Trusts
AU|ASX|NAB|National Australia Bank Ltd|1|2|3|Finance|Major Banks
AU|ASX|NCM|Newcrest Mining Ltd|1|2|3|Basic Industries|Precious Metals
AU|ASX|NWS|News Corporation Ltd|1|2|3|Consumer Services|Broadcasting
AU|ASX|OSH|Oil Search Ltd|1|2|3|Energy|Oil & Gas Production
AU|ASX|ORI|Orica Ltd|1|2|3|Basic Industries|Major Chemicals
AU|ASX|ORG|Origin Energy Ltd|1|2|3|Energy|Oil & Gas Production
AU|ASX|QBE|QBE Insurance Group Ltd|1|2|3|Finance|Specialty Insurers
AU|ASX|QRN|QR National Ltd|1|2|3|Transportation|Railroads
AU|ASX|QAN|Qantas Airways Ltd|1|2|3|Transportation|Air Freight/Delivery Services
AU|ASX|RIO|Rio Tinto Ltd|1|2|3|Basic Industries|Mining & Quarrying of Nonmetallic Minerals (No Fuels)
AU|ASX|STO|Santos Ltd|1|2|3|Health Care|Biotechnology: Biological Products (No Diagnostic Substances)
AU|ASX|SHL|Sonic Healthcare Ltd|1|2|3|Health Care|Biotechnology: Electromedical & Electrotherapeutic Apparatus
AU|ASX|SGP|Stockland|1|2|3|Consumer Services|Real Estate Investment Trusts
AU|ASX|SUN|Suncorp Group Ltd|1|2|3|Finance|Life Insurance
AU|ASX|TLS|Telstra Corp Ltd|1|2|3|Public Utilities|Telecommunications Equipment
AU|ASX|TOL|Toll Hldgs Ltd|1|2|3|Transportation|Air Freight/Delivery Services
AU|ASX|TCL|Transurban Group NPV|1|2|3|Transportation|Transportation Services
AU|ASX|WES|Wesfarmers Ltd|1|2|3|Consumer Services|Food Chains
AU|ASX|WDC|Westfield Group|1|2|3|Finance|Real Estate
AU|ASX|WRT|Westfield Retail Trust|1|2|3|Consumer Services|Real Estate Investment Trusts
AU|ASX|WBC|Westpac Banking Corp|1|2|3|Finance|Major Banks
AU|ASX|WPL|Woodside Petroleum Ltd|1|2|3|Energy|Oil & Gas Production
AU|ASX|WOW|Woolworths Ltd|1|2|3|Consumer Services|Food Chains
```

Loading symbols manually

Go->Symbols Management->Symbols->Add New Symbol

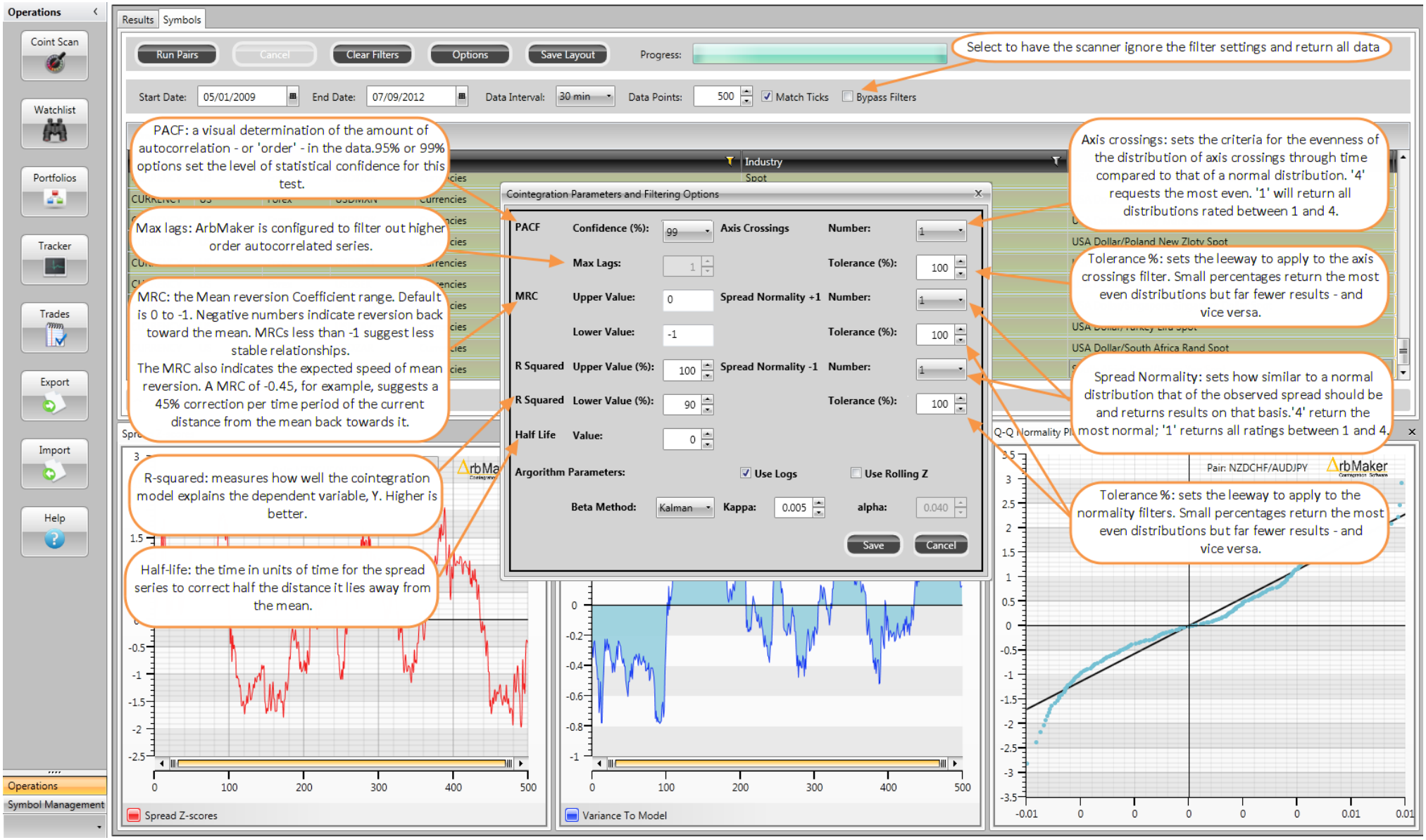
A new line will appear on screen for users to fill in. Only the Exchange and Country fields are pull-down choices; the others are freehand entries.

Scanning

Run an End-of-Day test

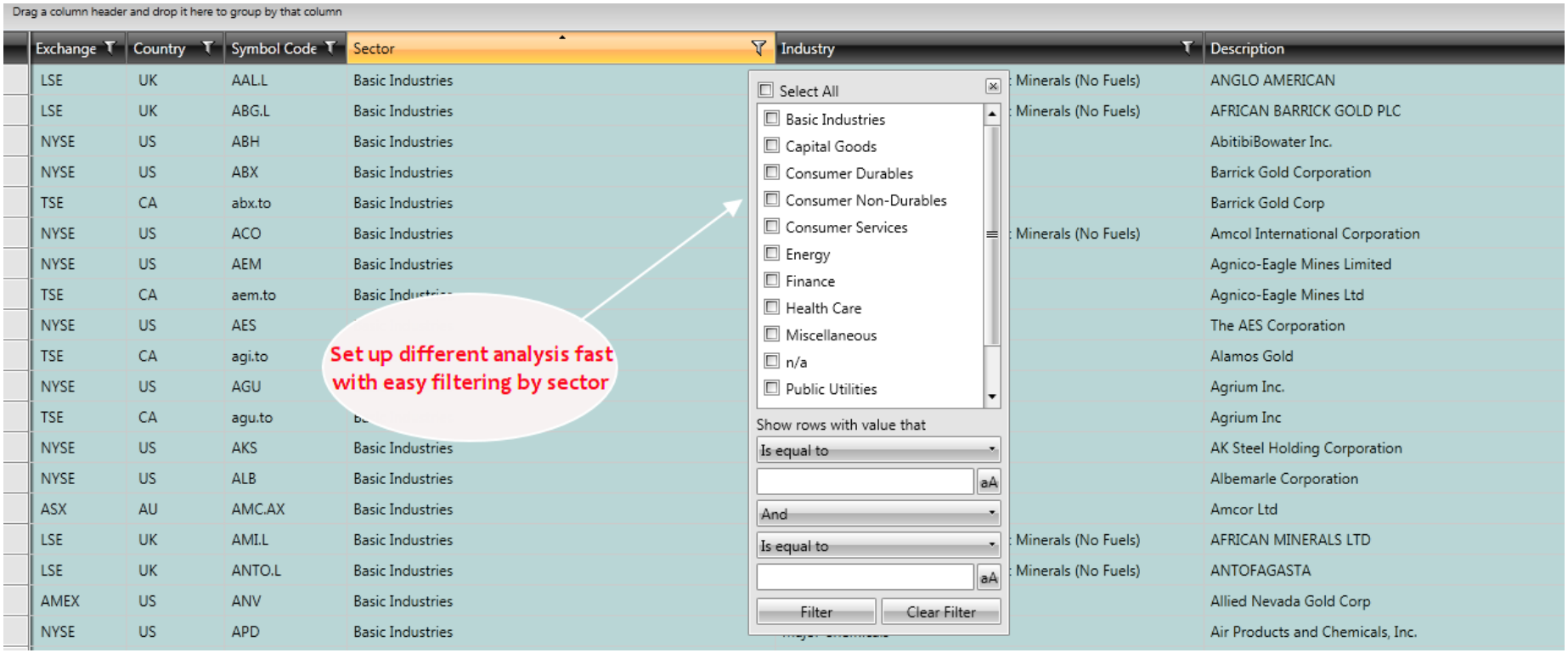
1. Go->Operations->Cointegration.
2. Set the date range. Default is the trough quarter of 2009.
3. Click 'Options' and choose your scan parameters (see "The Options Filter" section and Appendix E for a full explanation of each of these parameters).

The screen you will see is shown overleaf:



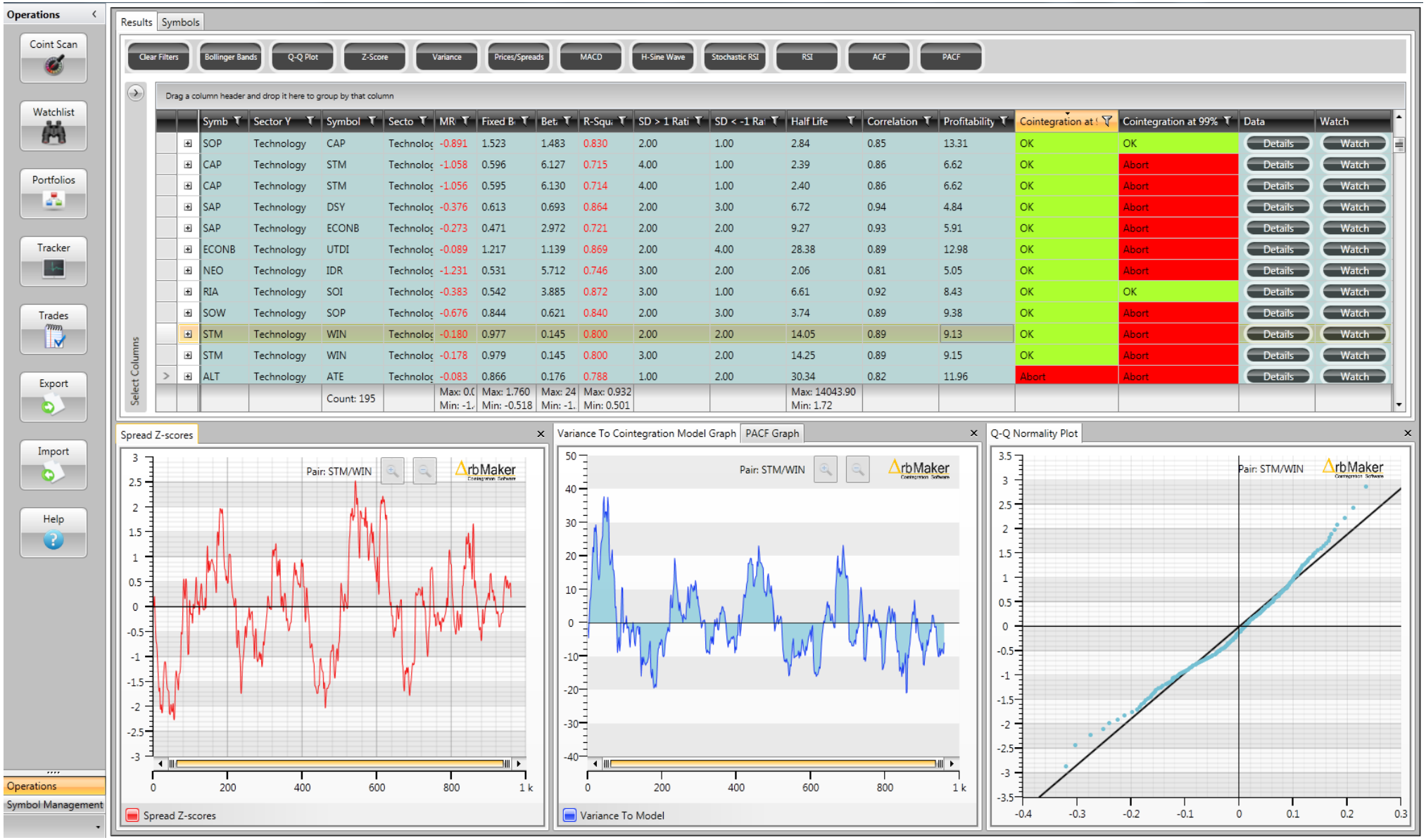
(Note that the 'Bypass Filters' box will work for up to 500 pairs; and more info on the PACF is in Appendix A).

4. Select your pairs. This can be freehand with the mouse or with the arrow keys. The filters provide great precision over the types of company selection. For example:



5. Click "Run Pairs". Default data will come from either Google or Yahoo as per the (adjustable) parameters under Symbol Management->Exchanges screen below. To set up IQ feed or to use your MT4 feed, if you have an account with either, see Appendix B.

The results are then generated; and on the next page is an example of an end-of-day scan using Euronext data. The highlighted pair is STMicroelectronics quoted on the Milan Bourse and Wincor Nixdorf AG from the Frankfurt exchange. A detailed discussion of such results is described after the next two sections on intra-day scanning and the Google data feed.


Operations
Coint Scan
Watchlist
Portfolios
Tracker
Trades
Export
Import
Help
Operations
Symbol Management
Results
Symbols
Clear Filters
Bollinger Bands
Q-Q Plot
Z-Score
Variance
Prices/Spreads
MACD
H-Sine Wave
Stochastic RSI
RSI
ACF
PACF
Drag a column header and drop it here to group by that column
Select Columns
Spread Z-scores
Pair: STM/WIN
Variance To Cointegration Model Graph
PACF Graph
Variance To Model
Q-Q Normality Plot
ArbMaker

Run an Intra-Day test

ArbMaker also scans at the intra-day level. Users can select the following resolutions:

- 1 minute
- 15 minutes
- 30 minutes
- 60 minutes

And any number of observations between 500 and 2500.

The scans can be performed with either IQ, your MT4 feed or Google. Google, however, can be very slow at certain resolutions – please see the next section for an explanation and further comment on this feed.

The intra-day scanner uses matched ticks and transaction data by default. In practice this means that only transaction data from the same times is used for the cointegration algorithm. For example, if one symbol has data at 13h15 but not the other symbol then that data point is discarded.

In addition, the matched ticks algorithm converts all geographies to Coordinated Universal Time (UTC) in order to take account of differences between time zones and local time stamps. In practice this means that only data generated by two symbols when their respective markets are concurrently open will be considered by the algorithm.

Users can also select whether to include or exclude pre market and post market data using the “Open H.” option under the ‘Data Sources’ tab.

Note that when calling for observations of a given length – say, 1500 – the software looks at the last 1500 data for both symbols and matches it up. It will be the case, especially at shorter resolutions, that the final result may display far less than 1500 matched ticks.

The option of running an intra-day scan without the matching is not recommended for robust results.

A screen shot with guidance on how the intra-day algorithm is set up and run is on the following page:

Operations

Coint Scan

Watchlist

Portfolios

Tracker

Trades

Export

Import

Help

Results | Symbols

Run Pairs | Cancel | Clear Filters | Options | Save Layout | Progress:

Start Date: 05/01/2009 | End Date: 07/09/2012 | Data Interval: 1 Day | Data Points: 750 | Match Ticks | Bypass Filters

1 min
5 min
15 min
30 min
1 Hour
1 Day

Drag a column header and drop it here to group by that column

Exchange	Country	Type	Symbol Code	Sector	Industry	Description
AMS	NL	Equity	EXACT	Technology	EDP Services	EXACT HOLDING
HEL	FI	Equity	FSC1V	Technology	Computer Software: Prepackaged Software	F-Secure Oyj
STO	SE	Equity	HEXA-B	Technology	Electrical Products	Hexagon AB
AMS	NL	Equity	IBMA	Technology	Computer Manufacturing	IBM
EBR	BE	Equity	IBMC	Technology	EDP Services	IBM CERT
BCN	ES	Equity	IDR	Technology		S S.A EUR0.20 SER 'A'
ETR	DE	Equity	IFX	Technology		O N
EPA	FR	Equity	ILD	Technology		
AMS	NL	Equity	LOG	Technology		
EBR	BE	Equity	MELE	Technology		
EPA	FR	Equity	NEO	Technology		
STO	SE	Equity	NOKI-SEK	Technology		TION
AMS	NL	Equity	OCE	Technology		
EPA	FR	Equity	RIA	Technology		
EPA	FR	Equity	RICOP	Technology		
ETR	DE	Equity	SAP	Technology		ktien o.N.
HEL	FI	Equity	SFT1V	Technology		
EPA	FR	Equity	SOI	Technology		
EPA	FR	Equity	SOP	Technology		P
ETR	DE	Equity	SOW	Technology	Computer Software: Prepackaged Software	Software AG Inhaber-Aktien o.N.
BIT	IT	Equity	STM	Technology	Semiconductors	STMICROELECTRONICS EUR1.04
EPA	FR	Equity	STM	Technology	Semiconductors	STMICROELECTRONICS
HEL	FI	Equity	TIE1V	Technology	EDP Services	Tieto Oyj
AMS	NL	Equity	TOM2	Technology	Telecommunications Equipment	TOMTOM
AMS	NL	Equity	UNIS	Technology	EDP Services	UNISYS
AMS	NL	Equity	UNIT4	Technology	Computer Software: Programming, Data Processing	UNIT4
ETR	DE	Equity	UTDI	Technology	EDP Services	United Internet AG Namens-Aktien o.N.
HEL	FI	Equity	VAIAS	Technology	Electronic Components	Vaisala Oyj
ETR	DE	Equity	WIN	Technology	Computer Manufacturing	Wincor Nixdorf AG Inhaber-Aktien o.N.

Scan type is decided here. By selecting "1 Day" the scan will run on end-of-day data. All other resolutions are intra-day choices.

For intra-day scans, use the pull down menu and make any choice other the "1 Day". This automatically enables the "Data Points" pull down to the right. The "Data Points" menu never applies to end-of-day scans.

The "Match Ticks" box, when selected, means that only transaction data from the same time slot is used by the cointegration algorithm. For, example, if one symbol has trade data at 13h15 but not the other symbol then that data point is discarded.

This ensures like-for-like comparisons and actionability (by avoiding situations where one half of a pair trade pre-market and/or post-market whilst the other does not).

Errors

Operations

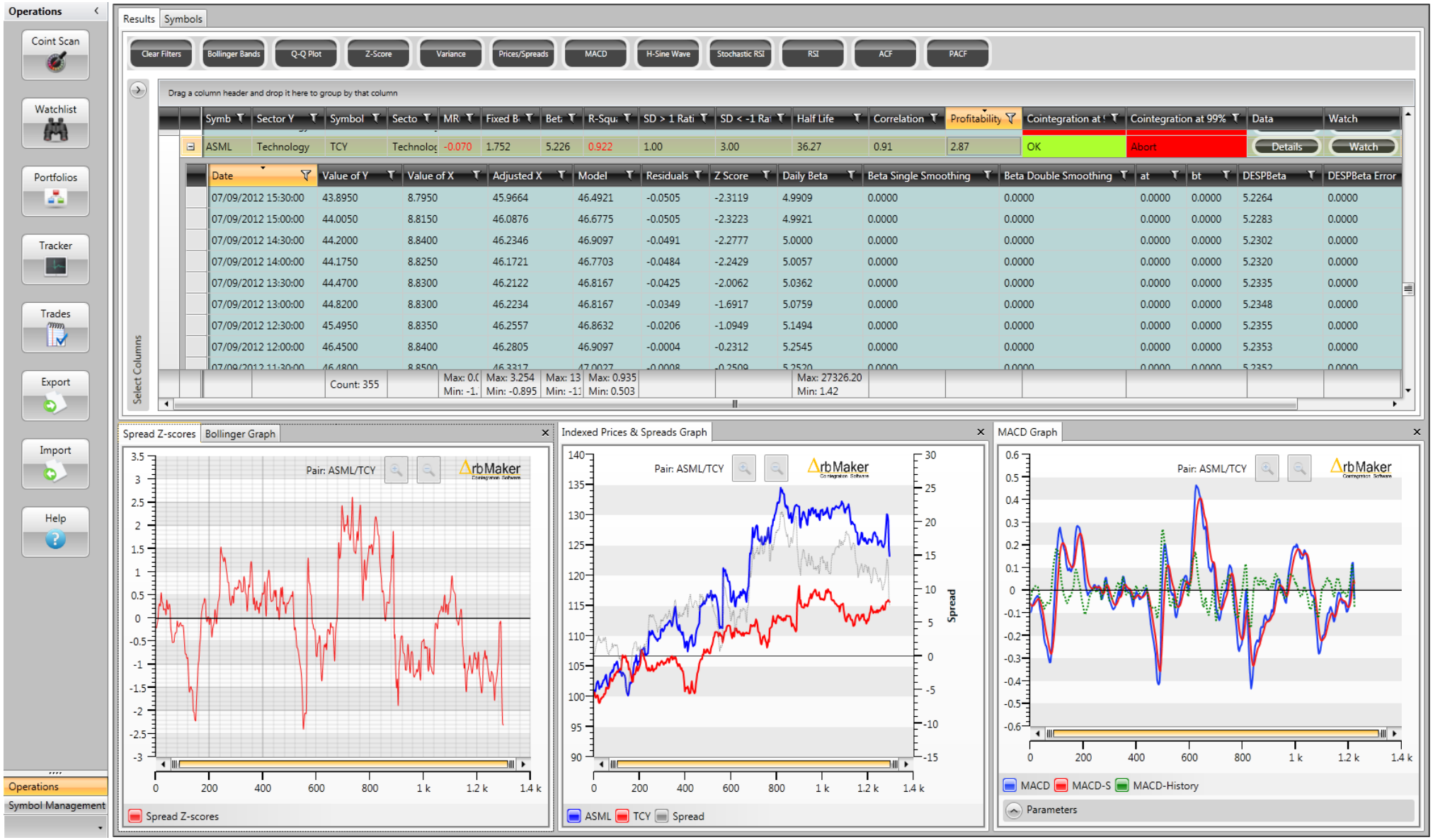
Symbol Management

On the following page are some sample results of an intra-day scan of several Industries within the Technology sector of the Euronext and London markets.

The graphs show Dutch ASML Holding N.V. and the UK's TeleCity Group PLC. The scan called for 1500 observations at 30 minute intervals. Here we've opened the sub grid holding underlying data (controlled by the + sign next to each pair at the start of each row).

Graphs and screen layouts are fully configurable and can be saved by using the ‘Save layout’ buttons in each module (eg: ‘Coint. Scan’, ‘Portfolio’, ‘Watchlist’ and ‘Tracker’).

Note that ArbMaker is able to perform cross time zone scans like this by automatically converting local stock market times to Coordinated Universal Time and then matching concurrent transactions times across different zone. Daylight Savings Time is also automatically taken into account.


Operations
Coint Scan
Watchlist
Portfolios
Tracker
Trades
Export
Import
Help
Operations
Symbol Management
Results
Symbols
Clear Filters
Bollinger Bands
Q-Q Plot
Z-Score
Variance
Prices/Spreads
MACD
H-Sine Wave
Stochastic RSI
RSI
ACF
PACF
Drag a column header and drop it here to group by that column
Select Columns
Symb
Sector Y
Symbol
Secto
MR
Fixed B
Bet
R-Squ
SD > 1 Rati
SD < -1 Ra
Half Life
Correlation
Profitability
Cointegration at
Cointegration at 99%
Data
Watch
ASML
Technology
TCY
Technolog
-0.070
1.752
5.226
0.922
1.00
3.00
36.27
0.91
2.87
OK
Abort
Details
Watch
Date
Value of Y
Value of X
Adjusted X
Model
Residuals
Z Score
Daily Beta
Beta Single Smoothing
Beta Double Smoothing
at
bt
DESPBeta
DESPBeta Error
07/09/2012 15:30:00 43.8950 8.7950 45.9664 46.4921 -0.0505 -2.3119 4.9909 0.0000 0.0000 0.0000 0.0000 5.2264 0.0000
07/09/2012 15:00:00 44.0050 8.8150 46.0876 46.6775 -0.0505 -2.3223 4.9921 0.0000 0.0000 0.0000 0.0000 5.2283 0.0000
07/09/2012 14:30:00 44.2000 8.8400 46.2346 46.9097 -0.0491 -2.2777 5.0000 0.0000 0.0000 0.0000 0.0000 5.2302 0.0000
07/09/2012 14:00:00 44.1750 8.8250 46.1721 46.7703 -0.0484 -2.2429 5.0057 0.0000 0.0000 0.0000 0.0000 5.2320 0.0000
07/09/2012 13:30:00 44.4700 8.8300 46.2122 46.8167 -0.0425 -2.0062 5.0362 0.0000 0.0000 0.0000 0.0000 5.2335 0.0000
07/09/2012 13:00:00 44.8200 8.8300 46.2234 46.8167 -0.0349 -1.6917 5.0759 0.0000 0.0000 0.0000 0.0000 5.2348 0.0000
07/09/2012 12:30:00 45.4950 8.8350 46.2557 46.8632 -0.0206 -1.0949 5.1494 0.0000 0.0000 0.0000 0.0000 5.2355 0.0000
07/09/2012 12:00:00 46.4500 8.8400 46.2805 46.9097 -0.0004 -0.2312 5.2545 0.0000 0.0000 0.0000 0.0000 5.2353 0.0000
Count: 355
Max: 3.254
Min: -0.895
Max: 0.935
Min: 0.503
Max: 27326.20
Min: 1.42
Spread Z-scores
Bollinger Graph
Pair: ASML/TCY
ArbMaker
Spread Z-scores
Indexed Prices & Spreads Graph
Pair: ASML/TCY
ArbMaker
Spread
ASML
TCY
Spread
MACD Graph
Pair: ASML/TCY
ArbMaker
MACD
MACD-S
MACD-History
Parameters

Google Finance Feed: some comments

ArbMaker includes a second free data feed – Google's.

- The feed opens access to new markets. Mainly this is because: (1) it has what so far appears to be more reliable data for geographies such as Italy, India's National and Bombay Stock Exchanges and the UK; and (2) it covers others that Yahoo and IQ do not such as Japan's Tokyo Stock Exchange.
- The feed also carries intra-day data. On the one hand this creates a new analysis horizon; and on the other it is a useful tool in jurisdictions where short sales cannot be carried overnight – notably India.
- Google cover forex with end-of-day data from Citibank – at least officially. It is possible to get 60 minute ticks from them for FX for some pairs. However, even if a user asks for less than that the max we have seen return is 60 minutes.
- Google data is real time in the US, UK, Italian and Indian equity markets (see proviso below)

The feed is good but imperfect:

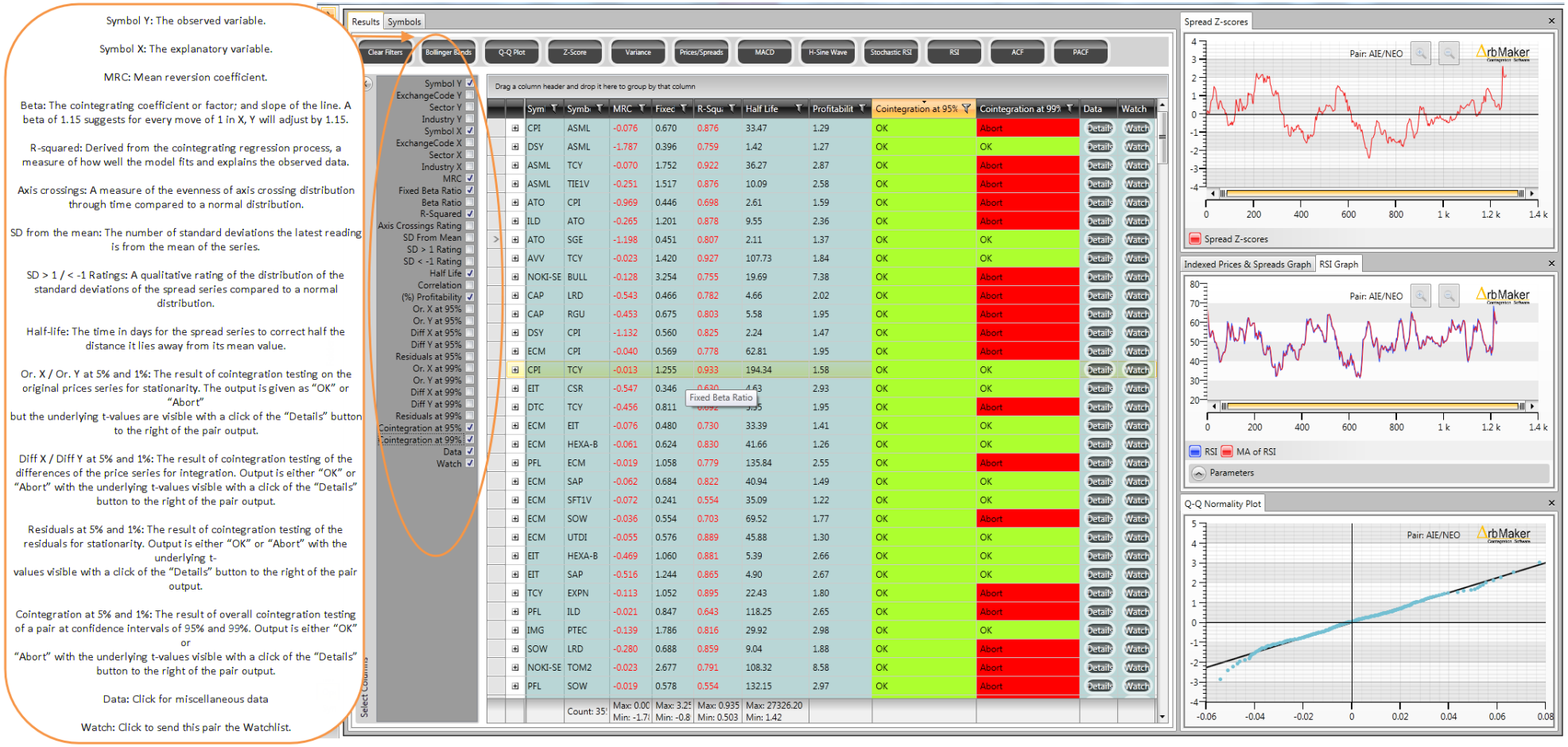
1. Where we can cross reference its quality easily (against IQ for example) there are instances where data values are slightly different. Generally these are not material. However, we have found two examples from a pool of over 40 where stock splits have not been applied retrospectively at the end-of-day level (Universal Health Services, Inc. for example).
2. For non-US companies the types of problem we have seen are missing data (very rare), smaller periods of continuous data than competitor feeds (rare) and one case where an Irish firm (CRH Plc.) quoted on the London Stock Exchange carries early data in euros (e.g. €10.25) and recent data in pence (e.g. 891p).
3. The proviso on Google's real time US quotes is this: the last price does not fully consolidate all exchange volume. This only happens over the subsequent 15 minutes. Therefore the 'live' price is in fact not the true real time price. Google carry this note to explain:

   Real-time price data represents trades which execute on the NASDAQ and NYSE exchanges. Volume information, as well as price data for trades that don't execute on those exchanges, are consolidated and delayed by 15 minutes (NASDAQ), 20 minutes (NYSE).

4. There is a similar volume delay effect for the real time price given for the UK but it is much smaller. We have not audited the other RT exchanges.
5. At the intra-day level the 15 minute and 60 minute increments are not fully reliable. This is because query requests sometimes go repeatedly unanswered or are returned incomplete. We have implemented a quality check process on the data which will loop many times in order to fetch complete queries. However, these two resolutions remain problematic.

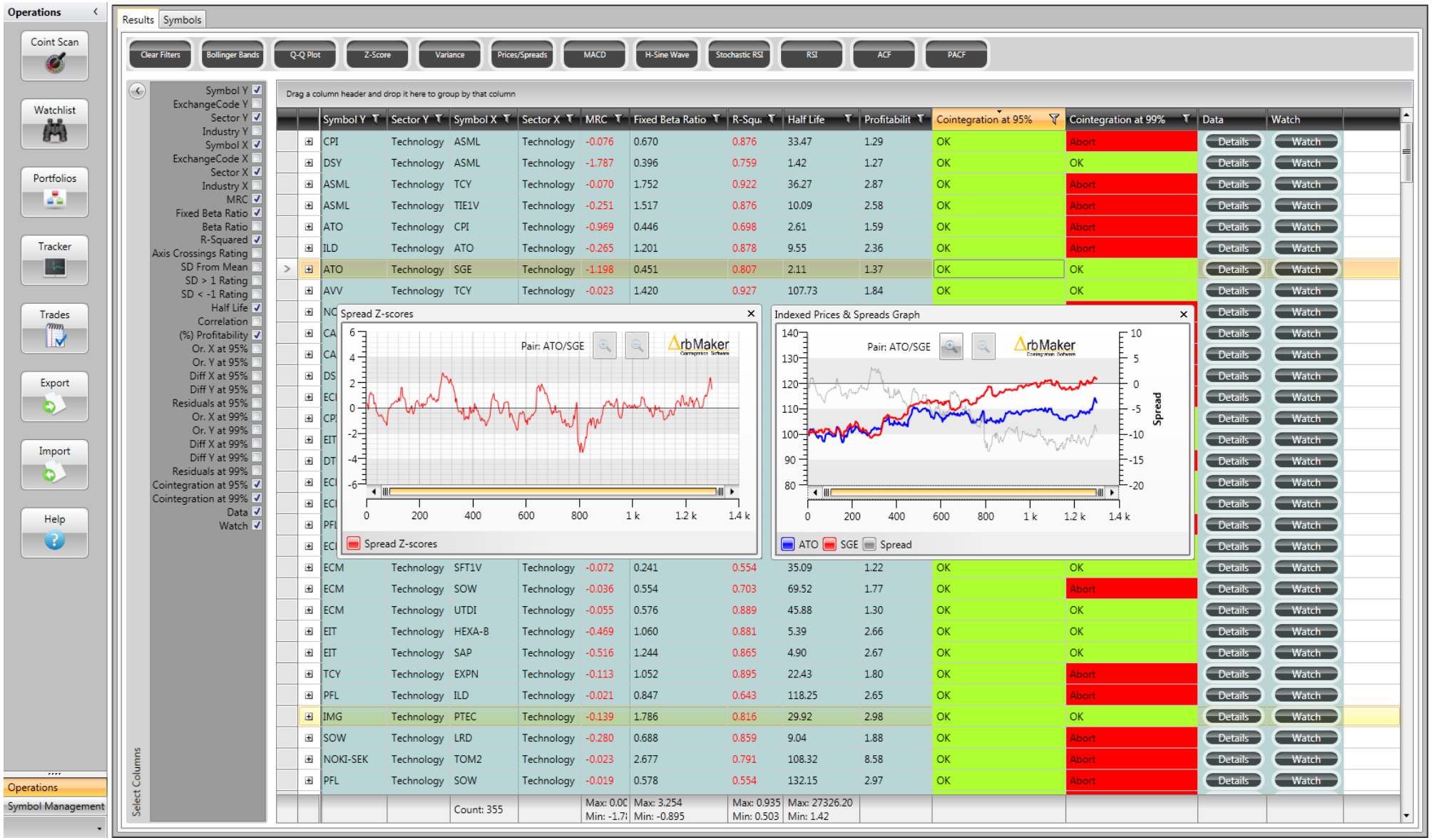
End-of-day Results and Graphs

Once a test is completed the output will be posted to the "Results" tab. A typical screen looks like the one below with more or less information available by adding/removing columns. Brief descriptions of these options are marked and there are additional notes on the terms used in Appendix E:

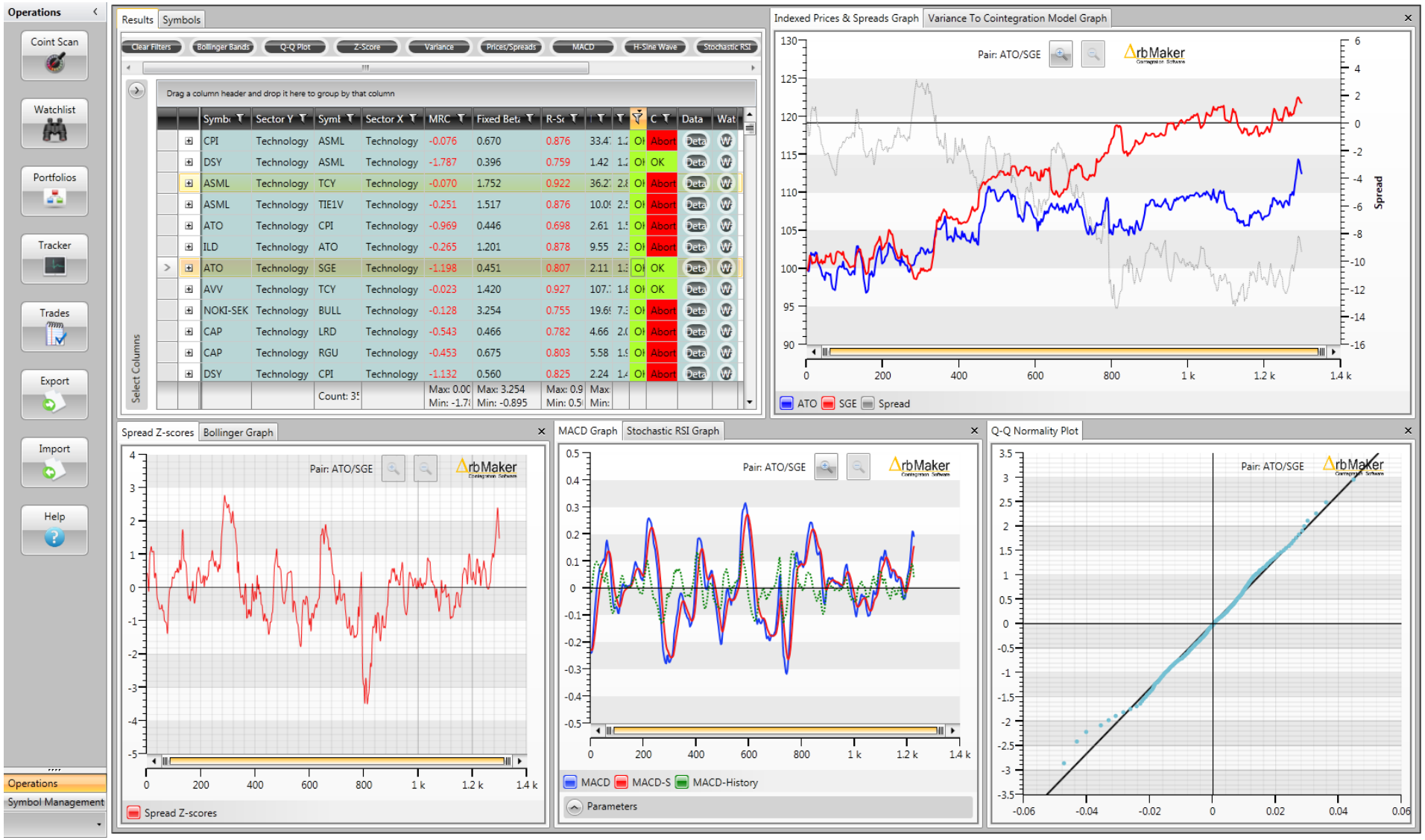


The "Cointegration" columns indicate whether a pair is cointegrated with 95% confidence and 99% confidence with "OK" being a good result and "Abort" being a fail.

Selecting a pair then permits graphing via the buttons at the top of the screen.



These graphs can be manipulated and anchored/docked by user choice. For example:



This screen has both anchored graphics and graphs tabbed within graphs.

The Options filter

The Options filter serves two purposes:

1. Allows users to pull pairs that meet specific criteria aimed at maximizing the output of tradable pairs
2. Filtering lets the software work more efficiently by allowing it to ignore outright fails and (for example) hard to trade pairs

The criteria in detail: how to use them

PACF confidence

The Partial Autocorrelation Function. Appendix A covers this in detail. This specific control determines how rigorously, in term of statistical confidence, the scan handles autocorrelation (see the glossary entry below if necessary).

Max lags

The number of lags ArbMaker will look back at and adjust the residuals data for. Generally speaking, the more lags chosen the harder it is to trade the pair. The software is locked at "1" in order to automatically filter out autocorrelated pairs – and a choice of 1 actually means ArbMaker only considers series not requiring any lagging.

By using results unaffected by autocorrelation operations are simplified. This is partly a choice in response to beta user feedback for a more streamlined user experience but there are also other practical reasons.

Cointegration testing involves running many regressions. But sometimes, in order to remove autocorrelation, one of the price series needs to be offset against the other by one or more time periods (ie the "lag"). An example from economics illustrates the point: car and home sales are typically related to interest rate levels. But the relationship is not instantaneous – the impact on sales might trail the change in interest rates by 1 or more time periods. To properly analyze the two series (either visually in a chart or by regression) it is necessary to shift – or lag – the sales data so it lines up with the change in rates that impacted it.

Removing the autocorrelation is the same thing but a little in reverse – the goal is to randomize the data, not find correlations.

MRC

The Mean Reversion Coefficient (consult the glossary for the definition). Values between 0 and -1 suggest stable systems. Values less than -1 are not untradeable but suggest less stable systems for which the readjustment may over shoot.

R squared

Set to 0 to 100 by default (ie ignored by the filter). Higher R2 returns results where the model has better explanatory power of the dependent Y variable.

Half-life

Half-life (see the glossary entry for a detailed definition) is measured in days in the options screen. It is also derived from the MRC and because of this is by default to 0 (which means it is ignored) by the filter. Running both at the same time is asking for conflicting results and makes little sense: thus use a value for either the Half-life filter or the MRC in the filter. But not both.

Axis crossings & Tolerance

The more evenly the spread of a pair cross the x axis the higher, theoretically, the quality of the trading entry points – assuming the chart is oscillating evenly above and below the line (see the "Spread Normality" settings below). The Axis crossing rating ranks these crossings by evenness per quartile on a scale of 1 to 4 with 4 being the best.

These rankings – and the returns ArbMaker brings – also depend on the "Tolerance" settings chosen. The tolerance is the amount of leeway users permit ArbMaker to exercise when scanning pairs. For example, if a pair makes 36 crossings during the date range analyzed a perfect distribution by quartile would equal 9. With a tolerance of 35% the software would accept an amount 35% either side of 9 (rounded). Thus observed crossings per quartile between 6 and 12 would get a ranking of "4".

The default is 1 meaning all ranks 1 through 4 are returned.

Spread Normality

As a general rule, the greater the normality of the spread series the easier it is to forecast and therefore trade profitably. The Spread Normality settings apply a qualitative rating on a scale of 1 to 4 (with 4 being the best) on the distribution by quartile of the spread series. There is one setting for the positive spread values and another for the negative spread values. The ranking is made by comparing the actual distribution to what it would be in a normal distribution.

Again, there is a Tolerance parameter. There is no "best" setting. 100% is the max setting and will pull the most returns. We suggest 65% is a base from which to experiment.

For an example of a chart ranked 1 for axis crossings and spread normality versus another ranked 4 all the way through please look at the "Using ArbMaker: a how-to-use-it-example" section under the section "3. Normality Ratings".

Use Logs/Prices

Choose between natural logs or raw price data. Natural logs are used by convention but the turning points of both are the same. However, it can be useful to compare the two: cointegration in one but not the other may suggest the relationship is weak.

Use Rolling Z

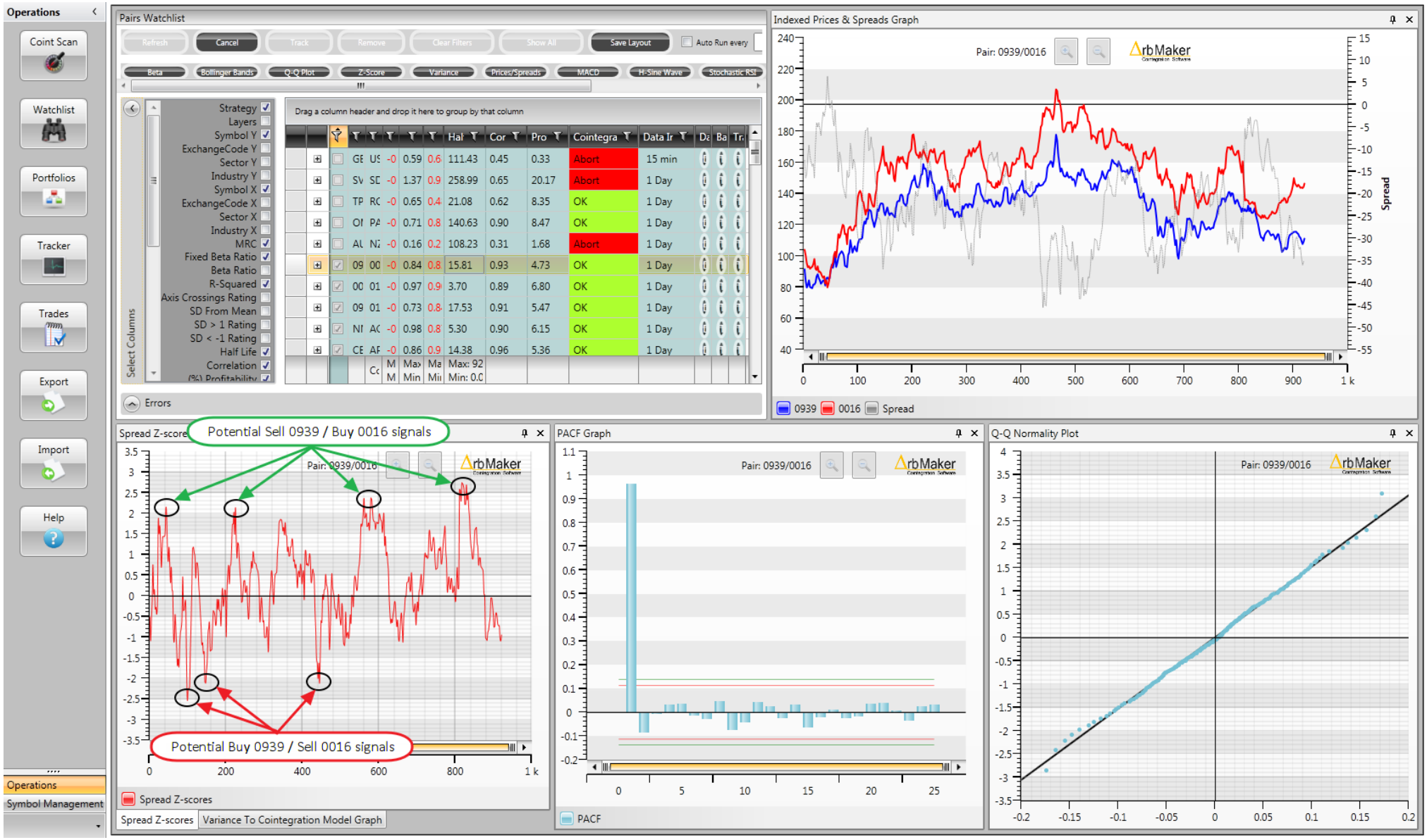
If ticked this uses observation-by-observation calculations to present the Z-score on an accumulated rather than summed basis of the entire data population. The effect brings greater accuracy to back testing and signal generation.

ArbMaker: a how-to-use-it example

The Goal

This software is a tool to help find and trade equity arbitrage opportunities consistent with the Engle Granger cointegration methodology.

That means producing cointegrated pairs of securities - like the one graphed in the screen shot overleaf - which produce highly tradable windows of opportunity corresponding to the black circles overlaid on the key “Spread Z-score” plot:


Operations
Coint Scan
Watchlist
Portfolios
Tracker
Trades
Export
Import
Help
Operations
Symbol Management
Pairs Watchlist
Refresh
Cancel
Track
Remove
Clear Filters
Show All
Save Layout
Auto Run every
Beta
Bollinger Bands
Q-Q Plot
Z-Score
Variance
Prices/Spreads
MACD
H-Sine Wave
Stochastic RSI
Select Columns
Strategy
Layers
Symbol Y
ExchangeCode Y
Sector Y
Industry Y
Symbol X
ExchangeCode X
Sector X
Industry X
MRC
Fixed Beta Ratio
Beta Ratio
R-Squared
Axis Crossings Rating
SD From Mean
SD > 1 Rating
SD < -1 Rating
Half Life
Correlation
Drag a column header and drop it here to group by that column
Cointegra
Data Ir
Errors
Indexed Prices & Spreads Graph
Pair: 0939/0016
ArbMaker
Spread
0939
0016
Spread
Spread Z-scores
Potential Sell 0939 / Buy 0016 signals
Potential Buy 0939 / Sell 0016 signals
Spread Z-scores
Variance To Cointegration Model Graph
PACF Graph
PACF
Q-Q Normality Plot

The Key indicators and tools

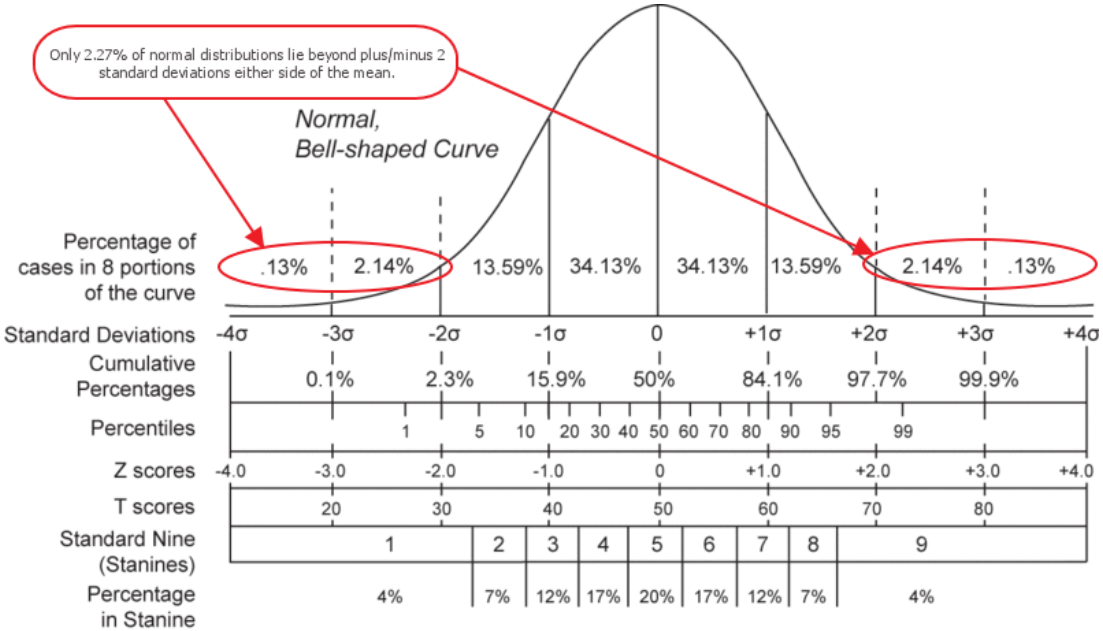
1. Spread charts

The most important chart shown is the "Spread Z-scores". In the back tester another version of this chart appears under the title "Bollinger Bands". All other information, graphed or numeric, supports the validity and credibility of these charts and the trading opportunities they reveal.

First of all, what is a Z-score? It is just another name for standard deviation which is itself a measure of spread in a statistical sample.

Still, why are Z scores so crucial?

An example will help: if, as has happened seven times in less than 3 years in the chart of 0939/0016 (Hong Kong pair China Construction Bank corporation / Sun Hung Kai Properties Limited) above, the spread of a pair of equities reads ± 2 Z scores from the mean value of the series; and the trader has checked that the overall distribution of the series is normal or near normal; then he knows that it is an exceptional reading. Only 2.27% of a normal distribution will fall in those areas. The graphic below of the classic "Bell curve" helps visually explain this:



All of this suggests, *if the pair underlying the spread is truly cointegrated*, that future observations will trend the graph back toward the mean value – because that is where most observations must lie in an approximately normally distributed series of data.

2. Normality charts

For the Z scores to be helpful the data it applies to should be as normal as possible. Fully normal is just about an impossibility in a trading context; but an approximation is not. ArbMaker uses to two plots to tackle the task:

(i) PACF

Please consult Appendix A.

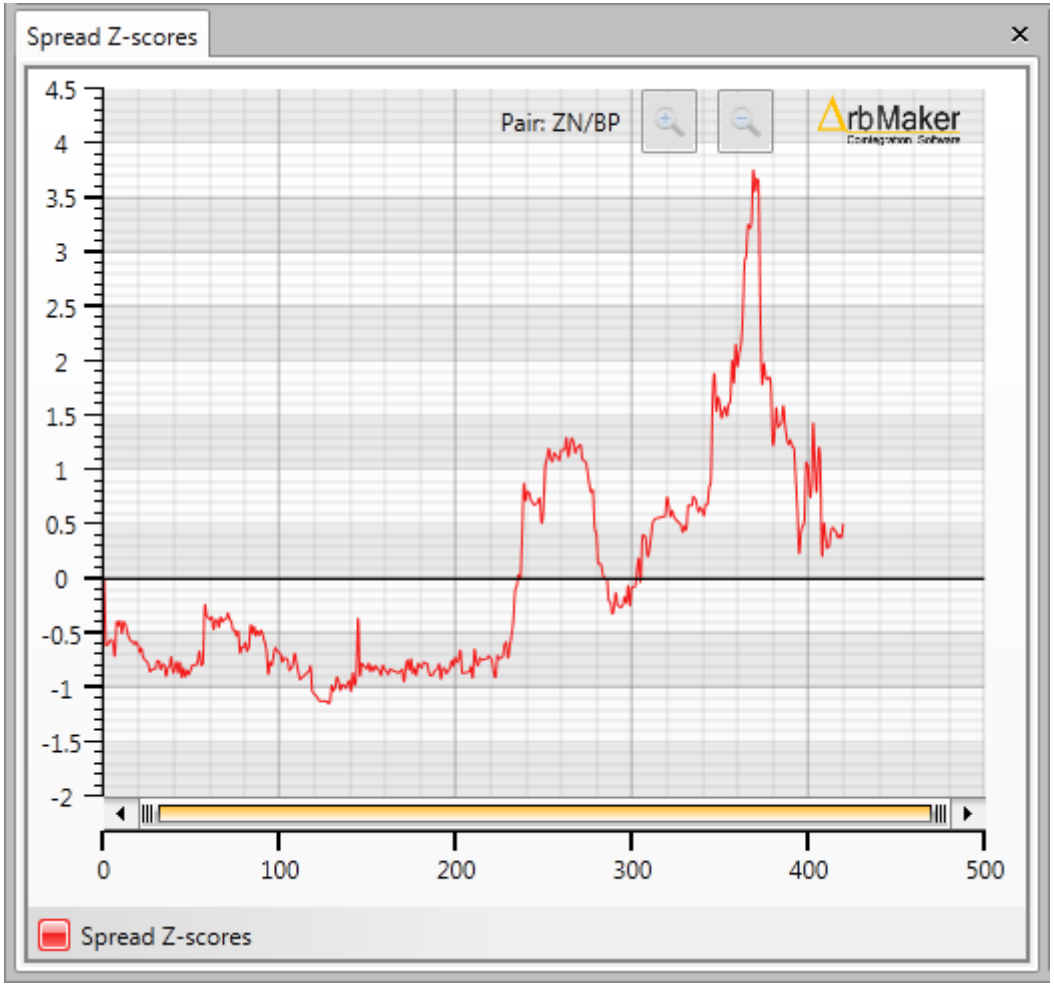
(ii) Q-Q Normality

Please see the entry for "Normality" in the Glossary section below.

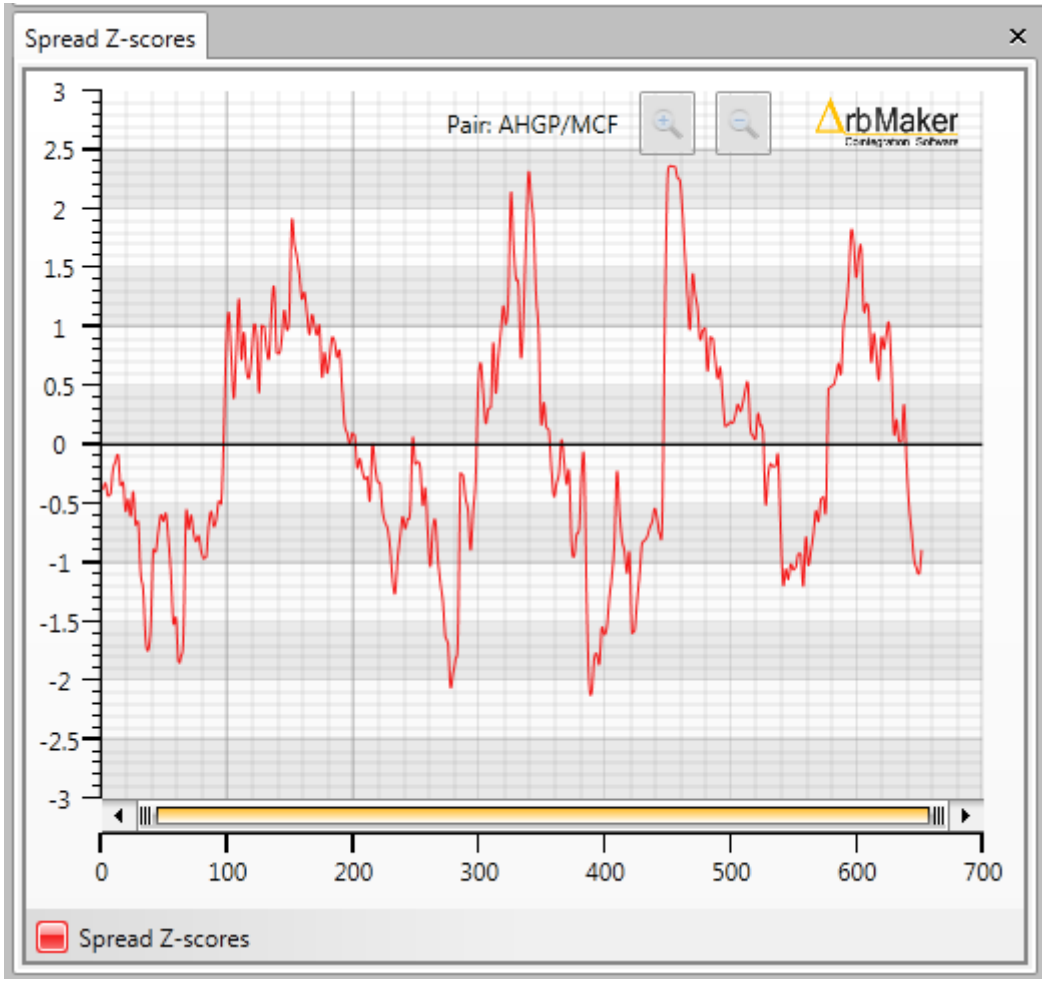
3. Normality Ratings

ArbMaker uses qualitative ratings in addition to the PACF and Q-Q plots to rank - on a scale of 1 to 4 (with 4 being the best) - the number of times the spread series in the "Spread Z-scores" chart crosses its own axis; and to rank the actual distribution of the spread values compared to a normal distribution.

These are the key to finding evenly oscillating spread charts of pairs that are potentially the most tradable. On the next page is an example of an intraday chart with rankings of "1" in terms of axis crossings, "1" for its positive standard deviations and "1" for its negative standard deviation:



And overleaf is an example of another with rankings of “4”, “3” and “4”:



These rankings – and the returns ArbMaker brings – also depend on the "Tolerance" settings chosen. The tolerance is the amount of leeway users permit ArbMaker to exercise when scanning pairs. For example, if a pair makes 36 crossings during the date range analyzed a perfect distribution by quartile would equal 9. With a tolerance of 35% the software would accept an amount 35% either side of 9 (rounded). Thus observed crossings per quartile between 6 and 12 would get a ranking of "4".

Trading it

The "Spread Z-scores" chart plots the divergence and re-convergence of cointegrated pairs thus identifying their tradable extremes. These tradable points are measured by standard deviations and tend to fall in the region of ± 1.5 to 2 standard deviations. When these levels are reached it is the signal to traders to take a position in the underlying securities composing the spread series. ArbMaker's setup is such that Symbol Y, as shown in the output screen, is the short side when Z scores hit positive extremes.

In the case of the chart at the start of this "how-to" section the companies are China Construction Bank (0939) and Sun Hung Kai Properties Limited (0016) with 0939 being the Y Symbol.

At a position of +2 (touched at observation ~820) the signal to sell 0939 and buy 0016 was made. ArbMaker provides the signal, the underlying prices and the proportion of each to take in the long/short equation (derived from the beta of each pair – see Appendix L for more on fixed and time-varying betas).

Using the beta

Pairs trading using the Engle Granger methodology is about analyzing the extent to which one company impacts the movement of another. In our charts the lead company is called "Symbol X" and the responding company "Symbol Y". Beta shows the sensitivity of the relationship between these two.

For example, a beta of 2 suggests a movement of $1 in Symbol X will produce a movement in Symbol Y of $2. For trading purposes this means buying equal dollar amounts of X and Y would be a mistake – the hedge would be out of balance. It also means that entering pairs trades where beta does not equal one is not a dollar-neutral trade. That is, one side has a different outlay to the other which sometimes makes financing requirements more expensive than a dollar-neutral trade.

The calculation to balance pairs with beta is:

Dollar amount of Symbol Y = beta x dollar amount of Symbol X

Or:

Dollar amount of Symbol X = dollar amount of Symbol Y / beta

The back tester in ArbMaker performs the balancing automatically under the fixed beta regime. With a time-varying beta the balancing is performed in the spread calculation thus leaving each half of the hedge money neutral – see point 2 in Appendix L for the math behind this.

Tracking it

ArbMaker also lets users save pairs like 0939/0016 to a watch list in order to track them. That list can update automatically or whenever a user desires, manually.

The Watchlist

From the "Results" tab users can save any pair they wish to follow by clicking on the "Watch" button. These pairs are viewable by clicking on the "Watchlist" button in the left hand pane. **The first time pairs are loaded the "Refresh" button must be clicked to activate them on the list and make them visible**. Similarly, whenever new pairs are added to the list the screen must be refreshed to activate them.

The Watchlist can also be configured with graphs in the same way as the "Results" screen. Further, it can be set to update automatically in increments of 5 minutes by ticking the "Auto run" box and selecting the interval. Or users can leave it unticked and update the list manually by pressing the "Refresh" button.

An important note: if you compile a watch list using the Google or Yahoo feeds and then switch to IQ or MT4 (or vice versa) some pairs may come back empty and show "Abort" instead of "OK" in the Cointegration columns. This is not a bug. Different feeds do not match 100% and cointegration results are sensitive. Some Google and Yahoo pairs are not cointegrated under IQ (and vice versa); or, more often, the filter criteria under the "Options" button marginally exclude the cointegrated pairs from one or the other feed.

Details tab

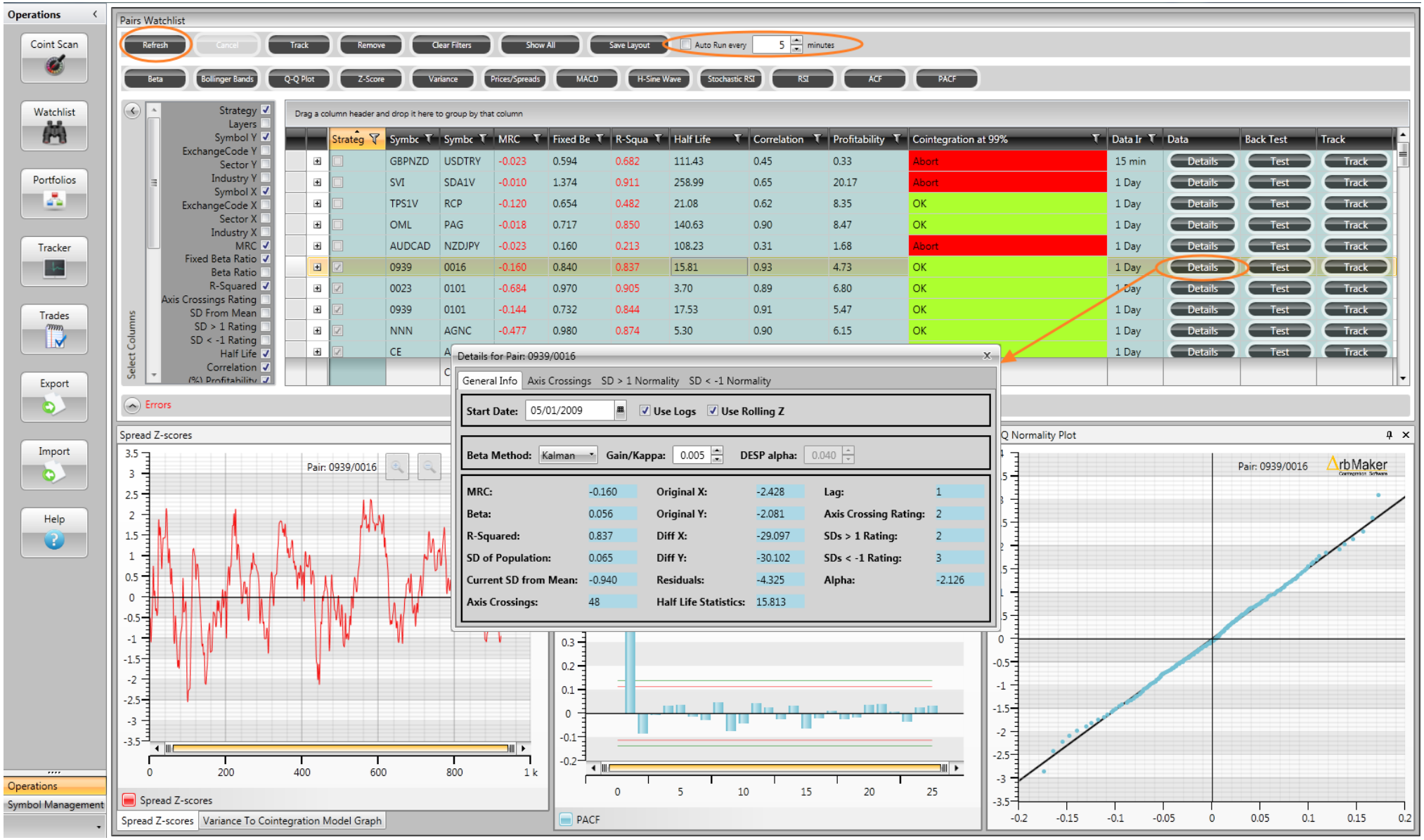
By clicking the "Details" button (see the screen shot on the next page) the following changes to the parameters of any pair can be made:

1. The starting date: to change the date range – and therefore the stat and graphical output – of a given pair in the Watchlist:

   Go->Watchlist->Details->General Info

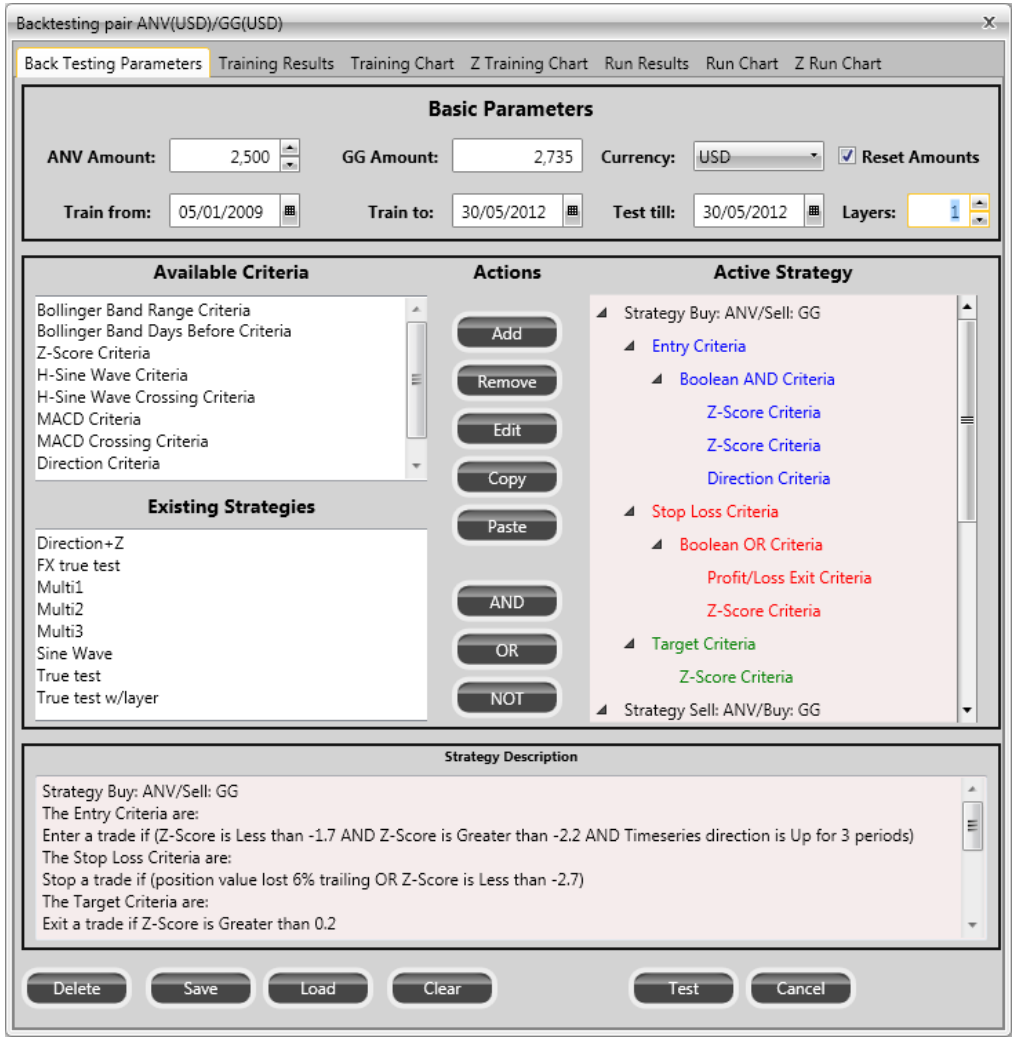
   A dialogue window opens with assorted statistical data. There is also a "Start Date". Change this either freehand or using the calendar tool and then exit. Hitting the "Refresh" button will update the series with the new starting date.

2. Logs vs prices: select a cointegration analysis using either natural logs or prices. Natural logs are used by convention but the turning points with raw prices are the same. However, it can be useful to compare the two: cointegration in one but not the other may suggest the relationship is weak.
3. Rolling Z vs single Z: a rolling Z uses point-by-point calculations to show the Z-score on an accumulated basis rather than on the basis of the entire data population.
4. Beta method: choose from either the fixed beta methodology or one of the time-adaptive models (DESP or Kalman – see Appendix L for details about the settings).


Operations
Coint Scan
Watchlist
Portfolios
Tracker
Trades
Export
Import
Help
Operations
Symbol Management
Pairs Watchlist
Refresh
Cancel
Track
Remove
Clear Filters
Show All
Save Layout
Auto Run every
5
minutes
Beta
Bollinger Bands
Q-Q Plot
Z-Score
Variance
Prices/Spreads
MACD
H-Sine Wave
Stochastic RSI
RSI
ACF
PACF
Select Columns
Strategy
Layers
Symbol Y
ExchangeCode Y
Sector Y
Industry Y
Symbol X
ExchangeCode X
Sector X
Industry X
MRC
Fixed Beta Ratio
Beta Ratio
R-Squared
Axis Crossings Rating
SD From Mean
SD > 1 Rating
SD < -1 Rating
Half Life
Correlation
Drag a column header and drop it here to group by that column
Strateg
Symbc
Symbc
MRC
Fixed Be
R-Squa
Half Life
Correlation
Profitability
Cointegration at 99%
Data Ir
Data
Back Test
Track
GBPNZD USDTRY -0.023 0.594 0.682 111.43 0.45 0.33 Abort 15 min
SVI SDA1V -0.010 1.374 0.911 258.99 0.65 20.17 Abort 1 Day
TPS1V RCP -0.120 0.654 0.482 21.08 0.62 8.35 OK 1 Day
OML PAG -0.018 0.717 0.850 140.63 0.90 8.47 OK 1 Day
AUDCAD NZDJPY -0.023 0.160 0.213 108.23 0.31 1.68 Abort 1 Day
0939 0016 -0.160 0.840 0.837 15.81 0.93 4.73 OK 1 Day
0023 0101 -0.684 0.970 0.905 3.70 0.89 6.80 OK 1 Day
0939 0101 -0.144 0.732 0.844 17.53 0.91 5.47 OK 1 Day
NNN AGNC -0.477 0.980 0.874 5.30 0.90 6.15 OK 1 Day
CE 1 Day
Details
Test
Errors
Details for Pair: 0939/0016
General Info
Axis Crossings
SD > 1 Normality
SD < -1 Normality
Start Date: 05/01/2009
Use Logs
Use Rolling Z
Beta Method: Kalman
Gain/Kappa: 0.005
DESP alpha: 0.040
MRC: -0.160
Beta: 0.056
R-Squared: 0.837
SD of Population: 0.065
Current SD from Mean: -0.940
Axis Crossings: 48
Original X: -2.428
Original Y: -2.081
Diff X: -29.097
Diff Y: -30.102
Residuals: -4.325
Half Life Statistics: 15.813
Lag: 1
Axis Crossing Rating: 2
SDs > 1 Rating: 2
SDs < -1 Rating: 3
Alpha: -2.126
Spread Z-scores
Pair: 0939/0016
Spread Z-scores
Variance To Cointegration Model Graph
PACF
Q Normality Plot
Pair: 0939/0016
ArbMaker

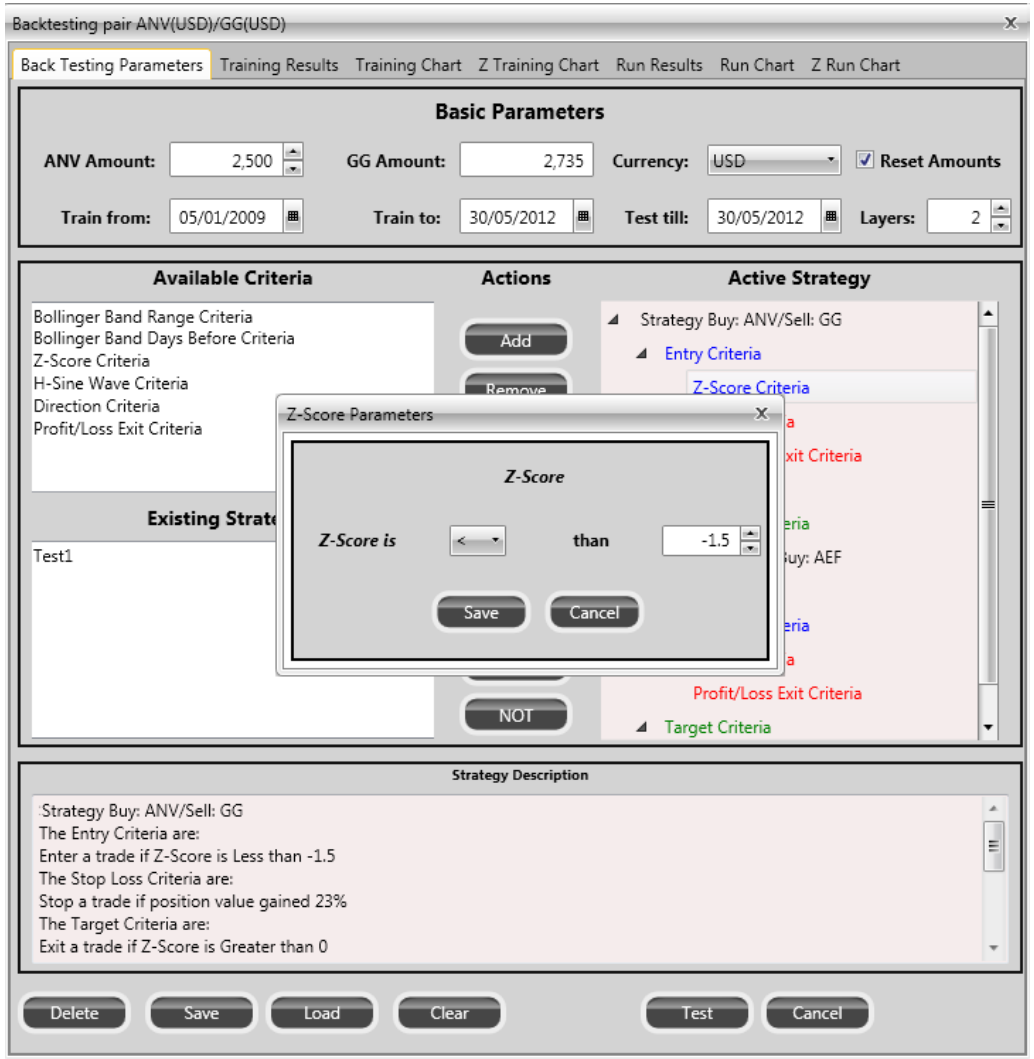
The Back tester

The back tester is accessed from the Watchlist screen by clicking on the “Test” button. This calls up the dialog box below where test criteria are chosen via a ‘tree menu’:



Back tester Quick Start guidance:

1) In 'Active Strategy' click 'Entry Criteria'
2) In 'Available Criteria' select a criteria such as 'Z-Score'
3) Click Add and the screen below appears:



4) Enter your parameters
5) Repeat for each part of the 'Active Strategy': Entry, Stop loss and Target.
6) As you create the strategy an equivalent text description is created as a sense check that you are getting what you thought
7) Once a strategy has been created it is remembered by the pair. This is an important point: by remembering the strategy when a pair is moved from the watch list to a portfolio (using the 'Track' button) the strategy goes with it. The strategy can subsequently be finessed if required from inside the portfolio itself.
8) Decide if you wish to tick the "Reset Initial Amount" box. Unticked and the test will roll over profits (and losses) into the subsequent trade.
9) Hit "Test". The results will be accessible under the various tabs at the top of the dialog box.

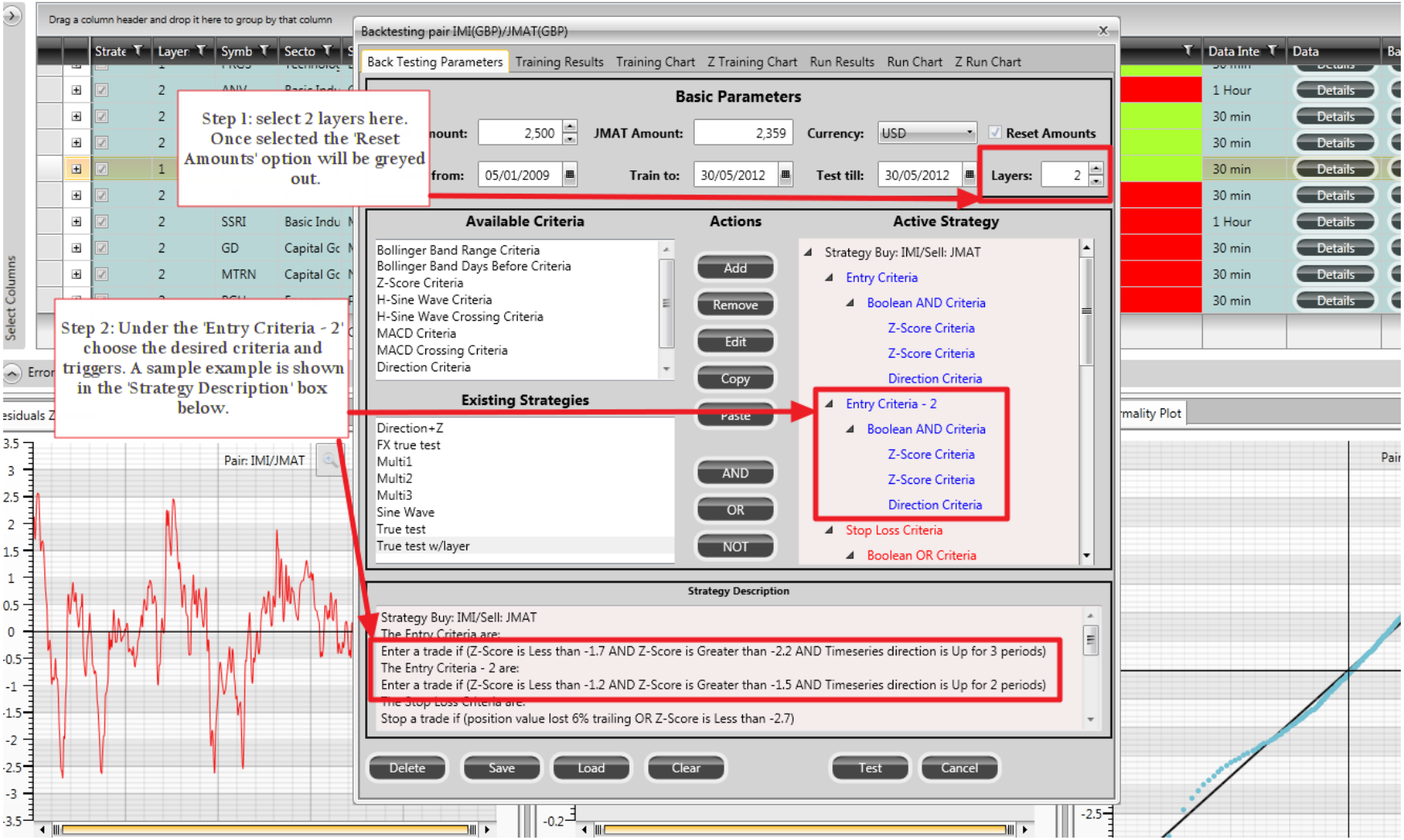
Some comments:

- It is extremely useful to preserve strategies using the "Save" button for quick application to other pairs (in turn done by clicking the "Load" button)
- Once saved, a strategy can be applied across an entire portfolio in a couple of clicks via the "Assign Strategy" button inside the 'Portfolio' screen
- If using multiple criteria in a strategy these are by default assigned the Boolean control 'AND'. That is, all conditions must be met in order for the ensemble to apply
- To assign a Boolean such as "Or", first move and define the parameters for chosen criteria to the 'Entry', 'Stop Loss' or 'Target' section of the "Active Strategy" (the criteria must be within the same section). Then highlight select all the criteria desired in the section and click "Or".
- The 'Copy' and 'Paste' controls are only live if a Boolean control has been explicitly added. The idea being that users designing complicated strategies involving several criteria and permutations may wish to use them on both halves of the pair. A copy/paste is faster than a retype. With simpler strategies this is not the case.
- Commissions are automatically calculated.

Layering:

To reward strategies that show initial profit users can scale into that winning position by automatically adding an additional 'layer' when defined entry criteria are triggered.

Setting up a second layer is explained in the following screen shot:



Layers are currently limited to 2 and execute for the same amounts. In the shot above, for example, both layer 1 and 2 for the Y symbol will equal $2500. But, since the split for the second layer takes account of changes in beta, layer 2 for symbol X may not be the same as the $2359 it is showing for layer 1.

In and Out-of-sample testing with the back tester

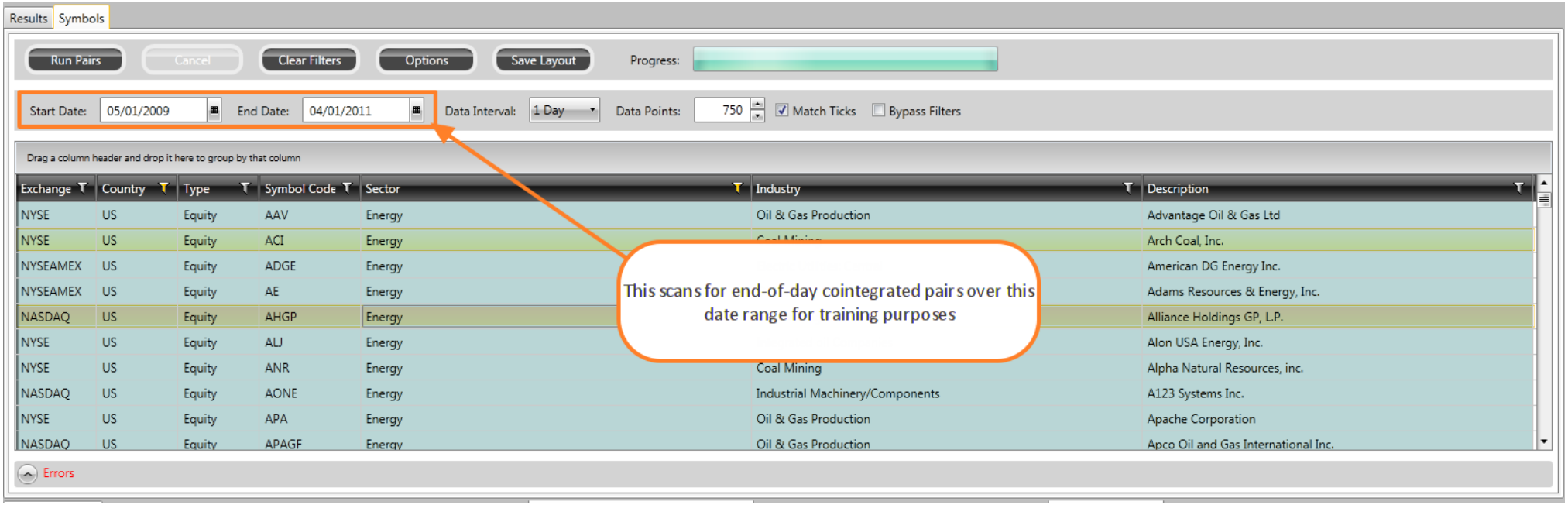
Once the strategy is in place it can then be tested in and out-of-sample if desired. There are two different methods to achieve this:

(1) A single cointegrated sample period is split into different periods. The first split period is used for training and assigning the criteria for entering and exiting potential trades. The second period is then used to "walk forward" these criteria and establish their effectiveness.
(2) Two contiguous date ranges are used: the first for training pairs established as cointegrated through a historical test; and the second for testing the durability and profitability of those relationships up until the present time.

Walk forward testing

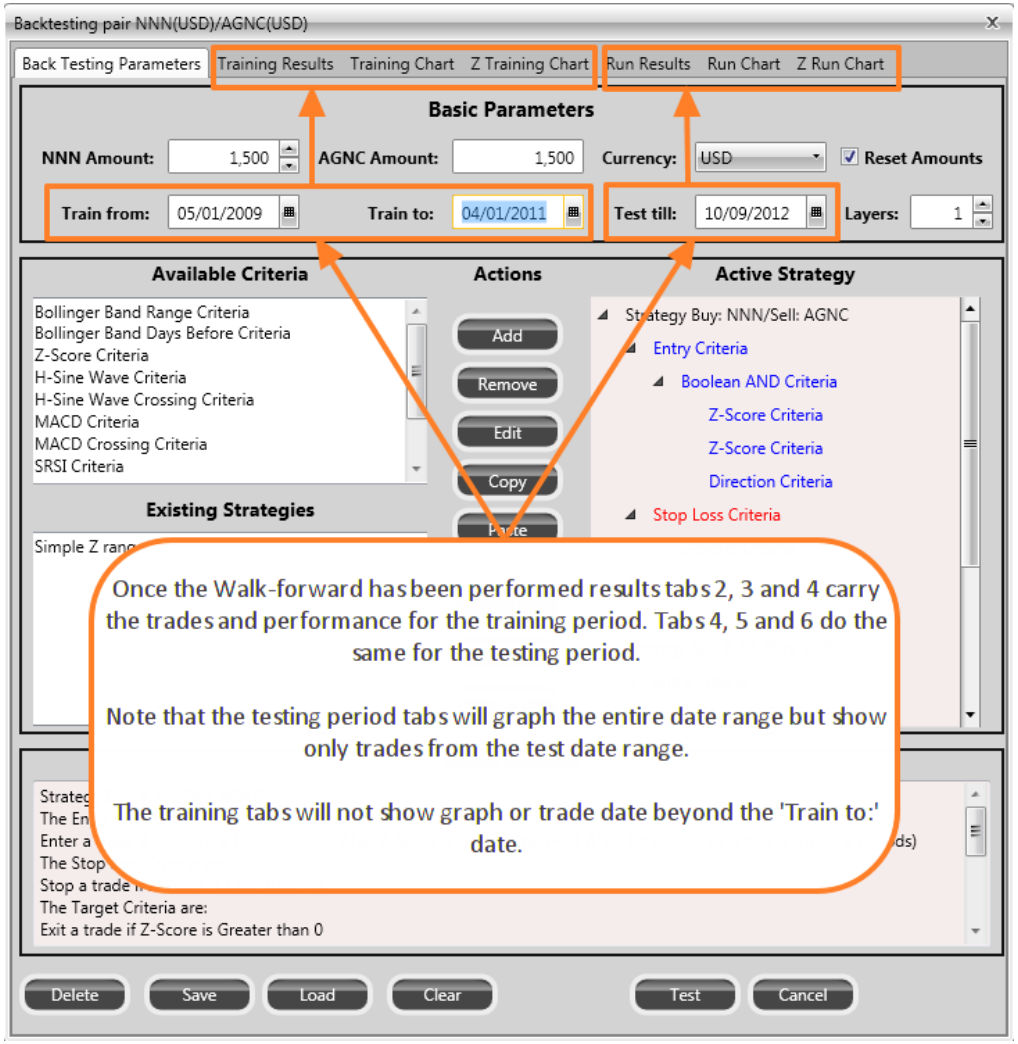
For the walk-forward method described in step (2) above it is necessary to scan for pairs in the Cointegration module using a historical date range.

For example, assume today is 10 September 2012 and an 18 month testing period is required for pairs that were trained over the date range January 2009 to January 2011. The set-up for an end-of-day scan is shown in the screen shot on the next page:

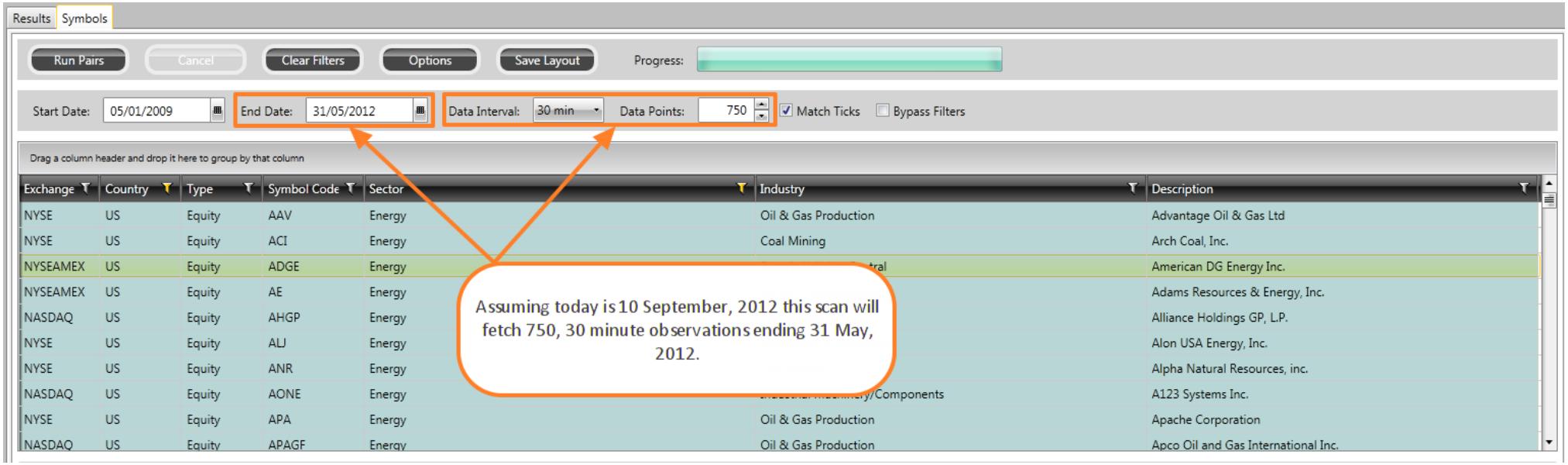


Once the scan has returned pairs the user moves those he wished to walk-forward to the Watchlist.

The next step is to open the back tester and split the Train/Test dates as shown in the following screen shot:



The process is altered for intraday walk-forward tests. It is necessary only to choose the number of observations for the historic cointegration scan and the <u>end date desired</u>. So, for example, the next screen shot shows a request for 750 observations at the 30 minute frequency level ending on 31 May, 2012:



As with the end-of-day scan the resulting pairs may then be moved to the Watchlist for the walk forward to today's assumed date, 10 September, 2012.

Note that neither Yahoo nor Google are suitable for walking forward pairs under the intra-day regime due to poor or insufficient history.

Cautionary comments:

There are a number of points to bear in mind with sampling. Perhaps most important is that although conventional wisdom suggests that weak out-of-sample results mean unreliable in-sample results this is not necessarily the case. In-sample data is not always biased to detect spurious predictability.

For example, in method (1) above splitting a sample may mean a loss of information and less predictive power. This is aggravated in samples of small size. Thus an out-of-sample test may end up falsely rejecting valid in-sample results.

There is also the difficulty in method (1) of reconciling instances where the split period used for the training turns out not to be a period over which the pair is cointegrated – hence the attraction of historical scans as described in the preceding section for method (2).

A separate consideration is the inherent bias against in-sample results on the grounds that they may inadvertently have been curve fitted or data mined. There are reasons to question the relevance of this assumption in the case of sampling cointegrated pairs – although it is true since by nature of the scanning process users will be seeking defined profiles – a form of curve fitting.

Overall, then, users might take the view that both in-sample and out-of-sample test results should be viewed as *informing* the pursuit of tradable pairs rather than one being the underwriter of the other.

Back testing results

The summary results and the trade-by-trade record are displayed as shown in this screen shot:

Backtesting pair KLIC(USD)/JBL(USD)

Back Testing Parameters | Training Results | Training Chart | Z Training Chart | Run Results | Run Chart | Z Run Chart

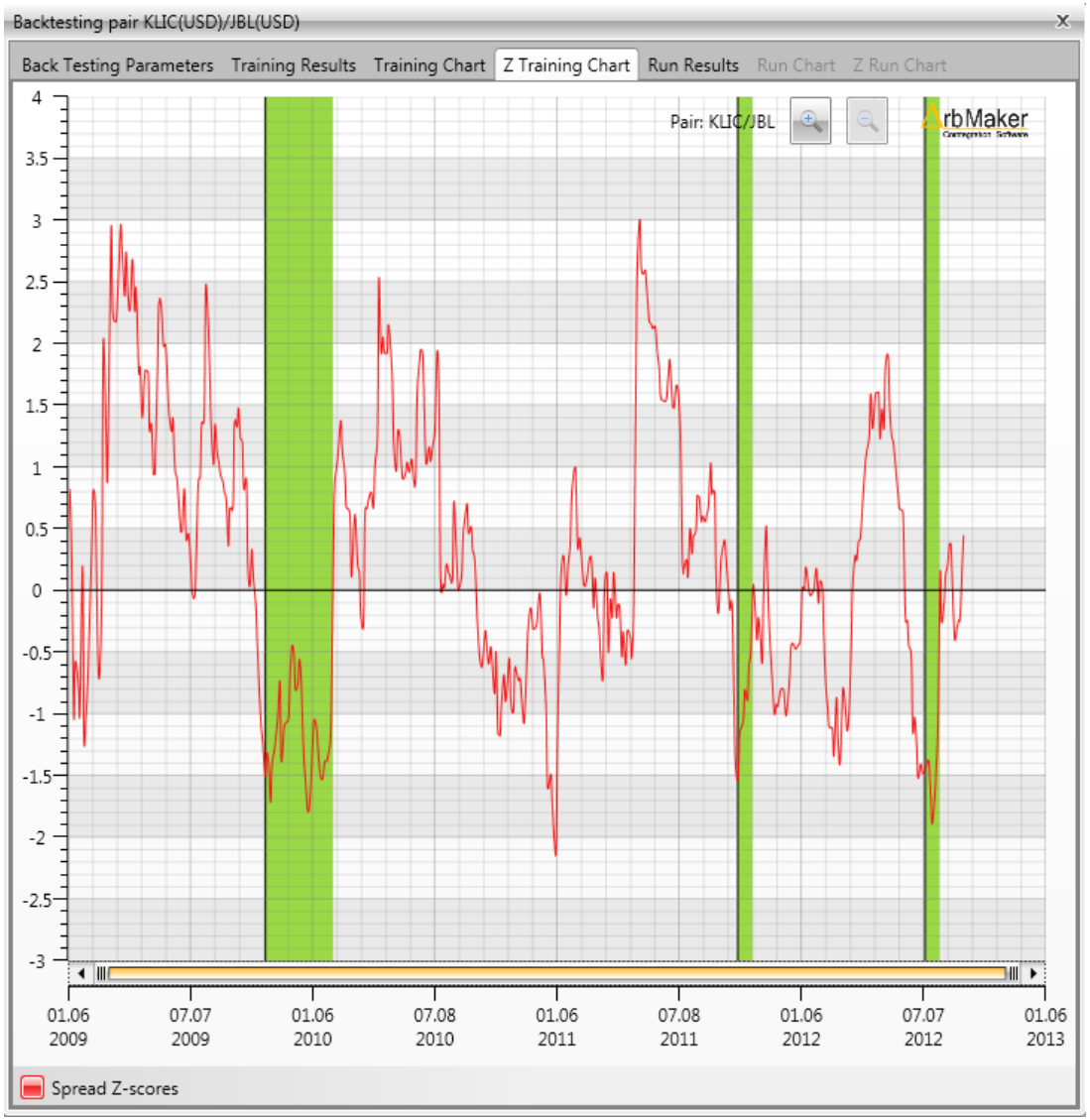
Initial Amount:	3000.00	**Largest Win:**	483.28
Total Net Profit:	1147.94	**Largest Loss:**	0.00
Total Profit per Trade:	382.65	**Average Win:**	382.65
% of Winning Trades:	100.00	**Average Loss:**	NaN
% of Losing Trades:	0.00		

Trades

Type	Net Profit	Profit	X Profit	Y Profit	X Shares	Y Shares	X Value In	X Fx Ra
BuyYSellX	483.28	488.38	29.58	458.80	102	310	14.65	1.000
BuyYSellX	393.48	397.66	-236.72	634.38	88	218	17.04	1.000
BuyYSellX	271.18	275.18	-158.08	433.26	76	174	19.62	1.000
Count: 3	Total: 1147.94 Average: 382.65	Total: 1161.22 Average: 387.07	Total: -365.22 Average: -121.74	Total: 1526.44 Average: 508.81				

These results can be copy/pasted into other applications such as Excel.

Trade entries can also be considered graphically:



Creating and testing Portfolios

Portfolios are created and tested inside 'Operations' in ArbMaker. Clicking 'Operations' takes you to the screen below (shown horizontal in ArbMaker). You may:

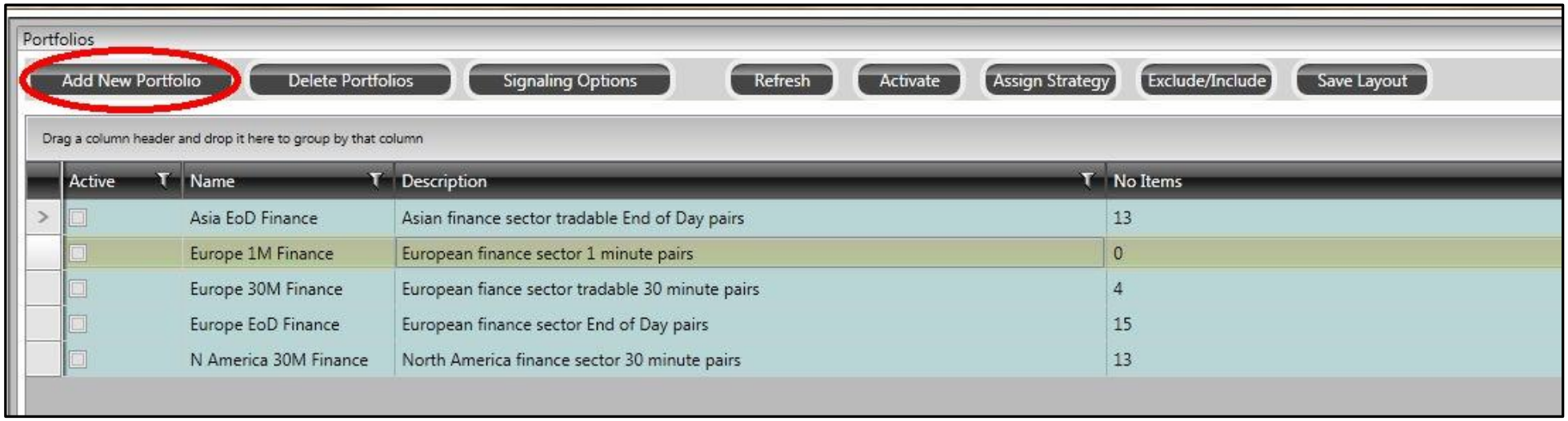
- Create several portfolios; however, you can only activate and test one portfolio at a time
- Add an unlimited number of pairs or items into a portfolio

Clicking 'Portfolios' takes you to the blank portfolio screen below:

Create portfolios

- Click "Add New Portfolio"
- Type the portfolio name in the 'Name' field --> Press <Enter> and type a short description of the portfolio (if you wish) in the 'Description' field--> Press <Enter>
- ArbMaker will create the new portfolio

The ArbMaker screen below show portfolios created and assigned with pairs from different global markets, and high and low frequencies of scanned pairs in the 'Finance' sector using the steps above.

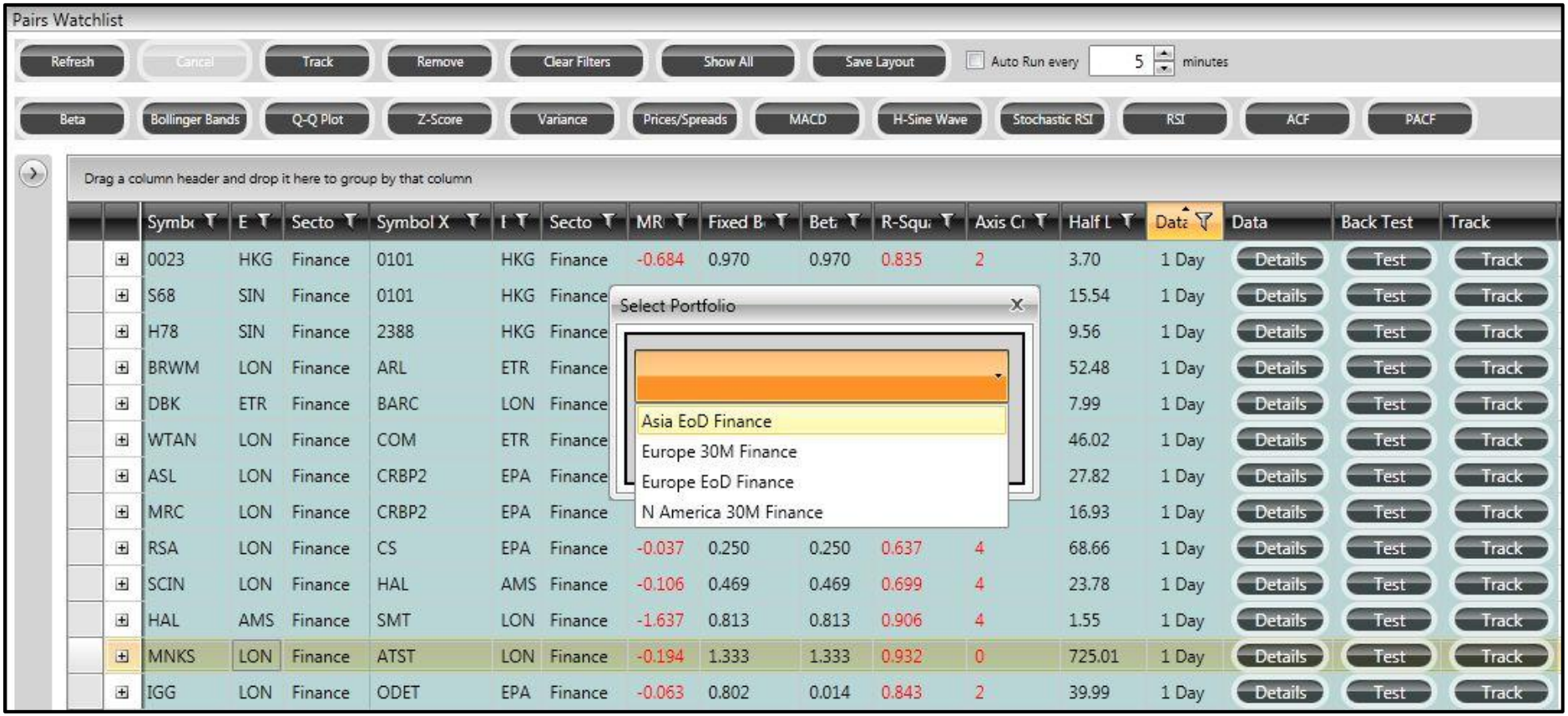


Add pairs to portfolios

To add pairs to a portfolio from the Watchlist.

- Inside the Watchlist click “Track” on the appropriate row - of the pair you want to include in a portfolio. It is also possible to do a batch transfer of multiple rows of pairs to a single portfolio by using the ‘Track’ button at the top of the Watchlist screen. Just select the desired rows and then click ‘Track’.
- A 'Select Portfolio' window appears. Click the down arrow and select the portfolio to which the pairs are to be added
- Click 'OK' - ArbMaker adds the pair to the portfolio you selected

A pair or symbol can be allocated to multiple portfolios. Below, the pair 0023/0101 is being moved to the 'Asia EoD Finance' portfolio from the Watchlist:



Click the “Refresh” button to update the number of items in each portfolio.

Back test a portfolio

The portfolio tester works from the bottom up. That is, pairs you back test individually in the Watchlist (as described in the previous section) ‘remember’ the back tester parameters you assigned to them. Such pairs, when moved to a portfolio, will carry the strategy assigned in the Watchlist to the portfolio. Pairs moved into a portfolio that have not been back tested in the Watchlist may be back tested directly inside the portfolio.

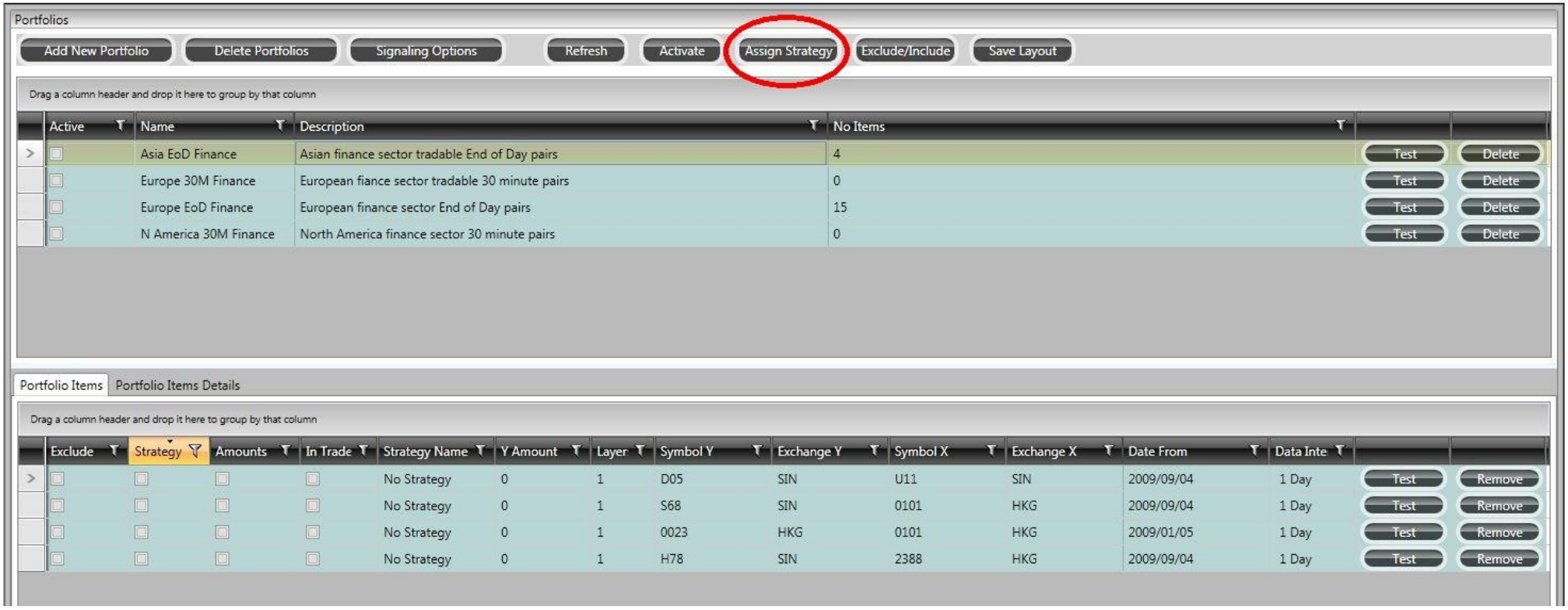
Assigning a portfolio-wide strategy

Each pair in a portfolio must have a trading strategy before the portfolio can be **back** or **market** tested. Strategies may be assigned to individual pair in the Watchlist. If, however, you want to assign one strategy to all the pairs in a portfolio, ArbMaker assists you with entering the strategy, i.e., ArbMaker will help you if you want to assign one strategy to all the pairs in a portfolio:

- Go->Portfolios->Select the Portfolio->Assign Strategy

Note the following:

- None of the pairs in the highlighted portfolio, 'Asia EoD Finance' has been assigned a strategy in the Watchlist
- The bottom pane of the portfolio window shows the pairs in the portfolio



- If you have existing strategies, ArbMaker will present a window with all the existing strategies (See 'Add Pairs to a Portfolio).
- Click the down arrow and select the strategy you want to assign to the portfolio
- Click 'OK'

- A strategy named 'Simple X' strategy has been assigned to the 'Asia EoD Finance' portfolio
- Note the bottom pane has the strategy name and a list of the items in the highlighted 'Asian EoD Finance' portfolio in the 'Portfolio Items' tab. This strategy name can be changed manually and moves with the pair to the Trades tab.
- You may access more detailed information about the items in the 'Portfolio Items Details' tab

Back testing a portfolio

You can back test a portfolio in ArbMaker. Before you back test a portfolio, you must be sure that all individual items in the portfolio are assigned a strategy

- If you have assigned a strategy to a pair in the Watchlist and also back tested the item there, the pair will carry this information when assigned to a portfolio - you may also change a pair's strategy inside a portfolio - make sure you back test the individual pair if you do
- If all the items or pairs assigned to a portfolio have been individually back tested in the Watchlist, the created portfolio is ready for a portfolio back test
- If you have assigned a portfolio level strategy inside 'Portfolios', your portfolio is also ready for a portfolio back test if the pairs are configured under a time-varying regime (ie: DESP or Kalman). If they are using a fixed beta they will have to be run individually to assign the correct amounts to each side of the pair prior to testing inside a portfolio.

To back test a portfolio

- Click the 'Test' button on the portfolio to bring up the next window below (note the name of the portfolio on the top left corner of the window)

The window shows all the items in the portfolio and the amounts allocated to each half of the pair

Before you click 'Test' on the dialogue box to actually analyze the selected portfolio make sure that:

- the pairs you want are inside the portfolio
- each strategy box is ticked
- the pairs are all from the same date interval (1 min/5 min/15 min/30 min/1 Hour/1 Day). Mixed resolutions will not be processed

When you click “Test” on the window below, ArbMaker back tests the entire portfolio using the individual criteria applied by the user to each pair:

Backtesting portfolio Asia EoD Finance

Portfolio Testing Parameters | Portfolio Summary Results | Portfolio Ratios Results | Equity Curve

Basic Parameters

Portfolio Total Amount: 80153 **Start Date:** 05/01/2009 **End Date:** 12/09/2012

Portfolio Base Currency: USD ☑ **Reset Initial Amount**

Strategy	Symbol Y	Exchange Y	Y Amount	Y Lots	Symbol X	Exchange X	X Amount	X Lots
☑	0939	HKG	5000.00	0.00	0016	HKG	5000.00	0.00
☑	0001	HKG	5000.00	0.00	0011	HKG	5000.00	0.00
☑	0004	HKG	5000.00	0.00	0023	HKG	5000.00	0.00
☑	0023	HKG	5000.00	0.00	0101	HKG	5153.00	0.00
☑	0023	HKG	5000.00	0.00	0005	HKG	5000.00	0.00
☑	0101	HKG	5000.00	0.00	0016	HKG	5000.00	0.00
☑	0939	HKG	5000.00	0.00	0101	HKG	5000.00	0.00
☑	0101	HKG	5000.00	0.00	0019	HKG	5000.00	0.00

Test Cancel

The next three screens below give the results for a portfolio back test with an array of performance ratios/measures:

Backtesting portfolio Asia EoD Finance

Portfolio Testing Parameters | Portfolio Summary Results | Portfolio Ratios Results | Equity Curve

Initial Amount:	10341.26	**Largest Win:**	454.32
Total Net Profit:	1969.49	**Largest Loss:**	0.00
Total Profit per Item:	246.19	**Average Win:**	246.19
% of Winning Items:	100.00	**Average Loss:**	NaN
% of Losing Items:	0.00	**Commissions:**	17.59

Portfolio Items | Portfolio Trades

Item	Initial Amoun	Trades	Net Profit	Commissi	Profit/Tra	% Of Win	% Of Loss	Largest W	Largest Lo	Average
0939/001	1290.19	4	274.78	5.22	68.69	100.00	0.00	81.988	0.00	68.694
0001/001	1290.19	5	312.05	2.58	62.41	100.00	0.00	95.721	0.00	62.411
0004/002	1290.19	2	97.74	1.03	48.87	100.00	0.00	53.892	0.00	48.871
0023/010	1309.93	4	454.32	2.11	113.58	100.00	0.00	162.959	0.00	113.580
0023/000	1290.19	3	313.10	1.76	104.37	66.67	33.33	200.374	-18.26	165.679
0101/001	1290.19	2	155.35	1.07	77.67	100.00	0.00	89.228	0.00	77.674
0939/010	1290.19	2	250.70	2.77	125.35	100.00	0.00	132.335	0.00	125.350
0101/001	1290.19	2	111.45	1.06	55.73	100.00	0.00	104.877	0.00	55.727

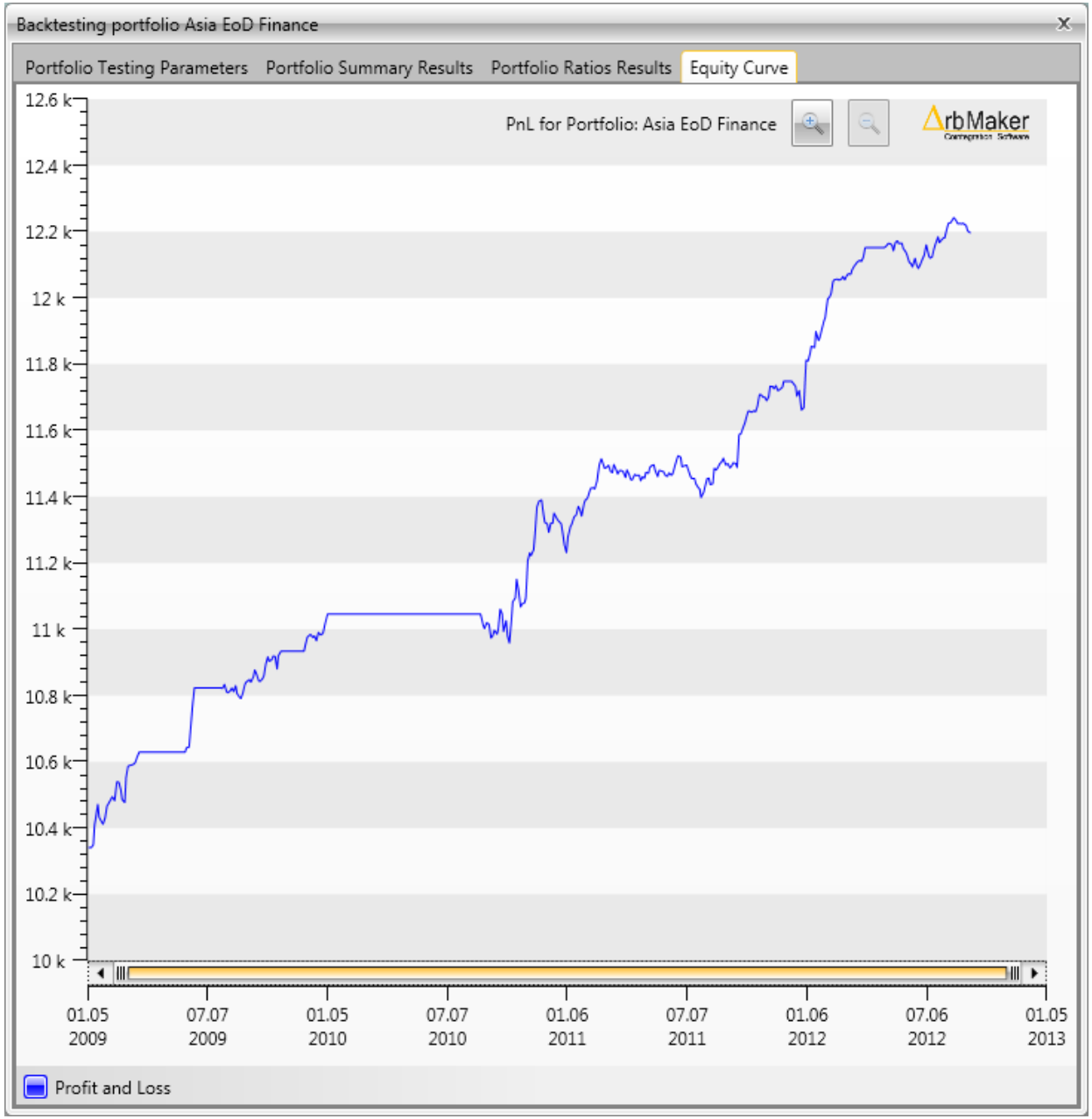
Backtesting portfolio Asia EoD Finance

Portfolio Testing Parameters | Portfolio Summary Results | Portfolio Ratios Results | Equity Curve

Kurtosis:	12.227	**Sharpe Ratio:**	0.112
Skewness:	1.477	**Sharpe Ratio:**	0.200
Omega:	1.510	**Upside Potential:**	0.592
Calmar Ratio:	0.011	**Stutzer Index:**	0.000
Jensen's Alpha:	0.017	**Information Ratio:**	-0.028
Beta:	0.002	**Treynor:**	8.206
Drawdown:	1.58		

PnL and Index

Date	PnL Value	PnL Ratio	Index Value	Index Ratio
05, Jan, 2009	10341.26	0.000	927.45	0.000
06, Jan, 2009	10341.26	0.000	934.70	0.782
07, Jan, 2009	10341.26	0.000	906.65	-3.001
08, Jan, 2009	10341.26	0.000	909.73	0.340
09, Jan, 2009	10341.26	0.000	890.35	-2.130
12, Jan, 2009	10341.26	0.000	870.26	-2.256
13, Jan, 2009	10341.26	0.000	871.79	0.176
14, Jan, 2009	10356.84	0.151	842.62	-3.346
15, Jan, 2009	10383.07	0.253	843.74	0.133
16, Jan, 2009	10434.19	0.492	850.12	0.756
20, Jan, 2009	10474.96	0.130	805.22	-5.282
21, Jan, 2009	10468.26	-0.064	840.24	4.349


Backtesting portfolio Asia EoD Finance
Portfolio Testing Parameters
Portfolio Summary Results
Portfolio Ratios Results
Equity Curve
PnL for Portfolio: Asia EoD Finance
ArbMaker
12.6 k
12.4 k
12.2 k
12 k
11.8 k
11.6 k
11.4 k
11.2 k
11 k
10.8 k
10.6 k
10.4 k
10.2 k
10 k
01.05 2009
07.07 2009
01.05 2010
07.07 2010
01.06 2011
07.07 2011
01.06 2012
07.06 2012
01.05 2013
Profit and Loss

Some comments:

- For measures such as “Largest Win:” the data is shown at the pair level. Thus $454.32 in this case corresponds to the pair (not trade) with the largest total profit
- Daily returns data is under the “P&L and Index Values”
- For intra-day tests we do not display an equity curve nor portfolio ratios
- The risk free rate being used to generate the Sharpe is that of the 13 week US T-bill
- The modified VaR (to be added) is calculated at the 95% confidence interval
- The default threshold rate, where applicable to a performance ratio, is also the 13 week US T-Bill rate.
- Portfolio tests of this size will take ~1 minute to compute over three year date ranges
- When looking at the Sharpe ratio in these shot bear in mind that Sharpe assumes normally distributed returns – the skew and kurtosis show the returns are not normally distributed!

The glossary in Appendix F includes definitions of the ratios included in ArbMaker.

Market test a portfolio

In addition to a **back test** of your portfolio, ArbMaker will **market test** your portfolios during a trading day. Market testing uses parameters and strategies in each pair in a portfolio to signal entry into and exit from trades. It also calculates profit/loss from the entry and exit using prices at the time entry and exit criteria are executed. If applicable, fx rates are also included in the process.

In short, the back tester looks at the past data on a pair to calculate a portfolio's trade metrics or parameters; however, market tester uses live market data on a pair and sends buy/sell signals using the parameter and strategies you have set on each pair inside the Watchlist or Portfolio.

Market testing is accomplished in the **Portfolios, Tracker and Trade** tabs in ArbMaker Operation. It starts with activating a portfolio inside 'Portfolio', continues with tracking items inside 'Tracker', and ends with closing a position in 'Trades'

To activate a portfolio:

1. Follow the instructions in "Create portfolios" and "Add symbols or pairs to portfolios" above.
2. Make sure you have set trading strategies for each pair in the portfolios you want to market test.

1. Activate a Portfolio

When the **market or markets** of the pairs in your portfolio, you activate the portfolio with the following steps to market test it:

- Go to the 'Portfolios' tab
- Select the portfolio you want to activate (click anywhere on the row of the portfolio except on the 'Test' or 'Delete' buttons)
- Click the 'Activate' button
- Go to the 'Tracker' tab to keep track of your active portfolio or items

After you assign a strategy at portfolio level you can activate the portfolio for a market test without a back test; ArbMaker will automatically run a market test of the strategies

Only one portfolio may be active at any time; however, in-trade-items may come from several portfolios which may have been activated at different times. When the market closes, there will be no further signals for pairs from that market. This means the 'Active Portfolio' and 'In trade Items' tabs will not update.

Save Layout | Beta | Bollinger Bands | Q-Q Plot | Z-Score | Variance | Prices/Spreads | MACD | H-Sine Wave | Stochastic RSI | RSI | ACF | PACF

Active Portfolio

Active portofolio is: Europe 1

Auto Run every 10 minutes Refresh Exclude Items that fail 99% Cointeg

Drag a column header and drop it here to group by that column

Symbol	Excha	Symb	Excha	Fixed B	Pro			Sig	Data	Trade
SL	LON	POH1S	HEL	0.478	0.33	At	At	No Acti	Details	Trade
CBG	LON	ALV	ETR	1.019	0.31	At	Ol	No Acti	Details	Trade
ACA	EPA	DBK	ETR	1.009	0.70	At	At	No Acti	Details	Trade
BDB	BIT	JUP	LON	1.142	1.33	Ol	At	No Acti	Details	Trade
HSBA	LON	GSS	LON	1.161	0.30	At	At	No Acti	Details	Trade
DBK	ETR	CS	EPA	1.842	1.50	At	At	No Acti	Details	Trade
ICP	LON	ARL	ETR	0.548	0.41	At	At	Action S	Details	Trade
OML	LON	AFKS	MCX	0.000	0.00	At	At	No Acti	Details	Trade
PCT	LON	EXO	BIT	0.700	0.29	Ol	Ol	No Acti	Details	Trade
AV	LON	POH1S	HEL	0.826	0.38	At	At	No Acti	Details	Trade
ARL	ETR	BARC	LON	0.565	0.74	At	At	No Acti	Details	Trade
CBG	LON	STJ	LON	0.850	0.40	Ol	Ol	No Acti	Details	Trade
HSBA	LON	ALV	ETR	0.831	0.18	At	At	No Acti	Details	Trade
MF	EPA	RF	EPA	1.196	0.54	At	At	No Acti	Details	Trade
RBS	LON	ACA	EPA	0.772	0.86	At	At	No Acti	Details	Trade
RBS	LON	DBK	ETR	0.838	0.72	At	At	Action S	Details	Trade

Select Columns

Count: 16 Max: 1.842 Min: 0.000

Buy 1585.00 shares/lots of symbol UBI for: 3.1540 & Sell 900.00 shares/lots of symbol ACA for: 5.5550 on the 2012/09/10 12:59:07 PM
Buy 1557.00 shares/lots of symbol SDA1V for: 3.2100 & Sell 490.00 shares/lots of symbol PRU for 1500 on the 2012/09/10 04:15:13 PM

Errors Signals

In Trade Items

Open Items

Auto Run every 1 minutes Refresh

Drag a column header and drop it here to group by that column

Status	Symb	Symb	Fixed B	Bet	Profitab	Sign	Data	Close Trade
Executed	ACA	UBI	1.323	1.735	1.05	Action Si	Details	Close
Executed	ICP	ARL	0.548	0.173	0.42	No Actio	Details	Close
Executed	SDA1V	PRU	0.786	0.401	0.52	No Actio	Details	Close
Executed	RBS	DBK	0.847	0.078	0.73	No Actio	Details	Close

Select Columns

Count: 4 Max: 1.323 Min: 0.548 Max: 1.7 Min: 0.0

Buy 900.00 shares of symbol ACA for 5.53 & Sell 1585.00 shares of symbol UBI for 3.16 on the 2012/09/10 04:50:38 PM

Errors Signals

Items with a market signal are removed from the 'Active Portfolio' pane of the 'Tracker' window to the 'Open Items' pane. They will remain there until the exit conditions are met. The items are also recorded in the 'Trades' tab.

When <u>entry</u> conditions in the strategy of a pair are met in the 'Active Portfolio,' pane, ArbMaker generates a signal to open a market position.

When the <u>exit</u> conditions in the strategy of a pair are met in the 'In Trade Items' pane ArbMaker generates a signal to close a market position.

2. Track your Portfolio/Portfolios (See window above)

The Tracker keeps up with active portfolios and items inside the 'Active Portfolio' and 'In Trade Items' panes. The process flow between the 'Active Portfolio' and 'In Trade Items' tabs is described below:

- All the pairs in an activated portfolio are moved to the Portfolio 'Tracker' screen, shown above
- Inside 'Tracker' are two main panes, 'Active Portfolio' and 'In Trade Items' panes
- You may resize the two panes with: -> Left Click and hold a point in the middle of the two panes -> Move left or right to resize

The main activities in Tracker are handled as follows:

1. When the entry conditions in a pair's strategy are met, a signal is generated in "Active Portfolio" to **open a position**.
2. The pair becomes an 'Open Item' and it is moved to the 'In Trade Items' pane on refresh.
3. You may refresh the two panes either manually by clicking 'Refresh', or automatically by checking the <Auto Run Every> checkbox and setting the number of minutes - activated pairs is transferred from the "Active Portfolio" pane to the "In Trade Items" on refresh.
4. The pair remains an 'Open Item' until its exit criteria are met. When that happens a signal is also generated to **close a position**.

Important note: if an 'Open Item' falls out of cointegration it will no longer be updated. The next release of ArbMaker will correct this.

3. Close Your Trades

Active trades in 'In Trade Items' pane are recorded and closed in the 'Trades' tab.

(i) Open Trades

- Click 'Trades' to open the Trades tab in ArbMaker
- The tab opens to 'Open Trades', shown below (the trades here are also shown in the 'In Trade Items' pane above)

The 'Trades' pane inside the 'Trades' tab shows constantly changing profitability of a pair in accordance with its strategy.

Refresh Trades | Delete | Active | Start Date: 05/01/2009 | End Date: 10/09/2012 | PnL: 398.29 | Show PnL

Open Trade | Closed Trades

Drag a column header and drop it here to group by that column

Instrumei	Type	Symbol Y	Symbol X	Strategy Name	Profit	Net Profit	X Shares/Lots	Y Shares/Lots	Commission X In	Commission Y In	In Date	Out Date
Equity	BuyYSellX	MTL	GREK		231.12	226.56	113.00	256.00	1.00	1.28	06 September 2012 3:39 PM	07 September 2012
Equity	BuyYSellX	KN	APR	From Import	145.36	115.08	107.00	691.00	7.55	7.55	24 August 2012 9:04 AM	07 September 2012
Equity	BuyXSellY	FR	SIPH	From Import	27.48	-2.78	23.00	39.00	7.54	7.54	30 August 2012 11:58 AM	07 September 2012

(ii) Closed Trades

- Click 'Trades' to open the Trades tab in ArbMaker
- The tab opens to 'Open Trades', shown above (the trades here are also shown in the 'In Trade Items' pane above)
- Click 'Closed Trades' inside the 'Trades' tab to see closed trades
- You can Click <Close Trade> 'In Trade Items' pane to force a trade to close before the exit strategy

Refresh Trades | Delete | Active | Start Date: 05/01/2009 | End Date: 11/09/2012 | PnL: | Show PnL

Open Trades | Closed Trades

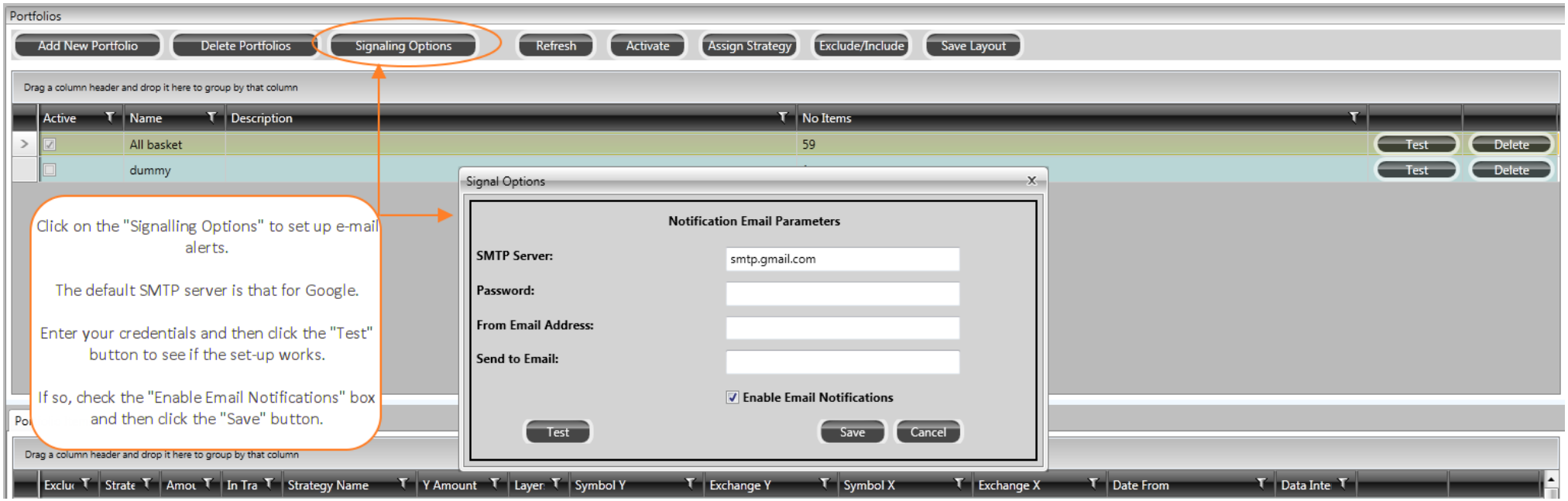
Drag a column header and drop it here to group by that column

Instrumei	Type	Symbol Y	Symbol X	Strategy Name	Profit	Net Profit	X Shares/Lots	Y Shares/Lots	In Date	Out Date
Equity	BuyXSellY	ATRC	OXBT		118.39	98.30	1796.00	213.00	05 September 2012 6:28 PM	06 September 2012 5:03 PM
Equity	BuyYSellX	CE	APR	From Import	207.92	177.81	107.00	489.00	23 August 2012 4:31 PM	30 August 2012 12:52 PM
Equity	BuyXSellY	AT	KBCA	From Import	152.44	122.19	208.00	261.00	27 August 2012 9:52 AM	07 September 2012 11:17 AM

Inside the 'Trades' tab:

- You can 'Refresh Trades' to bring both tabs up-to-date
- Refresh profit/loss by clicking 'Show P&L' to bring it up-to-date - this is only for 'Open Trades'

Set up email alerts for entry and exit signals

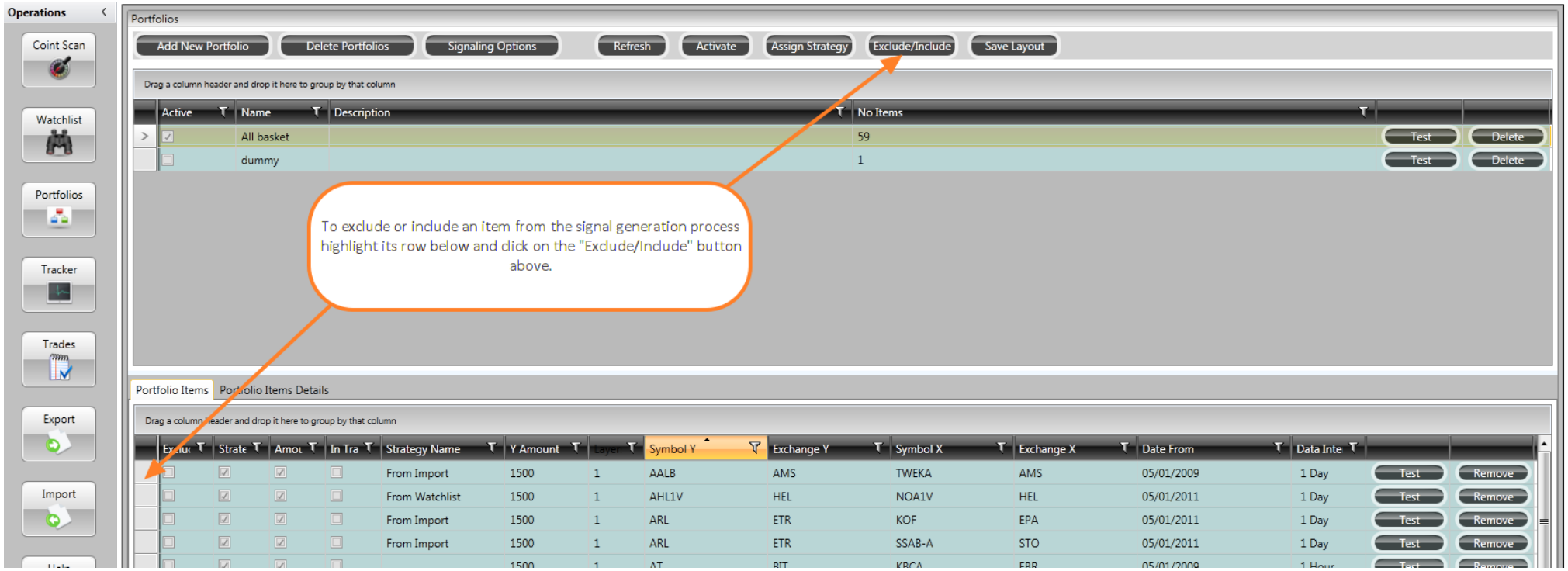


Excluding from the portfolio items that fail 99% cointegration

When running auto updated portfolios it may be useful to have the system automatically exclude from the signal generation process pairs that fall out of 99% cointegration. This is done by simply selecting checking the 'Exclude items that fail 99% cointegration' box shown in the screen shot below:

The 'Exclude items that fail 99%' button has been made automatic – it retests items that fail and re-marks them as tradable if they once again pass at 99%. Why is this useful? It means that an Active Portfolio list can take account of pairs that may be showing signs of breakdown and exclude them from the trading signals algorithms.

In cases where users wish to temporarily exclude an item for other reasons – for example, during earnings announcements – pairs can be disabled from trading signal generation by following the process set out in the following screen shot.

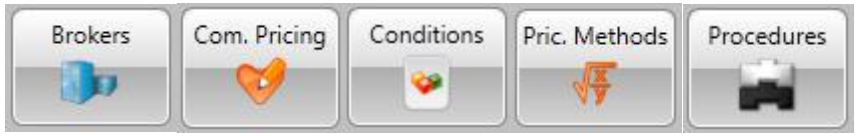


A word of caution on Foreign Exchange (Fx Rates) in the 'Trades' tab

Issues may arise with Google's foreign exchange rates which we use for non-trading tasks in the software's reporting functions. We have seen on completed trades (meaning the 'Active' box of a pair is unchecked) calls to the Google foreign exchange database sometimes will not return data. In these cases ArbMaker will use a value of '1' in the 'X Fx Value' and Y Fx value' fields. This can cause spectacular looking P&L results. To fix:

1. Obtain the correct foreign exchange from a credible data source and manually enter it into the correct foreign exchange (Fx Rate) row inside 'Trades'
2. Click 'Refresh Trades': the P&L will update with refresh to take the manual edit into account

Commissions



To help you obtain a realistic P&L (profit/loss) from the back and market tests; or to provide a more reasonable assessment of the outcome from the back and market tests, ArbMaker calculates the P&L net of commissions. ArbMaker uses the exact (at the time of release) commission structure of Interactive Brokers (IB) in its default calculation.

The methodology on calculating commissions is based on setting between one and seven conditions that capture commission charges by a broker in an equity market. The default values of the conditions in ArbMaker are based on IB's charges. But they are not defined for all equity markets around the world, so ArbMaker includes the flexibility to add a new **procedure** for an equity market that is not defined in the default or to use the base conditions to define a new **broker**.

Please note that you may not change the seven base conditions. These cover most of the commission structures across brokerages. If you require additional conditions please contact us. The seven conditions are:

Commission pricing method conditions
(i) Flat fee
(ii) Minimum price
(iii) Maximum price
(iv) Maximum price over threshold
(v) Percentage of total
(vi) Price per item
(vii) Stamp duty (%)

Suppose you want to add a procedure for Mexican equities (which is deliberately not in the default settings for the purposes of this example); and also want to define a new broker. Further, let's assume that the commission structure on Mexican equities is one of "Minimum price" and "Percentage of Total" or items (i) and (v) in the table above. The buttons shown at the top of this section, under the 'Symbol Management' screen, guide you through the process.

1. If you are adding a new broker: Go -> Symbol Management->Brokers ->Add New Broker.
    - Add a 'Broker Code', 'Broker Name' and 'Additional Information'. You may use names or labels that make sense to you – this is for reference purposes
2. Go -> Symbol Management->Procedures ->Add New Procedure.
    - Add a Procedure Code/Name, for e.g., MEXT/"Mexico stocks" (if Mexico stocks are traded with a different broker from IB, you might include a suffix the name or abbreviation of the broker to MEXT)
3. Go -> Symbol Management->Pric. methods->Add New Method
    - Enter the value for each condition used on commissions in the trading jurisdiction - use drop downs in 'Procedures' and 'Condition' to choose condition and enter the appropriate data in Date To, Amount From, Amount To and Value; repeat for all the conditions related to the jurisdiction or broker. For example, Mexico set the "Minimum price" and "Percentage of total" commission. The UK has, among others, the unique condition of the "Stamp duty (%)".
4. Finish in Com. Pricing, Go-> Symbol Management->Com. Pricing->Add New Com. Pricing
5. Assign Broker-Exchange-Pricing Method from drop downs. If your 'Exchange' does not appear in the list, Go-> Symbol Management->Exchanges->Add New Exchange and fill in the values of the fields.

FX pairs and ArbMaker

Running Forex pairs in ArbMaker differs from equities in critical ways. An overriding consideration is that pip factors in some pairs (only crosses in our experience) can vary between brokers. This is not a reference to differences in minimum quote movements. Some broker quote prices to five places for, say USDGBP, and others four.

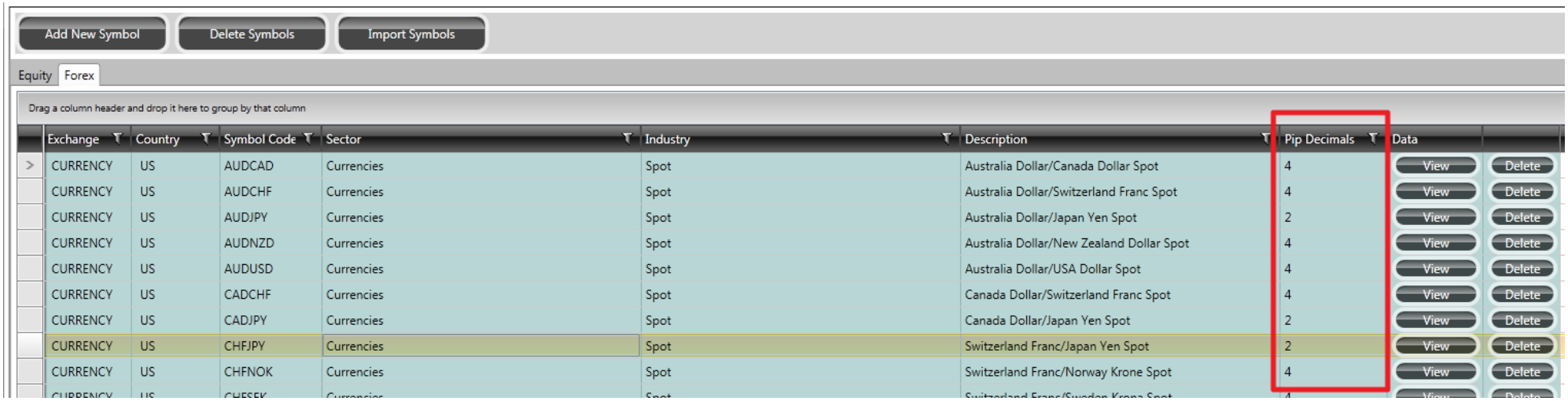
The difference here applies to the pip factor. For USDGBP it is, for example, 0.0001 a factor we have never seen vary. USDJPY is 0.01. These are well known examples.

However, for some pairs (NOKJPY is one, TRYJPY and USDMXN others) the pip factor is not cited consistently between brokers. Possibly their published spec sheets for pip factors may contain errors; or may reflect genuine differences for whatever curious reason. Either way **it is critical that users confirm the product specification of their broker in regard to pip factors before relying on results.** The pip factor impacts margin, profit and volume calculations.

For this reason the pip factors in ArbMaker are user-adjustable. The defaults can be seen by going to:

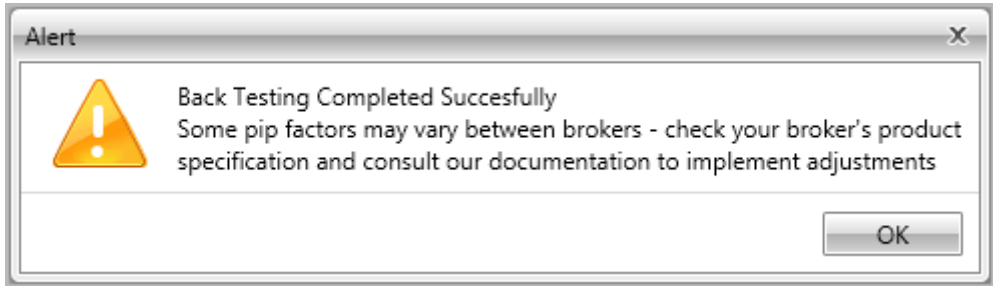
Symbol Management->Symbols->Forex

and are defined in the "Pip Decimals" column – see the screen shot below. Thus if your broker uses 0.001 for NOKJPY the entry to make is "3" for three decimal places. If the broker uses 0.0001 the entry would be "4".



Exchange	Country	Symbol Code	Sector	Industry	Description	Pip Decimals	Data	
CURRENCY	US	AUDCAD	Currencies	Spot	Australia Dollar/Canada Dollar Spot	4	View	Delete
CURRENCY	US	AUDCHF	Currencies	Spot	Australia Dollar/Switzerland Franc Spot	4	View	Delete
CURRENCY	US	AUDJPY	Currencies	Spot	Australia Dollar/Japan Yen Spot	2	View	Delete
CURRENCY	US	AUDNZD	Currencies	Spot	Australia Dollar/New Zealand Dollar Spot	4	View	Delete
CURRENCY	US	AUDUSD	Currencies	Spot	Australia Dollar/USA Dollar Spot	4	View	Delete
CURRENCY	US	CADCHF	Currencies	Spot	Canada Dollar/Switzerland Franc Spot	4	View	Delete
CURRENCY	US	CADJPY	Currencies	Spot	Canada Dollar/Japan Yen Spot	2	View	Delete
CURRENCY	US	CHFJPY	Currencies	Spot	Switzerland Franc/Japan Yen Spot	2	View	Delete
CURRENCY	US	CHFNOK	Currencies	Spot	Switzerland Franc/Norway Krone Spot	4	View	Delete

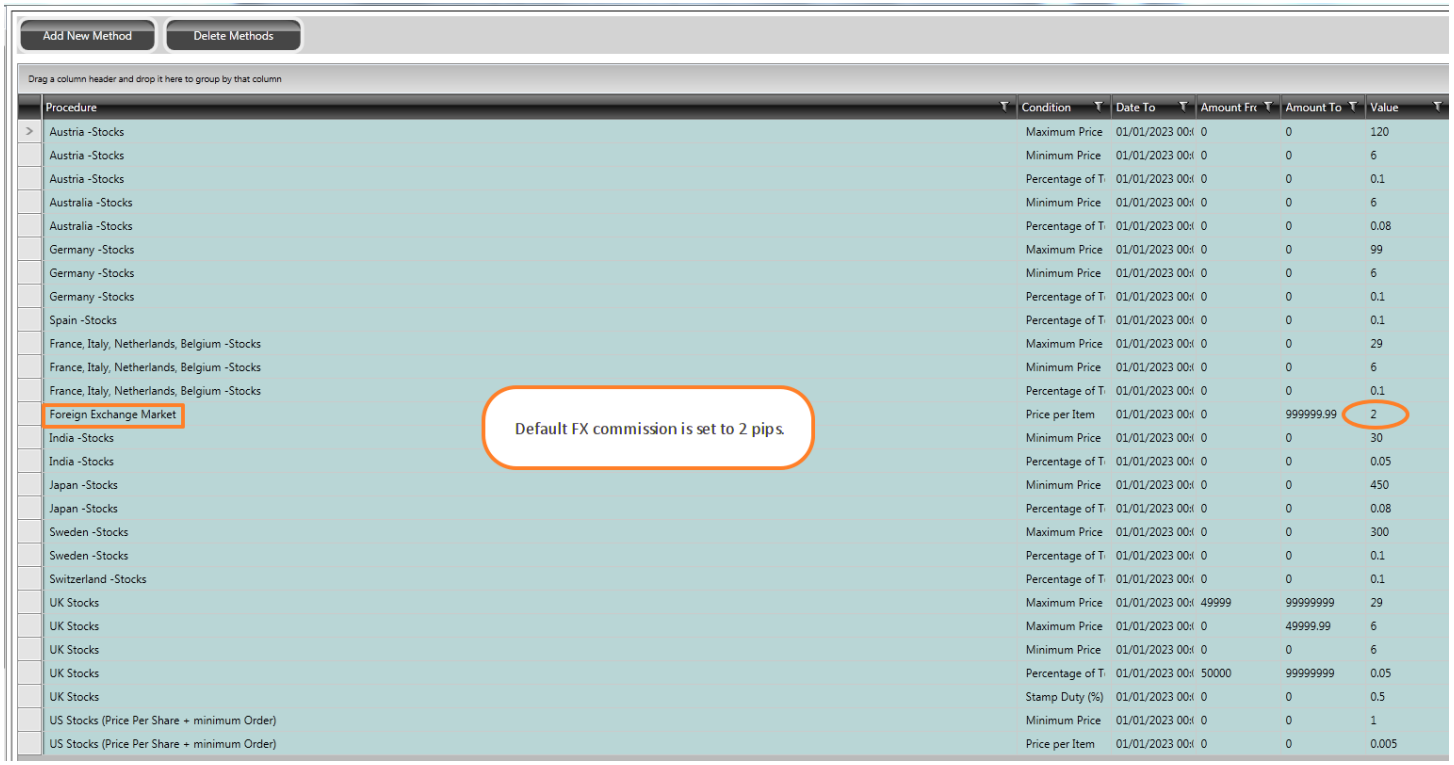
We consider the setting of the pip factors so important we have implemented the following pop-up warning in the software reminding users to check them:



<u>Sole responsibility and liability for 'Pip Decimal' values - whether the default values or user edits – rests with the user</u>.

Broker charges

FX commission is set by default to 2 pips in Symbol management->Pric. Methods:



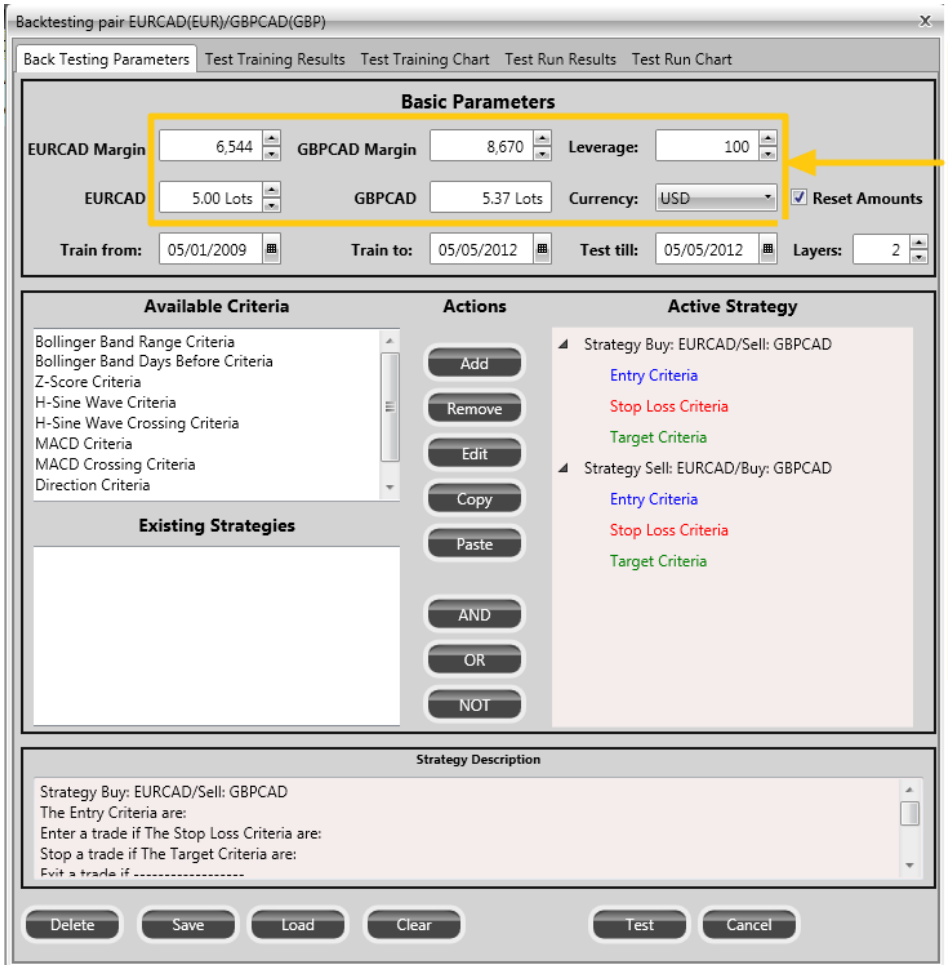
Procedure	Condition	Date To	Amount Fr	Amount To	Value
Austria -Stocks	Maximum Price	01/01/2023 00	0	0	120
Austria -Stocks	Minimum Price	01/01/2023 00	0	0	6
Austria -Stocks	Percentage of T	01/01/2023 00	0	0	0.1
Australia -Stocks	Minimum Price	01/01/2023 00	0	0	6
Australia -Stocks	Percentage of T	01/01/2023 00	0	0	0.08
Germany -Stocks	Maximum Price	01/01/2023 00	0	0	99
Germany -Stocks	Minimum Price	01/01/2023 00	0	0	6
Germany -Stocks	Percentage of T	01/01/2023 00	0	0	0.1
Spain -Stocks	Percentage of T	01/01/2023 00	0	0	0.1
France, Italy, Netherlands, Belgium -Stocks	Maximum Price	01/01/2023 00	0	0	29
France, Italy, Netherlands, Belgium -Stocks	Minimum Price	01/01/2023 00	0	0	6
France, Italy, Netherlands, Belgium -Stocks	Percentage of T	01/01/2023 00	0	0	0.1
Foreign Exchange Market	Price per Item	01/01/2023 00	0	999999.99	2
India -Stocks	Minimum Price	01/01/2023 00	0	0	30
India -Stocks	Percentage of T	01/01/2023 00	0	0	0.05
Japan -Stocks	Minimum Price	01/01/2023 00	0	0	450
Japan -Stocks	Percentage of T	01/01/2023 00	0	0	0.08
Sweden -Stocks	Maximum Price	01/01/2023 00	0	0	300
Sweden -Stocks	Percentage of T	01/01/2023 00	0	0	0.1
Switzerland -Stocks	Percentage of T	01/01/2023 00	0	0	0.1
UK Stocks	Maximum Price	01/01/2023 00	49999	99999999	29
UK Stocks	Maximum Price	01/01/2023 00	0	49999.99	6
UK Stocks	Minimum Price	01/01/2023 00	0	0	6
UK Stocks	Percentage of T	01/01/2023 00	50000	99999999	0.05
UK Stocks	Stamp Duty (%)	01/01/2023 00	0	0	0.5
US Stocks (Price Per Share + minimum Order)	Minimum Price	01/01/2023 00	0	0	1
US Stocks (Price Per Share + minimum Order)	Price per Item	01/01/2023 00	0	0	0.005

If your broker does not load the spread change the “2” to “0”. Other structures can be set-up using the guidance in the Commissions section.

Margin

Forex margin is calculated in ArbMaker using this formula: *Standard lot size * number of lots * (base currency/reporting currency) / leverage*

For example, if ArbMaker is configured with USD as its default currency then USD is the ‘reporting currency’; and for a pair such as NZDEUR ‘NZD’ is defined as the base currency. Margin can also be manually adjusted during back testing.



The FX back tester differs from that for equities in that it includes margin and lot fields.

Y lots are set to a default of 5.

X lots are automatically calculated as a function of the Y amount, the cointegrating equation and the underlying currency ratio. The first decimal place corresponds to Mini lots; and the second to Micro lots.

Margin is a function of overall lot size and leverage. It is automatically generated. However, it can be manually adjusted also.

A comment on the drawdown calculation in the FX results:

This is not the same as for equities. Under FX drawdown is defined as the maximum loss suffered against the initial amount. For example, with an initial amount of $1,000 and a series of six trades as shown below drawdown = $-160.

Initial amount:	**1000**		
Trade	Gain/loss	Cumulative amount	Drawdown
1	-100	900	-100
2	50	950	-100
3	-100	850	-150
4	50	900	-150
5	-30	870	-150
6	-30	840	-160

Adding FX pairs to the database

The structure of the database holding forex information differs from that of equities – this is due to the addition of the pip decimal field mentioned earlier. Thus users adding symbols or creating a database as set out in our "Quick Start" section must note that the structure is this:

Country|Exchange Code|Symbol|Description|dummy value 1|dummy value 2|dummy value 3|Instrument|Type|Pip Decimal

This screen shot show a concrete example of the structure a currencies database file must follow:

Pip decimals - Notepad

File Edit Format View Help

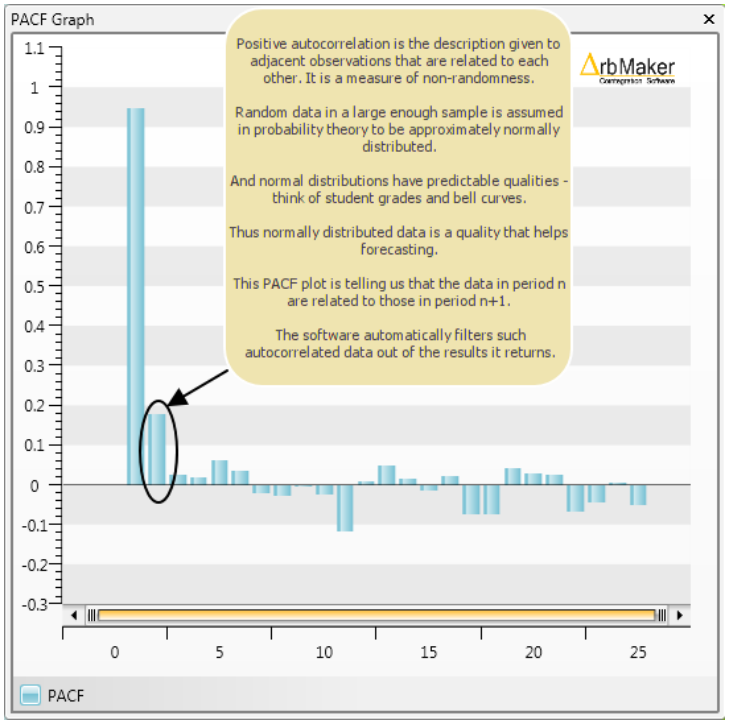
```
US|CURRENCY|AUDCAD|Australia Dollar/Canada Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|AUDCHF|Australia Dollar/Switzerland Franc Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|AUDJPY|Australia Dollar/Japan Yen Spot|1|2|3|Currencies|Spot|2
US|CURRENCY|AUDNZD|Australia Dollar/New Zealand Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|AUDUSD|Australia Dollar/USA Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|CADCHF|Canada Dollar/Switzerland Franc Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|CADJPY|Canada Dollar/Japan Yen Spot|1|2|3|Currencies|Spot|2
US|CURRENCY|CHFJPY|Switzerland Franc/Japan Yen Spot|1|2|3|Currencies|Spot|2
US|CURRENCY|CHFNOK|Switzerland Franc/Norway Krone Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|CHFSEK|Switzerland Franc/Sweden Krona Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURAUD|European Common Market Euro/Australia Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURCAD|European Common Market Euro/Canada Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURCHF|European Common Market Euro/Switzerland Franc Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURCZK|European Common Market Euro/Czech Republic Koruna Spot|1|2|3|Currencies|Spot|3
US|CURRENCY|EURDKK|European Common Market Euro/Denmark Krone Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURGBP|European Common Market Euro/United Kingdom Pound Sterling Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURHUF|European Common Market Euro/Hungary Forint Spot|1|2|3|Currencies|Spot|2
US|CURRENCY|EURJPY|European Common Market Euro/Japan Yen Spot|1|2|3|Currencies|Spot|2
US|CURRENCY|EURNOK|European Common Market Euro/Norway Krone Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURNZD|European Common Market Euro/New Zealand Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURPLN|European Common Market Euro/Poland New Zloty Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURSEK|European Common Market Euro/Sweden Krona Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURTRY|European Common Market Euro/Turkey Lira Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|EURUSD|European Common Market Euro/USA Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|GBPAUD|United Kingdom Pound Sterling/Australia Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|GBPCAD|United Kingdom Pound Sterling/Canada Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|GBPCHF|United Kingdom Pound Sterling/Switzerland Franc Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|GBPJPY|United Kingdom Pound Sterling/Japan Yen Spot|1|2|3|Currencies|Spot|2
US|CURRENCY|GBPNZD|United Kingdom Pound Sterling/New Zealand Dollar Spot|1|2|3|Currencies|Spot|4
US|CURRENCY|GBPSEK|United Kingdom Pound Sterling/Sweden Krona Spot|1|2|3|Currencies|Spot|4
```

Glossary

Autocorrelation

Autocorrelation is used to identify an appropriate model in studying or analysing a time series. Autocorrelation answers the question, "Is there a (linear) relationship between the value of a series now and the value of the same series one or more time periods in the past?"

Positive autocorrelation is the tendency for a given condition to persist – for example, during rainy season tomorrow is likely to be raining and wet if today is raining and wet. In equity markets a parallel might be price momentum – especially in the days after financial results. Positive reaction is followed by positive reaction; and negative by negative. But why is it important for pairs traders? The Partial Autocorrelation Function graph overleaf helps explain:



Negative autocorrelation, on the other hand, is the tendency for negative observations to be followed by positive observations and vice versa. Think of an exam situation. A student spends too much time on the first question, senses time slipping away and rushes through the second not spending enough time to get full marks.

On the third he feels he back on track and again spends too long finishing. Come the fourth question he tries to recuperate the time once more…and so on with the cycle repeated for the entire exam.

Autoregression & Lags

A time series may, among others, be modelled and forecasted using a white noise model, a moving average (MA) model, an autoregressive (AR) model or a combination of a MA and AR (ARMA). The dominant model in ArbMaker is the AR.

An AR model is a linear regression of the current value (y_t) of a time series against one or more prior values of the series (y_{t-1}, y_{t-2}, etc.), with t = 1, 2, 3 … t. The values of the time series before the present are characterised as lags: so the value one time period back, y_{t-1}, is referred to as lag one; that two time periods back, y_{t-2} is lag two; and so on.

Ignoring lag selection will distort results (in the worst case materially flattering them) and lead to poor trade decisions.

Beta (β)

The cointegrating coefficient or factor; and slope of the line. A beta of 1.15 suggests for every move of 1 in X, Y will adjust by 1.15.

Coefficient of correlation (R^2)

The output of most regressions, in this context it shows how closely the modelled price of the Y variable follows the observed Y price. The resulting R^2 thus is a proxy for how good a fit the model is for the pairs being considered. R-squared, however, is only one of the outputs from the cointegrating regression that should be evaluated in reaching a conclusion and taking a market position.

Cointegrating regression

A cointegrating regression, like a single linear regression, regresses two or more series or variables and uses output statistics from the regression to determine if they are cointegrated. There are, however, important considerations when interpreting outputs.

Among the outputs are the mean reversion coefficient, beta (β), the coefficient of determination (R^2/R-squared) and t-values all of which are used to interpret the degree and nature of the cointegration, if any.

Cointegration

Cointegration is a statistical property of two or more time series that indicates whether the series have a long term relationship. When two series are cointegrated their prices may move away from each other in the short term, but they will in time revert to a mean value. This mean value is identified by the cointegrating regression of the two variables.

Correlation

A less robust measure than cointegration, correlation measures the strength of the relationship between two sets of data. A high correlation between two pairs of equities indicates that the two move together. Knowledge from the statistical tests is combined with knowledge of the market, industry or sector to take a market position on the two securities.

Half-life

The mean reversion coefficient is the basis for the half-life calculation in ArbMaker:

t½ = ln(2)/mean reversion coefficient

Where ln refers to the log of 2. Half-life is not a magic number; and numbers derived from mean reversion coefficients > absolute (1) deserve scepticism. ArbMaker outputs the half-lives of pairs but the quantity and timing of the cross-overs on the spread chart, in combination with ArbMaker's proprietary normality measures, should not be ignored and are frequently more helpful.

Mean reversion coefficient

Also called an 'adjustment coefficient' it indicates the expected 'speed' of mean reversion per time period. Thus a mean reversion coefficient of -0.45 suggests 45% movement towards equilibrium one time period from now.

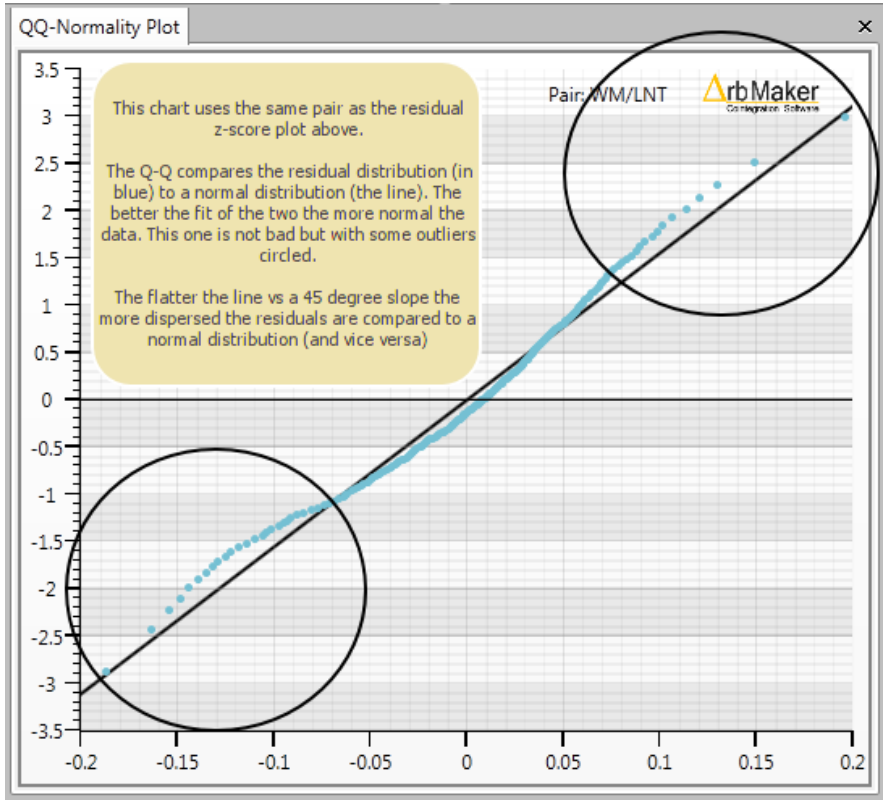
Absolute mean reversion coefficient values between 0 and 1 suggest stable systems; absolute values greater than one are less stable and also suggest over-shoot. For a cointegrating equation to be valid the mean reversion coefficient should be between zero and -1. The negative sign indicates adjustment back towards equilibrium. Mean reversion coefficients greater than 0 and 1 in a stationary time series signal autocorrelation.

Modelling time series – lags, autocorrelation and partial autocorrelation

Most data on economic and financial variables are time series. A time series is a sequence of variables measured over different intervals in time – daily, weekly, monthly quarterly or annual, for example. A first step in the statistical analysis of equity prices for pairs is selecting an appropriate model of the series generated over time by the economic or financial phenomenon.

Normality

Since the sum total of all residual values equals zero they display, by definition, mean-reverting characteristics and oscillate around zero. For pairs traders they will also, ideally, be normally distributed *both through time and around zero*. ArbMaker has configurable tools designed to assess the degree to which this is so – forecasting and trading become easier when the most promising such cases can be identified. An example is the Q-Q Normality chart below:



Analysing the spread for normality and mean-reversion is a crucial aspect of assessing the tradability of a pair. Simply identifying the presence of cointegration alone is not sufficient to achieve consistent results.

Pairs trading

A market-neutral trading strategy used by arbitrageurs to make money from the divergence and re-convergence of prices of a pair of equities.

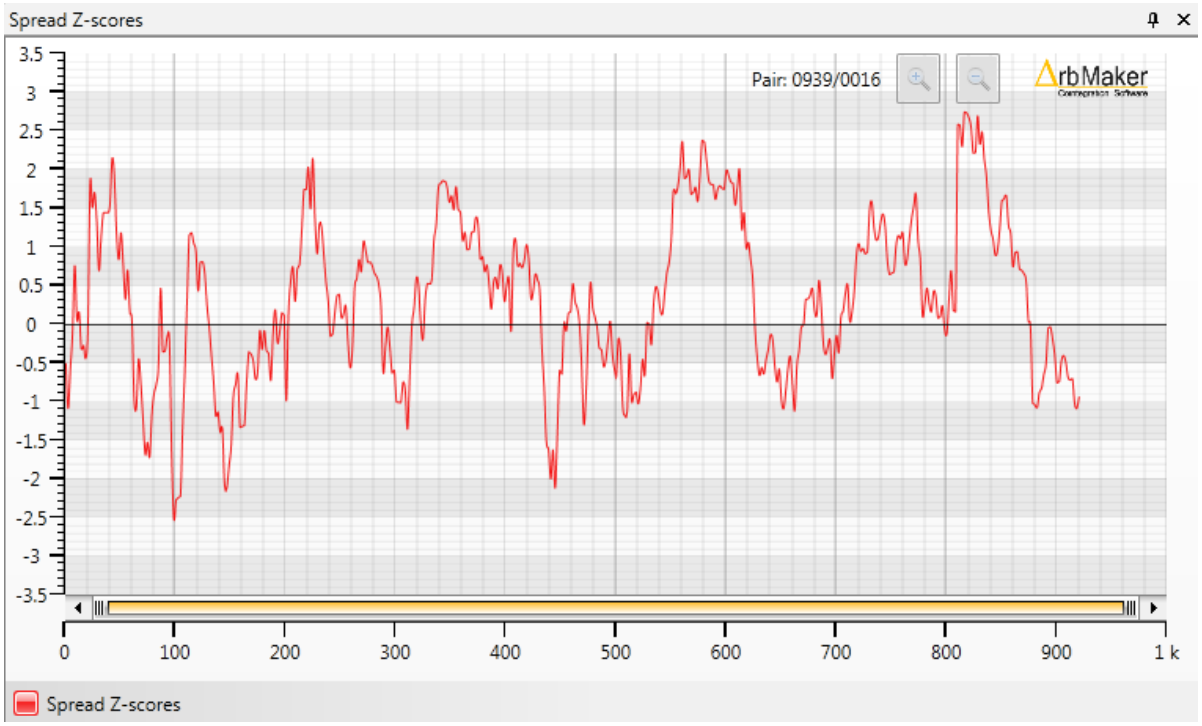
Key to the strategy is an analysis of the historical movements of the prices of the two stocks: the historical data of the pair are statistically tested to see if a relationship exists between them.

Partial Autocorrelation

ArbMaker uses a partial autocorrelation calculation to determine the appropriate lag order of the AR model. If the sample autocorrelation plot indicates that an AR model may be appropriate, then the sample partial autocorrelation is calculated and plotted to identify the order of the model. The order is the number of lags to include as regressors in the model and is shown on a PACF plot at the point where the partial autocorrelations essentially become zero. Lagged pairs are generally tougher to trade because normalising their residuals means offsetting data series in the recalculation of the regressions necessary to test for cointegration. This in turn means losing observation points from the graphical representations of the relationship. For trading purposes that is not very helpful. ArbMaker thus automatically filters out higher lagged pairs from its returns.

Residuals

Suppose a sample of investment bankers is taken and the average bonus of the group is calculated. The amount by which each individual banker's bonus differs from this average is called a residual or prediction error. Summing these residuals necessarily equals zero – they mean revert by definition. The spread calculation in ArbMaker software mirrors the shape of the residuals (although this can be 'tuned' – see Appendix L). The chart below is an example of a spread plotted as Z-scores:



The predictability of the series is linked to its normality. Thus when the spread strays towards extremes of normality – say 1.5 to 2.0 standard deviations either side of the mean – traders may judge it a good time to enter a long/short trade in the underlying securities.

Finance theory assumes that the residuals of equity returns are uncorrelated with market returns. This is why relative value strategies (like pairs trading) that undertake full residual analyses are termed “market-neutral” and can work in all equity market environments.

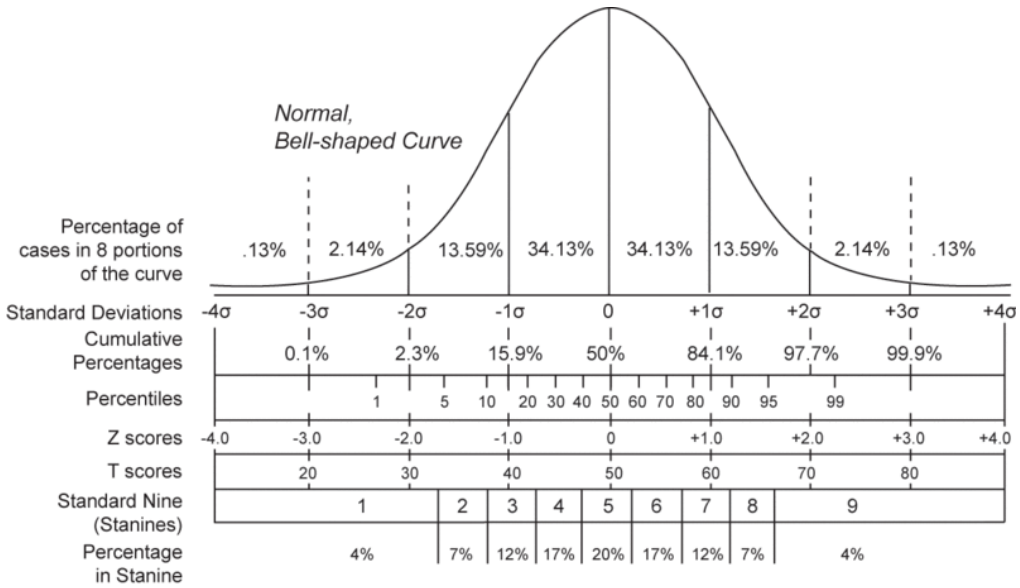
Stationarity

Prerequisite to running a cointegrating regression is testing that the time series are integrated of the same order. The order of integration of a time series tells us about the stochastic properties of the series over time. In simple terms, a stationary series has a zero mean and constant variance.

Stationarity is a desirable property in analysing and forecasting time series. The degree of non-stationarity and order of a series is determined by the number to times it must be differenced to make it stationary. Most economic and financial series are integrated of order one, or have a single ‘unit roots’ – ie they are differenced once to achieve stationarity.

Standard deviation

A measure of spread. A rough rule of thumb is that around two thirds of observations in a given distribution fall within a single standard deviation of the mean of the distribution; 95% fall within 2 standard deviations; and just about everything with 3 standard deviations. The graph below illustrates:



Z scores

Simply what standard deviations are called by convention. This measure combined with the hunt for normal distributions (see the entry on normality above) is key to using ArbMaker successfully.

Why? If, for example, the spread chart of a pair of equities currently reads ±2 Z scores from the mean value of the series - and the trader has checked that the distribution is normal or near normal - he knows that it is an exceptional reading. From the graphic in the standard deviation entry above only 2.27% of the distribution will fall there.

This suggests, *if the pair underlying the spread is truly cointegrated*, that future observations will trend the graph back toward the mean value – because that is where most observations must lie in a normally distributed series of data.

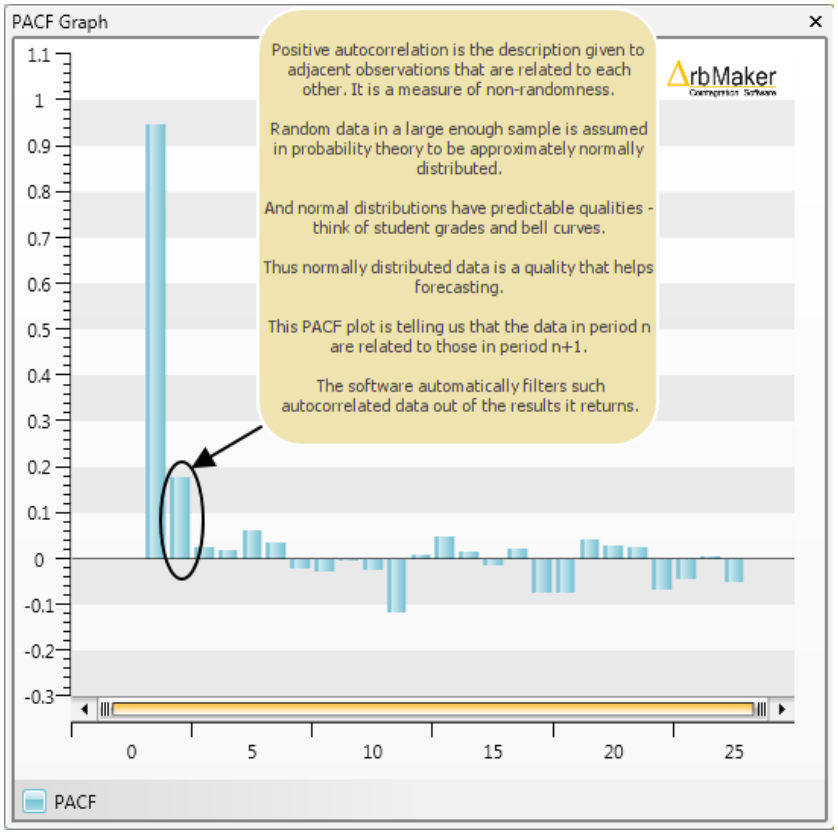
Tradability

In applying cointegration to pairs trading, the spread values are analysed to make the best determination of when the prices of the pair have deviated from their long-term mean; and to estimate the time of mean reversion of the series. This is, in essence, the process of gauging tradability. To assist this judgement ArbMaker uses normality filters during the scanning process that help return the most tradable pairs in addition to reporting mean reversion statistics.

Appendix A: PACF (Partial Autocorrelation Function)

The PACF is a visual determination of the amount (or "order") of autocorrelation in the data. The 95% and 99% set the level of statistical confidence for this calculation.

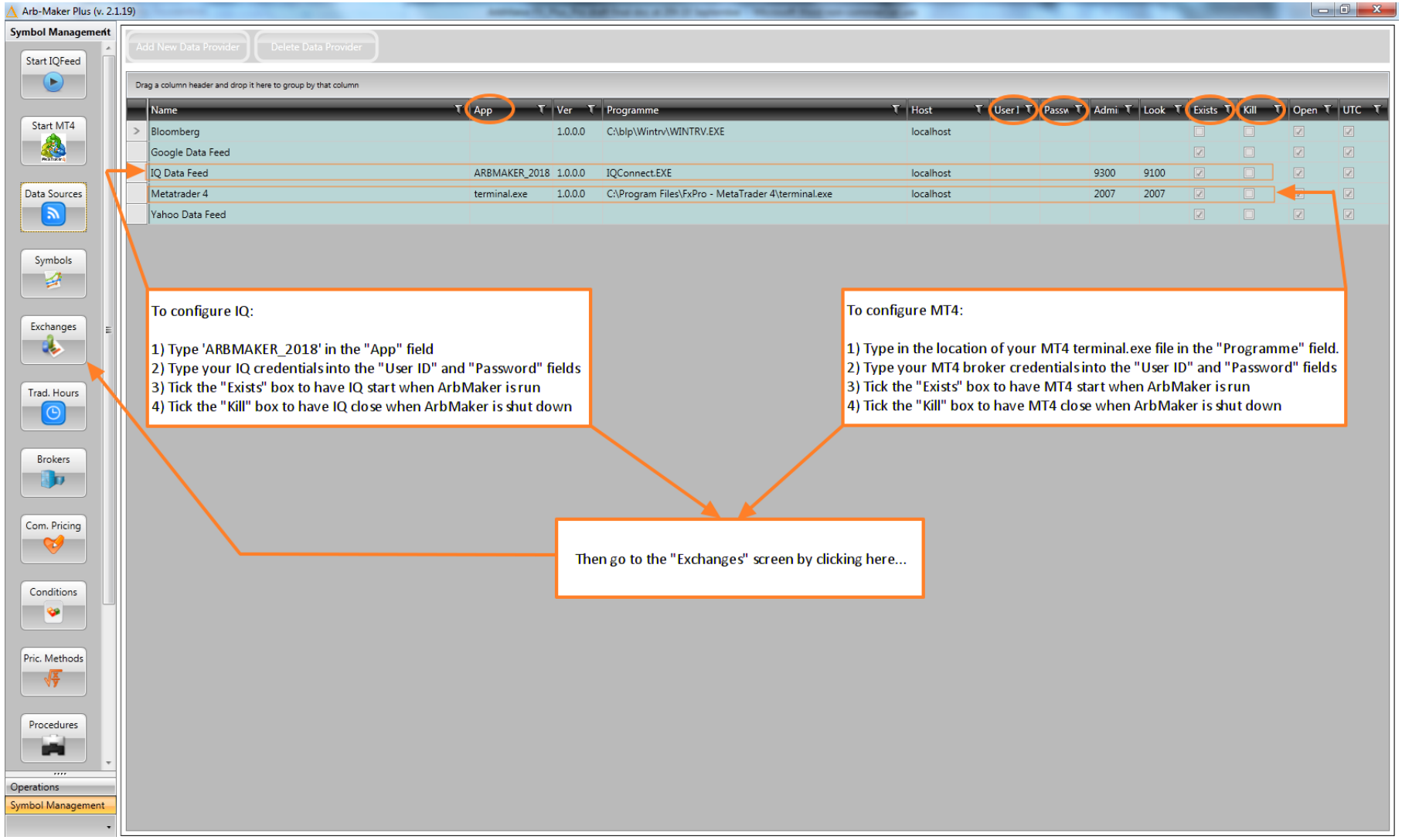
Autocorrelation above the "1" level of the PACF chart is non-random and invalidates cointegration results unless it is adjusted for by lagging the data and rerunning a series of regressions.



When ArbMaker finds autocorrelation it automatically filters the results from its returns. The process of normalizing autocorrelated data by a process of lagging the data means some observed data points fall out of the calculation - one data point per lag. Graphs with the latest observations missing – especially those key charts based on spread data - do not help trade timing, they hurt it.

Appendix B: To set up IQ or MT4 as a data feed

Go Symbol Management->Data Sources. Then follow the directions in the screen shot below. MT4 also requires the ArbMaker Expert Advisor – see Appendix C.



And then, under the “Exchanges” button:

Arb-Maker Plus (v. 2.1.17)

Symbol Management

Start IQFeed | Start MT4 | Data Sources | Symbols | Exchanges | Trad. Hours | Brokers | Com. Pricing | Conditions | Pric. Methods | Procedures

Operations | Symbol Management

Add New Exchange | Delete Exchanges

Drag a column header and drop it here to group by that column

Exchange Co	Country	Type	Description	Provider	Default	IQ F	YH	IB P	IB S	IB C	Bloc	MT	Sma
AMS	NL	Equity	Euronext Amsterdam	Google Data Fe	Yahoo Data Fee		AS						
ASX	AU	Equity	Australian Securities Exchange	Google Data Fe	Yahoo Data Fee		AX						
BCN	ES	Equity	Madrid Stock Exchange	Yahoo Data Fee	Yahoo Data Fee		MC						
BIT	IT	Equity	Milano Italia Borsa	Google Data Fe	Yahoo Data Fee		MI						
BOM	IN	Equity	Bombay Stock Exchange	Google Data Fe	Yahoo Data Fee		BO						
BUE	AR	Equity	Buenos Aires Mercado de Valores	Yahoo Data Fee	Yahoo Data Fee		BA						
CPH	DK	Equity	Copenhagen Stock Exchange C20	Google Data Fe	Yahoo Data Fee		CO						
CURRENCY	US	Forex	Forex Capital Markets	IQ Data Feed	IQ Data Feed	FXCM							
EBR	BE	Equity	Euronext Brussels	Google Data Fe	Yahoo Data Fee		BR						
ELI	PT	Equity	Euronext Lisbon	Google Data Fe	Yahoo Data Fee		LS						
EPA	FR	Equity	Euronext Paris	Google Data Fe	Yahoo Data Fee		PA						
ETR	DE	Equity	Frankfurt Stock Exchange XETRA	Google Data Fe	Yahoo Data Fee		F						
HEL	FI	Equity	Helsinki Stock Exchange	Google Data Fe	Google Data Fe								
HKG	HK	Equity	Hong Kong Stock Exchange	Google Data Fe	Yahoo Data Fee		HK						
ISE	IE	Equity	Irish Stock Exchange	Yahoo Data Fee	Yahoo Data Fee		IR						
LON	UK	Equity	London Stock Exchange	Google Data Fe	Yahoo Data Fee		L						
MCX	RU	Equity	Moscow Stock Exchange	Google Data Fe	Google Data Fe		ME						
MXK	MX	Equity	Bolsa Mexicana de Valores	Yahoo Data Fee	Yahoo Data Fee		MX						
NASDAQ	US	Equity	National Association of Securities Dealers Automated Quotations	IQ Data Feed	Google Data Fe				NMS				✓
NSE	IN	Equity	National Stock Exchange of India	Yahoo Data Fee	Yahoo Data Fee		NS						
NYSE	US	Equity	New York Stock Exchange	Google Data Fe	Google Data Fe								✓
NYSEAMEX	US	Equity	NYSE Amex	Google Data Fe	Google Data Fe								✓
NYSEARCA	US	Equity	NYSE Arca	Google Data Fe	Google Data Fe								✓
NZE	NZ	Equity	New Zealand Stock Exchange	Google Data Fe	Yahoo Data Fee		NZ						
OSL	NO	Equity	Oslo Stock Exchange OBX	Yahoo Data Fee	Yahoo Data Fee		OL						
SAO	BR	Equity	Bolsa de Valores, Mercadorias & Futuros de São Paulo	Yahoo Data Fee	Yahoo Data Fee		SA						
SEO	KR	Equity	Korean Stock Exchange	Yahoo Data Fee	Yahoo Data Fee		KS						
SIN	SG	Equity	Singapore Exchange	Yahoo Data Fee	Yahoo Data Fee		SI						
STO	SE	Equity	Stockholm Stock Exchange OMX	Google Data Fe	Yahoo Data Fee		ST						
TSE	CA	Equity	Toronto Stock Exchange	IQ Data Feed	Google Data Fe	C	TO						
TYO	JP	Equity	Tokyo Stock Exchange	Google Data Fe	Google Data Fe								
VTX	CH	Equity	Swiss Market Index	Yahoo Data Fee	Yahoo Data Fee		VX						

Bloomberg
Google Data Feed
IQ Data Feed
Metatrader 4
Yahoo Data Feed

Finally, click on the provider boxes of the exchange in order to set the desired feed.

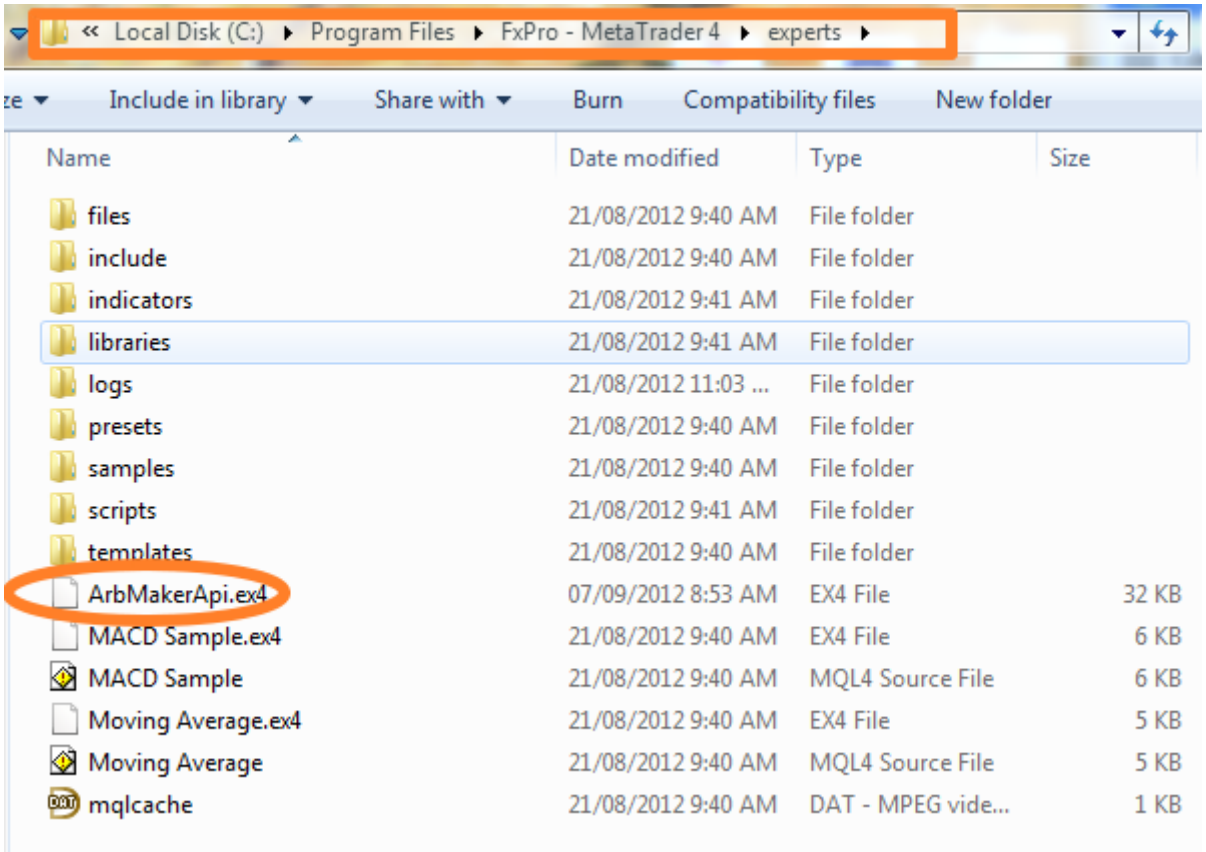
For example, to set the NASDAQ exchange to be fed by IQ click the box in the Provider column corresponding to the NASDAQ exchange; and from the pulldown choose "IQ"

If you subscribe to IQ's forex data it is necessary to enter the suffix of the subscription type. Here, for example, the subscription level is indicated by the suffix 'FXCM'

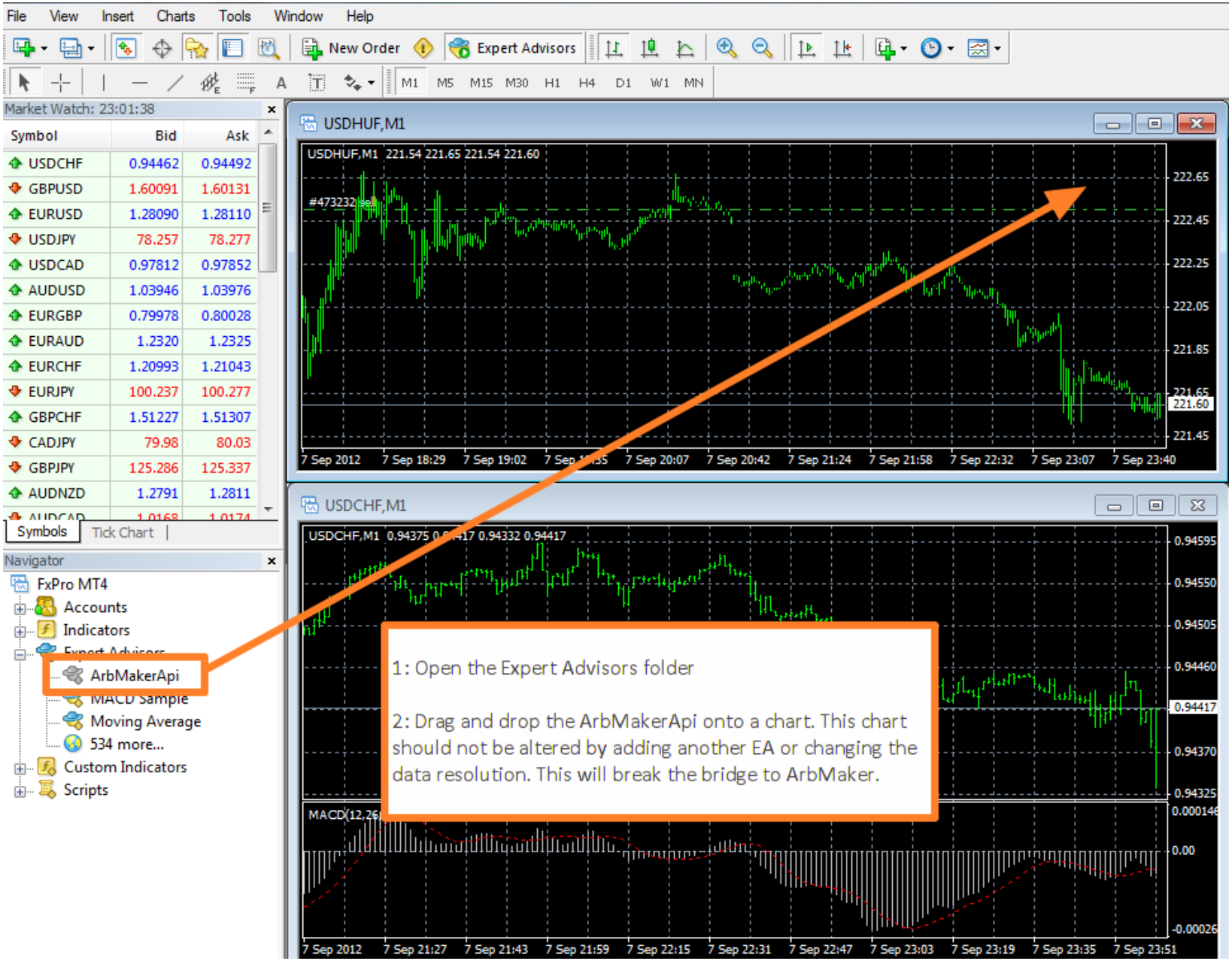
Appendix C: Installing the MetaTrader4 data feed bridge

To bridge the MT4 data feed into ArbMaker requires the use of the ArbMaker Expert Advisor (EA). The steps to take are:

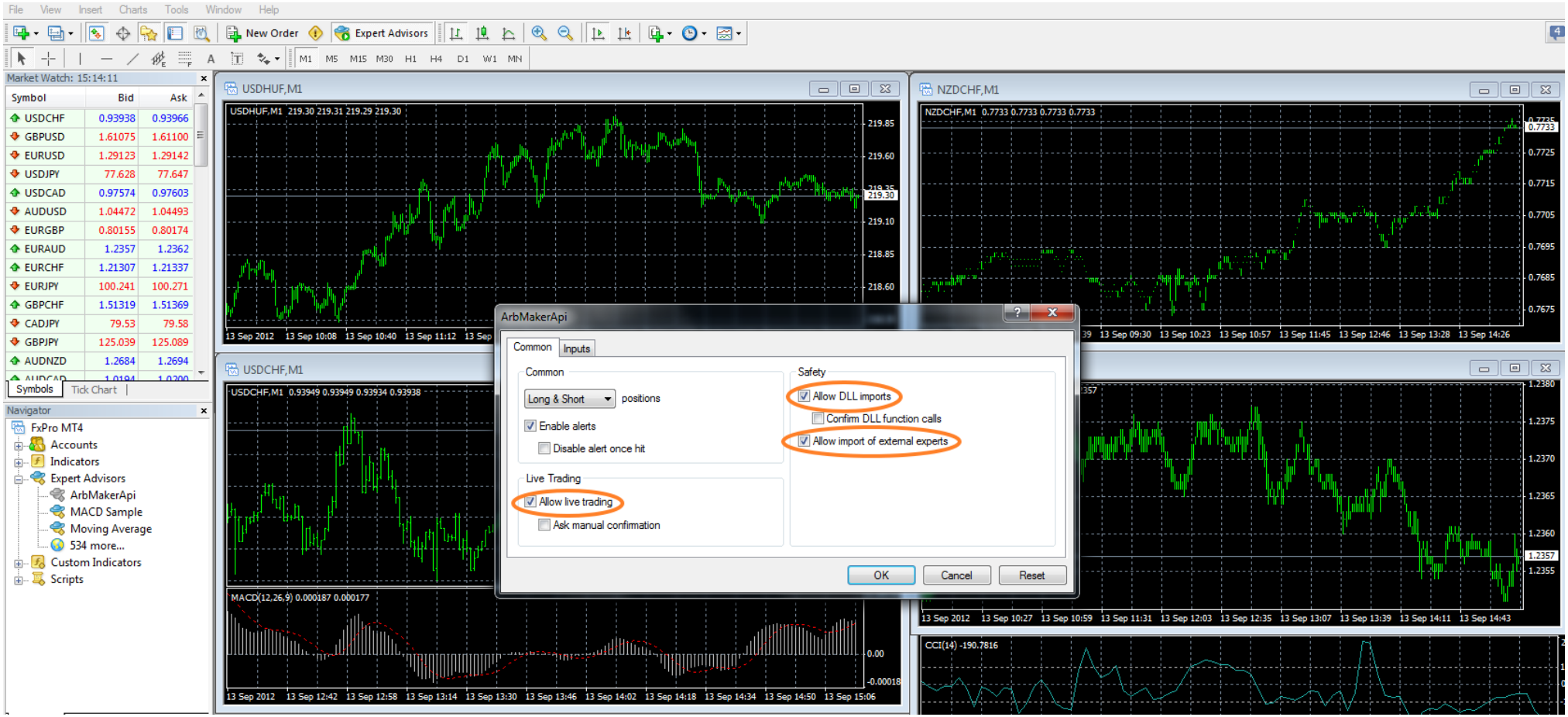
1. Download the ArbMaker EA here. Its name is ArbMakerApi.ex4.
2. Copy it to your MT4 'Experts' folder. This means navigating to a folder on your hard drive that will look much like the address shown in the following screenshot and then copying the ArbMakerApi.ex4 you downloaded in step 1 into it.



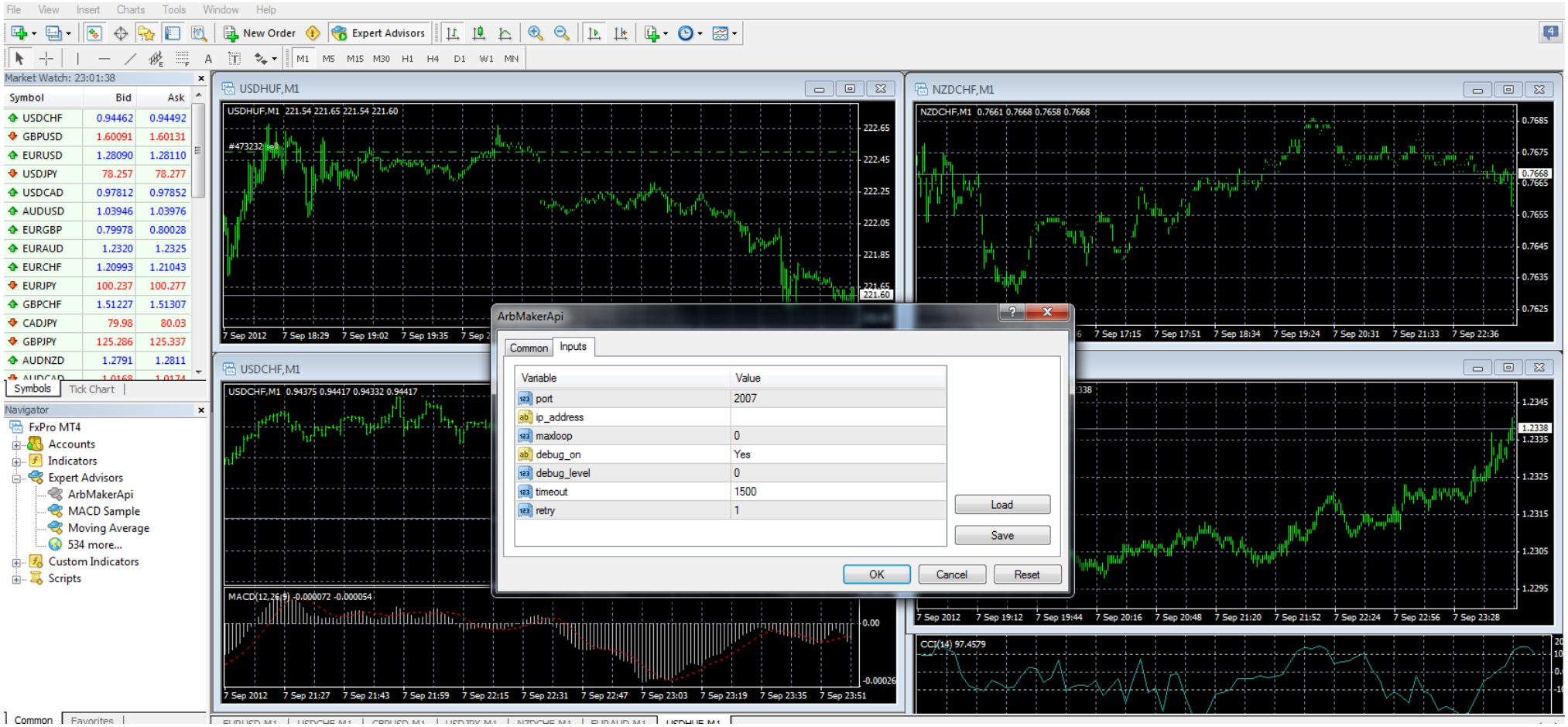
3. Open MetaTrader4 and follow the instructions on the next screen shot. The 'Experts Advisors' folder is the one shown in the MT4 Navigator box (see next shot) and not the one referred to in step 2:


File View Insert Charts Tools Window Help
New Order
Expert Advisors
M1 M5 M15 M30 H1 H4 D1 W1 MN
Market Watch: 23:01:38
Symbol Bid Ask
USDCHF 0.94462 0.94492
GBPUSD 1.60091 1.60131
EURUSD 1.28090 1.28110
USDJPY 78.257 78.277
USDCAD 0.97812 0.97852
AUDUSD 1.03946 1.03976
EURGBP 0.79978 0.80028
EURAUD 1.2320 1.2325
EURCHF 1.20993 1.21043
EURJPY 100.237 100.277
GBPCHF 1.51227 1.51307
CADJPY 79.98 80.03
GBPJPY 125.286 125.337
AUDNZD 1.2791 1.2811
Symbols
Tick Chart
Navigator
FxPro MT4
Accounts
Indicators
ArbMakerApi
MACD Sample
Moving Average
534 more...
Custom Indicators
Scripts
USDHUF,M1
USDHUF,M1 221.54 221.65 221.54 221.60
USDCHF,M1
USDCHF,M1 0.94332 0.94417
MACD(12,26
1: Open the Expert Advisors folder
2: Drag and drop the ArbMakerApi onto a chart. This chart should not be altered by adding another EA or changing the data resolution. This will break the bridge to ArbMaker.

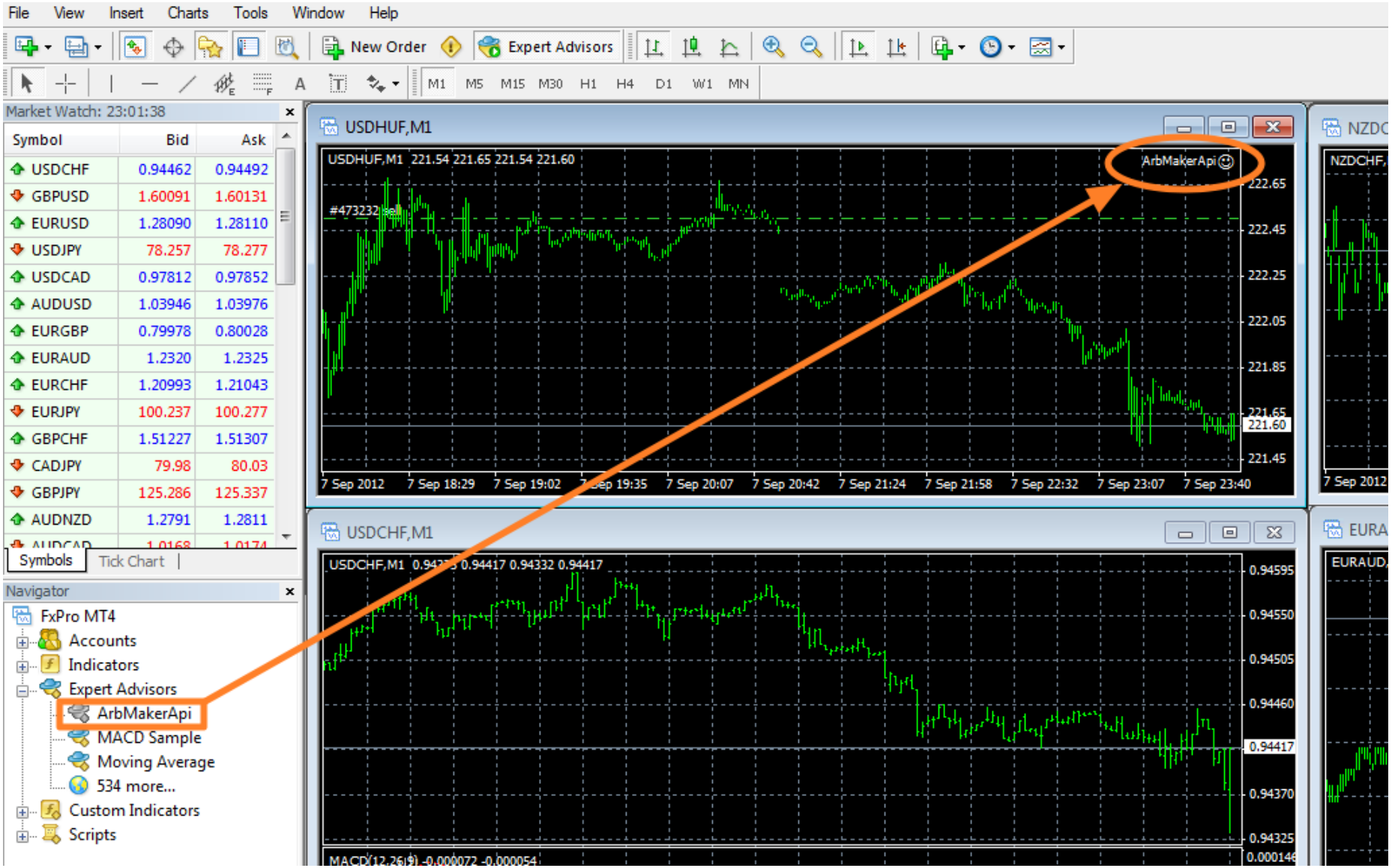
4. The ArbMakerApi parameters box appears. On the first “Common” tab, tick the “Allow live trading” box as shown in the shot below. This will only enable the feed – ArbMaker cannot execute trade via the MT4 platform until the release of our execution bridge in Q4 2012. Tick also the ‘Allow DLL imports’ and ‘Allow import of external experts’ as shown.



5. Move to the “Inputs” tab of the same parameter box and check the values shown in the screenshot on the next page. The ‘Timeout’ can be increased if your data connection is slow; and increasing the ‘Retry’ will also help. But both will slow down scan times overall:

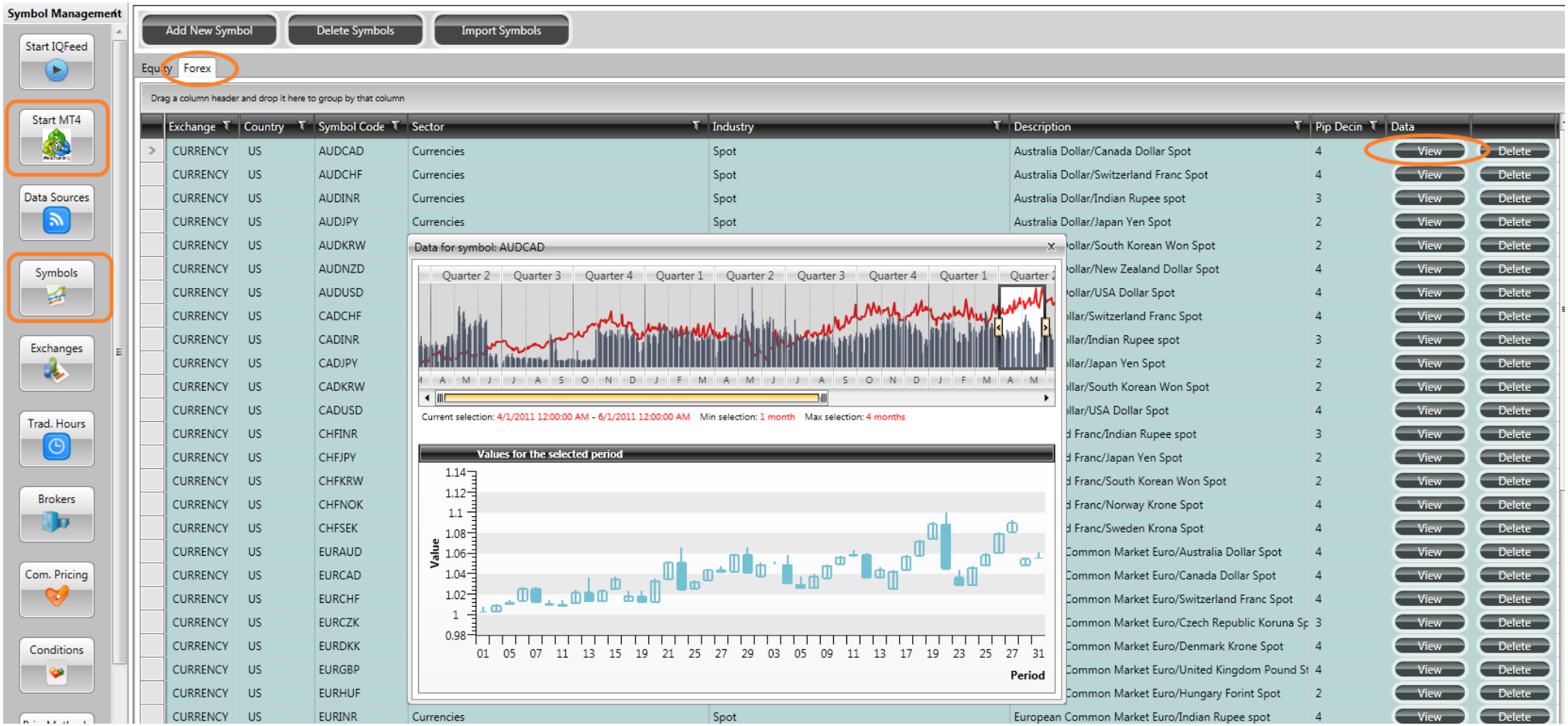


6. Click OK. MT4 will show the ArbMakerApi icon as successfully installed – see the screen shot on the following page.



7. Test the connection by (a) going to Symbol Management->Symbols; (b) Click the Start MT4 button; (c) Then click the 'Symbols' button and under the 'Forex' tab select a FX air to 'View'. A graph of the chosen rate should open as in the screen shot below.

8. If after step 7(a) a connection error box appears recheck the parameters in steps 4 to 6, restart MT4 and test the connection once more.



Appendix D: Symbol management

ArbMaker includes Google's finance feed alongside Yahoo and IQ. All three use distinct symbologies particularly with non-US companies.

In order to handle these smoothly ArbMaker has eliminated the need to use prefixes or suffixes when dealing with codes such as "AAL.L" (a Yahoo code) or "LON:AAL" (Google's approach). Data files now simply carry the code – in this case "AAL".

If you are an existing subscriber, this has meant changes to some exchange and country codes. The benefit is that to use Yahoo or Google users need only change the feed control and not be concerned with the prefixes or suffixes. The downside is that existing watch lists that include non-US symbols carrying prefixes or suffixes will have to be modified in 2 ways: firstly, by removing the prefixes and suffixes; and secondly by changing the exchange and country codes where necessary.

These are easy if tedious alterations from the exported .txt watch list file.

We have created new data base files across the 28 exchanges we now cover - here is a sample shot of the new "Exchanges" screen:

Exchange Co	Country	Type	Description	Provider	Default	IQ F	Y
ASX	AU	Equity	Australian Securities Exchange	Google Data Fe	Yahoo Data Feed		ax
MXK	BA	Equity	Mercado de Valores	Google Data Fe	Yahoo Data Feed		mx
SAO	BR	Equity	Bolsa de Valores, Mercadorias & Futuros de São Paulo	Google Data Fe	Yahoo Data Feed		sa
TSE	CA	Equity	Toronto Stock Exchange	IQ Data Feed	IQ Data Feed	C	to
VTX	CH	Equity	Swiss Market Index	Google Data Fe	Yahoo Data Feed		vx
ETR	DE	Equity	Frankfurt Stock Exchange XETRA	Google Data Fe	Google Data Feed		f
CPH	DK	Equity	Copenhagen Stock Exchange C20	Yahoo Data Fee	Google Data Feed		co
BCN	ES	Equity	Iberia Index	Yahoo Data Fee	Google Data Feed		mc
EPA	FR	Equity	Paris Stock Exchange	Google Data Fe	Google Data Feed		pa
HKG	HK	Equity	Hang Seng Index	Google Data Fe	Yahoo Data Feed		hk
BOM	IN	Equity	Bombay Stock Exchange	Google Data Fe	Google Data Feed		bo
NSE	IN	Equity	National Stock Exchange of India	Google Data Fe	Google Data Feed		ns
ISE	IR	Equity	Irish Stock Exchange	Yahoo Data Fee	Google Data Feed		ir
BIT	IT	Equity	Milano Italia Borsa	Google Data Fe	Yahoo Data Feed		mi
TYO	JP	Equity	Tokyo Stock Exchange (NIKKEI)	Google Data Fe	Google Data Feed		
SEO	KS	Equity	Korean Stock Exchange	Yahoo Data Fee	Google Data Feed		ks

Appendix E: Guide to terms used in the ArbMaker software screens

Axis crossings

A measure of the evenness of axis crossing distribution through time compared to a normal distribution.

Beta

The cointegrating coefficient or factor; and slope of the line. A beta of 1.15 suggests for every move of 1 in X, Y will adjust by 1.15.

Cointegration at 5% and 1%

The result of overall cointegration testing of a pair at confidence intervals of 95% and 99%. Output is either "OK" or "Abort" with the underlying t-values visible with a click of the "Details" button to the right of the pair output.

Diff X / Diff Y at 5% and 1%

The result of cointegration testing of the differences of the price series for integration. Output is either "OK" or "Abort" with the underlying t-values visible with a click of the "Details" button to the right of the pair output.

Half life

The time in days for the residual series to correct half the distance it lies away from its mean value.

Or. X / Or. Y at 5% and 1%

The result of cointegration testing on the original prices series for stationarity. The output is given as "OK" or "Abort" but the underlying t-values are visible with a click of the "Details" button to the right of the pair output. Please see Appendix J for a fuller description.

Model

The value of Y, the dependent share price, as a function of what the cointegration process has determined (via regression analysis) the statistical relationship between X and Y to be.

MRC

Also called an 'adjustment coefficient' it indicates the expected 'speed' of mean reversion per time period. Thus a mean reversion coefficient of -0.45 suggests 45% movement towards equilibrium one time period from now.

Absolute mean reversion coefficient values between 0 and 1 suggest stable systems; absolute values greater than one are less stable and also suggest over-shoot. For a cointegrating equation to be valid the mean reversion coefficient should be between zero and -1. The negative sign indicates adjustment back towards equilibrium. Mean reversion coefficients greater than 0 and 1 in a stationary time series contain autocorrelation.

Profitability

An estimate of likely profitability of a pair. Its validity depends on:

- the normality of the spread
- price availability – for example, a signal system that waits for confirmation patterns may mean best price slips
- the entry level criteria of the chosen strategy

These factors will typically reduce the number in a back test; and it is nearly always the case that very high percentages mislead because of them.

R-squared

Derived from the cointegrating regression process, a measure of how well the model fits and explains the observed data.

Residuals at 5% and 1%

The result of cointegration testing of the residuals for stationarity. Output is either "OK" or "Abort" with the underlying t-values visible with a click of the "Details" button to the right of the pair output. Please see Appendix J for a fuller description.

SD > 1 / < -1 Ratings

A qualitative rating of the distribution of the standard deviations of the spread series compared to a normal distribution.

SD from the mean

The number of standard deviations the latest reading is from the mean of the series.

Symbol Y

The observed variable.

Symbol X

The explanatory variable.

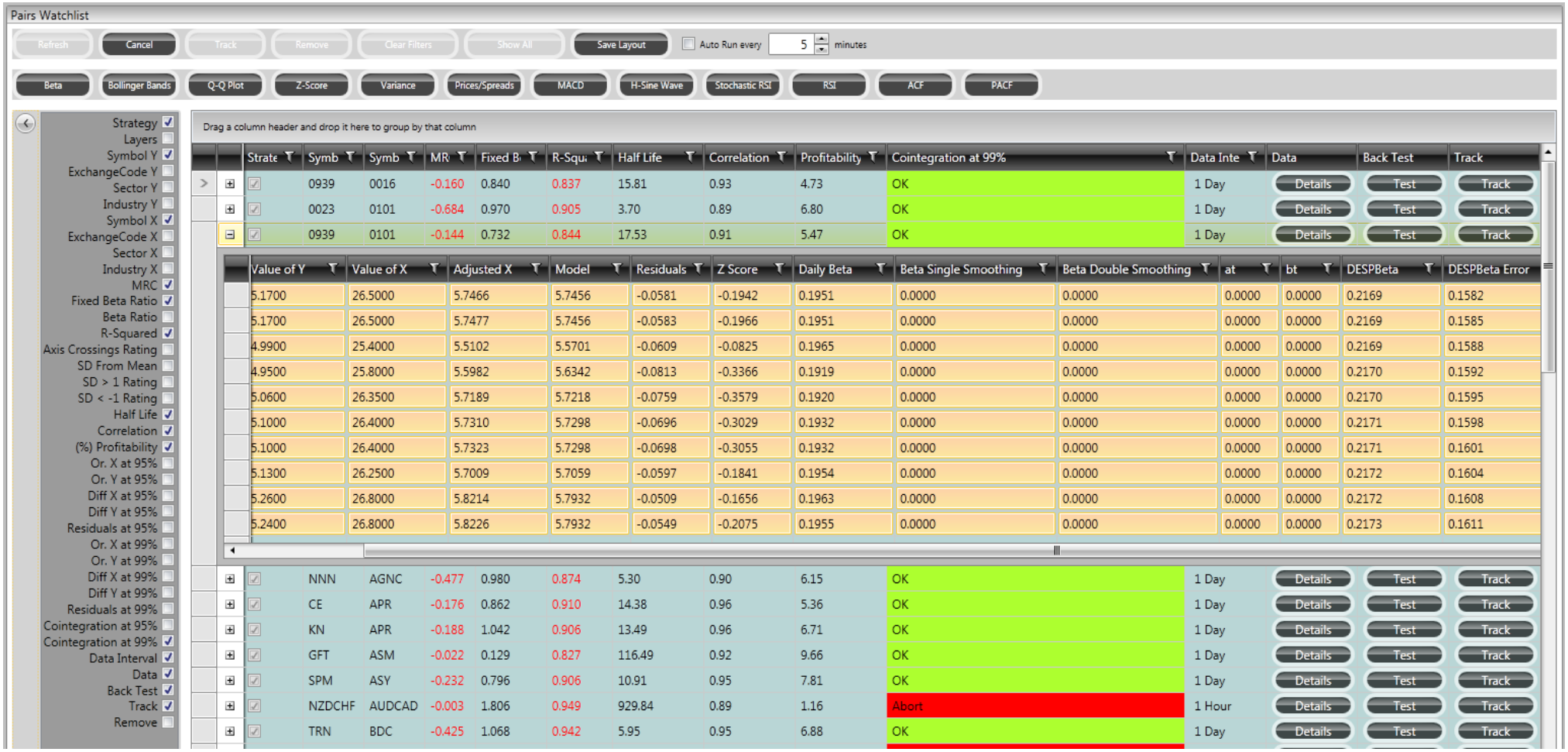
Appendix F: Guide to terms and ratios used in the Performance Reporting screen

n	Usually the count or number of observations in a sample or data series.
Arithmetic mean	Arithmetic mean is commonly referred to as "average" or as "mean", a mathematical representation of the typical value of a series of numbers, computed as the sum of all the numbers in the series divided by the count of all numbers in the series.
Standard deviation	A measure of the dispersion of a set of data from its mean. The more spread apart the data, the higher the deviation. In ArbMaker' back testing it is applied to the entire period tested – it is not annualised. Standard deviation is also known as historical volatility and is used by investors as a gauge for the amount of expected volatility. A volatile stock will have a high standard deviation while a stable blue chip stock will have a low standard deviation.
Skewness	A statistic that measures the distribution of a data sample around a centre of the distribution such as the mean. If the distribution is equally dispersed to the left and right of the mean, it is symmetric and unskewed, and the statistic is zero; otherwise it is either skewed to the right - positive statistic or to the left - negative statistic, and asymmetric. The normal distribution is a symmetric and unskewed distribution.
Kurtosis	A statistic that measures the height and sharpness of the peak relative to the rest of the data in a symmetric normally distributed dataset. The statistic is referenced on the normal distribution, which has a kurtosis measure of 3. A platykurtic distribution has a kurtosis less than 3: compared to a normal distribution, its central peak is lower and broader, and its tails are shorter and thinner. A leptokurtic distribution has a kurtosis greater than 3: Compared to a normal distribution, its central peak is higher and sharper, and its tails are longer and fatter.
Jensen's Alpha	A measure of how well a stock or a portfolio performs relative to the broader market. A high value of Alpha means that the stock or portfolio is earning returns above what is expected given its risk profile.
Beta	A value describing the relation of a stock or a portfolio in terms of its returns with those of the financial market as a whole. A beta of zero means its returns change independently of the changes in the market's returns. A beta greater than zero means that the asset's returns generally follow the market's returns. A beta less than zero means that the asset's returns generally move opposite the market's returns.
Sharpe Ratio	Measures the risk-adjusted performance of a stock or a portfolio. This measurement is very useful because although a portfolio can record higher returns than its peers, it is only a good investment if the higher returns do not come with too much additional risk. The greater a portfolio's Sharpe ratio, the better its risk-adjusted performance. A negative ratio means that a risk-less asset would perform better than the portfolio.
Sortino Ratio	Another measure of the risk-adjusted performance of a stock or a portfolio. It is similar to the Sharpe Ratio, as both adjust for riskiness of a portfolio. However, the Sortino Ratio only adjusts for the downside risk of a stock or a portfolio; the Sharpe Ratio, on the other hand, adjusts for both upside and downside risks. The Sortino Ratio would usually result in a higher ratio than the Sharpe Ratio, with similar interpretation.
Information	The ratio of relative return to relative risk (known as "tracking error"). Whereas the Sharpe Ratio looks at returns relative to a

Ratio	riskless asset, the Information Ratio is based on returns relative to a risky benchmark. A higher Information Ratio is considered to be better than a lower one.
M2	Modigliani–Modigliani measure: a measure of the risk-adjusted returns of an investment portfolio. It measures the returns of a portfolio, adjusted for the deviation of the portfolio relative to that of a benchmark (e.g., the market). It is derived from the widely used Sharpe Ratio, but it has the significant advantage of being in units of percent return, which makes it dramatically more intuitive to interpret.
Stutzer index	The Sharpe Ratio assumes that the returns to a portfolio are normally distributed. When they not, the Sharpe Ratio would overstate the performance of the portfolio. The Stutzer index corrects for this by assigning a lower Sharpe Ratio to a portfolio that has negative skewness and high kurtosis. Where the distribution of portfolio returns is normal, the Stutzer index and Sharpe ratio are identical.
Omega	For even given threshold or targeted return level (r) the Omega Ratio is the weighted gain/loss ratio relative to r. It uses all of the information in a return series instead of simple calculations of figures such as mean and variance.
Maximum Drawdown	The amount by which your account has fallen in value relative to the highest value that was previously attained. It is calculated by subtracting the value at any given point from the highest value that occurred prior to the value you are subtracting. The larger your drawdown is, the more difficult it is to recover your account to its previous value and the greater the risk you are essentially taking with your portfolio.
Treynor Ratio	A measurement of the returns earned by a managed diversified portfolio in excess of that which could have been earned on a portfolio with no diversifiable risk (e.g., Treasury Bills or a completely diversified portfolio), per each unit of market risk assumed. The Treynor Ratio relates excess returns over the risk-free rate to the additional risk taken. The higher the Ratio, the better the performance of the portfolio under analysis.
T2 (Treynor Ratio Squared)	With the T2 ratio, the managed portfolio is adjusted such that it has the same degree of systematic or market risk as the market portfolio. The return on the adjusted managed portfolio can be readily compared with the return on the market portfolio since both have the same level of market risk. The differential return indicates the excess return of the managed portfolio in comparison to the benchmark portfolio after adjusting for differences in the market risk. T2 is a better measure of relative performance when the market risk of a managed portfolio is the relevant risk comparison metric.
Upside potential Ratio	Compares the returns to a portfolio (relative to its minimum accepted return) with the risk - risk of failure - that is associated with the upside or returns above the minimum. A ratio greater than one is desirable since it means the portfolio's upside outweighs its risk of failure.
Calmar ratio	Used to determine return relative to drawdown (downside) risk in a hedge fund. Generally speaking, the higher the Calmar ratio, the better.
Modified VaR Cornish-Fisher	Value-At-Risk (VaR) gauges the probability of losing more than a percentage of a portfolio based on the statistical analysis of historical price trends and volatilities of the portfolio. VaR assumes that the probability distribution of a portfolio's returns is normal. If not, the VaR model is adjusted to account for non-normality using the Cornish-Fisher expansion, which can adjust the VaR in terms of asymmetry (skewness) and kurtosis.

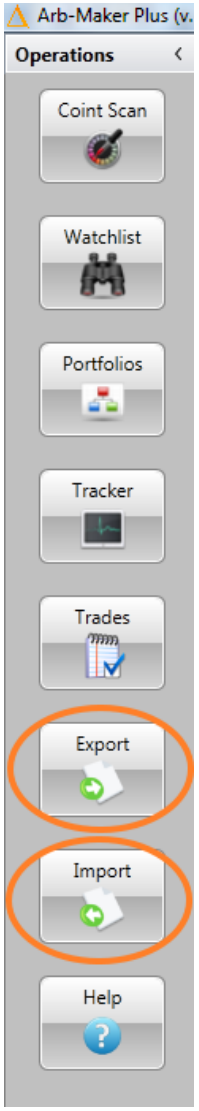
Appendix G: Exporting data

Certain ArbMaker data can be copy/pasted into other applications. For example, from the Results and Watchlist screens users can click the "+" to the left of any pair to see underlying prices, the modelled price for the Y symbol, Residuals and so forth. A screenshot from the Watchlist below shows these data with a selection highlighted ready for export:



Entries on the Symbols screen can also be copy/pasted.

Appendix H: Importing & Exporting the Watchlist



In order to back up symbols saved on the Watchlist, as well as facilitate synchronisation between copies of the software running on multiple computers, a .txt file can be generated from within the Watchlist itself that will contain a list of all pairs listed on the screen.

Export generates the file. Import asks the user to navigate to an already generated file and select it. Opening the file populates the Watchlist with its contents.

Note that if you import symbols not already in the main symbol database ArbMaker will not be able to run its algorithms against them.

Appendix I: Error codes

ArbMaker has a data error detection function built into its scan and Watchlist screens. The detected errors are of two types:

1. "Pair: SymbolY/SymbolX Failed Cointegration": Most commonly associated with pairs having significant gaps in the matching time series data or a material number of repeated values.
2. "Pair: SymbolY/SymbolX Failed Cointegration Due to Feed Temporal Failure": This error is rare and associated with the variations in volume and speed of IQ's data feed. These can potentially impact the timeout tolerances of ArbMaker and, should there be such an error, a restart of the IQ feed client will be required.
3. "<Symbol> has bad data": occurs where a the data series of a symbol is less than the date range the test was run for.

It is also possible for errors to be generated because symbols have changed or dropped. These will be classed as number 3 above and are usually worth checking in order to maintain an up to date database symbology.

Appendix J: The Cointegration process

The Original X, Original Y, Diff X and Diff Y numbers visible in the software are 'pre-cointegration' test results that determine if the conditions for going ahead with full cointegration testing have been satisfied. For cointegration to be valid time series data must meet two criteria:

1) On the one hand the "original" or "level" prices of the series must be non-stationary. "Original" data in the software are the daily share prices.
2) On the other hand the "differences" of the ordinary prices must be stationary. "Difference" data is difference between the share prices on day 2 vs day 1, day 3 vs day 2 and so on.

The Dickey Fuller (DF) and augmented Dickey-Fuller (ADF) tests are used to determine stationarity.

When conditions (1) and (2) are met the "residuals" can then be tested for stationarity – if they are in turn stationary then the two series are cointegrated.

"Stationary" simply asks that the means, variances and covariances of the data are constant and do not depend on the period in which they are measured. An example: typically, original (or level) central bank interest rates and sovereign bond rates are both non-stationary. But their differences are stationary. And tests on the residuals will usually show cointegration.

"Residuals" are the difference between actual observed values and those calculated with the regression equation. They are also called "fitting errors". The software gets the residuals by running an ADF regression on the ordinary prices of the shares.

The numbers in the Details tab are a by-product of the tests and are called t-values (or tau statistics in this context). To determine if a given t-value is acceptable (in terms of accepting or rejecting stationarity) it is compared to a set of "critical values" for the ADF procedure.

The critical values used on the final piece of the cointegration procedure, residual testing, apply a higher standard than those from the usual ADF process and come from MacKinnon's 1995 work "Numerical Distribution Functions for Unit Root and Cointegration Tests".

In all this regression running it can be forgotten that the testing results are sensitive to variable order – how does one know which financial instrument is leading and which is following? This is determined by yet more regression analysis within an "Error Correction Mechanism" built into ArbMaker. Without this results would be, at best, just wrong and, at worst, financially consequential for traders.

Appendix K: A cautionary note on the power of unit root tests

	Accept H_0	Reject H_0	Notes
H_0 is true	Correct Decision	Type I Error	

(H_0 = null hypothesis)

Statistical processes are not infallible.

ArbMaker uses cointegration as the basis of searching for tradable pairs. Two series may be cointegrated only if they are unit roots - the existence of which is set in hypothesis testing as the null hypothesis.

Unit root tests, including the Dickey-Fuller test used in ArbMaker, are susceptible to low power. It means they may accept the null hypothesis of a unit root when the alternative of a stationary series is more likely true.

In short, the test may pass near unit root processes when it should not. This is referred to as Type I Error. Such errors at the margin of unit roots / stationarity will let through series which behave partially like unit roots and may thus lead to decent results in ArbMaker's Back tester. One way to substantially mitigate the chance of this error is to increase the number of observations in the testing process.

Appendix L: Fixed and Time Adaptive betas

Beta captures elements of the risk return relationship between a pair of symbols. One method of calculating beta (β) is to find the slope of the line of best fit in a scatter chart of the prices of two symbols. It uses all the observations in a given period. So long as the beta ratio remains stable it is a method that works very well.

However, beta ratios can vary greatly. For these cases a beta calculation that adapts over time, whilst filtering out excessive noise, may improve returns. We have two methods to capture such variations in beta relationships: the first of these is Robert Goodell Brown's double exponential smoothing prediction (DESP) model; and the second is derived from Rudolf E. Kálmán's "Kalman Filter".

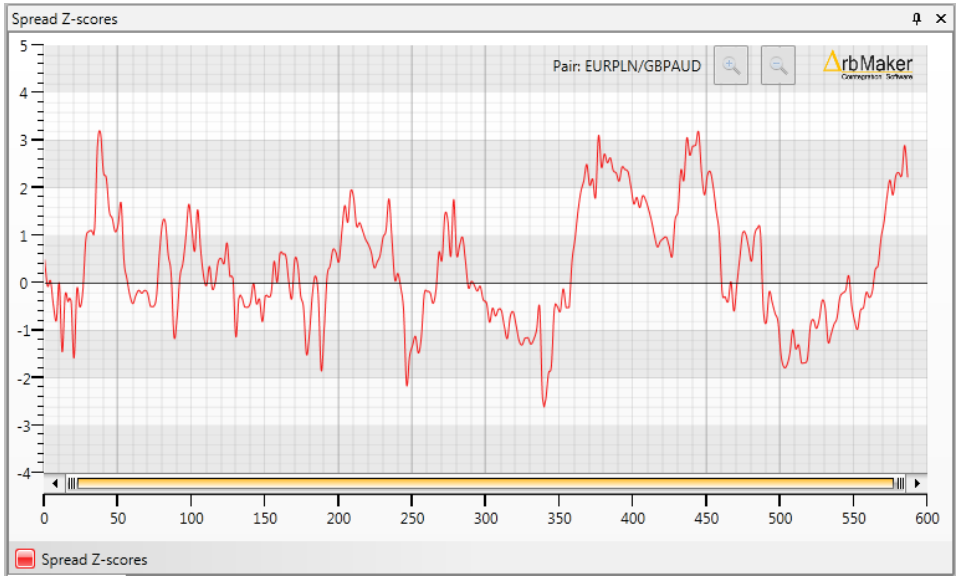
Why is this important? The beta determines the ratio of money in symbol X to money in symbol Y in any potential pairs trade. If the beta is volatile the balance may be inaccurate using a fixed beta. If it is stable, no.

ArbMaker implements the beta ratio in two distinct ways:

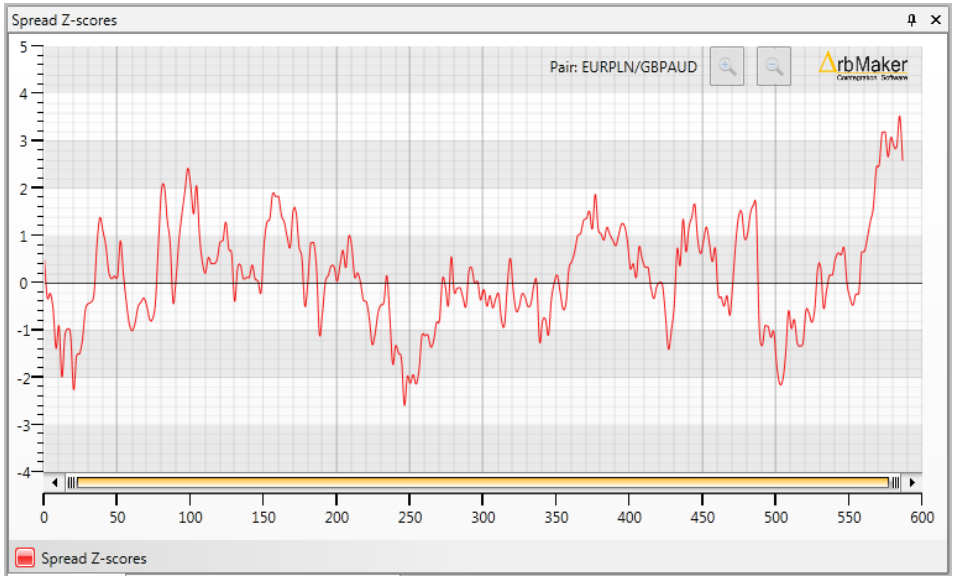
1. Where the beta calculation is fixed the ratio is applied directly to the amounts per side in the back testing window. Under this method a pair is not money neutral (unless beta equals 1). For example, a beta of 2 means amount Y will be twice amount X.
2. Where the beta calculation is adaptive it is applied directly to the spread calculation so that spread Z = Yprice - βXprice. This means amounts Y and X are of equal size in the back tester.

A key implication of the second point is that the shape of the spread under time-adaptive betas can be 'tuned' for profit performance.

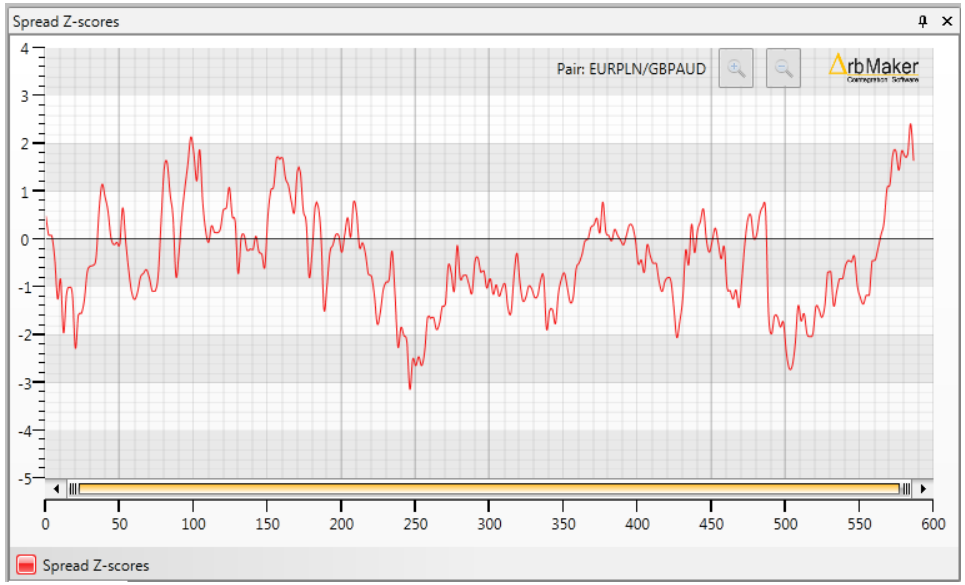
For example, on the next page is a spread for EURPLN/GBPAUD under a fixed regime:



The same under a DESP regime:

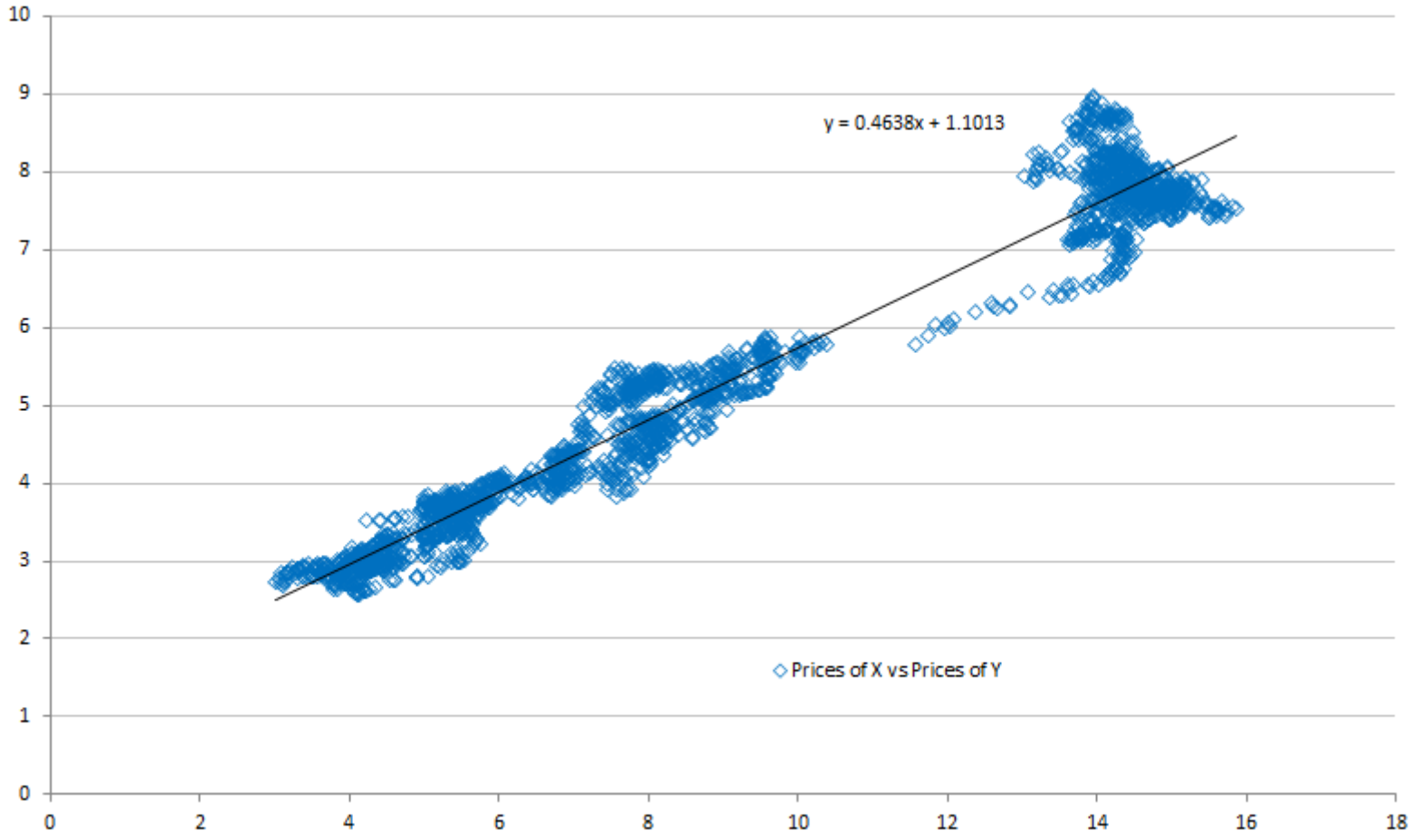


And the same under Kalman:



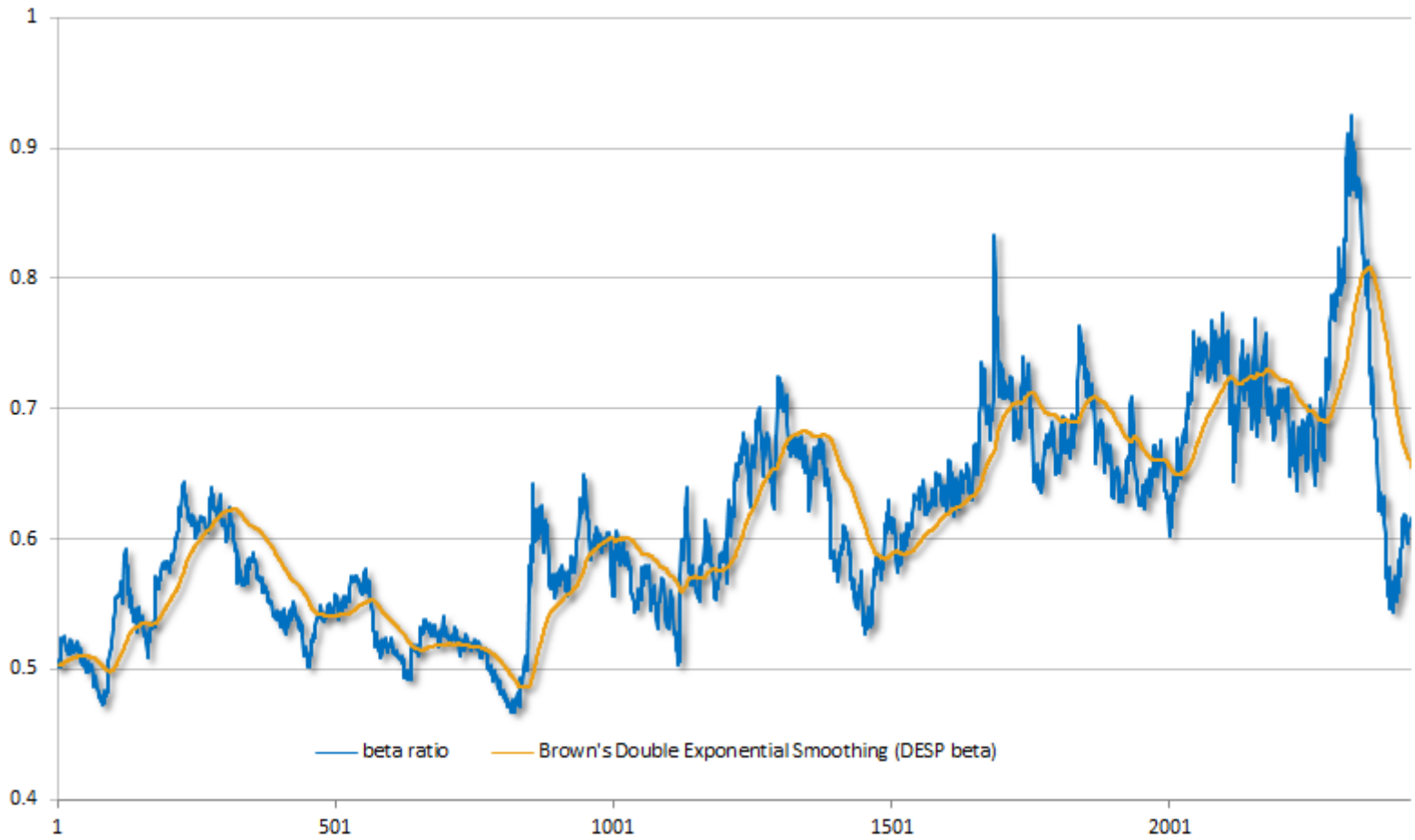
The fixed beta regime

In the graph below symbols X and Y show a fixed beta of 0.464 once a line of best fit is run through the scatter plot of prices. But consider the two graphs in the sections after this one – all three are derived from exactly the same price data.



Time-Adaptive method using the DESP

The blue line in the graphs below shows the daily price of Y divided by the price of X. This is the beta ratio. Set next to this plot a fixed beta of 0.464 does not seem such a great approximation. It does, however, eliminate all the noise contained in the beta ratio itself.



However a time-varying calculation can also do this. The yellow line above is the DESP. It uses a parameter called "αlpha" that is the smoothing constant and must lie between 0 and 1. The closer αlpha is to 0, the more weight given to older observations. As αlpha tends to 0, the DESP approaches a simple mean model. In the chart

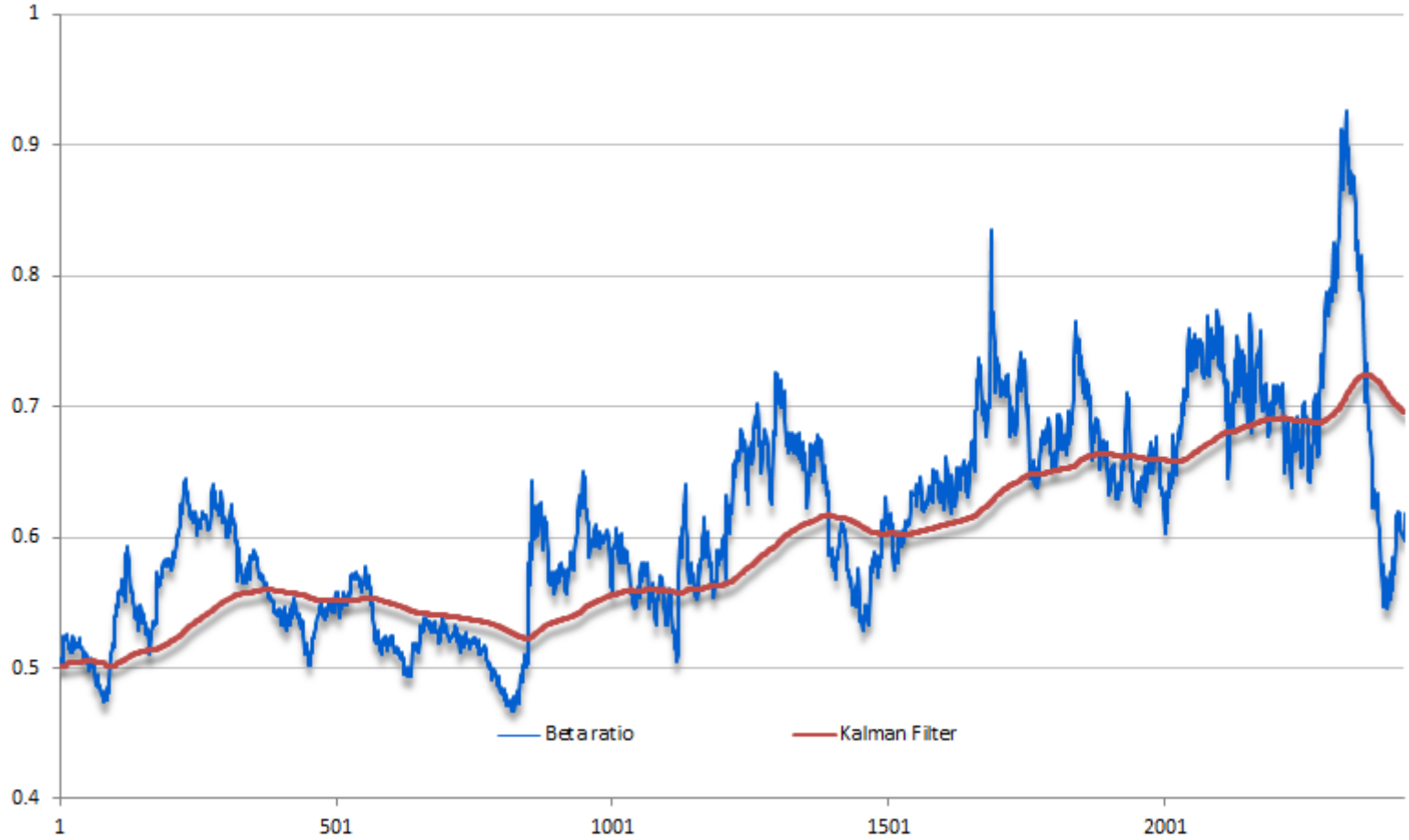
above αlpha is set to 0.004. Another way of looking at this number is that 1/αlpha equals the average age of the data used in plotting the DESP. So in this case the DESP line uses the last 250 observations.

There is no formally correct procedure for choosing αlpha. Were the goal to most closely predict the beta ratio *n* days ahead the statistical method of least squares would probably be used. But the goal in this application is to find that value of αlpha that produces the best returns in back-testing and which will serve as a proxy for use in real trading. If the αlpha is close to 1 the DESP series will be very noisy – that is, close to the original beta ratio – and the signals out of the spread chart would bounce around excessively and be of poor quality.

Finally, the DESP is a forecast. The number of days ahead the forecast attempts to predict is governed by a second parameter called *kappa*. By default this is set to 1 in ArbMaker software.

Time-Adaptive method using the Kalman Filter

If you have a Global Positioning System (GPS) in your mobile telephone or car then you are already using Mr. Kalman's filer. In a GPS the Kalman filter makes predictions of position and updates them based on incoming measurements. Wikipedia has a fine example involving a truck on this page.



We use a Kalman algorithm modified for a single variable - beta. Where the DESP uses αlpha to tune the beta ratio, this Kalman filter uses a parameter called "gain". In the context of pairs trading gain is a function (on the one hand) of the certainty that the observed beta ratio achieves optimal back-tested returns and (on the other hand) of the Kalman's beta prediction for making those returns optimal. With high gain the filter places more weight on observed beta and thus follows them more

closely. With low gain the filter follows the model predictions more closely, smoothing out noise but decreasing responsiveness to changes in the underlying beta ratio. In the chart above gain is set to 0.004. At the extremes a gain of one causes the filter to ignore prediction completely; while a gain of zero causes the observations to be ignored.

Some things to bear in mind

1. Selecting a beta calculation is a horses-for-courses exercise. One method is not always superior to another and much depends on the volatility of the underlying beta ratio. But in *general* terms, where the right horse has been selected for the course, we have observed that:

    - There are higher per trade results under a fixed regime
    - Time varying betas use shorter trade lengths
    - Time varying betas produce higher trade volumes but also a higher percentage of winners
    - The money-neutral design of the time varying beta methods requires less capital outlay per trade

2. We present both the fixed beta and the Beta ratio in the software data grids. If comparing ensure both are either in raw prices or natural logs for a like-for-like analysis.