



Keytrade Bank Testing of KeyPrivate tool

Customer report

March 2016



Scope of the document

This report summarizes the work performed by KPMG (Q3 / Q4 2015) on the testing of the Gambit model, which is based on Black-Litterman foundations. The testing was conducted on the Gambit version 2.7.5.2 (x64), and was kept unchanged during the testing period.

This document covers the main areas of investigation analyzed by KPMG, and is divided into the following sections:

- ❑ High-level description of the model
- ❑ Testing of the model
 - I. Procedure followed by KPMG
 - II. Executive summary of the testing
- ❑ Appendix
 - I. Detail of the testing:
 - General set-up of the model
 - Historical calibration and stress test results
 - Use of expert opinion
 - Optimization module
 - Rebalancing module
 - Back-testing methodology
 - Simulations results.
 - II. List of ETPs under review.

It should be noted that this report does not give an opinion on the model governance (the full review of which is not in the scope of the KPMG tests).

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I. Model description (1/3)

The model developed by Gambit is primarily based on the “Black Litterman” theory (Fischer Black and Robert Litterman, 1990), with some adjustments/fine-tuning to take into account the specific context in which the model will operate.

The Black Litterman model (“B&L”) uses Bayesian statistics to combine investor “views” (i.e. predictions on the future returns of some assets) together with historical data on past returns (“prior” assets performance/volatility).

The following sections present a high-level description of the four main components of the model*:

1. **Prior returns and volatilities**, i.e. the part of the model based on historical data;
2. **Views**, i.e. the views of the Investment Committee;
3. **Combination of the prior returns and views**; and
4. **Optimization and rebalancing**, i.e. the optimization of the expected return under several constraints, and the decision to rebalance the portfolio (taking into account the rebalancing costs).

1.1 Prior returns and volatilities

In the Black-Litterman context, the “prior (expected) returns” on the different assets are derived from their estimated volatilities (and correlations). Rather than considering historical returns, the model derives the “prior returns” by combining information on the risk of the assets (i.e. their volatility) and on the risk aversion coefficient of the market.

In order to convert the volatilities (and correlations) into expected returns, the following additional elements are needed:

- the risk aversion coefficient of the market (i.e. the “risk-return” trade-off); and
- the relative market weights of the different assets that make up the investment universe.

Combining these markets weights with the volatilities allows one to determine the covariance between an individual asset and the market (i.e. the undiversifiable risk of the asset). The risk aversion coefficient allows one to convert the latter in to an expected return.

** The technical details of the model have been simplified as much as possible in this report to facilitate reading. This documentation should therefore be seen as an intuitive presentation of the model, rather than a “model documentation” as such.*

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I. Model description (2/3)

1.2 Views

One of the key features of Black Litterman is that it allows investors to add “views” to the model. Each view expresses an opinion on the expected return of the assets. That is, the Investment Committee can express an opinion on the expected return of the asset that deviates from the (market-implied) prior return. The Investment Committee might for instance hold the opinion that the market is too optimistic or too negative about a particular asset.

Each view consists of two following elements:

- the opinion about the future expected return on the asset; and
- how uncertain the Investment Committee is about the view.

Clearly, when one expresses a view, there is no certainty that this view will materialize, as it is only an expectation. So, for every view, a level of uncertainty needs to be given. In the Gambit model, it is assumed that this uncertainty is proportional to the historical volatility of the asset under consideration.

1.3 Combination of prior returns and views

The next step is to combine the prior returns and views to obtain the “Black Litterman return”. The weighting scheme between the views and prior returns can be adjusted in the model by changing the level of uncertainty of the views (more precisely, by calibrating an “uncertainty coefficient” that applies on the views and scales their volatility). Note that Keytrade Bank assumes that views are independent (ie. no correlation between these views).

KeyTrade Bank targets a weight of 2/3 for the prior returns and 1/3 for the views. Note however that the relationship between the uncertainty coefficient and the weight is not that straightforward, and the exact weight given to views might differ from one asset to another.

Just as the prior returns and views are combined into a “Black Litterman return”, the volatilities on prior returns and views are combined to obtain a “Black Litterman volatility” (reflecting the additional uncertainty resulting from the views).

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I. Model description (3/3)

1.4 Optimization and rebalancing

The final step is to determine the optimal portfolio allocation, which maximizes the return under investment constraints (in terms of risk and concentration of investments).

The model will be run on a monthly basis to determine the optimal portfolio allocation, taking into account up-to-date market conditions and investment views. In order to limit rebalancing costs, the portfolio allocation will only be updated if the marginal gain exceeds the associated costs (incl. taxes).

In addition, rebalancing will be performed in case the risk of the portfolio breaches its initial risk limit, or if the investment allocation constraints (in particular, the minimum cash amount to be held) are breached.

1.5 Presentation of the ETPs in the universe

In order to replicate the “market”, Keytrade Bank has defined a list of 12 Exchange Traded Products (ETPs), composed of 10 Exchange Traded Funds (ETFs) and 2 Exchange Traded Commodities (ETCs). The list of ETPs at the time of the testing is presented in appendix. One should note that this list remains subject to changes.

Any modifications to the chosen ETF universe will be subject to a validation by the Investment Committee and a formal approval by the Risk Management department.

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II. Model testing (1/2)

2.1 Procedure followed by KPMG

The testing process has been divided into two steps:

- 1) A testing of the mathematical soundness of the model
- 2) The development of a parallel model, in order to challenge the results provided by the Gambit tool (for the optimization, back-tests and simulations).

For each area of investigation, KPMG assessed the appropriateness of the methodology and the results that were obtained. In case deviations with best practices were observed, KPMG assessed the potential impact these deviations could have on the results for the investor. In the next sections, the major findings are presented*.

In each section, KPMG describes the scope of the testing. Each section contains the following elements:

- The actual testing performed;
- Key strengths of the model;
- Additional remarks and areas for improvements (incl. findings, if any)
- A “traffic light” indicator which summarizes our opinion on the tests performed in each area.

An executive summary of the testing is presented in the next section.

* The minor findings were discussed with Keytrade, but not reported in this document

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II. Model testing (2/2)

2.2 Executive summary of testing

The table below summarizes the testing performed by KPMG. A full detail of this work can be found in appendix.

#	Summary of the testing	Traffic light
1.	General set-up of the model (calibration) The set-up of the model (calibration) is described in a formal procedure, and assumptions are documented. No further remarks.	
2.	Historical calibration and stress test results Keytrade put in place procedures that describe the monitoring of the parameters used in the tool, in order to ensure that they remain consistent in case of extreme market behaviors (in particular, the returns derived from the model). KPMG is of opinion that the use of such procedures provides additional safeguards to the model outputs.	
3.	Use of expert opinion Based on the procedure performed, KPMG has no specific remarks.	
4.	Optimization module The results obtained by KPMG are in line with those generated by the Gambit tool.	
5.	Rebalancing module Based on the procedure performed, KPMG has no specific remarks.	
6.	Back-testing methodology Based on the procedure performed, KPMG has no specific remarks.	
7.	Simulations KPMG is of opinion that the current methodology is fit for purpose.	

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III. Appendix (1/8)

3.1 Detail of the work performed

3.1.1 General set-up of the model (calibration)

Scope of the testing and work performed

#	Procedure followed by KPMG
1.	General set-up of the model (calibration) The main model parameters were investigated and challenged.

Model strengths

The testing highlighted the following strengths of the model:

- The model allows to incorporate Investment Committee views (hence is not only based on historical data, but also on experts insights);
- The methodology followed by Keytrade to determine the “market portfolio” is fit for purpose given the instruments considered in the universe, and is in line with literature.

Further observations

KPMG noted the following points of attention:

- The model is highly sensitive to market conditions changes. However, this sensitivity is mitigated by rebalancing criteria;
- The weights given to the views and prior returns are calibrated using specific scaling parameters. The link between these parameters and the weight given to the views is not always straightforward or transparent. To mitigate the risk of misunderstanding, Keytrade Bank has since put in place procedures for analysts to present the impact of each parameter choice on the return to the Investment Committee, which will thus be able to take the appropriate decisions at each rebalancing date.

KPMG advises that calibration parameters are reviewed periodically and updated if deemed necessary.

Conclusion/Findings

#	Summary of the testing
1.	General set-up of the model (calibration) The set-up of the model (calibration) is described in a formal procedure, and assumptions are documented. No further remarks.

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III. Appendix (2/8)

3.1 Detail of the work performed

3.1.2 Historical calibration and stress test results

Scope of the testing and work performed

#	Procedure followed by KPMG
2.	Historical calibration and stress test results KPMG performed several tests based on predefined market conditions (historical or hypothetical). These tests include situations of "high correlations/volatilities" (as in 2008), and the model runs under alternative calibration settings. KPMG also analyzed the methodology followed to reconstruct historical time-series.

Model strengths

KPMG obtained similar results as the Gambit tool in these extreme scenarios, meaning that the tool behaved as it should. In addition, KPMG confirms that the methodology and calculations used to generate historical time series are appropriate.

Further observations

The scenario testing highlights that the model outcome can vary significantly depending on the model parameters chosen. In addition, the results obtained (i.e. the realized returns) can differ significantly from those predicted by Black-Litterman, in particular during periods of market turmoil. As a consequence of the returns sensitivity to volatility jumps, prior returns can jump to unrealistic values when volatility strongly increases.

To control this volatility and ensure consistency in the model outputs, Keytrade has put in place procedures where calibration and market parameters (eg. Sharpe ratio, weights) are adjusted in case of extreme market conditions.

Conclusion/Findings

#	Summary of the testing
2.	Historical calibration and stress test results Keytrade put in place procedures that describe the monitoring of the parameters used in the tool, in order to ensure that they remain consistent in case of extreme market behaviors (in particular, the returns derived from the model). KPMG is of opinion that the use of such procedures provides additional safeguards to the model outputs.

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III. Appendix (3/8)

3.1 Detail of the work performed

3.1.3 Use of expert opinion

Scope of the testing and work performed

#	Procedure followed by KPMG
3. Use of expert opinion	KPMG assessed whether the use of expert opinion in the model settings was appropriately documented and supported by market best-practices.

Model strengths

A limited use of expert opinion is observed in the model settings. Most of the work has been challenged internally or is based on relevant financial literature.

Further observations

The model inherently includes expert judgement as inputs, as a result proper back-testing is critical. Keytrade implemented some back-testing procedures and defined the roles to be performed by analysts and the Investment Committee to verify that expert opinion is properly implemented.

Conclusion/Findings

#	Summary of the testing
3. Use of expert opinion	Based on the procedures performed, KPMG has no specific remarks.

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III. Appendix (4/8)

3.1 Detail of the work performed

3.1.4 Optimization module

Scope of the testing and work performed

#	Procedure followed by KPMG
4. Optimization module	KPMG performed a detailed testing (methodological testing and detailed testing on selected dates) of the model optimization module. This testing includes the analysis of model results and intermediary parameters (such as the covariance matrix and Black Litterman returns).

Model strengths

Overall, KPMG noticed that the results (and intermediary calculations) provided by the tool are in line with those independently obtained by KPMG.

Further observations

As noted in the calibration section, KPMG observed important moves in the portfolio allocation from one month to another. These variations are however mitigated by the rebalancing algorithm, which prevents jumps in the portfolio allocation and ensures that the portfolio is only rebalanced when the rebalancing generates a gain for the client.

Conclusion/Findings

#	Summary of the testing
4. Optimization module	The results obtained by KPMG are in line with those generated by the Gambit tool.

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III. Appendix (5/8)

3.1 Detail of the work performed

3.1.5 Rebalancing module

Scope of the testing and work performed

#	Procedure followed by KPMG
4. Optimization module	KPMG tested both the methodology and the results generated by the rebalancing algorithm developed by Gambit.

Model strengths

This module is key to the process, and ensures the control (i) of the rebalancing costs (hence avoids rebalancing with no added value to the customer) and (ii) of the risk profile of the portfolio ensuring it remains in line with the target risk of the investor.

Keytrade also put in place policies which describe how rebalancing is performed.

Further observations

The algorithm is limited in testing alternative portfolios. One could argue that some alternative portfolios, with lower returns but also lower transaction costs, could deliver a better "net return" to investors. The tool currently does not perform any test with alternative portfolios.

Conclusion/Findings

#	Summary of the testing
5. Rebalancing module	Based on the procedure performed, KPMG has no specific remarks.

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III. Appendix (6/8)

3.1 Detail of the work performed

3.1.6 Back-testing methodology

Scope of the testing and work performed

#	Procedure followed by KPMG
6. Back-testing methodology	KPMG tested the back-testing methodology and results for several profiles, between 2007 and 2015. Note that KPMG only tested the appropriateness of the back-testing methodology (and results). The analysis of these results (and comparison with appropriate benchmarks) was not in the scope of this testing.

Model strengths

KPMG results were in line with Gambit tool results, meaning that the model implemented by the bank behaved as it should.

Further observations

The risk profiles used by Keytrade Bank are based on quantitative criteria. Furthermore, a governance framework has been put in place to monitor the performance of the different portfolios (defining specific performance indicators that could trigger a review of the model parameters, e.g. the Sharpe ratio or weights given to views).

Finally, KPMG observed that the Black Litterman expected returns differed quite significantly from the actual (observed) returns. It is therefore key that the portfolio performances are adequately back-tested to ensure that the performance of the portfolio is in line with the target risk of the customer.

Conclusion/Findings

#	Summary of the testing
6. Back-testing methodology	Based on the procedure performed, KPMG has no particular remarks.

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III. Appendix (7/8)

3.1 Detail of the work performed

3.1.7 Simulations

Scope of the testing and work performed

#	Procedure followed by KPMG
7. Simulations	KPMG tested the methodology and calculations performed by Gambit for the simulations presented to the client. These simulations do not directly impact the portfolio allocation but are only presented for information purposes to the client.

Model strengths

Using similar assumptions, KPMG obtained similar results as those provided by the Gambit tool, meaning that the tool behaved as it should.

Further observations

Long term returns/volatilities are being used for the simulations (different from the Black-Litterman returns/volatilities used in the optimization). KPMG understands that on long-term simulations, the use of long-term inputs is appropriate.

Also, Keytrade defined policies regarding the definition (and update) of long-term returns.

Conclusion/Findings

#	Summary of the testing
7. Simulations	KPMG is of opinion that the current methodology is fit for purpose.

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III. Appendix (8/8)

3.2 List of ETFs at the time of the testing

Again, KPMG emphasizes that this list is subject to changes.

Asset class	Name	ISIN	CVMS / Ticker	Symbol
Share	iShares Core MSCI Pacific ex Japan UCITS ETF	IE00B52MJY50	79302221	CSPXJ
Share	ISHARES CORE MSCI JAPAN IMI UCITS ETF	IE00B4L5YX21	79302472	SJPA
Share	AMUNDI ETF MSCI EM	FR0010959676	79428306	AEEM
Share	iSHR ESTX50 B A	IE00B53L3W79	79432989	CSX5
Share	iSHR S&P500 B A	IE00B5BMR087	79433053	CSPX
Fixed income	AMUNDI HI YIELD EU	FR0011494822	70638260	AHYE
Fixed income	AMUNDI ETF EUR CRP	FR0010754119	79053681	CC4
Fixed income	AMUNDI ETF IG ALL	FR0010754192	79085757	CB3
Fixed income	AMUNDI GLOB EM BOND MARK IBX UCITS ETF	FR0010959668	79302104	AGEB
Fixed income	AMUNDI EURO INFLATION UCITS ETF	FR0010754127	79302166	CI3
Commodities	GOLD BULLION SEC	GB00B00FHZ82	79072965	GBS
Commodities	ETFS EUR DAILY HEDGED INDUSTRIAL METALS	JE00B78NPW60	79302270	EIMT
Cash	Cash	-	1	-

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