# Dollar – Euro exchange rate

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## Summary

The influence of six large-scale economic indices in Europe and the US on the Dollar-Euro exchange rate is investigated. First we looked for dominating recurring patterns that best describe the variability of the economic indices. Three patterns could be identified that describe more than 94% of the behaviour of the system. In a second step those most important patterns were used to model the exchange rate between Dollar and Euro over a period of 130 trading days. Daily closing data over a period of 26 weeks were used. We achieved correlations of above 0.8.

## 1. The problem

The Dollar-Euro exchange rate reflects to a large degree the relative economical strength of Europe and the US. In principle it should therefore be possible to model the exchange rate using indices that describe the economics in both regions. Two main problems occur when such an attempt is started:

- The signals we are looking for are hidden by noise
- It is not obvious which indices or which combinations of indices are the best to model the exchange rate

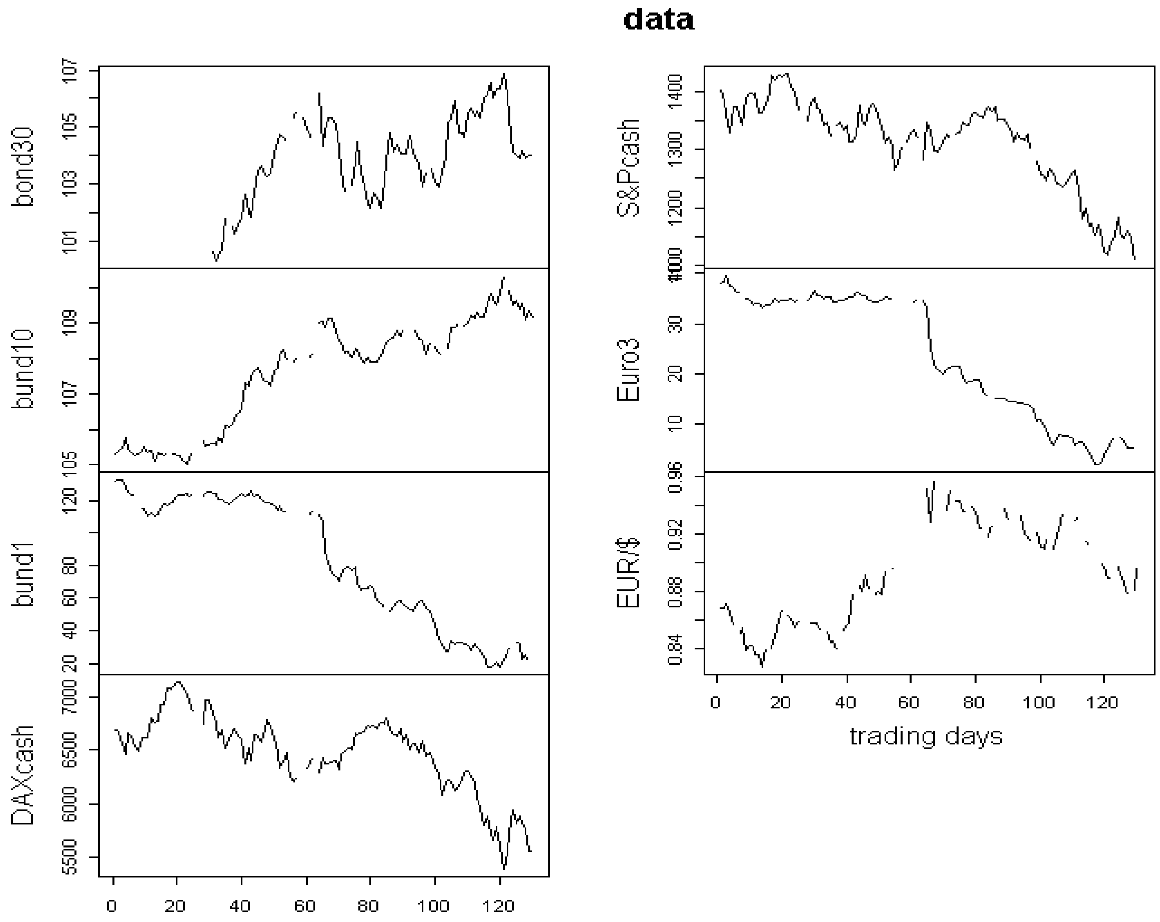
A systematic approach is required that first separates signal and noise, and second finds in a systematic manner an optimal combination of indices. Solving those problems yields valuable insight into the mechanisms that govern the Dollar-Euro exchange rate, which might be exploited in the future.

## 2. Data

The data used in this study cover the period 14$^{th}$ of August 2000 to 04$^{th}$ of April 2001. Daily closing values of the following indices were analysed:

- Bond 30 years
- Bund 10 years
- Bund 1 year
- Dax cash
- S&P cash
- Euro 3 months interest
- Dollar-Euro exchange rate

Please remark that with the exception of the Euro 3 months interest these are only German indices on the European side. In the following plot they are displayed:




The gaps correspond to missing data. The relatively large gap at around day 60 corresponds to Christmas 2000.

## 3. Methodology

The objective is to find statistically significant and robust relationships between the economical indices and the Dollar-Euro exchange rate. The difficulty, however, is that the data are noisy. It must be ensured that the model does not over-fit the data. Furthermore, it has to be investigated which economical indices are most useful for that purpose.

The first step is to separate the problem into predictable signals and unpredictable noise. The decision of what to call “signal” and what to call “noise” is non-trivial. A powerful method to do so is the expansion of the problem into a few characteristic “guess patterns”. In many cases only a few of such patterns are sufficient to explain the major part of the behaviour of the system. The specification of those characteristic patterns can be done in various ways depending on the problem. Once significant patterns are found they form the basis to identify statistical relationships between economic indices and the Dollar-Euro exchange rate.

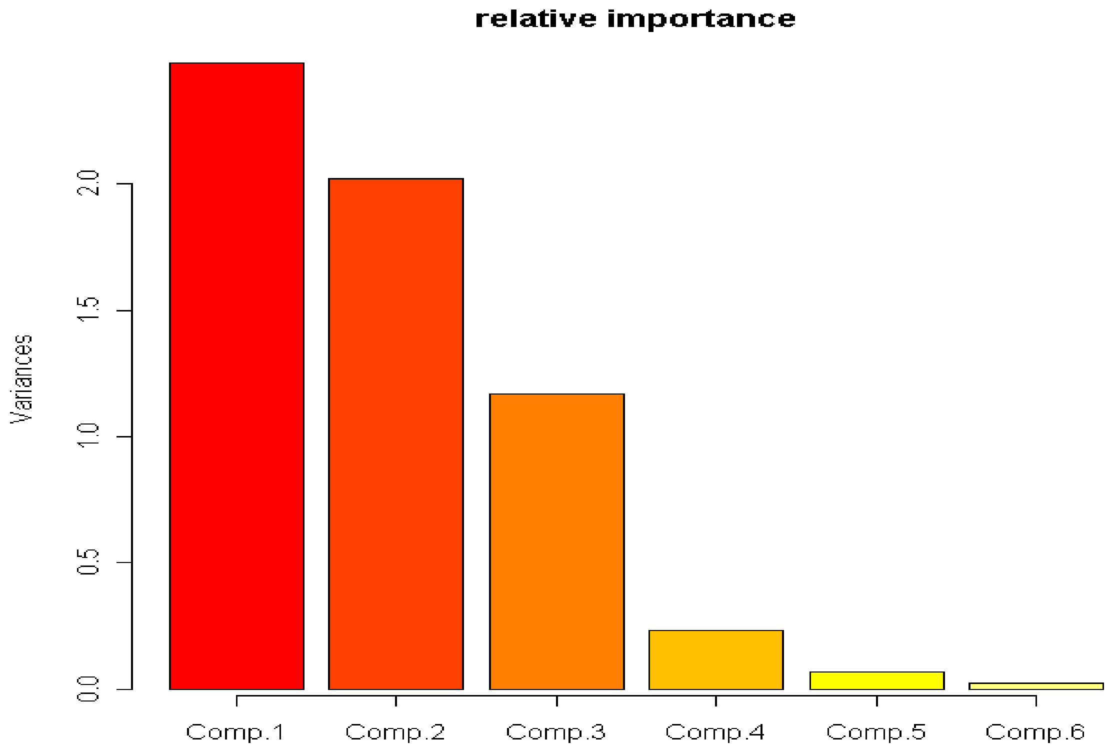
Based on this, the algorithm to find robust relationships is as follows:

1. Identify the dominant patterns for the economic indices and store them
2. Project the original data onto the respective patterns to obtain the time evolution coefficients of the patterns.
3. Determine a statistical model that describes the relationship between the dominant patterns and the exchange rate. Use this model to transform economic patterns into the exchange rate.

Signal and noise are separated from each other in an objective and natural way. In contrast to classical filtering methods this approach does not need any ad hoc assumptions. Various statistical modelling algorithms were tested, yielding 3 different modelling systems.

## 4. Results

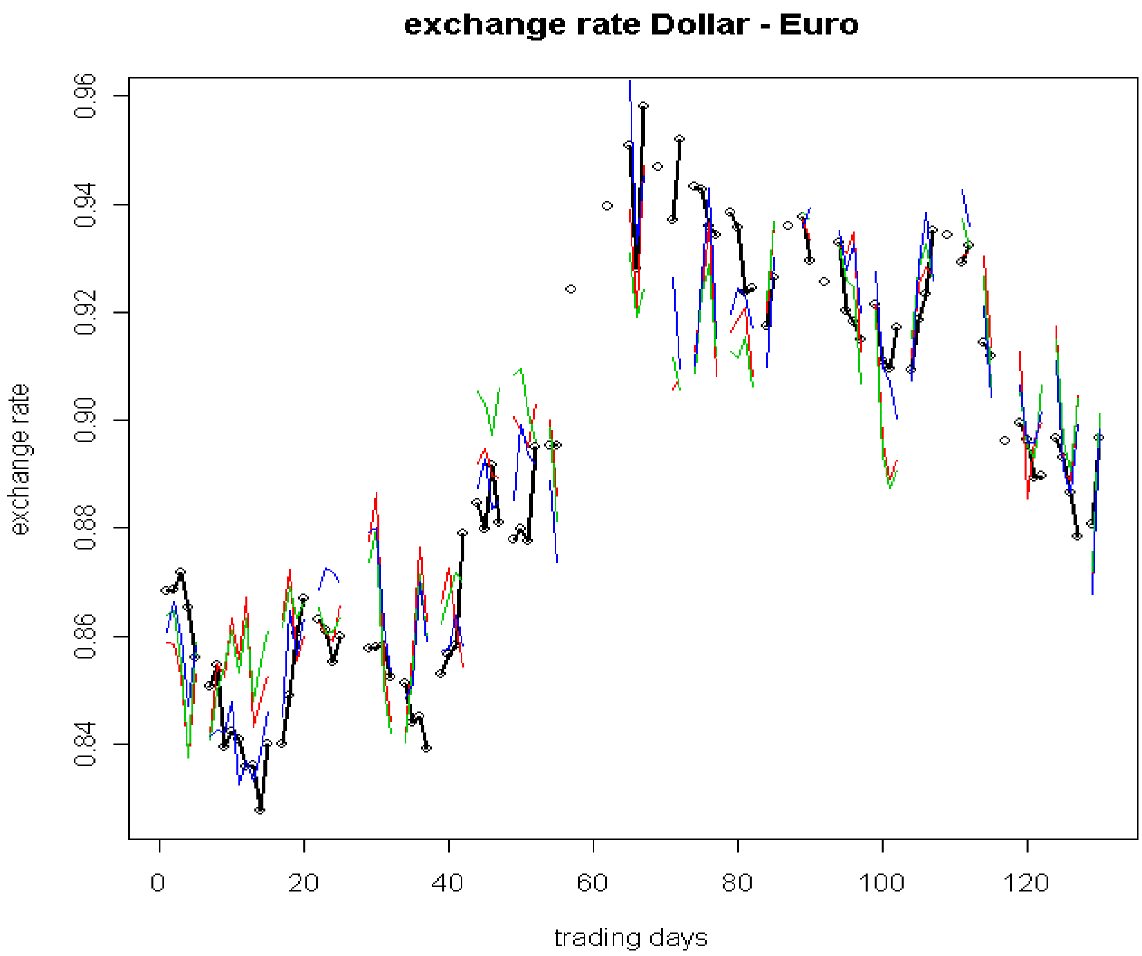
First we present the result of the pattern analysis and give a brief explanation. Since we have six input variables (the Dollar-Euro exchange rate is excluded since we want to model that one) we obtain a maximum of 6 patterns. In the following graph the coloured bars represent the relative importance of each pattern in descending order.




It is obvious that 3 patterns are sufficient to describe the whole system. Those three patterns account for more than 94% of the total variance of the system. Thus we have reduced the complexity of the modelling problem by a factor of 2 (i.e. from 6 raw input data to 3 patterns).

The patterns can be interpreted and thus provide some insight into the mechanisms, governing the system. The first pattern is basically the sum of bond30, bund10, bund1, and Euro3 minus DAXcash and S&Pcash. This index alone describes already 40% of the variability of the whole 6-variable system. The second pattern, which accounts for another 33% of the variance, is mainly the sum of the two cash indices plus bund1 and Euro3. The contribution of bond30 and bund10 to this pattern is minor. The third pattern is composed of the difference between bond30, bund10, DAXcash, and S&Pcash on one side and bund1 and Euro3 on the other side. Bond30 and bund10 contribute more to this pattern than the other variables. What we call patterns can be interpreted as the most significant indices to describe the system. Monitoring combined indices like that provides more insight than looking at the individual input data (indices).

The next step is now to project the most dominant indices onto the Dollar-Euro exchange rate. This approach is much less prone to overfitting than a direct approach, linking directly all six indices and the exchange rate to each other. We tested three different models and the results are presented in the following plot.




The black dots and the thick black line represent the actual exchange rate, whereas each coloured line stands for a reconstruction from the patterns using a different model. Overall the agreement is quite reasonable, and especially the major changes are well captured. It is interesting to note that model 3 (the blue line) outperforms the other two models. Model 1 and 2 are so called additive models, not allowing interactions between patterns. Model 3, however, is also seeking for non-linear interactions between different input variables. Obviously such interactions are important in this case, since the performance is clearly better.

It is also interesting to note that the European indices where mainly German indices. Since we succeeded in modelling the Dollar-Euro exchange rate using only those indices, we may either infer that all European economies behave basically in the same way, or that the value of the Euro is dominated by the German economy. Including data from other European countries would clarify this point.

## 5. Forecasts

So far we only spoke about analyses but not about forecasts. A similar approach as described in this paper can be applied to seek for possible relationships that allow real forecasting. A very brief look at the time evolution of pattern 1 and the exchange rate (not presented here) indicates a phase shift between the two, which could be exploited. Further investigations, however, are necessary to confirm this preliminary finding.

## 6. What next ?

In this analysis we reduced the complexity of the modelling problem by a factor of two (from six to three). Possibly a much larger benefit could be achieved if we used more input data. If we had, for instance, 50 different input data (from other European countries, other data types, …) we possibly could reduce the dimension of the system by a factor of 10 or even more. Our experience with highly complex systems like large computer networks or with climate related problems indicates, that this assumption is not overoptimistic. Very rarely one needs more than a few patterns (3 to 10) to capture the major part of the system variability.

Furthermore it sounds promising to address the forecast problem that we mentioned already in the previous section.

Nowadays so-called ensemble predictions are carried out to obtain probabilistic forecasts. Applying our statistical methods in such a way yields probabilistic predictions. Beside the prediction of the actual price these forecasts provide also information about the uncertainty of the forecast. Together with cost/loss optimisation methods probabilistic forecasts enable the optimisation of business strategies and the estimation of the mean value of a forecast system (this will be explained in an extra paper).