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Agents' Rationality and the CHF/USD Exchange Rate

Part II

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Part II

Hermann Garbers[1]

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Summary

In *H. Garbers* [3] the author was concerned with modeling the monthly logarithmic CHF/USD exchange rate, s_t. He rejected a model proposed by *B.T. McCallum.* Searching for a more appropriate framework a story by *P. De Grauwe* [2] was introduced, bringing complex cognitive processes and social practices into the picture.

This paper treats again *P. De Grauwe*'s story, supplements it and embedds it into a broader setting showing its links to a subtle concept of agents' rationality. We derive a testable implication of this approach. Although the test result is negative, it will be helpful for the misspecification analysis of *B.T. McCallum*'s model [7] (applied to s_t), which will finally be presented in Part III of this paper.

Contents

Introduction

We start again by discussing the subjective character of agents' probability distributions, but this time from a different perspective compared to Part I of the paper. While different methods are applied to treat them, further probabilities are introduced into the analysis. In chapter 4 we are, for instance, concerned measuring the probabilities of a certain system to remain in a taken up regime in period t during $t+1$ or its probability to change into another regime.

But before we are able to estimate and to discuss these probabilities, these regimes have to be introduced together with a lot of necessary "background knowledge" concerning especially the properties of cognitive processes.

1 Concepts of Rationality and Uncertainty

Remember:

> We started Part I of this paper by applying *B.T. McCallum*'s model (I) to s_t and rejected it.
>
> We made the RE hypothesis responsible for this rejection.
>
> We discussed *M. Kurz*'s theory [6] of rational belief which led us to the subjectivity of the probabilites implied, to endogenous uncertainties, to non-stationarities and regime switches.

While the subjectivity appeared in our previous paper together with the non-stationarity of the corresponding time series, the latter is not a necessary condition for the former one to show up.

In economics one generally begins with a statement (an Initial Hypothesis) such as:

> "Social science is the study of human behavior. (...) economics is that discipline within social science (...) which seeks explanation of human events on the basis of the changes in opportunities faced by individuals. (...). Tastes are assumed to be constant (...)." (*E. Silberberg*, p. 2 [11])

Hence a *complete preference association* is normally subscribed to the subjects. Further definition is achieved by the introduction of utility functions. In effect a (constrained) maximization of the utility functions formalizes the fact that economic agents behave rationally under the forces of *well-understood personal interest*.

On the basis of a rationality under well-understood personal interest of the agents, economics has developed a device for situations which are basically time independent and free of significant uncertainties. This has achieved results which are of importance for appropriate decision-makers (for example, owners of cinemas who must define the prices of entrance tickets and snacks during the break). *The basic problem is that without further major effort economists have subsequently transferred the statements obtained in this way to more general situations* (*D.M. Kreps*, p. 19 [5]).

In a widespread generalization of the initial hypothesis the *expected utility* theory represents the behavior of the individual as decisional behavior under uncertainty. It postulates a situation in which all possible results x_i of a decision are at first just as well known as the probability of the occurrence of x_i. For the evaluation of the decisions, which are interpreted as lotteries, determinations are then made according to utility values $u(\cdot)$ of the individual possible results (wins or losses), and their probabilities $p(x_i)$ of occurrence (given the decision). Finally, that decision is achieved which has the highest expected utility:

Let X be a finite set of N possible results of a lottery L, which can be described as a vector $(p_1, \ldots, p_N)$ of probabilities. The agents are assumed to possess preferences concerning the set $\mathcal{L}$ of all these vectors, which represent in each case a probability distribution of X. The preference ordering $(\geq)$ of an individual can then be characterized (under certain additional assumptions concerning "$\geq$"):

There is a function $u : X \to \mathbb{R}$, so that for L, L' from $\mathcal{L}$ it can be stated:

$$L \geq L' \quad \text{if and only if} \quad \sum_{n=1}^{N} p_n u_n \geq \sum_{n=1}^{N} p'_n u_n \quad .$$

However, if no such a priori probabilities are given, it is no longer possible to make use of the above theory. If a set $\Omega = \{1, \ldots, S\}$ of states of the world and a set of functions $h \in \mathcal{H}$ with $h : \Omega \to X$, which can be interpreted as "state contingent payoff functions", exists, then *L.J. Savage* [9] has proposed a theory which is based on a preference ordering $(\geq)$ on $\mathcal{H}$. With certain additional assumptions concerning $h, g \in \mathcal{H}$, this theory concludes that there is jointly a utility function $u : \Omega \to \mathbb{R}$ *and* probabilities $p_1, \ldots, p_s$, so that

$$h \geq g \qquad \text{implies} \qquad \sum_{s=1}^{S} p_s u\Big(h(s)\Big) \geq \sum_{s=1}^{S} p_s u\Big(g(s)\Big) \quad .$$

Hence in this case the *probabilities* p_s for the states of the world are dependent *on the preferences of the individuals*. Consequently they represent *subjective probabilities* which no longer represent autonomous descriptions of the real world.

In general it was possible to reveal essential deficiencies in the expected utility theory by *laboratory experiments* (*D.M. Kreps*, pp. 116ff [5]). In a large number of laboratory experiments, *A. Tversky and D. Kahneman* ([16], [17]), for example, found that

1. formulations of a decision problem, which are different, but equivalent in content, do not lead to equivalent decisions in completely analogous experiments
2. the evaluation of a decision for a given $u(x_i)$ is non-linear in the $p(x_i)$,
3. possible losses are given a substantially greater weight than corresponding profits.

In their prominent *Prospect Theory*, which represents a reaction to the apparent deficits, *A. Tversky and D. Kahneman* [16] replace the utility function u by an evaluation function v, which is concave in the range $x_i > 0$, convex for $x_i < 0$ and is more steeply inclined for $x_i < 0$ than for $x_i > 0$. In addition, instead of $p(x_i)$, they use a weighting function, which provides a greater weighting to initially small values of $p(x_i)$, giving the other $p(x_i)$ values a smaller weighting.

Hence the transition from the expected utility theory to the "Prospect" theory is not much more than the transition from one formalization to another formalization of a theory which remains based on the concept of an expected value. However, it is now an expected value, which additionally attempts, in a rather obscure fashion, to capture certain aspects of risk, above and beyond $u(\cdot)$.

An alternative and less ad hoc concept has been constructed in the "rational random behavior" model which is described in detail in *H. Theil* (p. 80) [15]. It contains an additional structure of non-trivial decision-processes proposing a procedure for agents to select "their" probabilities.

Let $\vec{x}$ represent the vector of the decision variables of a decision-maker, which may be an individual, a household, etc. $\vec{x}$ is affected by a very large number of factors, which the decision-maker groups into two classes in order to reduce the level of complexity: in the class which is recognized as being essential and in that of less important factors. In the planning stage, the decision-maker considers particularly the first class. For this purpose he has a criterion function $f(\vec{x})$, which systematically ignores the influence of the less important factors. It is assumed that f can be continuously differentiated three times and that at the location $\vec{x}^*$ there is a uniquely determined maximum within its range of definition, so that

$$f\left(\vec{x}\right) = f\left(\vec{x}^*\right) + \frac{1}{2}\left(\vec{x} - \vec{x}^*\right)' H\left(\vec{x} - \vec{x}^*\right) + \mathrm{O}\left(\left\|\vec{x} - \vec{x}^*\right\|^3\right) \tag{1}$$

with the symmetrical and negatively definite *Hessian* matrix $H(\vec{x}^*) =: H$.

In the planning phase the decision-maker additionally considers the class of less important influence factors. He anticipates that their existence implies in the implementation phase a decision vector, which must be viewed as a vectorial random variable, the distribution of which has to be defined in the first stage. Accordingly, the decision function appears as a decision distribution, which should be determined "rationally".

From (1) it follows that

$$f\left(\vec{x}^*\right) - f\left(\vec{x}\right) = -\frac{1}{2}\left(\vec{x} - \vec{x}^*\right)' H\left(\vec{x} - \vec{x}^*\right) + \mathrm{O}\left(\left\|\vec{x} - \vec{x}^*\right\|^3\right)$$

represents a loss in terms of f, if $\vec{x}$ is realized instead of $\vec{x}^*$. This loss can also be seen as a random variable, whose remainder $O\left(\|\vec{x} - \vec{x}^*\|^3\right)$, however, is ignored by the decision-maker in order to further reduce the level of complexity. The expected "loss" $(\bar{L})$ can then be written as

$$\bar{L} := -\frac{1}{2} E\left[\left(\vec{x} - \vec{x}^*\right)' H\left(\vec{x} - \vec{x}^*\right)\right] = -\frac{1}{2} \operatorname{trace} H\Sigma$$

with

$$\Sigma := E\Big[\big(\vec{x} - \vec{x}^*\big)\big(\vec{x} - \vec{x}^*\big)'\Big] \quad .$$

The decision-maker attempts to keep this as small as possible during the planning phase. At the same time he wants to remain as flexible as possible in terms of the distribution law of $\vec{x}$, *H. Theil* [15] introduced a corresponding function Φ, which decreases monotonously with $(\bar{L})$ and increases monotonously with the *entropy of the distribution* of $\vec{x}$. He can show that under the assumption that every component of $\vec{x}$ varies without limitation in the range $(-\infty, \infty)$, Φ is maximized by the probability density function

$$g_k(\vec{x}) = \frac{|-H|^{\frac{1}{2}}}{(2\pi k)^{\frac{n}{2}}} \exp\left\{\frac{1}{2k}\,\big(\vec{x} - \vec{x}^*\big)' H \big(\vec{x} - \vec{x}^*\big)\right\}$$

with $k > 0, \vec{x} \in \mathbb{R}^n$. *H. Theil* [15] designated this distribution as "rational random behavior for decision variables with range $(-\infty, \infty)$ and $k > 0$". Apparently the distribution sought is a multivariate normal distribution with the expected value $\vec{x}^*$ and the covariance matrix $(-kH^{-1})$. The value of $k > 0$ *depends* through Φ still *on the preferences* of the decision-maker concerning the entropy and the expected losses in the planning phase.

We conclude that a rigid decision distribution concept has been formalized, which connects uncertainty and rationality. Notice that again contrary to the so-called primary probabilities in natural science experiments, only probabilities are considered, which are essentially based on the preferences and the incomplete information of the decision-maker. The entropy-maximizing aspect of the approach in the second phase appears then to be an elegant aspect of agents' probability selection problem.

The "Rational Random Behaviour" model is, however, concerned with a representative agent in a strange static framework. To introduce time explicitly into this picture one can think of changes in $\vec{x}^*$, H and/or Σ from some periods to other ones implying a series of normal distribution $g_{k_1}(\vec{x}), \ldots$. Each $g_{k_i}(\vec{x})$ is indicating a certain regime ignoring, however, the specific dynamics of cognitive processes, which we are going to study now.

2 Dynamic Aspects of Cognitive Processes

Unlike the uncertainty we have been dealing with in chapter 1, the one which is present e.g. at foreign exchange markets, implies a complex structure.

Imagine an agent who interacts with his environment *without being able to act on the basis of a function*, which allocates a specific decision to each condition of the environment, should the environment be in the appropriate state.[2] Since he is only partially aware of the state of his environment, he can only reach a sufficient ability to judge it (e.g. a market) through an increasing number of interactions and observations. However, this generates in him a level of expectation and hence potentially may stop the search process: if a decision procedure does not satisfy the appropriate level of expectation, then the agent searches for further procedures – perhaps even more intensively, whereas in the other case it may be reduced or even completely stopped. Here the level of expectation does not represent a fixed value. Rather it may increase or decrease, for example, with the ease or difficulty of finding new procedures or with the efforts of comparable individuals. Accordingly the search implies an interaction between solutions and level of expectations (*H. Simon*, p. 323 [12]).

[2] This stands in contrast to so-called "reinforcement learning" (*R.S. Sutton, A.G. Barto* [14]) which designates a function of this kind as "politics".

It is quite obvious that by *H. Simon*'s bounded rationality concept complex cognitive processes (and social practices) of agents come into the picture. We proceed by learning about it under relatively simple experimental conditions.

In certain situations, the results of experimental economics indicate the existence of a "status quo bias" (endowment effect). *V.L. Smith* [13] gives an illustrating example of this effect, which we would like to describe here in a slightly modified form: a person buys a number of bottles of wine for 8 USD per bottle. A few years later he receives an offer of 100 USD per bottle. However, the offer is refused, even though he had never in his life paid more than 50 USD to buy a bottle of wine from a retailer.

What is manifested in this seemingly harmless little example is the observation made over and over again in the most varied experiments that, after acquiring goods (an alteration of their endowment), people very often value them more highly than before. This applies for goods with close substitutes, which are frequently traded on the market, but particularly for those which are rarely traded and have few possibilities of substitution. In the second case, however, a much larger positive difference between the price per unit which a person would request for a sale and that which they would be prepared to pay for the purchase of a further unit (*G.C. Morrison* [8]) is generally observed.

Nowadays in the literature it is generally agreed that the "status quo bias" indeed exists and signalizes a dependence of the preferences on the possession of individual goods. *Hence the preferences of economic subjects must indeed be viewed as endogenous and temporally variable.* A simple parallel with marketing research – to which the "status quo effect" could also be ascribed – confirms additionally that many of our courses of action are not based on a mechanical sequence, but rather that *extended stimulation/reaction models* have to be considered. They take account of certain *communicative intellectual processes* of an individual happening in a period between the stimulations and the reactions.

"Cognitive dissonances" are based on the fact that individuals possess a "cognitive system" focusing on its environment, on itself as well as on its behavior, and comprising its knowledge, its opinions and beliefs (in the sense of believing something to be true or untrue). Cognitive dissonances always attempt to establish consistency of the system. If this then is put under strain by a new "cognition", then the individual perceives the corresponding condition as unpleasant and attempts to return it to a stress-free condition.

Given then a complex cognitive situation, agents will be *driven* by the force of dissonances. These trigger the operation of "rationality principles", which at all events ensure a consistency in the system in the sense that its set of cognitive statements is "closed" with respect to elementary logical deductions: The cognitive system itself collects information concerning the status of its information processing and uses it consistently. In this way the system as a whole endeavours to become *coherent and connected*, without unexplained gaps. To demonstrate, consider an example which is taken from *R.J. Shiller* [10].

> "Psychologists Pennington and Hastie have shown the importance of stories in decision making by studying how jurors reached decisions in difficult cases. They found that jurors' approaches to reasoning through the complicated issues of the trial tended to take the form of constructing a story, filling out the details that were provided to them about the case into a coherent narrative of the chain of events. In describing their verdict, they tended not to speak of quantities or probabilities, or of summing up the weight of the evidence, but rather to merely tell a story of the case, typically a chronology of events, and to remark how well their story fit together and how internally consistent it was."

In total this thereby suggests that in the cognitive system of an individual, the operation of "rationality principles" is observed, which at all events ensures a consistency in his system and goes beyond that.

Note the treatment of probabilities in the above quotation.

3 Social Practices and the Rationality of Agents

Following *H. Simon*'s bounded rationality concept we find a dynamic structure in agents' cognitive processes. Additionally, the discussion points out to the existence of a *normative* aspect by linking those cognitive processes to certain *social practices*. Moreover, it is here that we finally come back to the story of *foreign exchange markets* told by *P. De Grauwe* [2] and presented with emphasis and at greater length in our earlier paper [3].

P. De Grauwe observed that since its introduction up to May 2000, the *Euro* has lost 25 % of its value in comparison with the *USD*. The drop appeared to be unrelated to any new information concerning basic fundamental variables. *P. De Grauwe* concluded:

> "(...) it is not the news in the fundamentals that drives the exchange rate changes, but rather the other way around: changes in the exchange rate lead to a selection of news about the fundamentals (present and future) that is consistent with the observed exchange rate changes. (...) Thus, when at the start of 1999 the dollar started to move upwards, this (...) set in motion a search for good news about America and bad news about Europe (...) (which) reinforced the exchange rate movements (...)."

We interpret *P. De Grauwe*'s story as fitting well into the framework of

a) *H. Simon*'s general bounded rationality approach,

b) *R.J. Shiller*'s statement that agents tend to tell a coherent story putting things together in an internally consistent way,

while it is

c) adressing additional aspects of uncertainty.

To illustrate c) we assume, for the time being, that s_t as well as some other variable are $I(1)$ variables. Simulating then two (independent) $I(1)$ processes (see *E. Zivot and J. Wang* [18], pp. 417ff) one gets a graph like the following:

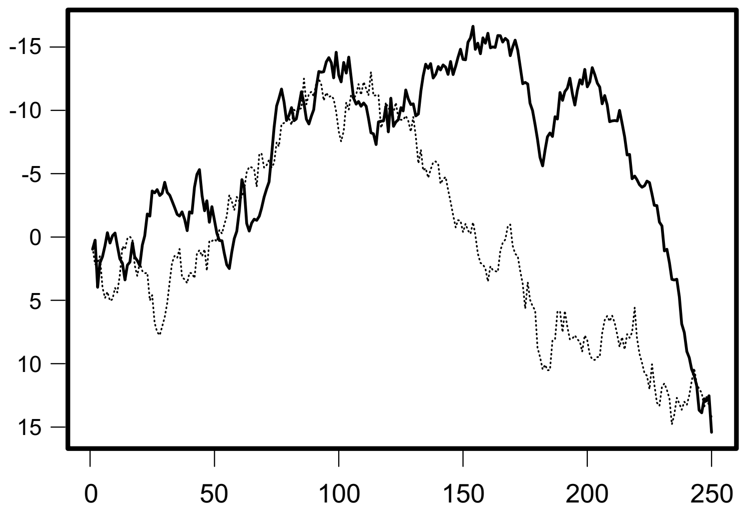

Figure 1: ***Two Simulated Independent Gaussian Random Walks***

Obviously, there are movements in the simulated time series which appear to be "economically relevant". Not knowing the possibly simple statistical origin of the movements, agents might look for an economic interpretation of it, relating the observations made to the influence of "fundamental variables".

Introducing then into this "world" of random walk processes (without drift) a cointegrating relationship will change the scenario drastically showing a much more stable world:

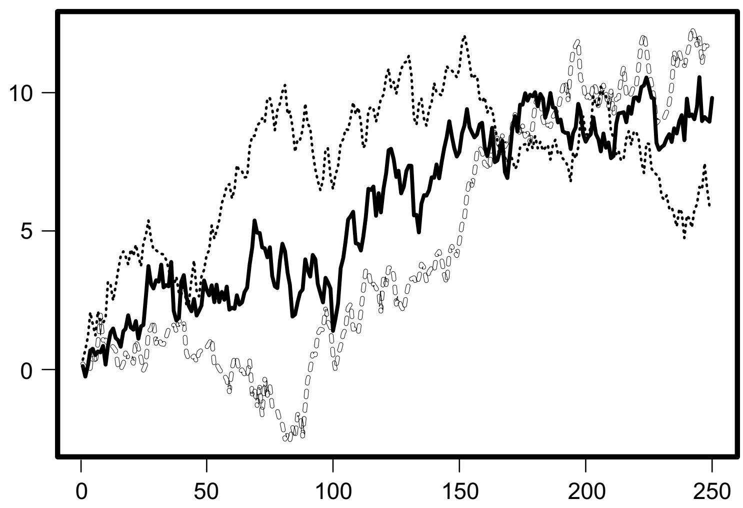

Figure 2: ***Simulated Trivariate Cointegrated System with one Cointegrating Vector***

However, we have not found a cointegrating relation within our set of foreign exchange variables. If then agents, looking for an interpretation of movements in the time series s_t, do not succeed in telling (subtle) coherent stories they still will make their decisions. But this means

1. that agents (often) act, looking afterwards for the identification of "causes",

2. that reasons will count and will be produced and consumed by agents, giving way for instance to national banks like the **S**wiss **N**ational **B**ank to become an influential participant (investor) at foreign exchange markets.[3]

3. Agents' behavior will not be explained completely if the explaining reasons are not at the same time justifying ones.

It follows that agents generate and participate in specific social practices. In a general social practice ideas are applied, semantic rules of logical thinking are obeyed and the power for a commitment by a better argument is alive. The practice happens mainly in discursive processes by which we make explicit a knowledge which is predominantly given implicit to us by our experiences. Moreover, it makes a difference between the intentions of an individual and a common one distributed among a society. The very existence of the common intentions implies, then, that agents live, think and deal in a *network of intentions* (which may change over time). Additionally, *the network is related to a common basis of data.*

Based on this set of data, agents realize that s_t does not follow a random walk process with an error term of a martingal difference sequence. It appears however that s_t is not "very far" from being a *rwp* and that a segmented *rwp* (see our previous paper, Part I) with drift showing three regimes will

[3] But national banks do behave according to *chosen targets* which change from time to time while s_t is not the only target variable e.g. of the SNB, a *price index* represents an often even more important one.

be a more adequate maintained hypothesis:

1. a rwp with a clear positive drift,
2. a rwp with a clear negative drift,
3. a rwp with a (near) zero drift.

A corresponding "social practice" is next concerned searching coherent stories in order to identify the current state of s_t and to predict the state of s_{t+1}.

4 Random Walk Processes as Basic Components

To model social practices within possibly changing networks of agents' intentions we presented a first sketch using different *rwp* jointly. To give a further justification for this approach consider the following arguments:

It has been shown by experiments in which laboratory markets simulate the trade on financial markets (*V.L. Smith et al.* [13]) that these markets show "stable" behavior anticipating future states if

1. agents are able to set up for this reliable expectations in an *environment which varies only to a small extent*, and
2. the costs of creating expectations are seen to be much lower for the agents than the probably resulting income.

Moreover, according to a description by *Working* and his followers (*K.J. Arrow* [1]), who, even before 1953, discovered through the observation of the fluctuation in security prices and the prices of commodity futures on real markets that they predominantly followed a "random walk"

$$P_t = P_{t-1} + \varepsilon_t$$

where $\varepsilon_t; t = 1, 2, \ldots$ is treated as a process of "white noise" which is at any time orthogonal to P_{t-1}.

Working concluded that the agents completely evaluate the information present in the data and in particular discover a predictability of future security prices, in order to appropriately alter their demand for the corresponding securities, in such a way as to explore all possibilities of achieving a profit.[4]

But *Working*'s model has later on been rejected, because of heteroscedasticity and/or regime switches in the ε_t's. Taking monthly data and considering for example *(demeaned) stock returns*, y_t, the following model, see *Ch.-J. Kim and Ch.R. Nelsen* [4], appears to be more in line with changing networks of intentions, especially the existence of dissonances and the resistance to alterations of the cognition:

The variable evolves, according to a first-order *Markov* process with an unobserved state variable A_t containing three states and the corresponding transition probabilities p_{ij}:

$$y_t \sim N\big(0, \sigma_t^2\big)$$

$$\sigma_t^2 = \sigma_1^2 A_{1t} + \sigma_2^2 A_{2t} + \sigma_3^2 A_{3t}$$

[4] *Working*'s description of financial markets was later on generalized by the *"rational expectation"* approach. According to the *RE* description, a price variable y_t representing the market price of specific goods or of securities at a point in time t, is broken down to

$$y_t = y_t^p + v_t$$

with

$$y_t^p = E\Big[y_t | I_{t-1}\Big] \qquad \text{and} \qquad E\Big[v_t | I_{t-1}\Big] = 0 \quad .$$

$E[\cdot | I_{t-1}]$ represents an expected value conditional on an information set I_{t-1}, and v_t is a mean innovation process only, ignoring moments of second order.

$$A_{it} = 1 \quad ; \quad \text{if} \quad A_t = i, \ i = 1,2,3$$

$$A_{it} = 0 \quad ; \quad \text{otherwise}$$

$$P_r\Big[A_t = j \mid A_{t-1} = i\Big] = p_{ij} \quad ; \quad i,j = 1,2,3$$

$$\sum_{j=1}^{3} p_{ij} = 1 \quad ; \quad \text{for } i = 1,2,3$$

$$\sigma_1^2 < \sigma_2^2 < \sigma_3^2$$

Notice that the above model introduces probabilities in two different ways. While the normality assumption concerning (y_t) could be justified by something like a rational random behavior concept, the set of transition probabilities p_{ij} cannot be justified in a similar manner. They are simply ascribed (by us) to the model while their operationality remains still to be shown.

Formalizing the approach for s_t correspondingly we get the following model:

$$(1-L)\big(s_t-\mu_{A_t}\big)=e_t \qquad ; \qquad e_t \sim N\big(0,\sigma^2_{A_t}\big)$$

$$Pr\Big\{A_t=j \;\big|\; A_{t-1}=i\Big\}=p_{ij} \qquad ; \qquad i,j=1,2,3$$

$$\sum_{j=1}^{3} p_{ij}=1 \qquad ; \qquad \forall\, i$$

$$\mu_{A_t}=\mu^{(1)}A_{1t}+\mu^{(2)}A_{2t}+\mu^{(3)}A_{3t}$$

$$\sigma^2_{A_t}=\sigma^2_1 A_{1t}+\sigma^2_2 A_{2t}+\sigma^2_3 A_{3t}$$

$$\text{where} \qquad A_{it}=\begin{cases}1 & if \;\; A_t=i\\ 0 & \text{otherwise}\end{cases} \quad .$$

Taking then the monthly data for s_t in the period 1975.2 - 2003.5 the estimated drift terms (μ) and the estimated variances (σ^2) for the regime errors are[5]

	value	s.e.
$\mu^{(1)}$	-0.036	0.016
$\mu^{(2)}$	0.003	0.004
$\mu^{(3)}$	-0.001	-0.019

σ^2_1	$0.708 \cdot 10^{-3}$
σ^2_2	$0.830 \cdot 10^{-3}$
σ^2_3	$3.050 \cdot 10^{-3}$

[5] The following results are generated using the *MSVAR* (Markov-Switching Vector AutoRegressions) software package, version 1.31, for Ox, written by H.-M. Krolzig, Oxford University.

Additionally, the transition matrix (p_{ij}) is estimated as

	$j=1$	$j=2$	$j=3$
p_{1j}	0.54	0.04	0.42
p_{2j}	0.05	0.93	0.02
p_{3j}	0.10	0.25	0.65

while the estimated smoother probabilities for regime 2 are presented in figure 3.

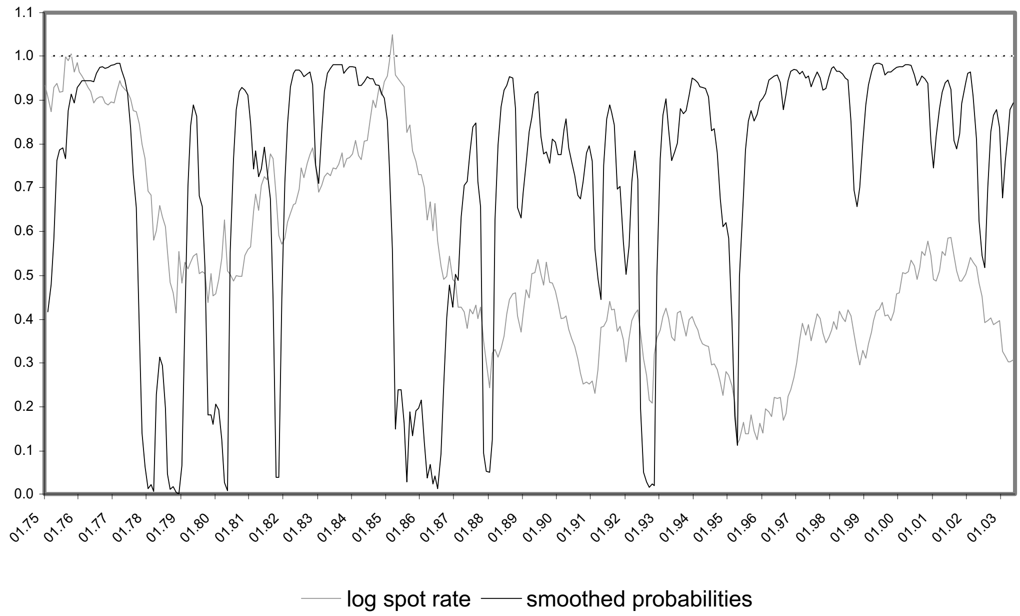

Figure 3: ***Spot Rate CHF/USD and Smoothed Probabilities Regime 2***

We have to admit that the above results are still very sensitive to a change in the time frame. Taking e.g. the shorter period 1978.2 - 2003.5 the estimated transition matrix is

	$j=1$	$j=2$	$j=3$
p_{1j}	0.01	0.01	0.98
p_{2j}	0.00	0.99	0.01
p_{3j}	0.57	0.06	0.37

We get again very different results for the period 1980.2 - 2003.5.

Assuming then the existence of 2 regimes only while considering the period 1980.2 - 2003.5 the estimated parameters are

	$j=1$	$j=2$
$p_{1,j}$	0.94	0.06
p_{2j}	0.03	0.97

	value	s.e.
$\mu^{(1)}$	-0.005	0.007
$\mu^{(2)}$	0.002	0.003

σ_1^2	$2.05 \cdot 10^{-3}$
σ_2^2	$0.9 \cdot 10^{-3}$

The following figure shows the estimated smoother probabilities for regime 1. Notice the strange results for the period 94.01 - 03.05 and remember that the subdivision of the period into regimes does result according to drift- *and* to variance considerations.

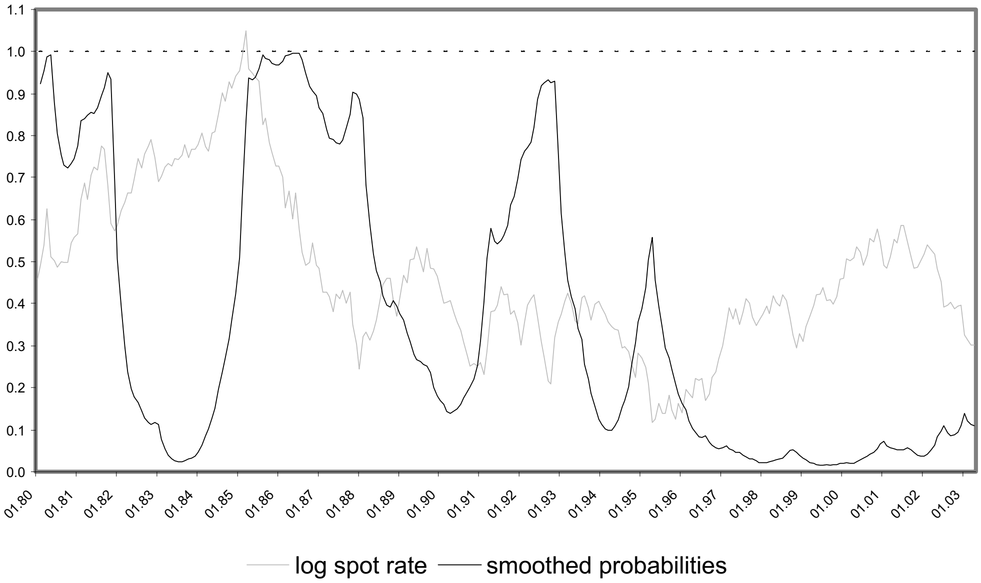

Figure 4: ***Spot Rate CHF/USD and Smoothed Probabilities Regime 1***

5 Conclusions

Obviously, the empirical results from above are very sensitive to a change in the time frame and/or the number of regimes. *There is however one regime which appears to be invariant across all our applications: It is the one with a positive (but not significant) drift and a relatively low variance.* We suppose that particularly because of the other periods of a non-increasing US dollar the switching regime model from above does not lead to well defined transition probabilities.

As there is no empirical evidence that the DGP of s_t can be described properly by a *univariate* segmented random walk process although there are some indications of switching regimes in s_t – what about constructing a *bivariate* process containing the spot rate together with a corresponding forward rate (an interest rate differential)? Obviously, this approach supplements *P. De Grauwe*'s quotation in a different way from the above. In Part III of this paper we will discuss and estimate a (revised) version of *B.T. McCallum*'s model, including a regime switching process together with a set of transition probabilities.

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