

ESTIMATING THE S&P FUNDAMENTAL VALUE USING STAR MODELS

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ABSTRACT

This paper develops a new empirical measure of the S&P fundamental value under the rational expectation hypothesis. Thus, using the linearization of Campbell and Shiller (1988) and referring to the developments of Challe (2002), we extend the Dividend Discount Model (DDM) by introducing nonlinearity in estimating the expected future dividends and the discounted rate. Among many nonlinear models, we retained the STAR (Smooth Transition Autoregressive) models.

JEL: C2, C5

INTRODUCTION

The fundamentalist approach is essentially and originally a contribution of Williams (1938). This author introduced the intrinsic value notion which leads to evaluate an asset price in function of its expected future results (e.g. Cash Flows). Otherwise, this reasoning, called “fundamentalist analysis”, suggests that each asset has a fundamental value around which its price fluctuates. Thus, this asset is over-valued when its price is above this value; it is under-valued if the price is under the intrinsic value, while the stock market is efficient when the price is equal to the fundamental value.

The estimation of this fundamental value has then been the subject of several studies and has raised a number of discussions (e.g. (Campbell and Shiller, 1988) and (Manzan, 2003)). Indeed, this value which is defined as the discounted sum of expected future cash flows raised several questions: Which cash-flows must we retain? How do we define the discount rate? What is the expectation process like? Is dividend growth constant or variable?

In practice, previous studies focusing on this topic had proposed different alternatives and the DDM, amongst the rational expectations hypothesis, was the most frequently used model. However, no study has ever introduced nonlinearity in estimating fundamental value, despite the persistence associated with dividend distribution which is essentially due to the coexistence of heterogeneous managers and shareholders.

This paper investigates whether introducing nonlinearity could improve the evaluation of the fundamental value. In particular, nonlinearity is introduced while estimating the expected future dividends and the discount rate. This nonlinearity can be justified differently. On the one hand, the presence of transaction costs could induce discontinuities in arbitrage, a band of inaction, asymmetry and inertia effects in the stock price adjustment dynamic. On the other hand, the coexistence of different shareholders and managers could imply heterogeneous dividend policies and different investment decisions. Finally, the mimetic behavior effect would lead operators to have different expectations about the fundamental and to define different intrinsic values that, in practice, depend on the strengths of the middle opinion of the market (e.g. (Jawadi, 2006)).

This paper is organized as follows. Section 2 presents a brief literature review. Section 3 presents the empirical fundamental value model and the STAR modelling. Section 4 discusses the empirical results. Section 5 presents the conclusions.

LITERATURE REVIEW

Fundamental value estimation has been the subject of several studies ((Shiller, 1981), (Campbell and Shiller, 1988), (Manzan, 2003), (Black *et al.*, 2003), (Jawadi, 2006), (Boswijk *et al.*, 2006), (Jawadi and Prat, 2007)). These studies retained many hypotheses and several results were obtained but there is no unanimous conclusion on fundamental price determinants. Indeed, fundamental value estimation is often restricted by some assumptions (i.e. discount rate, cash flows and expectations process) and no fundamental value modeling is chosen unanimously. Furthermore, these previous studies mainly confronted the following questions: Which discount rate is appropriate? Which expectation process is necessary to measure the expected future cash flows?

Overall, the dividends were often used to measure cash flows and the perfect or/and rational expectation hypothesis was retained. For example, Shiller (1981) used the DDM to estimate the fundamental value through a constant and variable discount rate. He showed the smooth character of the fundamental value and concluded on a “*volatility puzzle*” for the S&P500. Leroy and Porter (1981) and Froot and Obstfeld (1991) also used the DDM to estimate the S&P fundamental value. The authors justified the stock price deviations towards fundamentals by the hypothesis of bubbles, but concluded on nonlinearity while suggesting that “*even if one is reluctant to accept the bubble interpretation, the apparent nonlinearity of the price-dividend relation requires attention*”, (Froot and Obstfeld (1991, p.1208). Pesaran and Shin (1996) also focused on fundamental value estimation and used the persistence profile approach to study stock price adjustment. Saltoglu (1998) applied Pesaran and Shin’s approach on the annual data of the S&P 500 over the period 1871-1987 and they showed that the stock price adjustment speed is smooth. This smoothness was justified differently by the presence of heterogeneous transaction costs, the presence of distinct dividend policies and the coexistence of heterogeneous investors and expectations.

More recently, Black *et al.* (2003) focused on the estimation of the S&P fundamental value over the period 1947:2 – 2002:2 using the price output ratio. The authors used benefits to measure cash flows and retained the hypothesis of constant discount rate. The authors used a linearization methodology similar to that of Campbell and Shiller (1988) and showed, as in Shiller (1981), that the estimated fundamental value is more persistent than the observed stock price. Their results are constant even with a variable discount rate and a risk premium. Manzan (2003) also estimated the S&P fundamental value on annual data over the periods: 1871-1990 and 1871-2001. To achieve this, the author first used a simple version of the Gordon model. Secondly, he allowed discount rate and dividend growth to be variable. But overall, Manzan (2003) showed that the stock price was not mean-reverting after 1990. This study has been extended by Boswijk *et al.* (2006) over the period 1871-2003. The authors demonstrated that the fundamentals couldn’t justify the recent stock price evolution. Besides, they suggested the presence of two regimes: The chartist regime which was occasionally activated before 1990 but persisted after 1990 and a fundamentalist regime which was activated at the beginning of the period and had an important role at the end of the period implying the mean reversion in stock prices.

However, overall, these studies retained restricted hypotheses while estimating the S&P fundamental value (i.e. constant risk-free and constant dividend growth). The authors also assumed that the investors perfectly expected future cash flows. In this paper, we propose an alternative empirical study of the stock price fundamental value under the rational expectation hypothesis. Furthermore, we propose a new methodology using a dynamic DDM and introducing nonlinearity while measuring the expected fundamentals that define the stock price fundamental value. In particular, STAR models are used to propose new nonlinear fundamental value estimation. STAR models are particularly appropriate to reproduce the nonlinearity and the persistence characterizing dividend and discount rate dynamics.

The originality of this paper may thus be associated with the introduction of nonlinearity while estimating the variables that measure fundamental values. Indeed, the least recent studies were limited to linear fundamental value estimation.

THE MODEL

The Empirical Fundamental Value Formulation

Let P_t and D_t be respectively the asset price and its dividend; r^* is the average return and g is the average dividend growth. The return relative to the detention of the asset between t and $t+1$ is defined as follows:

$$r_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} - 1, \text{ where } r_{t+1} \text{ is the expost return} \tag{1}$$

Following Campbell and Shiller (1988), the linearization of this equation can only be done around stationary variables. However, P_t and D_t are often I (1). Thus, we could linearize it around the growth rates of these variables. Besides, we retained two hypotheses in order to simplify the approximation procedure. H_1 : The Dividend Yield Ratio ($\Gamma_t = \frac{D_t}{P_t}$) is stationary. H_2 : Dividends rise with a memorised rate. These hypotheses imply that the growth rates of P_t and D_t are both equal to g , while the equation (1) defines the average dividends yield ratio as follows: ($\Gamma_t^* = \frac{r^* - g}{1 + g}$), meaning that the memorised dividends would be projected at the same growth rate.

The equation (1) can be reformulated as follows:

$$1 + r_{t+1} = \frac{P_{t+1}}{P_t} + \frac{D_{t+1}}{D_t} \times \frac{D_t}{P_t} \tag{2}$$

If we assumed that the dividends are I (1) and that Γ_t is stationary, all the ratios of the second relation are stationary and the average dividends and stock price growth ratios are identical ($E(\frac{P_{t+1}}{P_t}) = E(\frac{D_{t+1}}{D_t})$).

Thus, the first-order Taylor approximation of the relation (2) which was also developed by Challe (2002) to test the efficient hypothesis yields the following equation:

$$r_{t+1} - r^* = \left(\frac{P_{t+1}}{P_t} - 1 - g\right) + (1 + g)(\Gamma_t - \Gamma_t^*) + \Gamma_t^* \left(\frac{D_{t+1}}{D_t} - 1 - g\right) \tag{3}$$

This relation is rewritten in terms of average proportional deviations as follows:

$$\frac{1 + r_{t+1} - (1 + r^*)}{1 + r^*} = \left(\frac{1 + g}{1 + r^*}\right) \left(\frac{\frac{P_{t+1}}{P_t} - 1 - g}{1 + g}\right) + \left(\frac{(1 + g)\Gamma_t^*}{1 + r^*}\right) \left(\frac{\Gamma_t - \Gamma_t^*}{\Gamma_t^*}\right) \left(\frac{1 + g}{1 + r^*}\right) \Gamma_t^* \left(\frac{\frac{D_{t+1}}{D_t} - 1 - g}{1 + g}\right) \tag{4}$$

However, as g and r_t are often small, it is possible to approximate $\ln(1 + g)$ and $\ln(1 + r_t)$ respectively by g and r_t . Thus, the log-linearization of the relation (1) around the growth ratios of P_t and D_t and the average dividend yield ratio gives:

$$\begin{aligned} r_{t+1} - r^* &\approx \rho(\Delta p_{t+1} - g) + (1 - \rho)(\lambda_t - \lambda^*) + (1 - \rho)(\Delta p_{t+1} - g) \\ &= (\lambda_t - \lambda^*) - \rho(\lambda_{t+1} - \lambda^*) + (\Delta d_{t+1} - g) \end{aligned} \tag{5}$$

Where: $p_t = \ln(P_t)$, $d_t = \ln(D_t)$, $\lambda_t = \ln(\Gamma_t)$, $\lambda^* = \ln(\Gamma^*)$ and $\rho = \frac{1+g}{1+r^*}$.

This relation can also be rewritten as:

$$\lambda_t - \lambda^* = (r_{t+1} - r^*) + \rho (\lambda_{t+1} - \lambda^*) + (\Delta d_{t+1} - g) \tag{6}$$

Under the assumption of absence of rational bubble, $\lim_{i \rightarrow \infty} \rho^i \lambda_{t+i} = 0$ and the previous relation is specified as:

$$\lambda_t - \lambda^* = \sum_{i=0}^{\infty} \rho^i (r_{t+1+i} - r^*) - \sum_{i=0}^{\infty} \rho^i (\Delta d_{t+1+i} - g) \tag{7}$$

While introducing the expectation hypothesis for each member of this equation, we obtained the following rational expression for the ratio Γ_t :

$$d_t - p_t = \lambda^* + \sum_{i=0}^{\infty} \rho^i E_t (r_{t+1+i} - r^*) - \sum_{i=0}^{\infty} \rho^i E_t (\Delta d_{t+1+i} - g) \tag{8}$$

This expression is a generalization of the Gordon-Shapiro model and it generates the following empirical fundamental price formulation:

$$p_t^f = -\lambda^* + d_t - \sum_{i=0}^{\infty} \rho^i E_t (r_{t+1+i} - r^*) + \sum_{i=0}^{\infty} \rho^i E_t (\Delta d_{t+1+i} - g) \tag{9}$$

Where: p_t^f is the fundamental price in logarithm.

This relation defines the fundamental value as an increasing function of expected future dividends and a decreasing function of discount rate. Nevertheless, the future dividends are not observed and we need an assumption on the expectation process used to estimate future dividends. Furthermore, we have to introduce another assumption on the investment horizon in order to get a measurable fundamental value expression. Thus, we express the fundamental price on (t+1) and we calculate the relation $(\rho p_{t+1}^f - p_t^f)$. Then, under the law of iterative expectations, the allowance is made for revisions of expectations of future dividends and discount rates and the hypothesis of infinite horizon is eliminated. Thus, we obtained:

$$p_{t+1}^f = -\lambda^* + d_{t+1} - \sum_{i=0}^{\infty} \rho^i E_{t+1} (r_{t+2+i} - r^*) + \sum_{i=0}^{\infty} \rho^i E_{t+1} (\Delta d_{t+2+i} - g) \tag{10}$$

Then, while computing the relation $(\rho p_{t+1}^f - p_t^f)$, we obtained the following relation:

$$\rho p_{t+1}^f - p_t^f = (1-\rho) \lambda^* + (g - r^*) + \rho d_{t+1} - d_t + E_t (r_{t+1}) - E_t (\Delta d_{t+1}) \tag{11}$$

Therefore, the following recurrent relation gives the fundamental price:

$$p_{t+1}^f = \frac{1}{\rho} p_t^f + \frac{1-\rho}{\rho} \lambda^* + \frac{g - r^*}{\rho} + d_{t+1} - \frac{1}{\rho} d_t + \frac{1}{\rho} E_t (r_{t+1}) - \frac{1}{\rho} E_t (\Delta d_{t+1}) \tag{12}$$

Equation (12) is the key relation, explaining the fundamental price at t+1 in terms of the fundamental price at t, log dividends at t and t+1, period-t expectations of period t+1 returns, and period-t expectations of the growth in log dividends between t and t+1. This is obtained by inverting an expression that explains the stock price at time t in terms of future prices (at t+1) and the various returns and dividends variables. Thus, it has taken what is fundamentally a forward-looking relationship, which explains today's stock

prices in terms of expected future prices, dividends, and discount rates, and turned it into a backward-looking relationship, which explains today's stock price in terms of yesterday's. Of course, this is based on allowance that is made for revisions of expectations of future dividends and discount rates.

In practice, this empirical formulation of the fundamental price is not directly measured. We need, on the one hand, to define an initial value for the fundamental price p_0^f to start the recurrent relation. On the other hand, we have to specify an expectation process for future expected dividends and discount rate. Thus, we retained the rational expectation hypothesis and we defined the expected sets of the above relations as follows:

$$E_t(r_{t+1}) = r_{t+1} + \varepsilon_{t+1} \tag{13}$$

$$E_t(\Delta d_{t+1}) = \Delta d_{t+1} + \varepsilon_{t+1} \tag{14}$$

Future sets would be generated while using STAR models while under the above assumption ε_{t+1} do have the properties of a white noise process. Using STAR models is justified by the asymmetry, the persistence and the structural breaks induced by the presence of transaction costs, the behavioural heterogeneity, the different dividend policies and the heterogeneous beliefs (e.g. Driffill and Sola (1998)).

Furthermore, our derivation of the fundamental value makes the assumption that the log of dividends has a constant growth rate in the long run, and that the discount rate has a constant long-run value, and, finally, that they both fluctuate around these in the short run. This may be consistent with the STAR model as we suppose that the STAR model may not imply that the long-run growth rate of log dividends and the long-run value of the discount rate depend on the regime. Similarly, we suppose that the response of the stock price to an innovation in dividends does not differ as between the two regimes.

Otherwise, different initial values p_0^f were proposed. First, we retained $p_0^f = p_0$ to generate a fundamental value series. Then, other values are tested and the optimal one is the value that minimizes the following statistic: $Q = \sum_{i=0}^{\infty} (p_t - p_t^f)^2$.

The STAR Model

STAR models and their statistical properties were developed by Teräsvirta (1994). STAR models can be seen as a combination of two linear representations that are linear per regime but nonlinear over the period. They define two regimes that are dependent with a transition function $F(\cdot)$ that is continuous and bounded between 0 and 1. Their main statistical property is that the transition between regimes is smooth and then more appropriate than the TAR (Threshold Autoregressive) model to reproduce financial series adjustment, because of the presence of many individuals or firms, each of whom switches sharply but at different times.

Formally, a univariate STAR representation is given by:

$$y_t = (\alpha_0 + \alpha_1 y_{t-1} + \dots + \alpha_p y_{t-p}) + (\beta_0 + \beta_1 y_{t-1} + \dots + \beta_p y_{t-p}) \times F(y_{t-d}, \gamma, c) + \varepsilon_t \tag{15}$$

Where: γ is transition speed ($\gamma > 0$), y_{t-d} is transition variable, d is the delay parameter, c is the threshold parameter, $F(\cdot)$ is the transition function and $\varepsilon_t \rightarrow N(0, \sigma^2)$.

Teräsvirta (1994) retained two types of transition functions: logistic and exponential functions that define respectively the Logistic STAR (LSTAR) model and the Exponential STAR (ESTAR) model.

The Logistic function is defined by $F(s_t, \gamma, c) = (1 + \exp\{-\gamma (s_t - c)\})^{-1}$, $\gamma > 0$, while the Exponential one is given by $F(s_t, \gamma, c) = 1 - \exp\{-\gamma (s_t - c)^2\}$, $\gamma > 0$. LSTAR models have often been used to reproduce the asymmetry characterizing industrial production series and unemployment rate sets (e.g. Teräsvirta (1994)), while ESTAR have been used by several studies to reproduce financial series adjustment (i.e. Manzan (2003)). Jawadi (2006) more explicitly presented the STAR modeling.

EMPIRICAL RESULTS

Our empirical study is centred on the monthly American stock index (S&P500) over the period January 1871 – June 2002 and the data come from Shiller's database which is described on the following website http://www.econ.yale.edu/~shiller/data/ie_data.xls. This choice helps us to compare our results to those of Shiller (2000) and Manzan (2003). All data are real and are transformed in logarithm. In practice, while using three unit root tests (ADF, PP and KPSS), we first checked the conditions of the Campbell and Shiller linearization and we then showed that P_t and D_t are I (1) while Γ_t is stationary. The second step is relative to STAR modeling for r_t and Δd_t .

Thus, we first specified the linear AR model and determined its p order while using the *AIC*, the autocorrelation function and the Ljung-Box tests. Therefore, we retained an AR (6) and AR (3) respectively for r_t and Δd_t . Secondly, we tested the null hypothesis of linearity against the alternative of STAR nonlinearity for different values for d ($1 < d < 3$ for Δd_t and $1 < d < 6$ for r_t). Linearity hypothesis is rejected for both series for all these values and it is more strongly rejected for $\hat{d}=4$ for r_t and for $\hat{d}=1$ for Δd_t indicating thus the presence of nonlinearity, different regimes and structural breaks in the processes generating adjustment dynamics of S&P dividends and returns series. These results are important and are also in line with those of Driffill and Sola (1998), Sarantis (2001) and Manzan (2003). They confirmed the use of the STAR model to calculate expected series. Thirdly, the last step in STAR specification is to choose the appropriate transition function while using the Fisher tests. Results indicated that for both series, the exponential function is retained. Therefore, ESTAR (6,4) and ESTAR (3,1) are respectively estimated by the NLSM for r_t and Δd_t . The results are presented in Table 1.

The second column's equation presents the ESTAR (ESTAR (6,2)) estimation for the S&P returns. Our results are in line with those of Sarantis (2001) who also retained an ESTAR (6,1) to study the S&P return. In particular, we showed that the American return dynamics are nonlinear and are well reproduced by a two-regime ESTAR model. Most estimators are significant at either 5% or 10%, while the Durbin Watson (DW), the Augmented Dickey Fuller (ADF), and the Jarque-Bera (JB) tests showed that residues have the appropriate statistical proprieties.

The third column reproduces the estimation of the S&P dividends by an ESTAR (3,1). Our results also showed that as in Driffill and Sola (1998) the S&P dividend adjustment dynamic is nonlinear and well reproduced by a two-regime ESTAR model. Both estimations significantly showed the superiority of ESTAR models in relation to the linear model.

Overall, these results confirmed both those of Driffill and Sola (1998) and Sarantis (2001) as ESTAR models seem to be more appropriate than linear process in reproducing the adjustment dynamics of the S&P dividends and returns. In particular, $\hat{\gamma}$ and \hat{c} are significant at 5% and 10% showing that adjustment is nonlinear, asymmetrical and smooth. The misspecification tests showed that $\hat{\epsilon}_t$ are stationary and have

the appropriate statistical properties, then confirming the rational expectation hypothesis for which ε_t should be near a white noise.

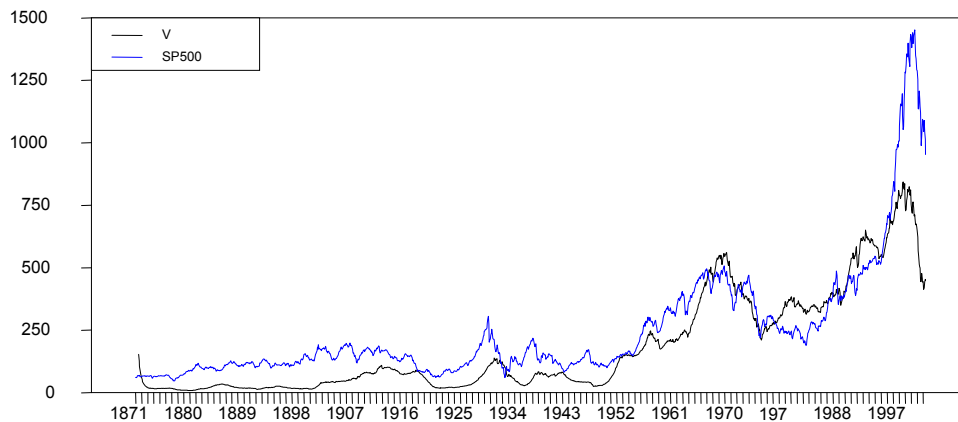
Table 1: ESTAR Estimation

Model	ESTAR (6,4) for the S&P Returns	ESTAR (6,4) for the S&P Dividend
(p, d)	(6,4)	(3,1)
α_0	0.04 (0.72)	0.011 (1.29)
α_1	0.22 (1.85)**	0.54 (2.86)*
α_2	-0.17 (-1.96)*	0.11 (1.79)**
α_3	-0.51 (-1.95)**	-0.07 (-1.74)**
α_4	6.68 (0.65)	-
α_5	1.16 (2.88)*	-
α_6	-0.37 (-1.99)*	-
β_0	0.03 (10.9)*	-0.0002 (-0.41)
β_1	0.13 (12.7)*	0.39 (13.5)*
β_2	-0.006 (-0.23)	0.16 (4.77)*
β_3	-0.02 (-1.77)**	0.11 (3.04)*
β_4	0.04 (1.74)**	-
β_5	0.08 (2.83)*	-
β_6	0.04 (1.74)**	-
γ	0.49 (1.81)**	0.0009 (1.69)**
c	0.005 (7.82)*	-0.0032 (1.98)*
DW	1.98	2.01
ADF	-28.15	-15.56
JB	4.79	8.79
ARCH (4)	18.73	16.67
$\frac{\sigma_{ESTAR}}{\sigma_{AR}}$	0.7	0.66

This table shows the ESTAR estimation of the returns and dividend growth. Values in bracket are the t-ratios. (*) and (**) designate respectively the significance at 5% and 10%.

Finally, in order to propose a new estimation for the S&P fundamental value, we retained the deterministic estimation of STAR models of r_t and Δd_t . Then, we expressed estimation in $(t+1)$ to deduce $E_t(r_{t+1})$ and $E_t(\Delta d_{t+1})$ and we estimated the S&P fundamental price given in the equation (12). Yet, in order to start the recurrent relation, we retained $p_0^f = p_0$. The estimated fundamental price and the observed S&P index are reproduced in Figure 1.

Figure 1: Stock Price and Fundamental Value



This figure shows the observed S&P Price and its estimated fundamental value.

As in Manzan (2003), we showed that changes in fundamental factors are not large enough to explain changes in observed price. Indeed, the American index was over-valuated at the beginning of the period. However, it fluctuates around its fundamental value until 1990, but it has experienced a considerable run-up after 1990, indicating the absence of mean reversion in American stock prices in this period. This persistence characterizing stock price deviations after 2000 is explained by the irrational fads in the investor's sentiment and by irrational exuberance. Otherwise, results showed that stock price generally deviates at short term from fundamentals, notably in periods of crises (e.g. 1929, 1973) and Crashes (e.g. 1987, 2001), but then reverts back in the long-run under the influence of fundamentalist interaction and market strengths.

CONCLUSION

The main contribution of this paper is to develop a new empirical measure of S&P fundamental value while extending the DDM by introducing the nonlinearities in estimating the fundamental value. We showed, on the one hand, that nonlinear models are more appropriate than linear models to reproduce return dynamics and expected future dividend evolution. On the other hand, we found that the stock price is nonlinearly mean-reverting. Indeed, the stock price could deviate and spend most of the time away from the fundamental at short term, but while transaction costs and the size of its deviations from fundamental are increasing, a strong evidence of mean-reverting in American stock price is found.

More importantly, this study proposes an original contribution to literature related to the stock price fundamental value modeling, while introducing nonlinearity in estimating the determinants of the intrinsic value. Contrary to the previous studies, the hypotheses of this study are less strong and restraining. However, it would be important to generalize this study to cover a more original application field (i.e. the G8 countries). It would also be interesting and promising to use this result to study the S&P deviations toward this estimated fundamental value in a nonlinear framework and to determinate the periods of under and overvaluation of the American stock market and, finally, to check whether the stock price is mean-reverting or not.

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BIOGRAPHY

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