Errata Corrige – Essentials of Time Series for Financial Applications

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Chapter 1 – Linear Regression Model

- Page 7, Example 1.2, Row n. 2: it should read as "... return on a portfolio **composed** by stocks ...".

- Page 13, Row n. 30: the vector **K = [1 -2 0 ... 0]'** should be transposed as shown.

- Page 18, Row n. 20: the separation among the cardinal number and the time lag of the first regressor x_1 is done by using a dot instead of a comma:

$$y_t = \beta_0 + \beta_1 x_{1,t} x_{2,t} + \varepsilon_t$$

- Page 22, Example 1.7 (Regression): the fourth regressor should be written as **bm_t** and NOT as **dm_t**.

- Page 23, Row n. 15: it should read as "... an iterative numerical algorithm that often **approaches** ...".

- Page 25, Example 1.8, Row n. 2: it should read as "... is the daily return on a portfolio **composed** ...".

- Page 34, Example 1.12 (Regression): As in the Example 1.7 the fourth regressor must be **bm_t** and NOT **dm_t**.

- Page 34, Example 1.12, Row n. 3: it should read as "... the variables are the same as in Example **1.7**...".

Chapter 2 – Autoregressive Moving Average (ARMA) Models and Their Practical Applications

- Page 41, Row n. 17: it should read as "... of different types of sample autocorrelations**)**."

- Page 42, Definition 2.1, Row n. 30: the condition for weakly stationarity of a linear process should be written as follows:

$$\sigma_z^2 \sum_{i=-\infty}^{+\infty} \Phi_i^2 < \infty$$

- Page 43, Example 2.1, Row n. 8: it should read as "(in fact, in Fig. 2.1B μ has been set equal to **0** ...)".

- Page 49, Last Row: $Cov(\varepsilon_t, \varepsilon_{t-j})$=0 ∀ j > 0.

- Page 50, Row n. 7: $Cov(\varepsilon_t, \varepsilon_{t-j})$=0 ∀ j > 0.

- Page 52, Row n. 14: it should read as "... shifts the time index of a **variable** ...".

- Page 58, Row n. 2: it should read as "... An AR(p) process is described by an **ACF**...".

- Page 58, Row n. 13: it should read as "...and the PACF of an MA model has the same shape **of the ACF** of an AR model.".

- Page 58, Definition 2.9 (Invertibility): the correct formula is the one provided in the space below:

$$y_t = \sum_{i=1}^{\infty} \Phi_i L^i y_t + u_t$$

- Page 59, Formula 2.84: γ_1 should not be in the formula, the following is the correct one:

$$\gamma_1 = \frac{(1 + \theta_1 \Phi_1)(\theta_1 + \Phi_1)}{1 - \Phi_1^2} \sigma_\varepsilon^2$$

- Page 60, fourth line, it should be "beginning with lag $q + 1$" and not q.

- Page 60, Formula 2.88: $\varphi_{s,s}$ must replace $\varphi_{3,3}$.

- Page 61, Row n. 4: it should read as "... computing the SACF and **SPACF** ...".

- Page 63, Formula 2.89: i = 1 is incorrect, the correct formula is the following:

$$\hat{\sigma}^2 = \frac{1}{T}\sum_{t=1}^{T}\hat{\varepsilon}_t^2.$$

- Page 67, Formula for Standardized Residuals, Row n. 7: the correct formula is the following:

$$\hat{\varepsilon}_t^s = \frac{(\hat{\varepsilon}_t - \hat{\bar{\varepsilon}})}{\hat{\sigma}_\varepsilon}$$

- Page 68, Formula 2.102: Sample Excess Kurtosis in Jarque-Bera Test:

$$\widehat{K} = \frac{1}{T}\sum_{t=1}^{T}\frac{\hat{\varepsilon}_t^4}{\hat{\sigma}_\varepsilon^4} - 3$$

- Page 68, Row n.4: is should read as "... note that in equation (2.101)..."
- Page 68, Row n. 13: it should read as "... are both **N(0,1)** distributed ..."
- Page 70, Table 2.6A and Table 2.6B: For the sake of clarity Table 2.6A should be renamed as "SACF and SPACF of Residuals of an ARMA(2,1) Model for US CPI Inflation Data" and Table 2.6B as "SACF and PACF of Squared Residuals of an ARMA(2,1) Model for US CPI Inflation Data".
- Page 72, Row n 1, it should read "The variance of the one-step ahead forecast ERROR
- Page 73, Formula 2.125: the expected value of the future innovation terms must be conditioned on the available information at time t, as it is done in the following formula:

$$\hat{y}_t(h) = \Phi_0 + \sum_{i=1}^{p}\Phi_1\hat{y}_t(h-1) + \sum_{j=1}^{q}\theta_j E_t[\varepsilon_{t+h-j}]$$

Chapter 3 -Vector Autoregressive Moving Average (VARMA) Models

- Page 78, Definition 3.1: the vector of μ must be transposed as in the definition is expressed as a Row vector and not as a column vector:

$$\mu = [\mu_1, \mu_2, \dots, \mu_N]'$$

- Page 79, Row n. 12, Bullet point n. 5: $\rho_{i,j}$ (q) must not be boldfaced.

- Page 82, Definition 3.2: $z_{i,t}$ is incorrect, while z_t is the correct version of the random variable.

- Pag 83, Row 22 should read "it is clear that when $-b_{2,1}$ is non-zero" (instead of $-b_{1,2}$);

- Pag 83, Row 23 should read "when $-b_{1,2}$ is non-zero" (instead of $-b_{2,1}$);

- Page 84, Row n. 11: it should read as "It **is** easy to see that ...".

- Page 85, Formula 3.34: the sign is incorrect, in the space below is proposed the correct version of the formula:

$$\sigma_2^2 = Var[u_{2,t}] = \sigma_{\varepsilon,2}^2 + b_{2,1}^2 \sigma_{\varepsilon,1}^2$$

- Page 85, Formula 3.37: the final Covariance Matrix of reduced form errors is incorrect, in the space below it is provided the correct version:

$$\Sigma_u = \begin{bmatrix} \sigma_{\varepsilon,1}^2 & -b_{2,1}\sigma_{\varepsilon,1}^2 \\ -b_{2,1}\sigma_{\varepsilon,1}^2 & \sigma_{\varepsilon,2}^2 + b_{2,1}^2\sigma_{\varepsilon,1}^2 \end{bmatrix}$$

- Page 85, Row n. 29 should read as "(N^2 - N)/2 **restrictions**".

- Page 85, Row n. 37: it should read as "... (three intercepts and **nine** autoregressive coefficients) ...".

- Page 86, Formula 3.39: the inverse of B is incorrect, in the space below is provided its correct version:

$$B^{-1} = \begin{bmatrix} 1 & 0 & 0 \\ -b_{2,1} & 1 & 0 \\ (b_{2,1}b_{3,2} - b_{3,1}) & -b_{3,1} & 1 \end{bmatrix}$$

- Page 86, Formula 3.40: formula for reduced form residuals is incorrect, in the space below is provided its correct version:

$$u_t = B^{-1}\varepsilon_t = \begin{bmatrix} 1 & 0 & 0 \\ -b_{2,1} & 1 & 0 \\ (b_{2,1}b_{3,2} - b_{3,1}) & -b_{3,1} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} =$$

$$= \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} - b_{2,1}\varepsilon_{1,t} \\ \varepsilon_{1,t}(b_{2,1}b_{3,2} - b_{3,1}) - b_{3,1}\varepsilon_{2,t} + \varepsilon_{3,t} \end{bmatrix}$$

- Page 86, Row n. 9: it should read as "... Eq. (3.39) earlier, **b$_{1,2}$**, **b$_{1,3}$**, and **b$_{2,3}$** ...".

- Page 87, Row n. 23: it should read as "... already stated in Chapter 2 for **univariate stationary time series ...**".

- Page 88, Row n. 8: it should read as "... and **pre-multiply** Eq. (3.55) ...".

- Page 88, ROW n. 15: it should read as "Finally, post-multiplying by $\tilde{y}'_{t-h}$ ..." (It should be transposed).

- Page 88, Formula 3.59: the expected value on the left-hand side of the equation should be changed as follows:

$$E(\tilde{y}_t \tilde{y}'_{t+1-h}) = A_1 E(\tilde{y}_t \tilde{y}_{t-h})' \quad for \ h > 0$$

- Page 88, Row n. 18: "... Therefore, the **cross-covariance** matrices ...".

- Page 88, Row n. 22: "... all the other **cross-covariance** matrices ...".

- Page 89, Example 3.2, Row n. 21: In the formula of the unconditional covariance matrix, when the vectorization is applied on the sample Var-Cov matrix, the matrix should be boldfaced.

- Page 89, in example 3.2, on September 30th, 2016 the 1-month T-bill rate had been 0.16% (as used in the formula) and not 0.26%.

- Page 89, Example 3.2, Row n. 24: In the formula of the unconditional covariance matrix the correction provided below should be applied:

$$\hat{\Sigma}_u \ not \ \hat{\Sigma}_0$$

- Page 90, $h > 0$ should always be $h > p$ everywhere in
  - $\Gamma_h = A_1\Gamma_{h-1} + \cdots + A_p\Gamma_{h-p}$ for $h > 0$;
  - $\rho_h = \Psi_1\rho_{h-1} + \cdots + \Psi_p\rho_{h-p}$ for $h > 0$, where $\Psi_i = D^{-1/2}A_iD^{-1/2}$.

- Page 90, at the bottom of the page, the sentence should read as "(...) this condition states that the roots of the characteristic polynomial associated with the matrix should all exceed one in modulus (i.e., they should lie outside the unit circle)"

- Page 91, Formula 3.74: the last subscript of matrix Y must be T and not t, see below:

$$Y = [y_1, y_1, \dots, y_T]$$

- Page 91, Formula 3.75: Kronecker product should be added in the formula as follows:

$$S(\vec{\beta}) = \mathbf{u}^T (\mathbf{I_T} \otimes \mathbf{\Sigma_u})^{-1} \mathbf{u}$$

- Page 91, Formula 3.80: the equation for u_t should be changed as follows in (B must be written as estimated):

$$\hat{u}_t = y_t - \hat{B} Z_{t-1}$$

- Page 95, Row n. 23 from the bottom, the parenthesis should read "$(p_0 - 1 = 3 \geq 1)$"
- Page 95, Row n. 22 from the bottom, the sentence should read "(...) this procedure until we CAN reject the null hypothesis."
- Page 95, Row n. 7 from the bottom, the sentence should read "(...) we CAN reject the null hypothesis (...)"
- Page 101, Row n. 10: the sum to infinity of the impact multipliers should not be expressed to the power of 2, the correct sum is the following:

$$\sum_{i=0}^{\infty} \Phi_{j,k(i)} \ for \ j, k = 1,2, \dots, N$$

- Page 101, Example 3.6, Row n. 5: **"="** is missing in the formula for the Var-Cov matrix of the reduced-form residuals.
- Page 101, Example 3.6, Row n. 7: the formula recalled from Section 3.2.1 on the Variance of the reduced-form errors of the 10-Y US Treasury bond is incorrect; below we provide the correct formula:

$$Var[u_{10Y,t}] = \sigma_2^2 + b_{2,1}^2 \sigma_1^2$$

- Page 101 at the bottom of E
- Page 102, Example 3.6, Row 8, the formula should be:

$$b_{2,1} = \frac{\hat{\sigma}_{1,2}}{\hat{\sigma}_1^2} = -\frac{0.0013}{0.047} = -0.027$$

- Page 102, Example 3.6, Row n. 3: the formula of the reduced-form errors of the 10-Y US Treasury bond is incorrect, in the space below is proposed the correct formula:

$$u_{10Y,t} = \varepsilon_{2,t} - b_{2,1}\varepsilon_{1,t} = \varepsilon_{2,t} + 0.027\varepsilon_{1,t}$$

- Page 102, Example 3.6, Row n. 21: "... The 1-month Treasury yield will be 0.0209 x **0.105** = 0.0021945 ..." (In the example the reduced form shock (0.105) has been replaced by the t+1 impact of it (0.10469) on the 10-year yield).

- Page 106, Example 3.8: the correlation matrix should be symmetric, however, the correlation among 1M and 1Y is symmetrically 0.051 both above and below the main diagonal and not 0.059.

- Page 108, Definition 3.5, Row n. 4: the condition for Granger should read as follows:

$$MSE_{yt}(h|F_t) < MSE_{yt}(h|F_t \backslash \{x_s|s \leq t\})$$

- Page 108, Row n. 7: it should read as: "... Granger causality using **"its complement"** ...".

- Page 109, Definition 3.6, even though formally this may be ok, the "$\leq$" is best replaced by a strict inequality, "<".

- Page 110, Row n. 7:" y_3 Granger causes at least one ..." should be does **NOT** Granger causes **none** of.

- Page 110, Example 3.9, Last Row: "... the 5-year yield seems to be exogenous to 1-month rates." should be "the 5-year and 1-month yield form a feedback system using a p-value of 0.10".

- Page 111, Last Row: it should read as "... where u_t is a white noise process ...".

- Page 112, Row n. 16: it should read as: "... matrices recursively **from h=p, p+1**, ..." (backspace typo).

- Page 112, Row n.6: If a VARMA model is stable it is also invertible. This statement is wrong, indeed, a stable VARMA model it is also **stationary**.

Chapter 4 – Unit Roots and Cointegration

- Page 113, Row 4:it should read as "... correlation function (SACF/**SPACF**) ...".

- Page 113, Row 6 from the bottom: it should read as "In fact, supposed that a series always changes **in expectation** by the same fixed amount...".

- Page 114, Row 3 from the top: μ should be replaced by δ_1; row 9 the shocks in the formula should be η_t and not ϵ_t.[1]

- Page 114, Row 6, the sentence "Note that the distinction is far from stark: all deterministic trends can be converted into stochastic trends." should read:

  Note that the distinction is far from stark: all **linear** deterministic trends can be converted into stochastic trends.

- Page 115, all the expectations in the row

$$E[y_t] = E_t[y_0 + \mu t + \sum_{\tau=1}^{t} \varepsilon_\tau] = y_0 + \mu t \text{ and } E_t[y_{t+s}] = E_t[y_0 + \mu(t+s) + \sum_{\tau=1}^{t} \varepsilon_\tau]$$

  should be unconditional expectations.

- Page 116, Definition 4.2 should read as

  When a time series process $\{y_t\}$ needs to be differenced d times before being reduced to the sum of constant terms plus a **stationary** (possibly, white noise) process, $\{y_t\}$ is said to contain d unit roots or to be integrated of order d; we also write that $y_t \sim I(d)$.

- Page 117, Example 4.1 (Last Equation): The term y_{t-1} should be negative and not positive, the correct formula is provided in the space below:

$$\Delta(\Delta y_{t+1}) = \Delta^2 y_{t+1} = \Delta y_{t+1} - \Delta y_t = \Delta y_t - y_{t-1} - \Delta y_t + \varepsilon_{t+1} = \varepsilon_{t+1} - y_{t-1}$$

- Page 125, Row n. 31: it should read as "... exclude the drift (in case of **Eq. 4.17**) ...".

- Page 125, Row 32: it should read as "... or include a time trend (in case of **Eq. 4.18**) ...".

- Page 128, row 5, P_{t+1} on the left-hand side of the ADF regression there should a first-difference, ΔP_{t+1}.

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[1] Thanks to Enrico Sammarco for pointing out the previous three bullet points.

- Page 131, Formula 4.33: At the denominator the error terms should be u and not ε, the correct formula is provided in the space below:

$$KPSS_T = \frac{\sum_{t=1}^{T}(\sum_{i=1}^{t} \hat{u}_t)^2}{T^2 \sum_{i=\left[-T^{\frac{2}{9}}\right]}^{[T^{\frac{2}{9}}]} \frac{1}{T-i} \sum_{t=i+1}^{T} \hat{u}_t \, \hat{u}_{t-1}}$$

- Page 134, Row n. 35: it should read as "... fluctuate in **heterogeneous** ways ...".
- Page 138, Row n. 10: it should read as "... such that a weighted linear **combination** ...".
- Page 140, Example 4.5, Row n. 18: it should read as "... which leads to a **non-rejection** of the null of no cointegration ..." (If you look at the p-values they are higher than 10%, leading to a NON rejection of the null Hp).
- Page 144, Result 4.6, Row n. 2: it should read as "... Λ is the **N x r matrix** of weights ...".

Chapter 5 – Single-Factor Conditionally, Heteroskedastic Models, ARCH and GARCH

- Page 154, Example 5.2, Row n. 13: it should read as "... significant **sample autocorrelation function (SACF)** coefficients ...".
- Page 159, Example 5.6, Row n. 6: it should read as "... compute **the** forecast conditional variances ...".
- Page 161, equation (5.11), in the second row, in the sum it should be $\lambda^{\tau-2}$ and not $\lambda^{\tau-1}$.
- Page 161, Formula 5.15: There is an error in the second sign that should be a "-" instead of a "+", the correct formula is provided in the space below:
$$E[\{y_{t+1} - \Phi_0 - \Phi_1 y_t\}^2] = E[\varepsilon_{t+1}^2] = \sigma^2$$

- Page 163, Example 5.7: In the first equation for $x_{t+1}, \varepsilon_{t+1} = \sigma_{t+1}|t\, z_{t+1}$ and NOT $\varepsilon_{t+1} = \sigma_{t+1}^2|t\, z_{t+1}$.
- Page 202, Example 5.21, Row n. 8: it should read as "... than **negative** news does ...".
- Page 204, Formula 5.94: the second regressor should have "-1" as subscript, in the space below it is provided the correct version:
$$\gamma_1\, I_{\{\hat{z}_{t-1} < 0\}}$$

- Page 206, Result 5.1, Formula 5.102: variances are not conditioned on the appropriate time t information set, in the space below it is provided the correct formula:

$$\sigma_{t+H|t}^2 = \bar{\sigma}^2 + (\alpha + \beta)^{H-1}\left(\sigma_{t+1|t}^2 - \bar{\sigma}^2\right)$$
$$= \bar{\sigma}^2 + (\alpha + \beta)^{H-1}[\alpha(\varepsilon_t^2 - \bar{\sigma}^2) + \beta(\sigma_{t|t-1}^2 - \bar{\sigma}^2)]$$

- Page 224, Row n. 38: it should read as "... the entire process asymptotically **converges** to ...".

Chapter 6 – Multivariate GARCH and Conditional Correlation Models

- Page 229, Row n. 3: the vector R_{t+1} being an Nx1 vector should be transposed:

$$R_{t+1} \equiv [R_{t+1}^1 \ R_{t+1}^2 ...]'$$

- Page 233, Row n. 9: it should read as "... of a series and that **absented** such condition ...".

- Page 238, Row n. 10: it should read as "... Clearly, **Eq. (6.29)** simplifies ...".

- Page 238, Row n. 29: there is a **backspace typo** among the **two z** $_{t+1}$.

- Page 238, Row n. 32: it should read as "... by θ_D C **θ, I_N** ..." (it is a **backspace typo**).

- Page 238, Row n. 33: "... matrix, and**,** similar to ..." (replacing the opened and never closed **"("** with a **","**).

- Page 240, Row n. 9: it should read as " ... way reported in **Eq. (6.37)** ...".

- Page 240, Row n. 9: it should read as " ... vech(C) as in **Eq. (6.37)** ...".

- Page 259, Example 6.10 (Last Regression): the error term should have as superscript **HML** instead of **SMB**.

- Page 261, Figure 6.17 (Right hand side): The title of the panel on the right hand side should read as **Corr(HML, Balanced Ptf)** and NOT **Corr(HTML, Balanced Ptf)**.

- Page 265, Row n. 22: it should read as "... on the main diagonal of $\Sigma_{t+1|t}$." (The parenthesis must be cancelled out because there is no open parenthesis before).

Chapter 7 – Multifactor Heteroskedastic Models, Stochastic Volatility

- Page 274, Example 7.1, Row n. 4: " ... v_t IID $\boldsymbol{\chi_1^2}$ ..." (V_t is distributed according to a chi-squared distribution with 1 degree of freedom, not t as in the book).

Chapter 8 – Models With Breaks, Recurrent Regime Switching, and Nonlinearities

- Page 296, Row n. 20-21: it should read as " ... the Sup-LR test in **Eq. (8.19)** ...".

- Page 305, Example 8.2, Last Row: it should read as " ... while **earnings** appear ...".

- Page 307, Row n. 19-20: it should read as " ... (see Chapter 4**)**, ..." (the parenthesis should be closed).

- Page 315, Row n. 9: it should read as "... using out-of-**sample mean**-square forecast error ..." (backspace typo).

Chapter 9 – Markov Switching Models

- Page 330, Row n. 2: it should read as " ... principle in chapter 10**)**." (The parenthesis should be closed).
- Page 342, Row n. 1: it should read as " ... if one defines $X_t = [y_t y_{t-1} ... y_{t-p} X_t]'$ ..." (I think it should be transposed in order to be a column vector and in order to obtain a 1x1 vector in the regression by pre-multiplying the transposed of Beta).
- Page 348, Row n. 12: it should read as " ... and the two will differe unless **(δx)2 = 1** ..." (A bracket that closes a never open bracket).
- Page 349, Row n. 19: it should read as " ... in this way that **implies** ...".

Chapter 10 – Realized Volatility and Covariance

- Page 388, Example 10.2, Row n. 7: it should read as "… the interpretation of the **SPACF** …".