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Apêndice

Apêndice A.1 – Derivação da Equação Diferencial de Black & Scholes

A análise de Black & Scholes tem como premissa a ausência de oportunidades de arbitragem e que o retorno da carteira deve ser a taxa de juros livre de risco.

Notação:

 $\Pi = carteira$

w = warrant(opção)

x = preço da ação no tempo t

r =taxa de juros sem risco

 v^2 = variância

c = preço de exercício

 t^* = dia de maturação

$$w_1 = \frac{\partial w}{\partial x}$$

$$w_{11} = \frac{\partial^2 w}{\partial x^2}$$

$$w_2 = \frac{\partial w}{\partial t}$$

Suponha uma carteira livre de risco:

$$\Pi = x + mw \tag{A.1.1}$$

Onde *m* é o número de opções (compradas) na carteira.

Se Π é uma carteira livre de risco, para que não haja possibilidade de arbitragem, tem-se:

$$d\Pi = r\Pi dt \tag{A.1.2}$$

Premissas adotadas no modelo:

1) Movimento Geométrico Browniano

$$\frac{dx}{x} = \mu dt + v dz \tag{A.1.3}$$

onde,

 μ é a média dos retornos da ação.

$$dz \sim N(0, dt)$$

2)

$$w = f(x, t; r, v, c)$$

Fazendo a expansão de Taylor:

$$dw = \frac{\partial f}{\partial x}dx + \frac{\partial f}{\partial t}dt + \frac{1}{2}\frac{\partial^2 f}{\partial x^2}dx^2 + \frac{1}{2}\frac{\partial^2 f}{\partial t^2}dt^2 + \frac{\partial^2 f}{\partial x \partial t}dxdt + \dots + \frac{1}{n!}\frac{\partial^n f}{\partial x^n}dx^n + \frac{1}{n!}\frac{\partial^n f}{\partial t^n}dt^n \dots$$

2.a) Lema de Itô

$$dw = \frac{\partial f}{\partial x}dx + \frac{\partial f}{\partial t}dt + \frac{1}{2}\frac{\partial^2 f}{\partial x^2}dx^2$$
 (A.1.4)

Os demais termos da expansão de Taylor foram desprezados por terem valor praticamente zero.

O termo $\frac{1}{2} \frac{\partial^2 f}{\partial x^2} dx^2$ não pode ser desprezado como os demais pois pela

equação (A.1.3) tem-se que
$$\frac{dx}{x} = \mu dt + v dz$$
 com $dz \sim N(0, dt)$.

$$dx = x\mu dt + xv dz$$
 : $dx^2 = (x\mu dt + xv dz)^2$

$$dx^{2} = x^{2}\mu^{2}dt^{2} + 2x^{2}\mu v dt dz + x^{2}v^{2}dz^{2}$$

Como $dt^2 \rightarrow 0$ e $dtdz \rightarrow 0$, logo:

$$dx^2 = x^2 v^2 dz^2 \tag{A.1.5}$$

Analisando dz^2 :

$$Var(dz) = E[dz^2] - \{E[dz]\}^2$$

$$E[dz^{2}] = Var(dz) + \{E[dz]\}^{2} = dt + 0 = dt$$
(A.1.6)

$$Var\left[dz^{2}\right] = E\left[dz^{4}\right] - \left\{E\left[dz^{2}\right]\right\}^{2} \tag{A.1.7}$$

A curtose pode ser representada como: $E[(x-\mu)^4] = 3\sigma^4$

Neste caso em especial, tem-se que:

$$E\left[\left(dz-0\right)^4\right] = 3\left(Var(dz)\right)^2$$

$$E\left|dz^{4}\right| = 3dt^{2} \tag{A.1.8}$$

Substituindo (A.1.6) e (A.1.8) em (A.1.7):

$$Var[dz^{2}] = E[dz^{4}] - \{E[dz^{2}]\}^{2} = 3dt^{2} - dt^{2} = 2dt^{2} = 0$$

$$Var\left[dz^{2}\right] = 0 \qquad (A.1.9)$$

Portanto, dz^2 tem média dt e variância 0(zero), o que nos faz concluir que trata-se de uma variável determinística, ou seja:

$$dz^2 = dt (A.1.10)$$

Substituindo (A.1.10) em (A.1.5):

$$dx^2 = \frac{1}{2}v^2x^2dt (A.1.11)$$

Substituindo (A.1.11) em (A.1.4):

$$dw = w_1 dx + w_2 dt + \frac{1}{2} w_{11} v^2 x^2 dt$$
(A.1.12)

3) Da Equação (A.1.1)

$$d\Pi = dx + mdw \tag{A.1.13}$$

Ao substituir dw obtido na equação (A.1.12) na equação (A.1.13), tem-se:

$$d\Pi = dx + m \left(w_1 dx + w_2 dt + \frac{1}{2} w_{11} v^2 x^2 dt \right)$$

$$d\Pi = \left(1 + m w_1 \right) dx + m w_2 dt + \frac{1}{2} m w_{11} v^2 x^2 dt$$
(A.1.14)

 $(1+mw_1)dx$ é uma parcela que representa risco já que dx está relacionado com as variações no preço do ativo. Afim de se eliminar esse risco, deve-se fazer:

$$(1+mw_1)=0$$
 : $m=-\frac{1}{w_1}$ (o sinal negativo indica uma posição vendida) (A.1.15)

Continuando:

$$d\Pi = mw_2 dt + \frac{1}{2} mw_{11} v^2 x^2 dt \tag{A.1.16}$$

Da equação (A.1.2)

$$d\Pi = r\Pi dt = r(x + mw)dt \tag{A.1.2}$$

Igualando (A.1.16) e (A.1.2):

$$mw_2dt + \frac{1}{2}mw_{11}v^2x^2dt = (rx + rmw)dt$$
(A.1.17)

Dividindo toda equação por mdt:

$$w_2 + \frac{1}{2}w_{11}v^2x^2 = \frac{rx}{m} + rw \tag{A.1.18}$$

Como
$$m = -\frac{1}{w_1}$$
 \Rightarrow $\frac{1}{m} = -w_1$

Substituindo na equação (A.1.18), chega-se a equação diferencial parcial

$$\frac{\partial w}{\partial t} + \frac{1}{2}v^2x^2\frac{\partial^2 w}{\partial x^2} + rx\frac{\partial w}{\partial x} - rw = 0$$
(A.1.19)

Apêndice A.2 – Distribuição da Taxa de Retorno

A propriedade lognormal dos preços do ativo pode ser usada para fornecer informações sobre a distribuição de probabilidade da taxa de retorno, continuamente capitalizada, obtida entre os instantes t e T. Defininamos a taxa de retorno ao ano continuamente capitalizada, realizada entre os instante t e T, como η . Segue-se que:

$$S_T = Se^{\eta(T-t)}$$

$$\eta = \frac{1}{T - t} \ln \frac{S_T}{S} \tag{A.2.1}$$

onde,

S = preço do ativo

Como:

$$\ln S_T - \ln S = \ln \frac{S_T}{S}$$

Como a váriavel $ln\ S$ segue o processo generalizado de Wiener, tem-se que a mudança em $ln\ S$ entre o instante t e T é normalmente distribuída:

$$\ln \frac{S_T}{S} \sim \phi \left[\left(\mu - \frac{\sigma^2}{2} \right) (T - t), \sigma \sqrt{T - t} \right]$$
 (A.2.2)

A partir das propriedades das distribuições normais, tem-se pela equação (A.2.1):

$$\eta \sim \phi \left[\mu - \frac{\sigma^2}{2}, \frac{\sigma}{\sqrt{T - t}} \right]$$
(A.2.3)

Assim sendo, a taxa de retorno continuamente capitalizada é distribuída normalmente com média $\mu-\sigma^2/2$ e desvio padrão $\sigma/\sqrt{T-t}$.

Apêndice A.3 - Modelos de Equilíbrio

Os modelos de equilíbrio geralmente começam com pressupostos acerca de variáveis econômicas, derivando um processo para a taxa livre de risco de curto prazo, r. Em seguida, eles exploram a implicação do processo para preços de títulos e opções. A taxa de curto prazo, r, no instante t, é a taxa que se aplica a um período de tempo infinitesalmente curto no instante t, sendo às vezes denominada de *taxa instantânea de curto prazo*. É importante enfatizar que o importante não é o processo de r no mundo real, pois, o preço de um título ou derivativo depende unicamente do processo seguido por r num mundo neutro ao risco.

O valor de um derivativo de taxa de juros, que fornece retorno f_T no instante T pode ser:

$$\hat{E}\left[e^{-\bar{r}(T-t)}f_{T}\right] \tag{A.3.1}$$

onde \bar{r} é o valor médio de r no intervalo de tempo entre t e \hat{E} denota o valor esperadonum mundo neutro ao risco.

Define-se P(t,T) como o preço, no instante t, do título de desconto cujo retorno é \$1 no instante T. A partir da equação (A.3.1), tem-se:

$$P(t,T) = \hat{E}\left[e^{-\bar{r}(T-t)}\right] \tag{A.3.2}$$

Se R(t,T) for a taxa de juros, continuamente capitalizada, no instante t, para o período t-T:

$$P(t,T) = e^{-R(t,T)(T-t)}$$
(A.3.3)

de modo que:

$$R(t,T) = -\frac{1}{T-t} \ln P(t,T)$$
 (A.3.4)

e, da equação (A.3.2):

$$R(t,T) = -\frac{1}{T-t} \ln \hat{E} \left[e^{-\bar{r}(T-t)} \right]$$
 (A.3.5)

Essa equação permite que a estrutura a termo das taxas de juros seja obtida, em determinado instante, a partir do valor de r naquele instante e apartir do processo para r com neutralidade ao risco. Ela demonstra que, uma vez definido todo o processo para r, teremos definido toda a estrutura a termo inicial das taxas de juros e como ela poderá desenvolver-se em todos os instantes futuros.

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Anexos

Anexo A.1 - Dados

A.1.1

Estrutura a termo de juros

dtTime,offset,size,1,2,5,21,42,63,126,189,365,730,1095,1460 2004/07/01, 13560, 12, 0.1580, 0.1578, 0.1577, 0.1577, 0.1623, 0.1598, 0.1647, 0.1678, 0.1703, 0.1770, 0.1828, 0.1849, 0.1842004/07/02.13572.12.0.1580.0.1577.0.1576.0.1575.0.1623.0.1591.0.1627.0.1655.0.1675.0.1720.0.1754.02004/07/05, 13584, 12, 0.1580, 0.1577, 0.1575, 0.1578, 0.1620, 0.1590, 0.1621, 0.1643, 0.1655, 0.1691, 0.1729, 0.1722004/07/06, 13596, 12, 0.1580, 0.1576, 0.1574, 0.1583, 0.1622, 0.1597, 0.1635, 0.1663, 0.1679, 0.1736, 0.1774, 0.1803, 0.1676, 0.1744, 0.1802004/07/07, 13608, 12, 0.1579, 0.1576, 0.1575, 0.1588, 0.1621, 0.1600, 0.1635, 0.1669, 0.1688, 0.1752, 0.1792, 0.1827,
0.1827, 0.1822004/07/08, 13620, 12, 0.1579, 0.1578, 0.1577, 0.1596, 0.1624, 0.1607, 0.1661, 0.1691, 0.1715, 0.1771, 0.1818, 0.1840, 0.1641, 0.1642004/07/09, 13632, 12, 0.1577, 0.1577, 0.1577, 0.1596, 0.1624, 0.1608, 0.1661, 0.1691, 0.1715, 0.1771, 0.1818, 0.1840, 0.1661, 0.1662004/07/12, 13644, 12, 0.1578, 0.1576, 0.1575, 0.1603, 0.1619, 0.1603, 0.1646, 0.1677, 0.1695, 0.1755, 0.1779, 0.1772004/07/13,13656,12.0.1578,0.1576,0.1575,0.1607,0.1617,0.1601,0.1650,0.1676,0.1692,0.1753,0.1805,0.18392004/07/14, 13668, 12, 0.1578, 0.1576, 0.1575, 0.1611, 0.1615, 0.1601, 0.1646, 0.1678, 0.1699, 0.1753, 0.1803, 0.1823, 0.18030, 0.1803, 0.1803, 0.18030, 0.18030, 0.18030, 0.18030, 0.18030, 0.18030, 0.18030, 0.18030, 0.180300, 0.18030, 0.18030, 0.18030, 0.18030, 0.18030, 0.180300, 0.180300, 0.180300, 0.180300, 0.1802004/07/15, 13680, 12, 0.1577, 0.1575, 0.1574, 0.1614, 0.1612, 0.1598, 0.1642, 0.1671, 0.1690, 0.1733, 0.1776, 0.1792, 0.176, 0.1762,
0.1762, 0.17622004/07/16, 13692, 12, 0.1577, 0.1575, 0.1574, 0.1618, 0.1609, 0.1595, 0.1635, 0.1662, 0.1677, 0.1726, 0.1773, 0.1805, 0.1662, 0.1677, 0.1726, 0.1773, 0.1805, 0.1662, 0.1677, 0.1726, 0.1773, 0.1805, 0.1662004/07/19, 13704, 12, 0.1577, 0.1575, 0.1574, 0.1621, 0.1607, 0.1596, 0.1640, 0.1667, 0.1683, 0.1736, 0.1784, 0.1821, 0.1822004/07/20, 13716, 12, 0.1577, 0.1575, 0.1574, 0.1625, 0.1605, 0.1596, 0.1641, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1641, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1744, 0.1794, 0.1810, 0.1669, 0.1685, 0.1669, 0.1685, 0.1669, 0.1685, 0.1669, 0.1685, 0.1669, 0.1685, 0.1669,
0.1662004/07/21,13728,12,0.1576,0.1575,0.1574,0.1632,0.1609,0.1602,0.1653,0.1683,0.1701,0.1772,0.1831,0.1852,0.1602,02004/07/22,13740,12,0.1576,0.1573,0.1571,0.1634,0.1606,0.1603,0.1659,0.1694,0.1714,0.1784,0.1837,0.1872,02004/07/23, 13752, 12, 0.1576, 0.1572, 0.1570, 0.1636, 0.1605, 0.1606, 0.1670, 0.1712, 0.1737, 0.1814, 0.1875, 0.1896, 0.1670, 0.1712, 0.1737, 0.1814, 0.1875, 0.1896, 0.1670, 0.1712, 0.1737, 0.1814, 0.1875, 0.1896, 0.1670, 0.1712, 0.1737, 0.1814, 0.1875, 0.1896, 0.1670, 0.1712, 0.1737, 0.1814, 0.1875, 0.1896, 0.1670, 0.1712004/07/26, 13764, 12, 0.1576, 0.1572, 0.1570, 0.1638, 0.1602, 0.1607, 0.1674, 0.1720, 0.1746, 0.1827, 0.1854, 0.1852004/07/27, 13776, 12, 0.1576, 0.1612, 0.1633, 0.1644, 0.1599, 0.1602, 0.1668, 0.1708, 0.1732, 0.1806, 0.1829,
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0.1913, 0.1765, 0.1913, 0.1913, 0.1765, 0.1913, 0.1912005/02/17,15468,12,0.1875,0.1874,0.1874,0.1886,0.1898,0.1908,0.1915,0.1895,0.1864,0.1754,0.1678,0.1641 2005/02/18, 15480, 12, 0.1875, 0.1875, 0.1875, 0.1886, 0.1899, 0.1910, 0.1919, 0.1900, 0.1868, 0.1759, 0.1688, 0.16462005/02/21, 15492, 12, 0.1875, 0.1873, 0.1872, 0.1885, 0.1900, 0.1910, 0.1921, 0.1902, 0.1872, 0.1773, 0.1706, 0.16682005/02/22.15504.12.0.1908.0.1780.0.1715.0.1669.0.1882.0.1875.0.1872.0.1870.0.1887.0.1901.0.1912.0.1926.0.1870.0.1887.0.1901.0.1912.0.1926.0.1870.0.1887.0.1901.0.1912.0.1926.0.1870.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1912.0.1926.0.1887.0.1901.0.1926.02005/02/23,15516,12,0.1875,0.1882,0.1886,0.1888,0.1901,0.1916,0.1926,0.1909,0.1882,0.1778,0.1711,0.16662005/02/24, 15528, 12, 0.1748, 0.1679, 0.1637, 0.1875, 0.1880, 0.1883, 0.1885, 0.1894, 0.1903, 0.1906, 0.1882, 0.1851, 0.1882005/02/25, 15540, 12, 0.1875, 0.1881, 0.1884, 0.1886, 0.1896, 0.1906, 0.1910, 0.1884, 0.1849, 0.1741, 0.1667, 0.1620, 0.1667, 0.1662005/02/28, 15552, 12, 0.1884, 0.1738, 0.1627, 0.1848, 0.1667, 0.1874, 0.1880, 0.1883, 0.1885, 0.1897, 0.1905, 0.1910, 0.1812,
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0.1889, 0.1882005/03/09,15636,12,0.1902,0.1908,0.1903,0.1877,0.1839,0.1720,0.1646,0.1591,0.1875,0.1882,0.1886,0.1893 2005/03/10, 15648, 12, 0.1875, 0.1884, 0.1889, 0.1897, 0.1906, 0.1910, 0.1909, 0.1882, 0.1844, 0.1730, 0.1659, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.16030, 0.160302005/03/11, 15660, 12, 0.1875, 0.1883, 0.1887, 0.1895, 0.1902, 0.1906, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1876, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1841, 0.1727, 0.1659, 0.1606, 0.1904, 0.1841, 0.1727, 0.1659, 0.1904, 0.1841, 0.1727, 0.1659, 0.1904, 0.1841, 0.1727, 0.1659, 0.1904, 0.1841, 0.1727, 0.1659, 0.1841, 0.1727, 0.1659, 0.1841, 0.1727, 0.1841, 0.1722005/03/14.15672.12.0.1875.0.1885.0.1891.0.1900.0.1906.0.1910.0.1909.0.1884.0.1850.0.1748.0.1684.0.16352005/03/15, 15684, 12, 0.1876, 0.1889, 0.1896, 0.1904, 0.1912, 0.1915, 0.1912, 0.1888, 0.1858, 0.1765, 0.1706, 0.1658, 0.1706, 0.1888, 0.1889, 0.1888, 0.1882005/03/16, 15696, 12, 0.1885, 0.1761, 0.1692, 0.1635, 0.1856, 0.1875, 0.1888, 0.1896, 0.1904, 0.1908, 0.1912, 0.1908, 0.1902005/03/17, 15708, 12, 0.1925, 0.1920, 0.1917, 0.1922, 0.1934, 0.1943, 0.1947, 0.1923, 0.1897, 0.1775, 0.1697, 0.1646, 0.1047,
0.1047, 0.1042005/03/18, 15720, 12, 0.1924, 0.1921, 0.1919, 0.1924, 0.1938, 0.1949, 0.1959, 0.1936, 0.1913, 0.1801, 0.1717, 0.16692005/03/21,15732,12,0.1924,0.1920,0.1918,0.1926,0.1943,0.1957,0.1974,0.1955,0.1927,0.1819,0.1746,0.1695,0.1943,0.1957,0.1944,0.1955,0.1944,0.1955,0.1944,0.1955,0.1944,0.1955,0.1944,0.1955,0.1944,02005/03/22,15744,12,0.1965,0.1945,0.1803,0.1728,0.1681,0.1916,0.1924,0.1920,0.1917,0.1926,0.1940,0.19532005/03/23,15756,12.0.1924,0.1920,0.1918,0.1928,0.1945,0.1957,0.1973,0.1955,0.1928,0.1827,0.1771,0.1726,0.1928,02005/03/24, 15768, 12, 0.1924, 0.1921, 0.1919, 0.1927, 0.1938, 0.1945, 0.1954, 0.1931, 0.1907, 0.1812, 0.1759, 0.1723, 0.1931, 0.1942005/03/28, 15780, 12, 0.1925, 0.1927, 0.1928, 0.1928, 0.1936, 0.1943, 0.1953, 0.1932, 0.1909, 0.1819, 0.1770, 0.1730, 0.1742005/03/29, 15792, 12, 0.1925, 0.1926, 0.1927, 0.1927, 0.1936, 0.1942, 0.1953, 0.1933, 0.1911, 0.1825, 0.1775, 0.1733, 0.1911, 0.1825, 0.1775, 0.1733, 0.1911, 0.1825, 0.1775, 0.1733, 0.1911, 0.1825, 0.1775, 0.1733, 0.1911, 0.1825, 0.1775, 0.1733, 0.1911, 0.1825, 0.1775, 0.1733, 0.1911, 0.1825, 0.1775, 0.1733, 0.1911, 0.1825, 0.1926, 0.1927,
0.1927, 0.1922005/03/30, 15804, 12, 0.1925, 0.1926, 0.1926, 0.1926, 0.1939, 0.1944, 0.1953, 0.1932, 0.1910, 0.1821, 0.1772, 0.1729, 0.1722005/03/31.15816.12.0.1925.0.1926.0.1926.0.1926.0.1940.0.1945.0.1956.0.1937.0.1918.0.1830.0.1778.0.17372005/04/01,15828,12,0.1925,0.1927,0.1928,0.1930,0.1941,0.1949,0.1960,0.1944,0.1925,0.1836,0.1784,0.1742,0.1941,0.1941,0.1941,0.1942,0.1944,0

A.1.2

Histórico de CDI

Data,CDI (% a.a),Data,CDI (% a.a),Data,CDI (% a.a),Data,CDI (% a.a) 01-Jul-04,15.71,10-Sep-04,15.81,24-Nov-04,17.19,02-Feb-05,18.26 02-Jul-04,15.69,13-Sep-04,15.86,25-Nov-04,17.17,03-Feb-05,18.25 05-Jul-04,15.69,14-Sep-04,15.87,26-Nov-04,17.17,04-Feb-05,18.25 06-Jul-04,15.7,15-Sep-04,15.89,29-Nov-04,17.18,09-Feb-05,18.25 07-Jul-04,15.69,16-Sep-04,16.16,30-Nov-04,17.2,10-Feb-05,18.23 08-Jul-04,15.73,17-Sep-04,16.15,01-Dec-04,17.22,11-Feb-05,18.23 09-Jul-04,15.77,20-Sep-04,16.17,02-Dec-04,17.21,14-Feb-05,18.22 12-Jul-04,15.71,21-Sep-04,16.12,03-Dec-04,17.2,15-Feb-05,18.22 13-Jul-04,15.71,22-Sep-04,16.15,06-Dec-04,17.19,16-Feb-05,18.2 14-Jul-04,15.69,23-Sep-04,16.14,07-Dec-04,17.19,17-Feb-05,18.7 15-Jul-04,15.71,24-Sep-04,16.17,08-Dec-04,17.17,18-Feb-05,18.69 16-Jul-04,15.7,27-Sep-04,16.17,09-Dec-04,17.17,21-Feb-05,18.69 19-Jul-04,15.7,28-Sep-04,16.17,10-Dec-04,17.19,22-Feb-05,18.69 20-Jul-04,15.7,29-Sep-04,16.14,13-Dec-04,17.19,23-Feb-05,18.68 21-Jul-04,15.71,30-Sep-04,16.17,14-Dec-04,17.2,24-Feb-05,18.68 22-Jul-04,15.69,01-Oct-04,16.18,15-Dec-04,17.2,25-Feb-05,18.68 23-Jul-04,15.7,04-Oct-04,16.16,16-Dec-04,17.69,28-Feb-05,18.68 26-Jul-04,15.71,05-Oct-04,16.15,17-Dec-04,17.69,01-Mar-05,18.67 27-Jul-04,15.7,06-Oct-04,16.15,20-Dec-04,17.7,02-Mar-05,18.65 28-Jul-04,15.7,07-Oct-04,16.15,21-Dec-04,17.69,03-Mar-05,18.65 29-Jul-04,15.7,08-Oct-04,16.15,22-Dec-04,17.7,04-Mar-05,18.64 30-Jul-04,15.74,11-Oct-04,16.15,23-Dec-04,17.71,07-Mar-05,18.66 02-Aug-04,15.75,13-Oct-04,16.17,24-Dec-04,17.71,08-Mar-05,18.64 03-Aug-04,15.76,14-Oct-04,16.16,27-Dec-04,17.71,09-Mar-05,18.63 04-Aug-04,15.77,15-Oct-04,16.16,28-Dec-04,17.7,10-Mar-05,18.62 05-Aug-04,15.78,18-Oct-04,16.16,29-Dec-04,17.72,11-Mar-05,18.62 06-Aug-04,15.77,19-Oct-04,16.15,30-Dec-04,17.75,14-Mar-05,18.62 09-Aug-04,15.77,20-Oct-04,16.15,31-Dec-04,17.76,15-Mar-05,18.63 10-Aug-04,15.76,21-Oct-04,16.63,03-Jan-05,17.76,16-Mar-05,18.64 11-Aug-04,15.77,22-Oct-04,16.67,04-Jan-05,17.72,17-Mar-05,19.15 12-Aug-04,15.76,25-Oct-04,16.69,05-Jan-05,17.72,18-Mar-05,19.17 13-Aug-04,15.75,26-Oct-04,16.69,06-Jan-05,17.72,21-Mar-05,19.18 16-Aug-04,15.76,27-Oct-04,16.67,07-Jan-05,17.71,22-Mar-05,19.19 17-Aug-04,15.75,28-Oct-04,16.67,10-Jan-05,17.71,23-Mar-05,19.2 18-Aug-04,15.73,29-Oct-04,16.66,11-Jan-05,17.7,24-Mar-05,19.21 19-Aug-04,15.74,01-Nov-04,16.67,12-Jan-05,17.72,28-Mar-05,19.2 20-Aug-04,15.74,03-Nov-04,16.7,13-Jan-05,17.7,29-Mar-05,19.2 23-Aug-04,15.77,04-Nov-04,16.7,14-Jan-05,17.72,30-Mar-05,19.19 24-Aug-04,15.77,05-Nov-04,16.71,17-Jan-05,17.74,31-Mar-05,19.21 25-Aug-04,15.74,08-Nov-04,16.71,18-Jan-05,17.73,01-Apr-05,19.21 26-Aug-04,15.74,09-Nov-04,16.71,19-Jan-05,17.73 27-Aug-04,15.78,10-Nov-04,16.71,20-Jan-05,18.22 30-Aug-04,15.81,11-Nov-04,16.71,21-Jan-05,18.23 31-Aug-04,15.82,12-Nov-04,16.72,24-Jan-05,18.24 01-Sep-04,15.79,16-Nov-04,16.73,25-Jan-05,18.24 02-Sep-04,15.81,17-Nov-04,16.72,26-Jan-05,18.22 03-Sep-04,15.78,18-Nov-04,17.21,27-Jan-05,18.23 06-Sep-04,15.79,19-Nov-04,17.21,28-Jan-05,18.22 08-Sep-04,15.8,22-Nov-04,17.21,31-Jan-05,18.25 09-Sep-04,15.78,23-Nov-04,17.19,01-Feb-05,18.25

A.1.3

Opção de compra JA54

Data do pregão, Mercadoria, Vencimento, Preço de exercício, Volume negociado, Negócios efetuados, Contratos negociados, Cotação média, Cotação do último negócio, Contrato objeto da opção

2004-06-17, D11, JA54,17,0,0,0,0,0, ABR5 2004-06-18, D11, JA54,17,0,0,0,0,0, ABR5 2004-06-21, D11, JA54, 17, 0, 0, 0, 0, 0, ABR5 2004-06-22, D11, JA54, 17, 0, 0, 0, 0, 0, ABR5 2004-06-23, D11, JA54,17,0,0,0,0,0, ABR5 2004-06-24, D11, JA54,17,0,0,0,0,0, ABR5 2004-06-25, D11, JA54,17,0,0,0,0,0, ABR5

Data do pregão, Mercadoria, Vencimento, Preço de exercício, Volume negociado, Negócios efetuados, Contratos negociados, Cotação média, Cotação do último negócio, Contrato objeto da opção

2004-06-28, D11, JA54, 17, 0, 0, 0, 0, 0, ABR5 2004-06-29, D11, JA54,17,0,0,0,0,0, ABR5 2004-06-30, D11, JA54,17,0,0,0,0,0, ABR5 2004-07-01, D11, JA54,17,189000,1,500,378,378, ABR5 2004-07-02, D11, JA54,17,0,0,0,0,0, ABR5 2004-07-05, D11, JA54,17,90000,1,300,300,300, ABR5 2004-07-06, D11, JA54,17,0,0,0,0,0, ABR5 2004-07-07, D11, JA54,17,0,0,0,0,0, ABR5 2004-07-08, D11, JA54,17,0,0,0,0,0, ABR5 2004-07-12, D11, JA54, 17, 61800, 1, 200, 309, 309, ABR5 2004-07-13, D11, JA54, 17, 0, 0, 0, 0, 0, ABR5 2004-07-14, D11, JA54,17,0,0,0,0,0, ABR5 2004-07-15, D11, JA54,17,386060,3,1500,257.37,262.12, ABR5 2004-07-16, D11, JA54, 17, 0, 0, 0, 0, 0, ABR5 2004-07-19, D11, JA54,17,340000,3,1500,226.67,225, ABR5 2004-07-20, D11, JA54,17,0,0,0,0,0, ABR5

2004-07-21, D11, JA54,17,120000,1,500,240,240, ABR5

2004-07-22, D11, JA54,17,140500,1,500,281,281, ABR5 2004-07-23, D11, JA54, 17, 0, 0, 0, 0, 0, ABR5

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Anexo A.2 – Código desenvolvido no programa MathLab

```
% Numero de dias uteis
global N;
global dt;
             % Incremento de tempo
global dS;
             % Incremento preco do ativo subscrito
              % Numero de valores "discretos" de S
global M;
global sigma; % volatilidade anual
global r;
            % Taxa livre de risco
             % Exercice price
global S;
global dU;
             % dias uteis entre o vencimento do ativo objeto e o vencimento da
opcao
%Abre arquivo
FID2 = fopen('Config_file.txt','rt');
if FID2 == -1
 LOG = strcat('Erro ao carregar Config file.txt - ',datestr(now));
else
 LOG = strcat('Nao houve erros ao carregar MV_ValorAcao.txt - ',datestr(now));
end
a = 1 / 6 - 1/(4 * sqrt(3)) * sigma * sqrt(dt);
b = 2 / 3;
c = 1 / 6 + 1 / (4*sqrt(3)) * sigma * sqrt(dt);
F = zeros(M + 1, N + 1);
% CC no Vencimento
for j = 1 : M + 1
  F(j, N + 1) = \max(S - (100000 / ((1 + j / 100) ^ (dU / 252))), 0);
end
% CC se S = 0
for i = 1 : N + 1
  F(1, i) = 0;
end
% CC se S = Smax
for i = 1 : N + 1
```

```
F(M+1,i) = 100000 / ((1+M/100)) ^ (dU/252); end for \ i = N: -1: 1 for \ j = 2: M F(j,i) = 1 / (1+r*dt) * (c*F(j-1,i+1)+b*F(j,i+1)+a*F(j+1,i+1)); end end
```