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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:

Π = 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

$$\frac{dx}{x} = \mu dt + v dz \quad (\text{A.1.3})$$

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:

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

2.a) Lema de Itô

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

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

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

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

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

$$dx^2 = x^2 v^2 dz^2 \quad (\text{A.1.5})$$

Analisando dz^2 :

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

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

$$\text{Var}[dz^2] = E[dz^4] - \{E[dz^2]\}^2 \quad (\text{A.1.7})$$

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

Neste caso em especial, tem-se que:

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

$$E[dz^4] = 3dt^2 \quad (\text{A.1.8})$$

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

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

$$\text{Var}[dz^2] = 0 \quad (\text{A.1.9})$$

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

$$dz^2 = dt \quad (\text{A.1.10})$$

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

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

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

$$dw = w_1dx + w_2dt + \frac{1}{2}w_{11}v^2x^2dt \quad (\text{A.1.12})$$

3) Da Equação (A.1.1)

$$d\Pi = dx + mdw \quad (\text{A.1.13})$$

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

$$\begin{aligned} d\Pi &= dx + m\left(w_1dx + w_2dt + \frac{1}{2}w_{11}v^2x^2dt\right) \\ d\Pi &= (1 + mw_1)dx + mw_2dt + \frac{1}{2}mw_{11}v^2x^2dt \end{aligned} \quad (\text{A.1.14})$$

$(1 + mw_1)dx$ 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:

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

Continuando:

$$d\Pi = mw_2dt + \frac{1}{2}mw_{11}v^2x^2dt \quad (\text{A.1.16})$$

Da equação (A.1.2)

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

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

$$mw_2 dt + \frac{1}{2}mw_{11}v^2x^2 dt = (rx + rmw)dt \quad (\text{A.1.17})$$

Dividindo toda equação por mdt :

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

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

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

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

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 . Definimos a taxa de retorno ao ano continuamente capitalizada, realizada entre os instante t e T , como η . Segue-se que:

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

e

$$\eta = \frac{1}{T-t} \ln \frac{S_T}{S} \quad (\text{A.2.1})$$

onde,

S = preço do ativo

Como:

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

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

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

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

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

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

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 infinitesimalmente 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:

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

onde \bar{r} é o valor médio de r no intervalo de tempo entre t e T e \hat{E} denota o valor esperado num 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:

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

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

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

de modo que:

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

e, da equação (A.3.2):

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

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 a partir 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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2004/12/08,14880,12,0.1771,0.1775,0.1724,0.1738,0.1747,0.1755,0.1767,0.1781,0.1790,0.1788,0.1777,0.1766
2004/12/09,14892,12,0.1725,0.1738,0.1745,0.1754,0.1766,0.1777,0.1788,0.1785,0.1770,0.1762,0.1765,0.1769
2004/12/10,14904,12,0.1783,0.1775,0.1760,0.1739,0.1744,0.1744,0.1724,0.1738,0.1747,0.1756,0.1766,0.1776
2004/12/13,14916,12,0.1724,0.1740,0.1749,0.1758,0.1767,0.1776,0.1780,0.1769,0.1751,0.1718,0.1721,0.1721
2004/12/14,14928,12,0.1724,0.1741,0.1751,0.1763,0.1714,0.1772,0.1779,0.1783,0.1770,0.1714,0.1714,0.1748
2004/12/15,14940,12,0.1725,0.1744,0.1755,0.1765,0.1772,0.1779,0.1778,0.1766,0.1747,0.1715,0.1714,0.1714
2004/12/16,14952,12,0.1788,0.1796,0.1798,0.1783,0.1759,0.1710,0.1702,0.1704,0.1774,0.1772,0.1771,0.1778
2004/12/17,14964,12,0.1774,0.1773,0.1772,0.1776,0.1785,0.1791,0.1787,0.1768,0.1742,0.1679,0.1663,0.1663
2004/12/20,14976,12,0.1774,0.1772,0.1771,0.1778,0.1789,0.1795,0.1788,0.1766,0.1734,0.1664,0.1647,0.1652
2004/12/21,14988,12,0.1774,0.1773,0.1772,0.1779,0.1791,0.1802,0.1804,0.1783,0.1750,0.1671,0.1652,0.1648
2004/12/22,15000,12,0.1774,0.1772,0.1770,0.1780,0.1795,0.1808,0.1811,0.1794,0.1761,0.1677,0.1652,0.1647
2004/12/23,15012,12,0.1774,0.1772,0.1770,0.1781,0.1799,0.1817,0.1834,0.1818,0.1787,0.1706,0.1679,0.1676
2004/12/24,15024,12,0.1770,0.1770,0.1770,0.1781,0.1788,0.1679,0.1799,0.1818,0.1834,0.1818,0.1706,0.1676
2004/12/27,15036,12,0.1835,0.1824,0.1793,0.1720,0.1696,0.1692,0.1774,0.1773,0.1773,0.1785,0.1803,0.1819
2004/12/28,15048,12,0.1797,0.1730,0.1712,0.1710,0.1774,0.1781,0.1785,0.1787,0.1804,0.1819,0.1835,0.1826
2004/12/29,15060,12,0.1774,0.1781,0.1785,0.1787,0.1804,0.1821,0.1835,0.1823,0.1793,0.1716,0.1695,0.1695
2004/12/30,15072,12,0.1829,0.1817,0.1782,0.1700,0.1671,0.1670,0.1774,0.1779,0.1782,0.1784,0.1803,0.1816
2004/12/31,15084,12,0.1784,0.1784,0.1784,0.1784,0.1803,0.1817,0.1829,0.1817,0.1782,0.1700,0.1671,0.1670
2005/01/03,15096,12,0.1774,0.1782,0.1787,0.1789,0.1810,0.1822,0.1834,0.1826,0.1788,0.1711,0.1686,0.1686
2005/01/04,15108,12,0.1774,0.1784,0.1790,0.1795,0.1813,0.1825,0.1833,0.1823,0.1791,0.1714,0.1691,0.1691
2005/01/05,15120,12,0.1774,0.1783,0.1789,0.1796,0.1815,0.1829,0.1838,0.1829,0.1799,0.1726,0.1703,0.1703

2005/01/06,15132,12,0.1775,0.1786,0.1792,0.1801,0.1822,0.1836,0.1849,0.1843,0.1817,0.1748,0.1727,0.1724
2005/01/07,15144,12,0.1774,0.1784,0.1790,0.1800,0.1820,0.1833,0.1845,0.1838,0.1807,0.1737,0.1713,0.1709
2005/01/10,15156,12,0.1840,0.1814,0.1744,0.1718,0.1710,0.1774,0.1785,0.1792,0.1804,0.1823,0.1834,0.1849
2005/01/11,15168,12,0.1774,0.1786,0.1793,0.1807,0.1825,0.1836,0.1850,0.1844,0.1816,0.1754,0.1730,0.1721
2005/01/12,15180,12,0.1836,0.1848,0.1840,0.1809,0.1744,0.1720,0.1710,0.1774,0.1786,0.1794,0.1808,0.1825
2005/01/13,15192,12,0.1774,0.1787,0.1795,0.1811,0.1827,0.1837,0.1849,0.1839,0.1811,0.1746,0.1721,0.1711
2005/01/14,15204,12,0.1774,0.1789,0.1798,0.1815,0.1832,0.1844,0.1855,0.1845,0.1816,0.1751,0.1721,0.1708
2005/01/17,15216,12,0.1857,0.1766,0.1734,0.1722,0.1831,0.1774,0.1792,0.1803,0.1822,0.1840,0.1851,0.1865
2005/01/18,15228,12,0.1774,0.1797,0.1810,0.1830,0.1846,0.1857,0.1869,0.1861,0.1837,0.1775,0.1745,0.1734
2005/01/19,15240,12,0.1775,0.1800,0.1815,0.1830,0.1847,0.1855,0.1865,0.1855,0.1832,0.1771,0.1740,0.1724
2005/01/20,15252,12,0.1776,0.1801,0.1815,0.1831,0.1848,0.1856,0.1866,0.1856,0.1833,0.1772,0.1741,0.1725
2005/01/21,15264,12,0.1823,0.1822,0.1821,0.1834,0.1856,0.1872,0.1889,0.1882,0.1861,0.1786,0.1739,0.1709
2005/01/24,15276,12,0.1825,0.1824,0.1823,0.1834,0.1854,0.1870,0.1884,0.1875,0.1852,0.1753,0.1689,0.1655
2005/01/25,15288,12,0.1825,0.2074,0.2226,0.1930,0.1903,0.1903,0.1900,0.1886,0.1860,0.1757,0.1691,0.1657
2005/01/26,15300,12,0.1862,0.1739,0.1634,0.1839,0.1671,0.1824,0.1830,0.1833,0.1835,0.1856,0.1869,0.1875
2005/01/27,15312,12,0.1825,0.1833,0.1838,0.1841,0.1866,0.1884,0.1904,0.1893,0.1863,0.1752,0.1684,0.1649
2005/01/28,15324,12,0.1824,0.1837,0.1844,0.1851,0.1879,0.1896,0.1920,0.1912,0.1885,0.1771,0.1699,0.1669
2005/01/31,15336,12,0.1824,0.1836,0.1843,0.1851,0.1877,0.1894,0.1918,0.1908,0.1883,0.1776,0.1711,0.1685
2005/02/01,15348,12,0.1825,0.1836,0.1843,0.1854,0.1878,0.1897,0.1918,0.1911,0.1887,0.1792,0.1735,0.1704
2005/02/02,15360,12,0.1824,0.1838,0.1847,0.1861,0.1883,0.1899,0.1918,0.1909,0.1884,0.1797,0.1742,0.1714
2005/02/03,15372,12,0.1825,0.1839,0.1847,0.1862,0.1882,0.1897,0.1910,0.1897,0.1866,0.1761,0.1700,0.1670
2005/02/04,15384,12,0.1825,0.1839,0.1847,0.1863,0.1882,0.1896,0.1907,0.1893,0.1863,0.1759,0.1699,0.1675
2005/02/09,15396,12,0.1825,0.1840,0.1849,0.1867,0.1884,0.1898,0.1907,0.1893,0.1864,0.1758,0.1697,0.1680
2005/02/10,15408,12,0.1825,0.1841,0.1851,0.1869,0.1886,0.1898,0.1903,0.1889,0.1863,0.1760,0.1702,0.1678
2005/02/11,15420,12,0.1680,0.1825,0.1842,0.1852,0.1870,0.1884,0.1895,0.1898,0.1883,0.1858,0.1758,0.1705
2005/02/14,15432,12,0.1825,0.1846,0.1859,0.1881,0.1895,0.1907,0.1918,0.1906,0.1881,0.1780,0.1721,0.1692
2005/02/15,15444,12,0.1825,0.1849,0.1863,0.1884,0.1896,0.1908,0.1918,0.1906,0.1882,0.1781,0.1718,0.1695
2005/02/16,15456,12,0.1903,0.1826,0.1851,0.1866,0.1888,0.1901,0.1913,0.1765,0.1698,0.1660,0.1875,0.1920
2005/02/17,15468,12,0.1875,0.1874,0.1874,0.1886,0.1898,0.1908,0.1915,0.1895,0.1864,0.1754,0.1678,0.1641
2005/02/18,15480,12,0.1875,0.1875,0.1875,0.1886,0.1899,0.1910,0.1919,0.1900,0.1868,0.1759,0.1688,0.1646
2005/02/21,15492,12,0.1875,0.1873,0.1872,0.1885,0.1900,0.1910,0.1921,0.1902,0.1872,0.1773,0.1706,0.1668
2005/02/22,15504,12,0.1908,0.1780,0.1715,0.1669,0.1882,0.1875,0.1872,0.1870,0.1887,0.1901,0.1912,0.1926
2005/02/23,15516,12,0.1875,0.1882,0.1886,0.1888,0.1901,0.1916,0.1926,0.1909,0.1882,0.1778,0.1711,0.1666
2005/02/24,15528,12,0.1748,0.1679,0.1637,0.1875,0.1880,0.1883,0.1885,0.1894,0.1903,0.1906,0.1882,0.1851
2005/02/25,15540,12,0.1875,0.1881,0.1884,0.1886,0.1896,0.1906,0.1910,0.1884,0.1849,0.1741,0.1667,0.1620
2005/02/28,15552,12,0.1884,0.1738,0.1627,0.1848,0.1667,0.1874,0.1880,0.1883,0.1885,0.1897,0.1905,0.1910
2005/03/01,15564,12,0.1874,0.1881,0.1885,0.1887,0.1898,0.1908,0.1913,0.1887,0.1853,0.1747,0.1678,0.1626
2005/03/02,15576,12,0.1874,0.1882,0.1887,0.1889,0.1905,0.1913,0.1916,0.1892,0.1859,0.1752,0.1682,0.1630
2005/03/03,15588,12,0.1874,0.1880,0.1884,0.1887,0.1898,0.1907,0.1907,0.1882,0.1847,0.1743,0.1677,0.1633
2005/03/04,15600,12,0.1877,0.1731,0.1657,0.1607,0.1841,0.1874,0.1880,0.1884,0.1888,0.1899,0.1905,0.1903
2005/03/07,15612,12,0.1875,0.1880,0.1883,0.1888,0.1899,0.1905,0.1901,0.1874,0.1839,0.1723,0.1655,0.1598
2005/03/08,15624,12,0.1875,0.1882,0.1885,0.1891,0.1899,0.1905,0.1901,0.1875,0.1839,0.1725,0.1652,0.1590
2005/03/09,15636,12,0.1902,0.1908,0.1903,0.1877,0.1839,0.1720,0.1646,0.1591,0.1875,0.1882,0.1886,0.1893
2005/03/10,15648,12,0.1875,0.1884,0.1889,0.1897,0.1906,0.1910,0.1909,0.1882,0.1844,0.1730,0.1659,0.1603
2005/03/11,15660,12,0.1875,0.1883,0.1887,0.1895,0.1902,0.1906,0.1904,0.1876,0.1841,0.1727,0.1659,0.1606
2005/03/14,15672,12,0.1875,0.1885,0.1891,0.1900,0.1906,0.1910,0.1909,0.1884,0.1850,0.1748,0.1684,0.1635
2005/03/15,15684,12,0.1876,0.1889,0.1896,0.1904,0.1912,0.1915,0.1912,0.1888,0.1858,0.1765,0.1706,0.1658
2005/03/16,15696,12,0.1885,0.1761,0.1692,0.1635,0.1856,0.1875,0.1888,0.1896,0.1904,0.1908,0.1912,0.1908
2005/03/17,15708,12,0.1925,0.1920,0.1917,0.1922,0.1934,0.1943,0.1947,0.1923,0.1897,0.1775,0.1697,0.1646
2005/03/18,15720,12,0.1924,0.1921,0.1919,0.1924,0.1938,0.1949,0.1959,0.1936,0.1913,0.1801,0.1717,0.1669
2005/03/21,15732,12,0.1924,0.1920,0.1918,0.1926,0.1943,0.1957,0.1974,0.1955,0.1927,0.1819,0.1746,0.1695
2005/03/22,15744,12,0.1965,0.1945,0.1803,0.1728,0.1681,0.1916,0.1924,0.1920,0.1917,0.1926,0.1940,0.1953
2005/03/23,15756,12,0.1924,0.1920,0.1918,0.1928,0.1945,0.1957,0.1973,0.1955,0.1928,0.1827,0.1771,0.1726
2005/03/24,15768,12,0.1924,0.1921,0.1919,0.1927,0.1938,0.1945,0.1954,0.1931,0.1907,0.1812,0.1759,0.1723
2005/03/28,15780,12,0.1925,0.1927,0.1928,0.1928,0.1936,0.1943,0.1953,0.1932,0.1909,0.1819,0.1770,0.1730
2005/03/29,15792,12,0.1925,0.1926,0.1927,0.1927,0.1936,0.1942,0.1953,0.1933,0.1911,0.1825,0.1775,0.1733
2005/03/30,15804,12,0.1925,0.1926,0.1926,0.1926,0.1939,0.1944,0.1953,0.1932,0.1910,0.1821,0.1772,0.1729
2005/03/31,15816,12,0.1925,0.1926,0.1926,0.1926,0.1940,0.1945,0.1956,0.1937,0.1918,0.1830,0.1778,0.1737
2005/04/01,15828,12,0.1925,0.1927,0.1928,0.1930,0.1941,0.1949,0.1960,0.1944,0.1925,0.1836,0.1784,0.1742

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

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

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Anexo A.2 – Código desenvolvido no programa MathLab

```

global N;    % Numero de dias uteis
global dt;   % Incremento de tempo
global dS;   % Incremento preco do ativo subscrito
global M;    % Numero de valores "discretos" de S
global sigma; % volatilidade anual
global r;    % Taxa livre de risco
global S;    % Exercice price
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
```