**Apéndices de artículo Viabilidad de introducir contratos de derivados de gas natural en el Mercado Mexicano de Derivados.**

**A.1. Modelo de Grey GM(1,1)**

A.1.1. Estimación de los parámetros de la demanda total GM(1,1)

﻿Call: lm(formula = demanda\_total ~ grey\_total)

Residuals: Min 1Q Median 3Q Max

-433.58 -213.31 -62.25 142.64 493.29

Coefficients: Estimate Std. Error t value Pr(>|t|)

(Intercept) 4.353e-02 1.737e-03 25.05 <2e-16 \*\*\*

grey\_total 2.910e+03 1.090e+02 26.71 <2e-16 \*\*\*

Signif. codes: 0 `\*\*\*´ 0.001 `\*\*´ 0.01 `\*´ 0.05 `.´ 0.1 ` ´ 1

Residual standard error: 289.6 on 21 degrees of freedom

Multiple R-squared: 0.9676, Adjusted R-squared: 0.9661

F-statistic: 627.7 on 1 and 21 DF, p-value: < 2.2e-16

Elaboración propia con Sofware R

A.1.2. Estimación de los parámetros de la demanda del sector eléctrico GM(1,1)

Call: lm(formula = demanda\_electrica ~ grey\_electrica)

Residuals: Min 1Q Median 3Q Max

-424.2 -278.0 -124.7 299.9 515.1

Coefficients: Estimate Std. Error t value Pr(>|t|)

(Intercept) 7.556e-02 4.706e-03 16.055 2.88e-13 \*\*\*

grey\_electrica 7.929e+02 1.046e+02 7.577 1.95e-07 \*\*\*

Signif. codes: 0 `\*\*\*´ 0.001 `\*\*´ 0.01 `\*´ 0.05 `.´ 0.1 ` ´ 1

Residual standard error: 321.2 on 21 degrees of freedom

Multiple R-squared: 0.9247, Adjusted R-squared: 0.9211

F-statistic: 257.8 on 1 and 21 DF, p-value: 2.88e-13

Elaboración propia con Sofware R

A.1.3. Estimación de los parámetros de la demanda del sector industrial GM(1,1)

﻿Call: lm(formula = demanda\_industrial ~ grey\_industrial)

Residuals: Min 1Q Median 3Q Max

-204.51 -47.43 -13.51 52.93 163.78

Coefficients: Estimate Std. Error t value Pr(>|t|)

(Intercept) 0.02391 0.00275 8.695 2.11e-08 \*\*\*

grey\_industrial 754.12166 36.68221 20.558 2.16e-15 \*\*\*

Signif. codes: 0 `\*\*\*´ 0.001 `\*\*´ 0.01 `\*´ 0.05 `.´ 0.1 ` ´ 1

Residual standard error: 88.19 on 21 degrees of freedom

Multiple R-squared: 0.7826, Adjusted R-squared: 0.7722

F-statistic: 75.6 on 1 and 21 DF, p-value: 2.113e-08

Elaboración propia con Sofware R

A.1.3. Estimación de los parámetros de la demanda del sector petrolero GM(1,1)

Call: lm(formula = demanda\_petrolera ~ grey\_petrolera)

Residuals: Min 1Q Median 3Q Max

-270.67 -64.76 25.64 84.59 170.99

Coefficients: Estimate Std. Error t value Pr(>|t|)

(Intercept) 1.834e-02 1.860e-03 9.857 2.49e-09 \*\*\*

grey\_petrolera 1.556e+03 4.854e+01 32.051 < 2e-16 \*\*\*

Signif. codes: 0 `\*\*\*´ 0.001 `\*\*´ 0.01 `\*´ 0.05 `.´ 0.1 ` ´ 1

Residual standard error: 118.8 on 21 degrees of freedom

Multiple R-squared: 0.8223, Adjusted R-squared: 0.8138

F-statistic: 97.16 on 1 and 21 DF, p-value: 2.491e-09

Elaboración propia con Sofware R

**A.2. Modelo de reversión a la media**

A.2.1. Estimación de la tasa de crecimiento de la demanda total con el modelo de reversión a la media

﻿Call: arima(x = vasicek$d\_total, order = c(1, 0, 0))

Coefficients: ar1 intercept

-0.229557 0.046322

s.e. 0.170953 0.007255

sigma^2 estimated as 0.041353: log likelihood = 42.21386, aic = -3.409901

Elaboración propia con Sofware R

A.2.2. Estimación de la tasa de crecimiento del sector eléctrico con el modelo de reversión a la media

Call: arima(x = vasicek$d\_electrica, order = c(1, 0, 0))

Coefficients: ar1 intercept

0.3497 0.099416

s.e. 0.2559 0.028099

sigma^2 estimated as 0.080347: log likelihood = 26.89890, aic = -2.078165

Elaboración propia con Sofware R

A.2.3. Estimación de la tasa de crecimiento del sector industrial con el modelo de reversión a la media

﻿Call: arima(x = vasicek$d\_industrial, order = c(1, 0, 0))

Coefficients: ar1 intercept

-0.26228 0.033476

s.e. 0.235885 0.019063

sigma^2 estimated as 0.075163: log likelihood = 28.46217, aic = -2.214101

Elaboración propia con Sofware R

A.2.4. Estimación de la tasa de crecimiento del sector petrolero con el modelo de reversión a la media

﻿Call: arima(x = vasicek$d\_petrolera, order = c(1, 0, 0))

Coefficients: ar1 intercept

-0.22465 0.017673

s.e. 0.184115 0.008649

sigma^2 estimated as 0.051099: log likelihood = 37.34776, aic = -2.986762

Elaboración propia con Sofware R

Tabla 3. Pronóstico de la tasa de crecimiento de la demanda total de gas natural

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TC | rt+1 − rt | a(b − rt) | rt+1 −rt −a(b−rt) | Z | μ | σ2 | Pronóstico |
| 1994 | 0.0444 |  |  |  |  |  |  |  |
| 1995 | 0.0003 | -0.0441 | 0.1005 | -0.1446 | -3.8511 | 0.0267 | -0.0042 | 0.0225 |
| 1996 | 0.0645 | 0.0642 | -0.0327 | 0.0969 | -0.4786 | 0.0455 | -0.0005 | 0.0450 |
| 1997 | 0.0741 | 0.0096 | 0.0345 | -0.0249 | 2.0855 | 0.0483 | 0.0023 | 0.0506 |
| 1998 | 0.0915 | 0.0173 | 0.0250 | -0.0077 | 2.2494 | 0.0534 | 0.0025 | 0.0559 |
| 1999 | -0.0121 | -0.1036 | 0.1737 | -0.2772 | -20.2068 | 0.0231 | -0.0222 | 0.0009 |
| 2000 | 0.0980 | 0.1101 | -0.0890 | 0.1991 | -9.3198 | 0.0553 | -0.0103 | 0.0450 |
| 2001 | 0.0063 | -0.0917 | 0.1590 | -0.2507 | -16.1136 | 0.0285 | -0.0177 | 0.0108 |
| 2002 | 0.1333 | 0.1270 | -0.1098 | 0.2368 | -14.1285 | 0.0656 | -0.0156 | 0.0501 |
| 2003 | 0.0956 | -0.0376 | 0.0926 | -0.1302 | -2.6921 | 0.0546 | -0.0030 | 0.0517 |
| 2004 | 0.0636 | -0.0321 | 0.0858 | -0.1178 | -1.7924 | 0.0452 | -0.0020 | 0.0433 |
| 2005 | -0.0155 | -0.0790 | 0.1435 | -0.2225 | -12.2124 | 0.0221 | -0.0134 | 0.0087 |
| 2006 | 0.1151 | 0.1305 | -0.1142 | 0.2447 | -15.2415 | 0.0603 | -0.0168 | 0.0435 |
| 2007 | 0.0446 | -0.0705 | 0.1330 | -0.2034 | -9.8353 | 0.0397 | -0.0108 | 0.0289 |
| 2008 | 0.0310 | -0.0135 | 0.0630 | -0.0765 | 0.5549 | 0.0357 | 0.0006 | 0.0363 |
| 2009 | -0.0009 | -0.0320 | 0.0857 | -0.1177 | -1.7813 | 0.0264 | -0.0020 | 0.0244 |
| 2010 | 0.0388 | 0.0398 | -0.0026 | 0.0423 | 1.7434 | 0.0380 | 0.0019 | 0.0399 |
| 2011 | 0.0270 | -0.0118 | 0.0608 | -0.0726 | 0.7265 | 0.0346 | 0.0008 | 0.0354 |
| 2012 | 0.0255 | -0.0015 | 0.0482 | -0.0497 | 1.5452 | 0.0341 | 0.0017 | 0.0358 |
| 2013 | 0.0410 | 0.0155 | 0.0273 | -0.0118 | 2.2261 | 0.0387 | 0.0025 | 0.0411 |
| 2014 | 0.0370 | -0.0041 | 0.0513 | -0.0554 | 1.3708 | 0.0375 | 0.0015 | 0.0390 |
| 2015 | 0.0409 | 0.0039 | 0.0415 | -0.0376 | 1.8538 | 0.0386 | 0.0020 | 0.0407 |
| 2016 | 0.0153 | -0.0256 | 0.0778 | -0.1034 | -0.8617 | 0.0311 | -0.0009 | 0.0302 |
| 2017 | 0.0382 | 0.0229 | 0.0181 | 0.0048 | 2.2598 | 0.0378 | 0.0025 | 0.0403 |
| 2018 | 0.0403 | 0.0021 | 0.0437 | -0.0416 | 1.7600 | 0.0384 | 0.0019 | 0.0404 |
| 2019 | 0.0404 | 0.0001 | 0.0462 | -0.0462 | 1.6432 | 0.0385 | 0.0018 | 0.0403 |
| 2020 | 0.0403 | -0.0001 | 0.0465 | -0.0466 | 1.6327 | 0.0384 | 0.0018 | 0.0402 |
| 2021 | 0.0402 | 0.0000 | 0.0464 | -0.0464 | 1.6367 | 0.0384 | 0.0018 | 0.0402 |
| 2022 | 0.0402 | 0.0000 | 0.0463 | -0.0463 | 1.6388 | 0.0384 | 0.0018 | 0.0402 |
| 2023 | 0.0402 | 0.0000 | 0.0463 | -0.0463 | 1.6393 | 0.0384 | 0.0018 | 0.0402 |
| 2024 | 0.0402 | 0.0000 | 0.0463 | -0.0463 | 1.6393 | 0.0384 | 0.0018 | 0.0402 |
| 2025 | 0.0402 | 0.0000 | 0.0463 | -0.0463 | 1.6393 | 0.0384 | 0.0018 | 0.0402 |

Elaboración propia con Sofware Excel

Tabla 4. Pronóstico de la tasa de crecimiento de la demanda eléctrica

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TC | rt+1 − rt | a(b − rt) | rt+1 −rt −a(b−rt) | Z | μ | σ2 | Pronóstico |
| 1994 | 0.1758 |  |  |  |  |  |  |  |
| 1995 | 0.0777 | -0.0981 | 0.1632 | -0.2613 | -3.6853 | 0.1136 | -0.0203 | 0.0934 |
| 1996 | 0.0121 | -0.0657 | 0.1421 | -0.2078 | -1.7424 | 0.0794 | -0.0096 | 0.0698 |
| 1997 | 0.0956 | 0.0835 | 0.0451 | 0.0384 | 1.4882 | 0.1229 | 0.0082 | 0.1311 |
| 1998 | 0.1566 | 0.0611 | 0.0597 | 0.0014 | 1.6023 | 0.1548 | 0.0088 | 0.1636 |
| 1999 | 0.0873 | -0.0693 | 0.1445 | -0.2138 | -1.9388 | 0.1186 | -0.0107 | 0.1080 |
| 2000 | 0.2312 | 0.1438 | 0.0058 | 0.1380 | 0.1265 | 0.1936 | 0.0007 | 0.1943 |
| 2001 | 0.1436 | -0.0875 | 0.1564 | -0.2439 | -3.0057 | 0.1480 | -0.0165 | 0.1315 |
| 2002 | 0.2981 | 0.1544 | -0.0011 | 0.1556 | -0.2717 | 0.2285 | -0.0015 | 0.2270 |
| 2003 | 0.2220 | -0.0760 | 0.1489 | -0.2249 | -2.3169 | 0.1889 | -0.0127 | 0.1761 |
| 2004 | 0.1175 | -0.1045 | 0.1674 | -0.2720 | -4.1277 | 0.1343 | -0.0227 | 0.1117 |
| 2005 | -0.0180 | -0.1355 | 0.1876 | -0.3231 | -6.4850 | 0.0637 | -0.0356 | 0.0280 |
| 2006 | 0.1869 | 0.2049 | -0.0340 | 0.2389 | -2.8182 | 0.1705 | -0.0155 | 0.1551 |
| 2007 | 0.1073 | -0.0796 | 0.1512 | -0.2308 | -2.5246 | 0.1290 | -0.0139 | 0.1151 |
| 2008 | 0.0560 | -0.0513 | 0.1328 | -0.1841 | -1.0228 | 0.1023 | -0.0056 | 0.0966 |
| 2009 | 0.0497 | -0.0063 | 0.1035 | -0.1098 | 0.6693 | 0.0990 | 0.0037 | 0.1027 |
| 2010 | 0.0012 | -0.0485 | 0.1310 | -0.1795 | -0.8922 | 0.0737 | -0.0049 | 0.0688 |
| 2011 | 0.0518 | 0.0506 | 0.0665 | -0.0159 | 1.5829 | 0.1001 | 0.0087 | 0.1088 |
| 2012 | 0.0075 | -0.0443 | 0.1282 | -0.1725 | -0.7036 | 0.0770 | -0.0039 | 0.0731 |
| 2013 | 0.0679 | 0.0604 | 0.0601 | 0.0003 | 1.6025 | 0.1085 | 0.0088 | 0.1173 |
| 2014 | 0.0535 | -0.0144 | 0.1088 | -0.1232 | 0.4261 | 0.1009 | 0.0023 | 0.1033 |
| 2015 | 0.0849 | 0.0315 | 0.0789 | -0.0475 | 1.4280 | 0.1174 | 0.0079 | 0.1252 |
| 2016 | 0.0213 | -0.0636 | 0.1408 | -0.2044 | -1.6344 | 0.0842 | -0.0090 | 0.0752 |
| 2017 | 0.0752 | 0.0539 | 0.0643 | -0.0104 | 1.5941 | 0.1123 | 0.0088 | 0.1211 |
| 2018 | 0.1211 | 0.0459 | 0.0696 | -0.0237 | 1.5590 | 0.1362 | 0.0086 | 0.1448 |
| 2019 | 0.1448 | 0.0237 | 0.0840 | -0.0602 | 1.3214 | 0.1486 | 0.0073 | 0.1558 |
| 2020 | 0.0465 | -0.0983 | 0.1634 | -0.2616 | -3.7001 | 0.0973 | -0.0203 | 0.0770 |
| 2021 | 0.0770 | 0.0305 | 0.0796 | -0.0491 | 1.4158 | 0.1132 | 0.0078 | 0.1210 |
| 2022 | 0.1210 | 0.0440 | 0.0708 | -0.0267 | 1.5471 | 0.1362 | 0.0085 | 0.1447 |
| 2023 | 0.1447 | 0.0237 | 0.0840 | -0.0603 | 1.3208 | 0.1485 | 0.0073 | 0.1558 |
| 2024 | 0.1558 | 0.0111 | 0.0922 | -0.0811 | 1.0934 | 0.1543 | 0.0060 | 0.1603 |
| 2025 | 0.1603 | 0.0045 | 0.0964 | -0.0919 | 0.9483 | 0.1567 | 0.0052 | 0.1619 |

Elaboración propia con Sofware Excel

Tabla 5. Pronóstico de la tasa de crecimiento de la demanda industrial

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TC | rt+1 − rt | a(b − rt) | rt+1 −rt −a(b−rt) | Z | μ | σ2 | Pronóstico |
| 1994 | 0.0134 |  |  |  |  |  |  |  |
| 1995 | 0.0714 | 0.0579 | -0.0396 | 0.0976 | 0.8264 | 0.0392 | 0.0030 | 0.0422 |
| 1996 | 0.0834 | 0.0120 | 0.0183 | -0.0063 | 1.6656 | 0.0426 | 0.0061 | 0.0487 |
| 1997 | 0.0234 | -0.0600 | 0.1092 | -0.1691 | -0.8620 | 0.0256 | -0.0032 | 0.0225 |
| 1998 | 0.0870 | 0.0636 | -0.0467 | 0.1103 | 0.5924 | 0.0436 | 0.0022 | 0.0458 |
| 1999 | 0.0626 | -0.0243 | 0.0642 | -0.0885 | 0.9753 | 0.0367 | 0.0036 | 0.0403 |
| 2000 | -0.0037 | -0.0664 | 0.1173 | -0.1837 | -1.3159 | 0.0180 | -0.0048 | 0.0131 |
| 2001 | -0.1773 | -0.1735 | 0.2525 | -0.4261 | -14.3970 | -0.0312 | -0.0527 | -0.0839 |
| 2002 | 0.1515 | 0.3288 | -0.3815 | 0.7103 | -42.9803 | 0.0619 | -0.1574 | -0.0955 |
| 2003 | -0.0429 | -0.1944 | 0.2789 | -0.4733 | -18.1553 | 0.0069 | -0.0665 | -0.0596 |
| 2004 | 0.0352 | 0.0781 | -0.0651 | 0.1432 | -0.1444 | 0.0290 | -0.0005 | 0.0284 |
| 2005 | -0.0223 | -0.0574 | 0.1060 | -0.1634 | -0.6933 | 0.0127 | -0.0025 | 0.0102 |
| 2006 | 0.0842 | 0.1065 | -0.1010 | 0.2075 | -2.1412 | 0.0429 | -0.0078 | 0.0350 |
| 2007 | 0.0257 | -0.0586 | 0.1074 | -0.1660 | -0.7686 | 0.0263 | -0.0028 | 0.0235 |
| 2008 | -0.0130 | -0.0386 | 0.0822 | -0.1209 | 0.3758 | 0.0153 | 0.0014 | 0.0167 |
| 2009 | -0.1108 | -0.0979 | 0.1570 | -0.2549 | -4.0795 | -0.0124 | -0.0149 | -0.0273 |
| 2010 | 0.1550 | 0.2658 | -0.3020 | 0.5679 | -26.8694 | 0.0629 | -0.0984 | -0.0355 |
| 2011 | 0.0711 | -0.0839 | 0.1394 | -0.2233 | -2.7444 | 0.0391 | -0.0101 | 0.0291 |
| 2012 | 0.0459 | -0.0252 | 0.0653 | -0.0905 | 0.9446 | 0.0320 | 0.0035 | 0.0355 |
| 2013 | 0.0498 | 0.0040 | 0.0285 | -0.0245 | 1.6158 | 0.0331 | 0.0059 | 0.0390 |
| 2014 | 0.0593 | 0.0095 | 0.0215 | -0.0120 | 1.6564 | 0.0358 | 0.0061 | 0.0419 |
| 2015 | 0.0478 | -0.0115 | 0.0480 | -0.0596 | 1.3552 | 0.0325 | 0.0050 | 0.0375 |
| 2016 | 0.0784 | 0.0306 | -0.0051 | 0.0357 | 1.5560 | 0.0412 | 0.0057 | 0.0469 |
| 2017 | 0.0469 | -0.0315 | 0.0732 | -0.1047 | 0.6985 | 0.0323 | 0.0026 | 0.0348 |
| 2018 | 0.0348 | -0.0121 | 0.0487 | -0.0607 | 1.3426 | 0.0289 | 0.0058 | 0.0346 |
| 2019 | 0.0289 | -0.0060 | 0.0410 | -0.0470 | 1.4738 | 0.0272 | 0.0054 | 0.0326 |
| 2020 | 0.0326 | 0.0037 | 0.0288 | -0.0251 | 1.6134 | 0.0282 | 0.0059 | 0.0341 |
| 2021 | 0.0341 | 0.0016 | 0.0315 | -0.0299 | 1.5898 | 0.0287 | 0.0058 | 0.0345 |
| 2022 | 0.0345 | 0.0004 | 0.0330 | -0.0327 | 1.5746 | 0.0288 | 0.0058 | 0.0345 |
| 2023 | 0.0345 | 0.0000 | 0.0334 | -0.0334 | 1.5705 | 0.0288 | 0.0058 | 0.0345 |
| 2024 | 0.0345 | 0.0000 | 0.0335 | -0.0335 | 1.5699 | 0.0288 | 0.0057 | 0.0345 |
| 2025 | 0.0345 | 0.0000 | 0.0335 | -0.0335 | 1.5699 | 0.0288 | 0.0057 | 0.0345 |

Elaboración propia con Sofware Excel

Tabla 6. Pronóstico de la tasa de crecimiento de la demanda petrolera.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TC | rt+1 − rt | a(b − rt) | rt+1 −rt −a(b−rt) | Z | μ | σ2 | Pronóstico | TC |
| 1994 | 0.0230 |  |  |  |  |  |  |  |
| 1995 | -0.0630 | -0.0860 | 0.1229 | -0.2089 | -6.3054 | -0.0083 | -0.0106 | -0.0189 |
| 1996 | 0.0770 | 0.1400 | -0.1537 | 0.2937 | -14.4686 | 0.0328 | -0.0243 | 0.0085 |
| 1997 | 0.0968 | 0.0198 | -0.0066 | 0.0264 | 1.9218 | 0.0386 | 0.0032 | 0.0419 |
| 1998 | 0.0761 | -0.0207 | 0.0430 | -0.0637 | 1.2786 | 0.0326 | 0.0021 | 0.0347 |
| 1999 | -0.0950 | -0.1711 | 0.2272 | -0.3983 | -28.3294 | -0.0177 | -0.0476 | -0.0653 |
| 2000 | 0.0974 | 0.1923 | -0.2179 | 0.4102 | -30.1780 | 0.0388 | -0.0507 | -0.0119 |
| 2001 | 0.0302 | -0.0672 | 0.0999 | -0.1671 | -3.2950 | 0.0191 | -0.0055 | 0.0135 |
| 2002 | 0.0221 | -0.0080 | 0.0275 | -0.0356 | 1.8128 | 0.0167 | 0.0030 | 0.0197 |
| 2003 | 0.0671 | 0.0449 | -0.0373 | 0.0823 | 0.7586 | 0.0299 | 0.0013 | 0.0312 |
| 2004 | 0.0273 | -0.0398 | 0.0664 | -0.1062 | -0.1040 | 0.0182 | -0.0002 | 0.0180 |
| 2005 | -0.0110 | -0.0383 | 0.0646 | -0.1028 | 0.0297 | 0.0070 | 0.0000 | 0.0070 |
| 2006 | 0.0639 | 0.0748 | -0.0740 | 0.1488 | -2.1860 | 0.0290 | -0.0037 | 0.0253 |
| 2007 | -0.0159 | -0.0797 | 0.1153 | -0.1950 | -5.2275 | 0.0055 | -0.0088 | -0.0032 |
| 2008 | 0.0233 | 0.0392 | -0.0303 | 0.0695 | 1.1305 | 0.0170 | 0.0019 | 0.0189 |
| 2009 | -0.0117 | -0.0351 | 0.0606 | -0.0956 | 0.3028 | 0.0067 | 0.0005 | 0.0073 |
| 2010 | 0.0405 | 0.0523 | -0.0463 | 0.0986 | 0.1932 | 0.0221 | 0.0003 | 0.0224 |
| 2011 | -0.0225 | -0.0631 | 0.0949 | -0.1579 | -2.7231 | 0.0036 | -0.0046 | -0.0010 |
| 2012 | 0.0397 | 0.0622 | -0.0585 | 0.1208 | -0.7386 | 0.0219 | -0.0012 | 0.0206 |
| 2013 | -0.0004 | -0.0401 | 0.0668 | -0.1069 | -0.1321 | 0.0101 | -0.0002 | 0.0099 |
| 2014 | 0.0015 | 0.0018 | 0.0154 | -0.0136 | 2.0199 | 0.0106 | 0.0034 | 0.0140 |
| 2015 | -0.0332 | -0.0347 | 0.0601 | -0.0948 | 0.3329 | 0.0004 | 0.0006 | 0.0010 |
| 2016 | -0.0355 | -0.0023 | 0.0204 | -0.0227 | 1.9564 | -0.0002 | 0.0033 | 0.0031 |
| 2017 | 0.0031 | 0.0385 | -0.0295 | 0.0680 | 1.1688 | 0.0111 | 0.0020 | 0.0131 |
| 2018 | 0.0131 | 0.0100 | 0.0054 | 0.0046 | 2.0512 | 0.0140 | 0.0034 | 0.0174 |
| 2019 | 0.0140 | 0.0010 | 0.0165 | -0.0155 | 2.0092 | 0.0143 | 0.0034 | 0.0177 |
| 2020 | 0.0177 | 0.0037 | 0.0132 | -0.0095 | 2.0378 | 0.0154 | 0.0034 | 0.0188 |
| 2021 | 0.0188 | 0.0011 | 0.0163 | -0.0152 | 2.0111 | 0.0157 | 0.0034 | 0.0191 |
| 2022 | 0.0191 | 0.0003 | 0.0173 | -0.0170 | 1.9996 | 0.0158 | 0.0034 | 0.0192 |
| 2023 | 0.0192 | 0.0001 | 0.0176 | -0.0175 | 1.9963 | 0.0158 | 0.0034 | 0.0192 |
| 2024 | 0.0192 | 0.0000 | 0.0177 | -0.0176 | 1.9956 | 0.0158 | 0.0034 | 0.0192 |
| 2025 | 0.0192 | 0.0000 | 0.0177 | -0.0177 | 1.9954 | 0.0158 | 0.0034 | 0.0192 |

Elaboración propia con Sofware Excel

**A.3 Modelo de Hubbert**

Call: lm(formula = hub ~ hubbert)

Residuals: Min 1Q Median 3Q Max

-0.018594 -0.009061 0.001231 0.006814 0.030074

Coefficients: Estimate Std. Error t value Pr(>|t|)

(Intercept) 0.1236100 0.0041657 33.35 <2e-16 \*\*\*

hubbert -0.0012504 0.0000669 -22.13 <2e-16 \*\*\*

---

Signif. codes: 0 `\*\*\*´ 0.001 `\*\*´ 0.01 `\*´ 0.05 `.´ 0.1 ` ´ 1

Residual standard error: 0.01107 on 67 degrees of freedom

Multiple R-squared: 0.8796, Adjusted R-squared: 0.8779

F-statistic: 489.7 on 1 and 67 DF, p-value: < 2.2e-16

Elaboración propia con Sofware R

**A.4. Simulación Montecarlo de la VME**

> mu <- 73.31342143

> sigma <- 0.057467269

> alpha <- 0.01

> conf <- 1 - alpha # VaR al 99%

> qnorm(alpha)

[1] -2.326348

> qnorm(alpha, mean = mu, sd = sigma)

[1] 73.17973

> pnorm(73.17973, mean = mu, sd = sigma)

[1] 0.009998808

> pnorm(qnorm(0.01))

[1] 0.01

> sim <- rnorm(10000, mean = mu, sd = sigma)

> quantile(sim, c(.01, .5))

1% 50%

73.17652 73.31420

Elaboración propia con Sofware R

**A.5. Simulación Montecarlo del precio Spot para el contrato de futuros de gas natural**

> norm.simulated <- replicate(n=1000, rnorm(n=8, mean = 73.31342143, sd = 0.057467269))

> sd(apply(norm.simulated,2,mean))

[1] 0.02045131

> mean(apply(norm.simulated,2,mean))

[1] 73.31294

> hist(apply(norm.simulated,2,mean))

> norm.simulated

Elaboración propia con Sofware R

**A.6. Opción call por el método Cox, Ross y Rubinstein**

Title: CRR Binomial Tree Option

Call: CRRBinomialTreeOption(TypeFlag = "ce", S = 74.154, X = 74.2787, Time = 365/52, r = 0.0812, b = 0, sigma = 0.05747, n = 7)

Parameters: Value:

TypeFlag ce

S 74.154

X 74.2787

Time 7.01923076923077

r 0.0812

b 0

sigma 0.05747

n 7

Option Price: 2.603768

Elaboración propia con Sofware R

**A.7. Opción put por el método Cox, Ross y Rubinstein**

Title: CRR Binomial Tree Option

Call: CRRBinomialTreeOption(TypeFlag = "pe", S = 74.154, X = 74.2787, Time = 365/52, r = 0.0812, b = 0, sigma = 0.05747, n = 7)

Parameters: Value:

TypeFlag pe

S 74.154

X 74.2787

Time 7.01923076923077

r 0.0812

b 0

sigma 0.05747

n 7

Option Price:

2.674291

Elaboración propia con Sofware R