**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