Carteras de inversión.

Una introducción al diseño y análisis.

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	Fundamental	Intermedio	Especializado
Finanzas	×	✓	×
Estadística	✓	×	×
R	×	✓	×

1 Introducción.

- Conceptos fundamentales del análisis riesgo–rendimiento.
- Construir y evaluar portafolios usando datos reales.
- Explicar la frontera media–varianza, destacando cómo se obtiene mediante métodos analíticos y numéricos.
- Cómo los pesos óptimos cambian cuando se permiten o restringen las ventas en corto.

2 Diez empresas públicas de Estados Unidos.

Ticker	Nombre de la empresa	Industria
AMD	Advanced Micro Devices, Inc.	Computación de alto rendimiento
CNC	Centene Corp.	Servicios de salud
GIS	General Mills, Inc.	Productos de consumo envasados
LMT	Lockheed Martin Corp.	Aeroespacial y defensa
LRCX	Lam Research Corp.	Semiconductores
NEM	Newmont Corp.	Minería de metales preciosos
SNPS	Synopsys, Inc.	Software de diseño
SYF	Synchrony Financial	Servicios financieros
TRMB	Trimble Inc.	Tecnología geoespacial
TTD	The Trade Desk, Inc.	Tecnología publicitaria

3 Paquetes.

```r
library(tidyquant)
library(tidyverse)
library(lubridate)
library(scales)
library(quadprog)
```

4 Inicialización

```r
tickers <- c("AMD","CNC","GIS","LMT","LRCX","NEM","SNPS","SYF","TRMB","TTD")
n_months <- 60L
price_start <- ymd("2020-09-01")
price_end <- price_start %m+% months(n_months + 1) - days(1)
returns_start <- price_start %m+% months(1)
returns_end <- returns_start %m+% months(n_months) - months(1)

prices <- tq_get(tickers, from = price_start, to = price_end, get = "stock.prices")

monthly_returns <- prices |>
  arrange(symbol, date) |>
  group_by(symbol) |>
  tq_transmute(select = adjusted, mutate_fun = periodReturn,
               period = "monthly", type = "arithmetic",
               col_rename = "monthly_return") |>
  filter(between(date, returns_start, returns_end)) |>
  slice_head(n = n_months) |>
  ungroup()

stopifnot(n_distinct(monthly_returns$symbol) == length(tickers))

asset_stats <- function(data) {
  data |>
    group_by(symbol) |>
    summarise(ER = mean(monthly_return, na.rm = TRUE),
              SD = sd(monthly_return, na.rm = TRUE),
              SR = ER / SD,
              .groups = "drop")}

cum_index <- function(data, start_date) {
  base <- tibble(date = start_date, symbol = unique(data$symbol), index_level = 1)
  data |>
    arrange(symbol, date) |>
    group_by(symbol) |>
    mutate(index_level = cumprod(1 + monthly_return)) |>
    ungroup() |>
    select(date, symbol, index_level) |>
    bind_rows(base) |>
    arrange(symbol, date)}

portfolio_series <- function(data, weights, label, start_date) {
  data |>
    filter(symbol %in% names(weights)) |>
    group_by(date) |>
    summarise(portfolio_return = sum(monthly_return * weights[symbol]), .groups = "drop") |>
    arrange(date) |>
    mutate(index_level = cumprod(1 + portfolio_return), symbol = label) |>
    select(date, symbol, index_level) |>
    bind_rows(tibble(date = start_date, symbol = label, index_level = 1))}

portfolio_stats <- function(data, weights, label) {
  pr <- data |>
    filter(symbol %in% names(weights)) |>
    group_by(date) |>
    summarise(portfolio_return = sum(monthly_return * weights[symbol]), .groups = "drop")
```

```
tibble(symbol = label,
       ER = mean(pr$portfolio_return, na.rm = TRUE),
       SD  = sd(pr$portfolio_return, na.rm = TRUE),
       SR = ER / SD)}

returns_wide <- monthly_returns |>
  select(date, symbol, monthly_return) |>
  pivot_wider(names_from = symbol, values_from = monthly_return) |>
  arrange(date)

returns_mat_all <- returns_wide |>
  select(-date) |>
  as.matrix()

mu_vec_all  <- colMeans(returns_mat_all, na.rm = TRUE)
cov_mat_all <- cov(returns_mat_all, use = "pairwise.complete.obs")
n_assets <- length(mu_vec_all)

stats_all <- tibble(symbol = names(mu_vec_all),
                    ER = mu_vec_all,
                    SD = apply(returns_mat_all, 2, sd, na.rm = TRUE))

color_values_all <- setNames(scales::hue_pal()(length(mu_vec_all)),
                             names(mu_vec_all))
```

5 Matriz de correlaciones.

```r
corr_mat <- returns_wide |>
  select(-date) |>
  cor(use = "pairwise.complete.obs")

print(round(corr_mat, 2), quote = FALSE, right = TRUE)
```

```
##        AMD   CNC   GIS   LMT  LRCX   NEM  SNPS   SYF  TRMB   TTD
## AMD   1.00 -0.10 -0.16 -0.12  0.71 -0.06  0.70  0.35  0.50  0.51
## CNC  -0.10  1.00  0.37  0.37  0.14  0.20 -0.16  0.12  0.01 -0.18
## GIS  -0.16  0.37  1.00  0.46 -0.20  0.25 -0.27 -0.15 -0.20 -0.20
## LMT  -0.12  0.37  0.46  1.00  0.00  0.32 -0.22  0.20  0.01 -0.10
## LRCX  0.71  0.14 -0.20  0.00  1.00  0.04  0.56  0.59  0.61  0.38
## NEM  -0.06  0.20  0.25  0.32  0.04  1.00 -0.04 -0.08 -0.05 -0.26
## SNPS  0.70 -0.16 -0.27 -0.22  0.56 -0.04  1.00  0.33  0.48  0.31
## SYF   0.35  0.12 -0.15  0.20  0.59 -0.08  0.33  1.00  0.67  0.29
## TRMB  0.50  0.01 -0.20  0.01  0.61 -0.05  0.48  0.67  1.00  0.44
## TTD   0.51 -0.18 -0.20 -0.10  0.38 -0.26  0.31  0.29  0.44  1.00
```

6 Pares de correlaciones mínimas.

```r
lowest_pairs <- corr_mat |>
  as_tibble(rownames = "symbol_i") |>
  pivot_longer(-symbol_i, names_to = "symbol_j", values_to = "corr") |>
  filter(symbol_i < symbol_j) |>
  arrange(corr) |>
  slice_head(n = 10)

print(lowest_pairs)
```

```
## # A tibble: 10 x 3
##    symbol_i symbol_j   corr
##    <chr>    <chr>     <dbl>
##  1 GIS      SNPS     -0.266
##  2 NEM      TTD      -0.263
##  3 LMT      SNPS     -0.217
##  4 GIS      TTD      -0.201
##  5 GIS      LRCX     -0.201
##  6 GIS      TRMB     -0.198
##  7 CNC      TTD      -0.180
##  8 AMD      GIS      -0.162
##  9 CNC      SNPS     -0.156
## 10 GIS      SYF      -0.148
```

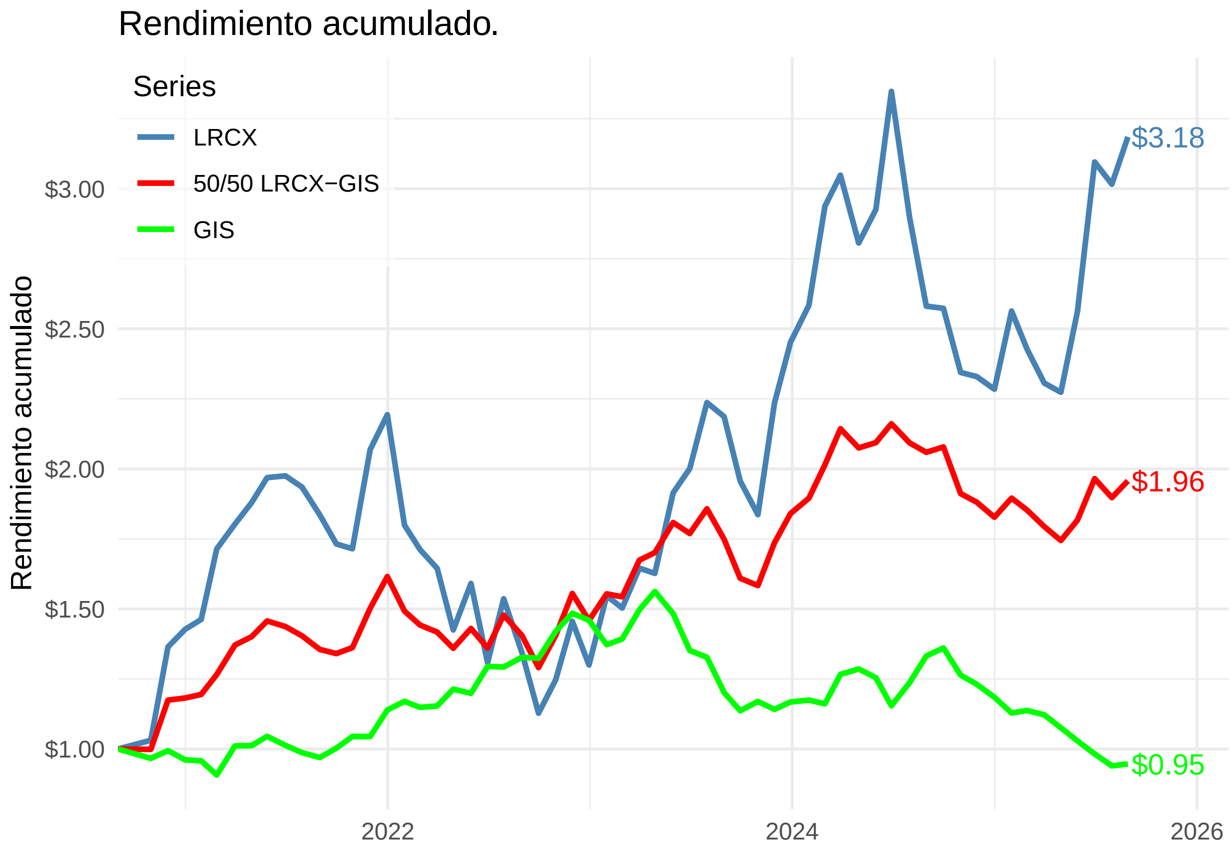
7 Riesgo-rendimiento: 10 activos individuales.

```r
stats <- asset_stats(monthly_returns)

print(stats)
```

```
## # A tibble: 10 x 4
##    symbol        ER     SD       SR
##    <chr>      <dbl>  <dbl>    <dbl>
##  1 AMD     0.0223   0.150   0.149
##  2 CNC    -0.00542  0.102  -0.0532
##  3 GIS     0.000182 0.0477  0.00382
##  4 LMT     0.00709  0.0647  0.110
##  5 LRCX    0.0257   0.111   0.231
##  6 NEM     0.0107   0.103   0.103
##  7 SNPS    0.0216   0.0902  0.240
##  8 SYF     0.0259   0.106   0.244
##  9 TRMB    0.0132   0.0970  0.136
## 10 TTD     0.0170   0.184   0.0926
```

8 Rendimiento acumulado, cartera ingenua.

```r
focus <- c("LRCX", "GIS")
color_values <- c("LRCX"="steelblue","GIS"="green","50/50 LRCX-GIS"="red")

cum_focus <- monthly_returns |>
  filter(symbol %in% focus) |>
  cum_index(price_start)

portfolio_50_50 <- portfolio_series(monthly_returns,
                                    c(LRCX = 0.5, GIS = 0.5),
                                    "50/50 LRCX-GIS", price_start)

plot_data <- bind_rows(cum_focus, portfolio_50_50)

last_vals <- plot_data |>
  group_by(symbol) |>
  summarise(final_value = last(index_level), .groups = "drop") |>
  arrange(desc(final_value))

label_data <- plot_data |>
  group_by(symbol) |>
  filter(date == max(date)) |>
  mutate(label = paste0("$", formatC(index_level, format="f", digits=2))) |>
  ungroup()

ggplot(plot_data, aes(date, index_level, color = factor(symbol, levels = last_vals$symbol))) +
  geom_line(linewidth = 1) +
  geom_text(data = label_data, aes(label = label), hjust = -0.05, vjust = 0.5, show.legend =
    FALSE) +
  scale_color_manual(values = color_values, limits = last_vals$symbol) +
  scale_x_date(expand = expansion(mult = c(0, 0.1))) +
  scale_y_continuous(labels = dollar_format(prefix = "$")) +
  labs(title = "Rendimiento acumulado.", y = "Rendimiento acumulado", x = NULL, color =
    "Series") +
  theme_minimal() +
  theme(legend.position = c(0,1), legend.justification = c(0,1),
        legend.background = element_rect(fill = alpha("white", 0.6), color = NA))
```



Rendimiento acumulado.
Series
LRCX
50/50 LRCX−GIS
GIS
Rendimiento acumulado
$3.00
$2.50
$2.00
$1.50
$1.00
2022
2024
2026
$3.18
$1.96
$0.95

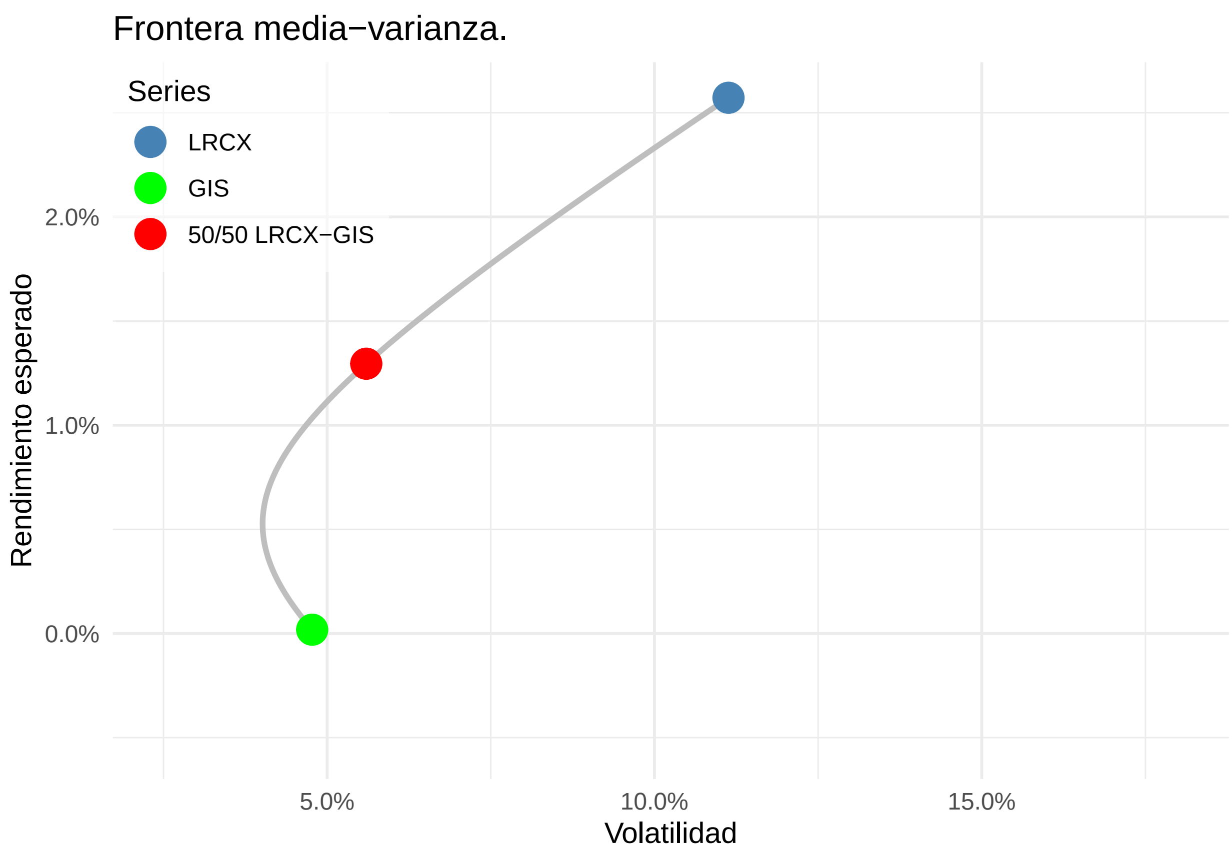
9 Riesgo-rendimiento: cartera ingenua y componentes.

```r
weights_50_50 <- c(LRCX = 0.5, GIS = 0.5)
stats_lrcx_gis <- stats |> filter(symbol %in% names(weights_50_50))
portfolio_stats_50_50 <- portfolio_stats(monthly_returns, weights_50_50, "50/50 LRCX-GIS")

final_table <- bind_rows(stats_lrcx_gis, portfolio_stats_50_50)

print(final_table)
```

```
## # A tibble: 3 x 4
##   symbol                ER     SD      SR
##   <chr>              <dbl>  <dbl>   <dbl>
## 1 GIS            0.000182 0.0477 0.00382
## 2 LRCX           0.0257   0.111  0.231
## 3 50/50 LRCX-GIS 0.0130   0.0560 0.231
```

10 Frontera media-varianza: 2 activos.

```r
returns_matrix_2 <- returns_wide |>
  select(all_of(focus))

cov_mat_2 <- cov(returns_matrix_2, use = "pairwise.complete.obs")
mu_vec_2  <- colMeans(returns_matrix_2, na.rm = TRUE)

frontier_data <- tibble(weight_lrcx = seq(0, 1, length.out = 200)) |>
  mutate(weight_gis = 1 - weight_lrcx,
         ER = weight_lrcx * mu_vec_2["LRCX"] + weight_gis * mu_vec_2["GIS"],
         variance = weight_lrcx^2 * var(returns_matrix_2$LRCX, na.rm = TRUE) +
           weight_gis^2 * var(returns_matrix_2$GIS, na.rm = TRUE) +
           2 * weight_lrcx * weight_gis * cov_mat_2["LRCX", "GIS"],
         SD = sqrt(variance))

mean_var_points <- final_table |>
  mutate(symbol = factor(symbol, levels = c("LRCX", "GIS", "50/50 LRCX-GIS"))) |>
  arrange(symbol)

ggplot() +
  geom_path(data = frontier_data, aes(SD, ER), color = "grey", linewidth = 1) +
  geom_point(data = mean_var_points, aes(SD, ER, color = symbol), size = 5) +
  scale_color_manual(values = color_values, limits = levels(mean_var_points$symbol)) +
    scale_x_continuous(limits = c(0.025, 0.18), labels = percent_format(accuracy = 0.1)) +
  scale_y_continuous(limits = c(min(mu_vec_all), max(mu_vec_all)),
                     labels = percent_format(accuracy = 0.1)) +
  labs(title = "Frontera media-varianza.",
       x = "Volatilidad", y = "Rendimiento esperado", color = "Series") +
  theme_minimal() +
  theme(legend.position = c(0,1), legend.justification = c(0,1),
        legend.background = element_rect(fill = alpha("white", 0.6), color = NA))
```



Frontera media−varianza.
Series
LRCX
GIS
50/50 LRCX−GIS
Rendimiento esperado
2.0%
1.0%
0.0%
5.0%
10.0%
15.0%
Volatilidad

11 Cartera de mínima varianza: método numérico de optimización.

```r
minvar2_label <- "Min-Var 2-Asset (LRCX-GIS)"

assets_2 <- focus
qp_2 <- solve.QP(Dmat = 2 * cov_mat_2,
                 dvec = rep(0, length(assets_2)),
                 Amat = matrix(1, nrow = length(assets_2), ncol = 1),
                 bvec = 1, meq = 1)

weights_minvar2_qp <- setNames(qp_2$solution, assets_2)

print(weights_minvar2_qp)
```

```
##      LRCX       GIS
## 0.1990057 0.8009943
```

12 Cartera de mínima varianza: método analítico algebráico para 2 activos.

$w_1^* = \frac{\sigma_2^2 - \sigma_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}}$.

```r
Sigma_2 <- cov_mat_2[assets_2, assets_2]
var1  <- Sigma_2[1, 1]; var2 <- Sigma_2[2, 2]; cov12 <- Sigma_2[1, 2]
w1 <- (var2 - cov12) / (var1 + var2 - 2 * cov12)
weights_minvar2_closed <- setNames(c(w1, 1 - w1), assets_2)

print(weights_minvar2_closed)
```

```
##      LRCX       GIS
## 0.1990057 0.8009943
```

13 Cartera de mínima varianza: método analítico matricial para 2 activos.

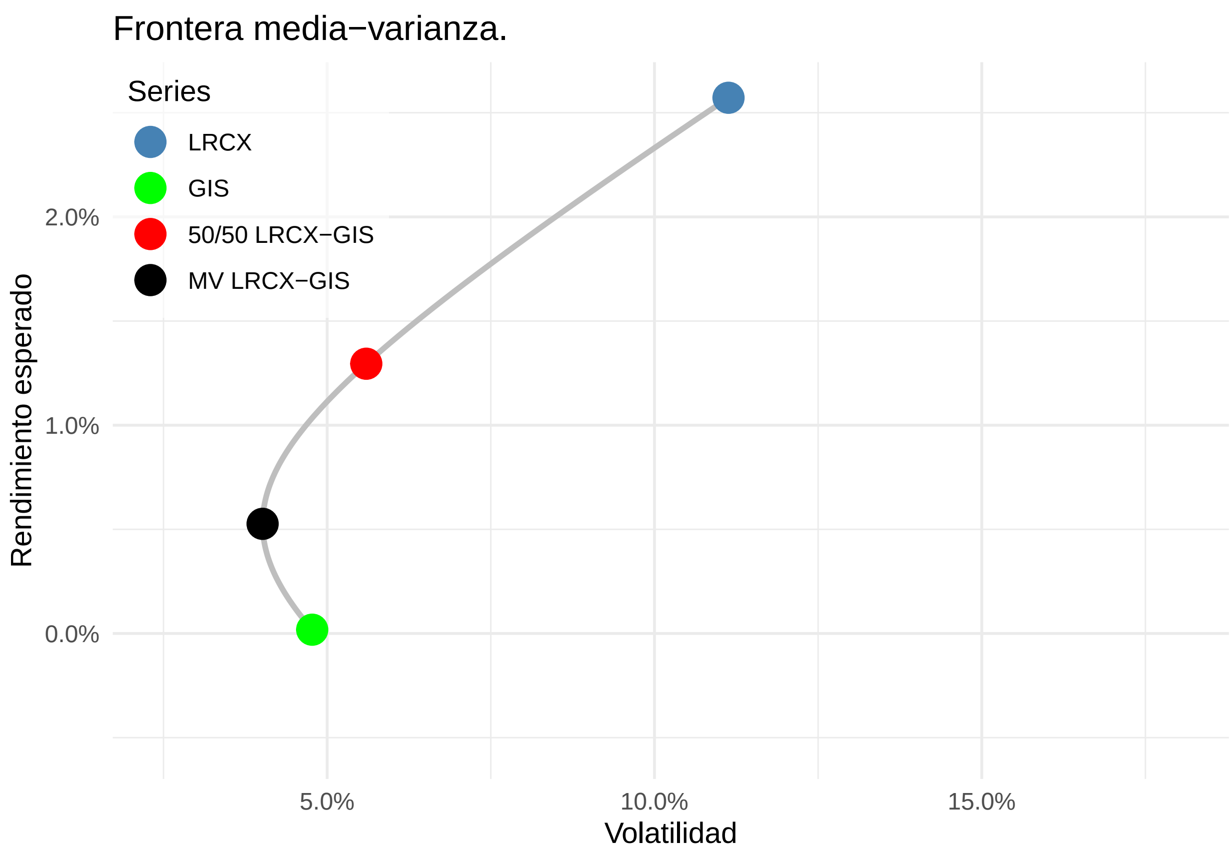
$w^* = \frac{\Sigma^{-1}\mathbf{1}}{\mathbf{1}^\top \Sigma^{-1}\mathbf{1}}$

```
Sigma_2 <- cov_mat_2[assets_2, assets_2, drop = FALSE]
ones <- rep(1, length(assets_2))
Sigma_inv <- solve(Sigma_2)
num <- Sigma_inv %*% ones
den <- as.numeric(t(ones) %*% Sigma_inv %*% ones)

w_star <- as.numeric(num / den)
names(w_star) <- assets_2

print(w_star)
```

```
##      LRCX       GIS
## 0.1990057 0.8009943
```

14 Frontera media-varianza: 2 activos, cartera MV.

```r
minvar2_label <- "MV LRCX-GIS"
minvar_point_2 <-
  tibble(symbol = minvar2_label,
         ER = sum(weights_minvar2_qp * mu_vec_2),
         SD = sqrt(as.numeric(t(weights_minvar2_qp) %*% cov_mat_2 %*% weights_minvar2_qp)))

mean_var_points_ext <- bind_rows(stats_lrcx_gis,
                                 portfolio_stats_50_50,
                                 minvar_point_2) |>
  mutate(symbol = factor(symbol,
                         levels = c("LRCX", "GIS", "50/50 LRCX-GIS", minvar2_label))) |>
  arrange(symbol)

color_values_ext <- c(color_values, setNames("black", minvar2_label))

ggplot() +
  geom_path(data = frontier_data, aes(SD, ER), color = "grey", linewidth = 1) +
  geom_point(data = mean_var_points_ext, aes(SD, ER, color = symbol), size = 5) +
  scale_color_manual(values = color_values_ext, limits = levels(mean_var_points_ext$symbol)) +
  scale_x_continuous(limits = c(0.025, 0.18), labels = percent_format(accuracy = 0.1)) +
  scale_y_continuous(limits = c(min(mu_vec_all), max(mu_vec_all)), labels =
    percent_format(accuracy = 0.1)) +
  labs(title = "Frontera media-varianza.",
       x = "Volatilidad", y = "Rendimiento esperado", color = "Series") +
  theme_minimal() +
  theme(legend.position = c(0, 1),
        legend.justification = c(0, 1),
        legend.background = element_rect(fill = alpha("white", 0.6), color = NA))
```


Frontera media−varianza.
Series
LRCX
GIS
50/50 LRCX−GIS
MV LRCX−GIS
2.0%
1.0%
0.0%
Rendimiento esperado
5.0%
10.0%
15.0%
Volatilidad

15 Cartera de mínima varianza: método numérico para 10 activos.

Pesos positivos.

```
minvar10_ns_label <- "MV (no shorts)"

weights_minvar10_ns <-
  solve.QP(2 * cov_mat_all, rep(0, length(mu_vec_all)),
           cbind(rep(1, length(mu_vec_all)), diag(length(mu_vec_all))),
           c(1, rep(0, length(mu_vec_all))), meq = 1)$solution

names(weights_minvar10_ns) <- names(mu_vec_all)

minvar_point_10_ns <-
  tibble(symbol = minvar10_ns_label,
         ER = sum(weights_minvar10_ns * mu_vec_all),
         SD = sqrt(as.numeric(t(weights_minvar10_ns) %*% cov_mat_all %*%
          ↪  weights_minvar10_ns)),
         SR = ER/SD)

minvar_point_10_ns
```

```
## # A tibble: 1 x 4
##   symbol                ER     SD    SR
##   <chr>              <dbl>  <dbl> <dbl>
## 1 MV (no shorts) 0.00717 0.0337 0.213
```

16 Cartera de mínima varianza: método numérico para 10 activos, pesos.

```
minvar_weights_table_ns <-
  tibble(symbol  = names(mu_vec_all),
         weight = weights_minvar10_ns,
         weight_pct = scales::percent(weights_minvar10_ns, accuracy = 0.01)) |>
  arrange(desc(weight)) |>
  bind_rows(tibble(symbol = "Total",
                   weight = sum(weights_minvar10_ns),
                   weight_pct = scales::percent(sum(weights_minvar10_ns),
                                                accuracy = 0.01)))

print(minvar_weights_table_ns)
```

```
## # A tibble: 11 x 3
##    symbol   weight weight_pct
##    <chr>     <dbl> <chr>
##  1 GIS    5.40e- 1 54.01%
##  2 SNPS   1.83e- 1 18.34%
##  3 LMT    1.12e- 1 11.17%
##  4 TRMB   4.62e- 2 4.62%
##  5 NEM    4.52e- 2 4.52%
##  6 SYF    3.05e- 2 3.05%
##  7 TTD    3.00e- 2 3.00%
##  8 CNC    1.30e- 2 1.30%
##  9 AMD    1.34e-18 0.00%
## 10 LRCX   0        0.00%
## 11 Total  1    e+ 0 100.00%
```

17 Cartera de mínima varianza: método analítico matricial para 10 activos, pesos.

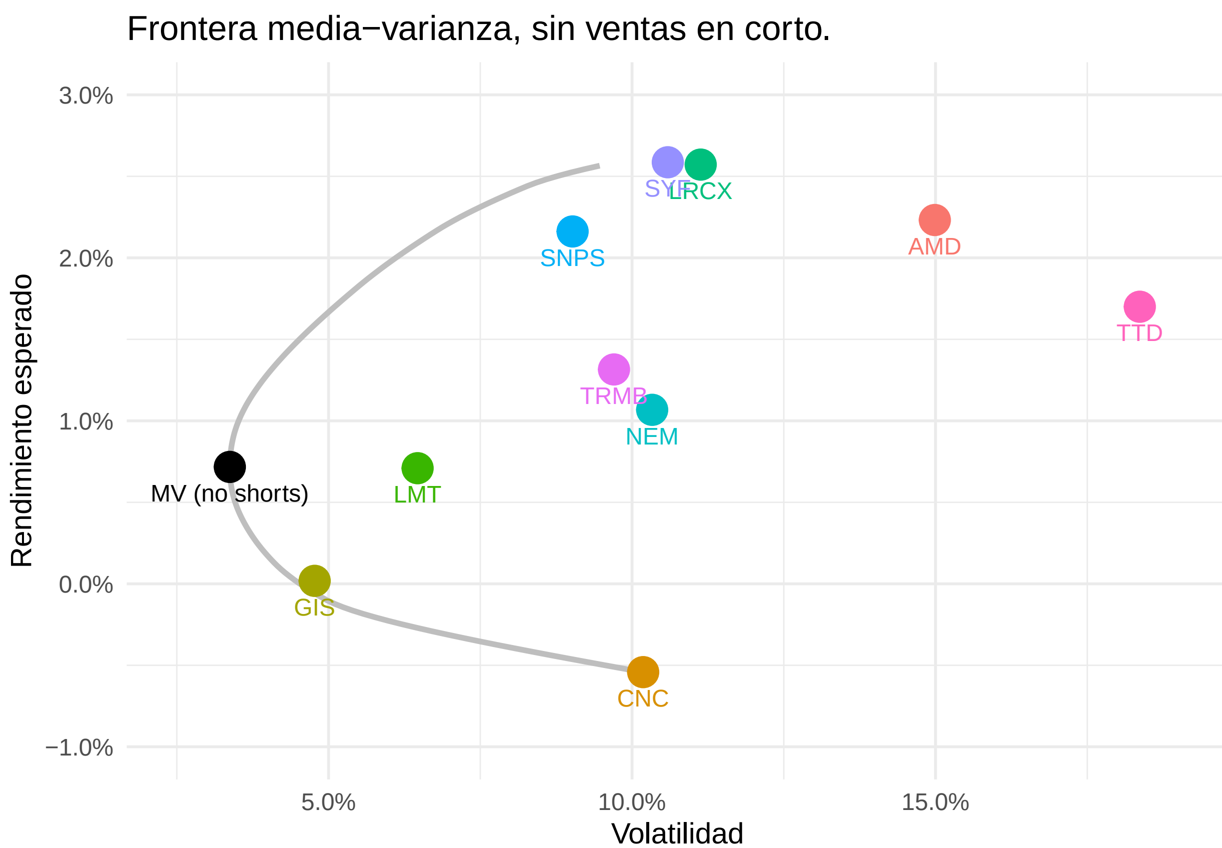
$w^* = \dfrac{\Sigma^{-1}\mathbf{1}}{\mathbf{1}^\top\Sigma^{-1}\mathbf{1}}$. Markowitz, ventas en corto permitidas.

```r
minvar10_short_label <- "MV (shorts)"

Sigma_all  <- cov_mat_all
ones_all   <- rep(1, length(mu_vec_all))
inv_Sigma_all <- solve(Sigma_all)
A_all <- as.numeric(t(ones_all) %*% inv_Sigma_all %*% ones_all)

weights_minvar10_short <- as.numeric(inv_Sigma_all %*% ones_all / A_all)
names(weights_minvar10_short) <- names(mu_vec_all)

minvar_point_10_short <-
  tibble(symbol = minvar10_short_label, ER = sum(weights_minvar10_short * mu_vec_all),
         SD = sqrt(as.numeric(t(weights_minvar10_short) %*% Sigma_all %*% weights_minvar10_short)))

weights_gmv_table_short <-
  tibble(symbol = names(mu_vec_all),
         weight = weights_minvar10_short,
         weight_pct = scales::percent(weights_minvar10_short, accuracy = 0.01)) |>
  arrange(desc(weight)) |>
  bind_rows(tibble(symbol = "Total",
                   weight = sum(weights_minvar10_short),
                   weight_pct = scales::percent(sum(weights_minvar10_short), accuracy = 0.01)))

print(weights_gmv_table_short)
```

```
## # A tibble: 11 x 3
##    symbol   weight weight_pct
##    <chr>     <dbl> <chr>
##  1 GIS     0.539   53.93%
##  2 SNPS    0.240   24.04%
##  3 LMT     0.106   10.62%
##  4 TRMB    0.0490  4.90%
##  5 TTD     0.0469  4.69%
##  6 NEM     0.0419  4.19%
##  7 LRCX    0.0416  4.16%
##  8 SYF     0.0187  1.87%
##  9 CNC     0.00510 0.51%
## 10 AMD    -0.0893  -8.93%
## 11 Total   1       100.00%
```

18 Frontera media-varianza: 10 activos, sin ventas en corto.

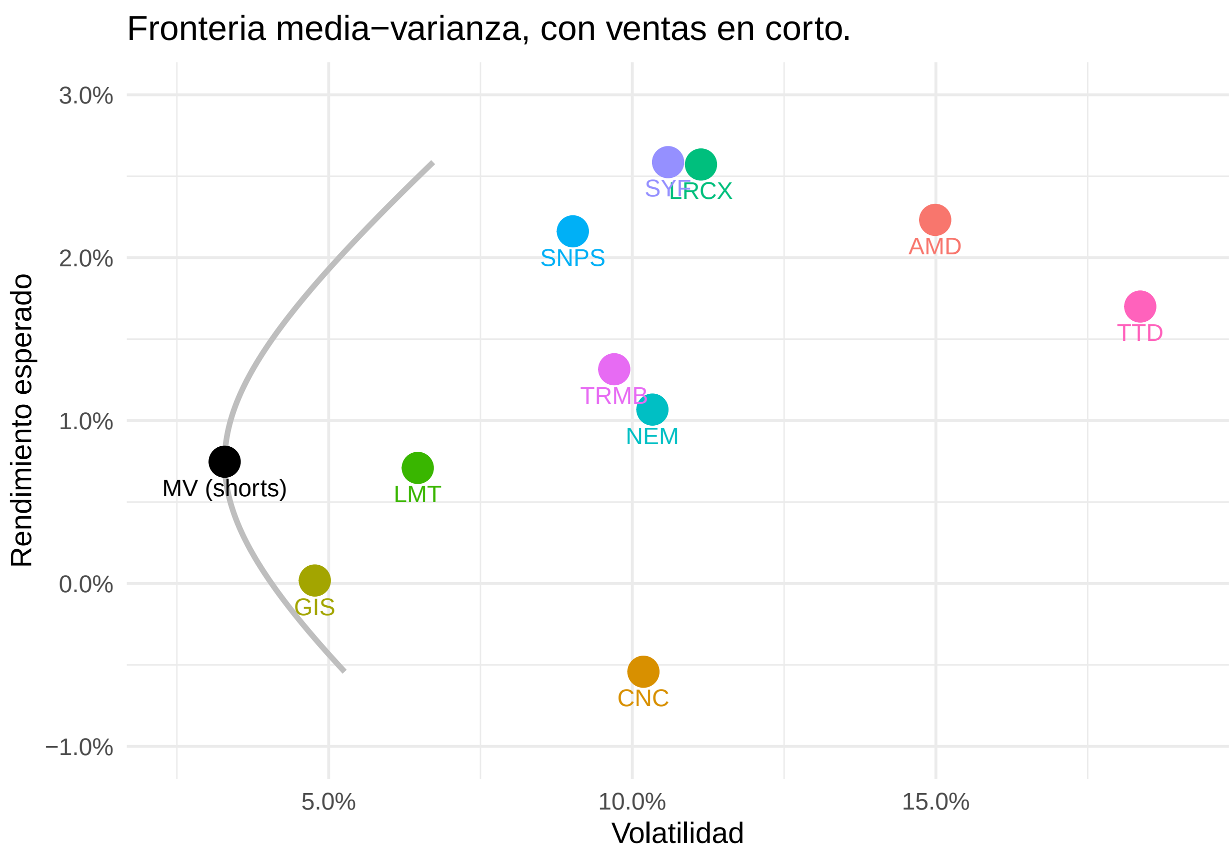
```r
target_returns <- seq(min(mu_vec_all), max(mu_vec_all), length.out = 150)
Amat_ns <- rbind(rep(1, n_assets), mu_vec_all, diag(n_assets))

frontier_points_ns <- map_dfr(target_returns, function(tr) {
  bvec <- c(1, tr, rep(0, n_assets))
  sol <- tryCatch(solve.QP(2 * cov_mat_all, rep(0, n_assets),
                           t(Amat_ns), bvec, meq = 2),
                  error = function(e) NULL)
  if (is.null(sol)) return(NULL)
  tibble(ER = tr,
         SD = sqrt(as.numeric(t(sol$solution) %*% cov_mat_all %*% sol$solution)))}) |>
  drop_na()

stats_all_ext_ns  <- bind_rows(stats_all, minvar_point_10_ns)
color_values_ext_ns <- c(color_values_all, setNames("black", minvar10_ns_label))

ggplot() +
  geom_path(data = frontier_points_ns, aes(SD, ER), color = "grey", linewidth = 1) +
  geom_point(data = stats_all_ext_ns, aes(SD, ER, color = symbol), size = 5) +
  geom_text(data = stats_all_ext_ns, aes(SD, ER, label = symbol, color = symbol),
            vjust = 2, size = 3, show.legend = FALSE) +
  scale_color_manual(values = color_values_ext_ns, limits = stats_all_ext_ns$symbol) +
  scale_x_continuous(limits = c(0.025, 0.19), labels = percent_format(accuracy = 0.1)) +
  scale_y_continuous(limits = c(-0.01, 0.03), labels = percent_format(accuracy = 0.1)) +
  labs(title = "Frontera media-varianza, sin ventas en corto.",
       x = "Volatilidad", y = "Rendimiento esperado") +
  guides(color = "none") +
  theme_minimal()
```



Frontera media−varianza, sin ventas en corto.
3.0%
2.0%
1.0%
0.0%
−1.0%
Rendimiento esperado
5.0%
10.0%
15.0%
Volatilidad
SYF
LRCX
SNPS
AMD
TTD
TRMB
NEM
MV (no shorts)
LMT
GIS
CNC

19 Frontera media-varianza: 10 activos, con ventas en corto.

```r
Amat_short <- rbind(rep(1, n_assets), mu_vec_all)

frontier_points_short <- map_dfr(target_returns, function(tr) {
  bvec <- c(1, tr)
  sol <- tryCatch(solve.QP(2 * cov_mat_all, rep(0, n_assets),
                           t(Amat_short), bvec, meq = 2),
                  error = function(e) NULL)
  if (is.null(sol)) return(NULL)
  tibble(ER = tr,
         SD = sqrt(as.numeric(t(sol$solution) %*% cov_mat_all %*% sol$solution)))}) |>
  drop_na()

stats_all_ext_short <- bind_rows(stats_all, minvar_point_10_short)
color_values_ext_short <- c(color_values_all, setNames("black", minvar10_short_label))

ggplot() +
  geom_path(data = frontier_points_short, aes(SD, ER), color = "grey", linewidth = 1) +
  geom_point(data = stats_all_ext_short, aes(SD, ER, color = symbol), size = 5) +
  geom_text(data = stats_all_ext_short, aes(SD, ER, label = symbol, color = symbol),
            vjust = 2, size = 3, show.legend = FALSE) +
  scale_color_manual(values = color_values_ext_short, limits = stats_all_ext_short$symbol) +
  scale_x_continuous(limits = c(0.025, 0.19), labels = percent_format(accuracy = 0.1)) +
  scale_y_continuous(limits = c(-0.01, 0.03),
                     labels = percent_format(accuracy = 0.1)) +
  labs(title = "Fronteria media-varianza, con ventas en corto.",
       x = "Volatilidad", y = "Rendimiento esperado") +
  guides(color = "none") +
  theme_minimal()
```


Fronteria media−varianza, con ventas en corto.
Rendimiento esperado
Volatilidad
3.0%
2.0%
1.0%
0.0%
−1.0%
5.0%
10.0%
15.0%
SYF
LRCX
AMD
SNPS
TTD
TRMB
NEM
MV (shorts)
LMT
GIS
CNC

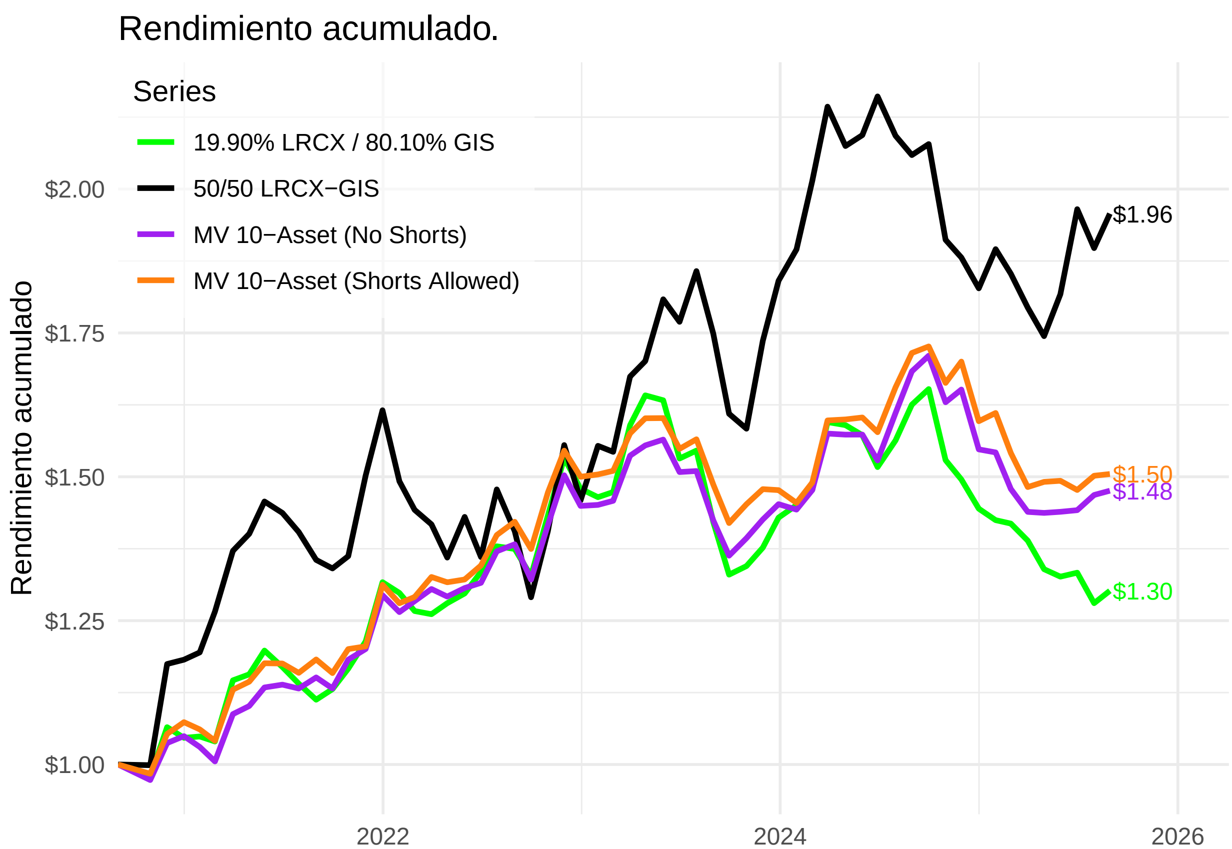
20 Riesgo-rendimiento: 10 activos individuales y carteras.

```r
weights_50_50 <- c(LRCX = 0.5, GIS = 0.5)
custom_weights  <- c(LRCX = 0.1990055, GIS = 0.8009945)
portfolio_label <- "19.90% LRCX / 80.10% GIS"

weights_specs <-
  list("50/50 LRCX-GIS" = weights_50_50,
       "19.90% LRCX / 80.10% GIS" = custom_weights,
       "MV 10-Asset (No Shorts)" = weights_minvar10_ns,
       "MV 10-Asset (Shorts Allowed)" = weights_minvar10_short)

portfolio_stats_ext <- imap_dfr(weights_specs, ~ portfolio_stats(monthly_returns, .x, .y))

final_table <- bind_rows(asset_stats(monthly_returns), portfolio_stats_ext) |>
  mutate(symbol = factor(symbol, levels = c(tickers, names(weights_specs)))) |>
  arrange(symbol)

print(final_table)
```

```
## # A tibble: 14 x 4
##    symbol                             ER     SD       SR
##    <fct>                           <dbl>  <dbl>    <dbl>
##  1 AMD                           0.0223  0.150   0.149
##  2 CNC                          -0.00542 0.102  -0.0532
##  3 GIS                           0.000182 0.0477  0.00382
##  4 LMT                           0.00709 0.0647  0.110
##  5 LRCX                          0.0257  0.111   0.231
##  6 NEM                           0.0107  0.103   0.103
##  7 SNPS                          0.0216  0.0902  0.240
##  8 SYF                           0.0259  0.106   0.244
##  9 TRMB                          0.0132  0.0970  0.136
## 10 TTD                           0.0170  0.184   0.0926
## 11 50/50 LRCX-GIS                0.0130  0.0560  0.231
## 12 19.90% LRCX / 80.10% GIS      0.00526 0.0401  0.131
## 13 MV 10-Asset (No Shorts)       0.00717 0.0337  0.213
## 14 MV 10-Asset (Shorts Allowed)  0.00747 0.0329  0.227
```

21 Rendimiento acumulado, todas las carteras.

```
portfolio_cum <- imap_dfr(weights_specs, ~ portfolio_series(monthly_returns, .x, .y,
  price_start))

last_values_port <- portfolio_cum |>
  group_by(symbol) |>
  summarise(final_value = last(index_level), .groups = "drop") |>
  arrange(desc(final_value))

series_levels <- last_values_port$symbol

palette_base <- c("50/50 LRCX-GIS" = "black",
                  "19.90% LRCX / 80.10% GIS" = "green",
                  "MV 10-Asset (No Shorts)" = "purple",
                  "MV 10-Asset (Shorts Allowed)" = "#ff7f0e")

portfolio_colors <- palette_base[series_levels]

portfolio_cum <- portfolio_cum |>
  mutate(symbol = factor(symbol, levels = series_levels))

label_data_port <- portfolio_cum |>
  group_by(symbol) |> filter(date == max(date)) |>
  mutate(label = paste0("$", formatC(index_level, format="f", digits=2))) |>
  ungroup()

ggplot(portfolio_cum, aes(date, index_level, color = symbol)) +
  geom_line(linewidth = 1) +
  geom_text(data = label_data_port, aes(label = label),
            hjust = -0.05, vjust = 0.5, size = 3.2, show.legend = FALSE) +
  scale_color_manual(values = portfolio_colors, breaks = series_levels,
                     limits = series_levels, drop = FALSE) +
  scale_x_date(expand = expansion(mult = c(0, 0.12))) +
  scale_y_continuous(labels = dollar_format(prefix = "$")) +
  labs(title = "Rendimiento acumulado.",
       y = "Rendimiento acumulado", x = NULL, color = "Series") +
  theme_minimal() +
  theme(legend.position = c(0, 1), legend.justification = c(0, 1),
        legend.background = element_rect(fill = alpha("white", 0.6), color = NA))
```



Rendimiento acumulado.
Series
19.90% LRCX / 80.10% GIS
50/50 LRCX−GIS
MV 10−Asset (No Shorts)
MV 10−Asset (Shorts Allowed)
Rendimiento acumulado
$2.00
$1.75
$1.50
$1.25
$1.00
2022
2024
2026
$1.96
$1.50
$1.48
$1.30

22 Conclusión.

- La diversificación reduce riesgo y permite construir portafolios con mejor relación riesgo–rendimiento que los activos individuales.
- La frontera media–varianza es una herramienta poderosa para visualizar las decisiones de inversión y comprender el intercambio entre riesgo y retorno.