Mesure de la biodiversité et de la structuration spatiale de l’activité économique par l’entropie : Annexe

Cette annexe contient:

- le code nécessaire pour reproduire l’ensemble des résultats et des figures de l’article;
- deux figures supplémentaires représentant les tailles relatives des secteurs économiques et des pays;
- le détail du test de significativité de la spécialisation de l’Italie.

Données

Les données sont un tableau de contingence contenant le nombre d’employés par secteur industriel (en lignes) et par pays (en colonnes).

```r
ES02Cx <- matrix(c(71924, 85083, 82510, 101575, 591468, 54896, 13827, 99482,
    316141, 34627, 511130, 53238, 93254, 10526, 389447, 40054, 21647, 121943,
    47741, 369885, 89958, 155573, 56948, 34427, 365056, 9319, 9814, 13298,
    15301, 71327, 4523, 1516, 9001, 46813, 3260, 58383, 7105, 13301, 717,
    37855, 3528, 2421, 6727, 3653, 22997, 14840, 17168, 5205, 4976, 36166,
    8665, 17329, 12914, 25983, 73448, 3951, 4452, 7366, 40050, 3122, 38896,
    4192, 14293, 274, 121725, 9061, 2962, 12130, 2734, 54119, 42995, 35531,
    5297, 7202, 51477, 6212, 3495, 99974, 25717, 35275, 1611, 6052, 14148,
    42550, 2214, 46451, 15480, 21528, 120, 196877, 20293, 9300, 3473, 1531,
    87121, 88345, 156210, 1348, 15792, 28524, 32762, 11271, 17263, 54290,
    92412, 9630, 17191, 5867, 47595, 19797, 62165, 16063, 18022, 209, 107122,
    22886, 25302, 13351, 13167, 126243, 28516, 56722, 33475, 25076, 69484,
    17078, 11044, 10353, 20102, 150984, 6027, 1430, 7428, 42950, 19590,
    64717, 4277, 14162, 47, 70408, 4255, 1376, 17242, 2989, 57602, 10198,
    12949, 31239, 6921, 55549, 11683, 16542, 9001, 23224, 114394, 7762,
    3017, 9096, 59256, 8111, 66027, 7896, 16740, 759, 80040, 4535, 3503,
    22283, 5790, 51282, 15145, 15955, 14702, 5806, 116408, 16985, 44267,
    14012, 29808, 384357, 16766, 2553, 10841, 82762, 12716, 148362, 5975,
    15003, 226, 105484, 5457, 2795, 43792, 9204, 74233, 11862, 22862, 20415,
    8437, 95611, 29391, 22633, 28565, 86554, 445576, 15956, 3998, 11254,
    89937, 12855, 146456, 10533, 48440, 319, 170116, 8761, 3057, 30964,
    4817, 186316, 25292, 57262, 22446, 31953, 165499, 31438, 27494, 21613,
    58816, 218474, 16056, 4396, 15024, 84791, 13180, 113602, 11918, 24760,
    744, 158860, 8715, 5427, 21101, 10291, 128566, 39003, 38980, 19492,
    16595, 75888, 35485, 24835, 12025, 45314, 296109, 5918, 528, 8385,
    57516, 14208, 76342, 4051, 17358, 1939, 117996, 633, 1306, 19596, 9912,
    65693, 7684, 29969, 32637, 22488, 65687, 74471, 54621, 56847, 189295,
    754724, 41021, 12949, 26970, 222220, 40224, 311044, 30885, 76704, 1614,
    498814, 14684, 10676, 89908, 24462, 301566, 80265, 91106, 77264, 74020,
    338466, 22833, 10731, 9610, 43389, 334588, 19935, 5633, 2802, 26217,
    24249, 132168, 5165, 44558, 86, 96534, 3483, 1817, 26380, 8394, 60332,
    9370, 31880, 21245, 14595, 108890, 43678, 15157, 21547, 101180, 470442,
    13189, 5449, 6703, 60208, 16826, 109277, 10451, 40214, 207, 151682,
    4840, 2684, 20175, 8131, 99629, 18576, 40020, 25542, 31371, 86750,
    79693, 30781, 31487, 127758, 1173382, 68554, 3896, 9746, 99514, 44950,
    178760, 11422, 61830, 991, 450846, 6064, 3657, 80751, 23334, 120209,
```

```
    22379, 51503, 73428, 40740, 181438, 30738, 29556, 21021, 159126, 924459,
    4843, 3300, 1798, 144252, 7195, 223319, 2591, 88571, 78, 159836, 4511,
    1843, 20295, 2649, 177137, 33610, 165951, 70391, 66519, 149171, 27707,
    12467, 21813, 26141, 116832, 10825, 7929, 9802, 54801, 6669, 47063,
    9777, 17850, 345, 131587, 27724, 6811, 23188, 5305, 167975, 29877,
    63173, 15140, 13879, 80728, 17872, 8753, 10219, 39933, 178913, 12566,
    2335, 8513, 40555, 4340, 84430, 3772, 27074, 805, 119175, 7657, 2406,
    18554, 3722, 55933, 13631, 16740, 11962, 8847, 80505, 27458, 19166,
    17366, 50475, 230049, 12794, 4818, 13510, 77271, 19656, 193286, 11236,
    21448, 1331, 160875, 8953, 5816, 46093, 21610, 128794, 20362, 30017,
    21069, 17277, 110841), nrow = 19, ncol = 25, byrow = TRUE)
rownames(ES02Cx) <- c("C10", "C11", "C13", "C14", "C16", "C17", "C18",
    "C20", "C22", "C23", "C24", "C25", "C26", "C27", "C28", "C29", "C31",
    "C32", "C33")
colnames(ES02Cx) <- c("AT", "BE", "BG", "CZ", "DE", "DK", "EE", "EL", "ES",
    "FI", "FR", "HR", "HU", "IS", "IT", "LT", "LV", "NL", "NO", "PL", "PT",
    "RO", "SE", "SK", "UK")
```

Tailles relatives des secteurs et des pays

Les tailles relatives des secteurs et des pays sont représentés ici:

```
library("ggplot2")
# Données
df <- data.frame(class = rownames(ES02Cx), n = rowSums(ES02Cx))
# Camembert
pie <- ggplot(df, aes(x = "", y = n, fill = factor(class))) + geom_bar(width = 1,
    stat = "identity") + labs(fill = "Secteur", x = NULL, y = NULL)
# Palette de couleurs
library("RColorBrewer")
getPalette <- colorRampPalette(RColorBrewer::brewer.pal(8, "Accent"))
fill <- scale_fill_manual(values = getPalette(ncol(ES02Cx)))
# Affichage en coordonnées polaires
coords <- coord_polar(theta = "y", start = 0, direction = -1)
# Figure
pie + coords + fill
```

```
# Données
df <- data.frame(class = colnames(ES02Cx), n = colSums(ES02Cx))
# Camembert
pie <- ggplot(df, aes(x = "", y = n, fill = factor(class))) + geom_bar(width = 1,
    stat = "identity") + labs(fill = "Pays", x = NULL, y = NULL)
# Figure
pie + coords + fill
```

Figures de l'article

Code pour créer les figures.

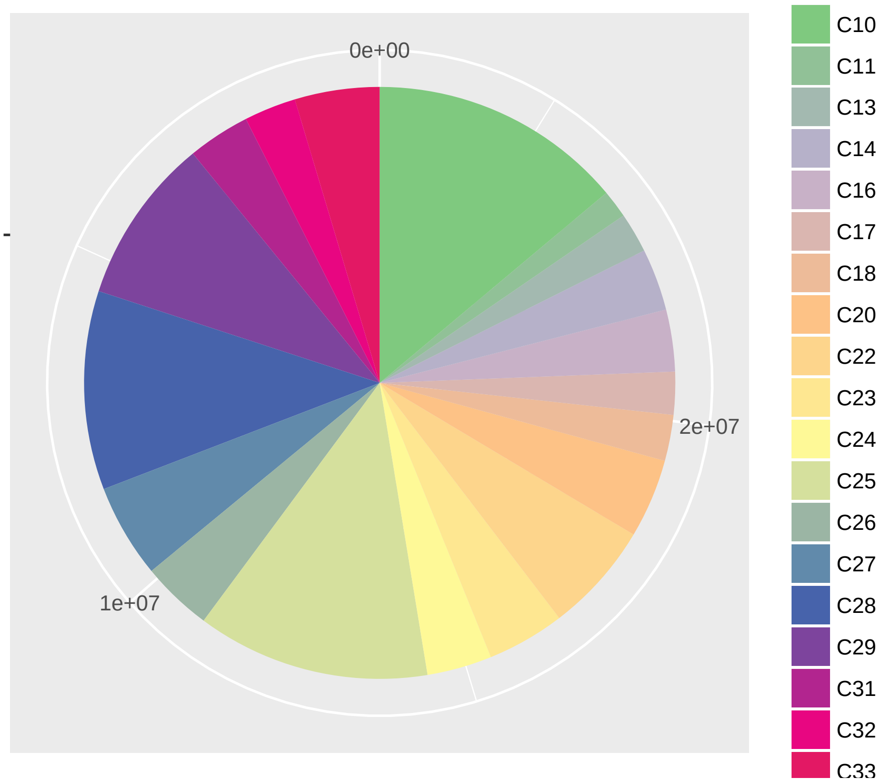


Figure 1: Taille relative des secteurs.

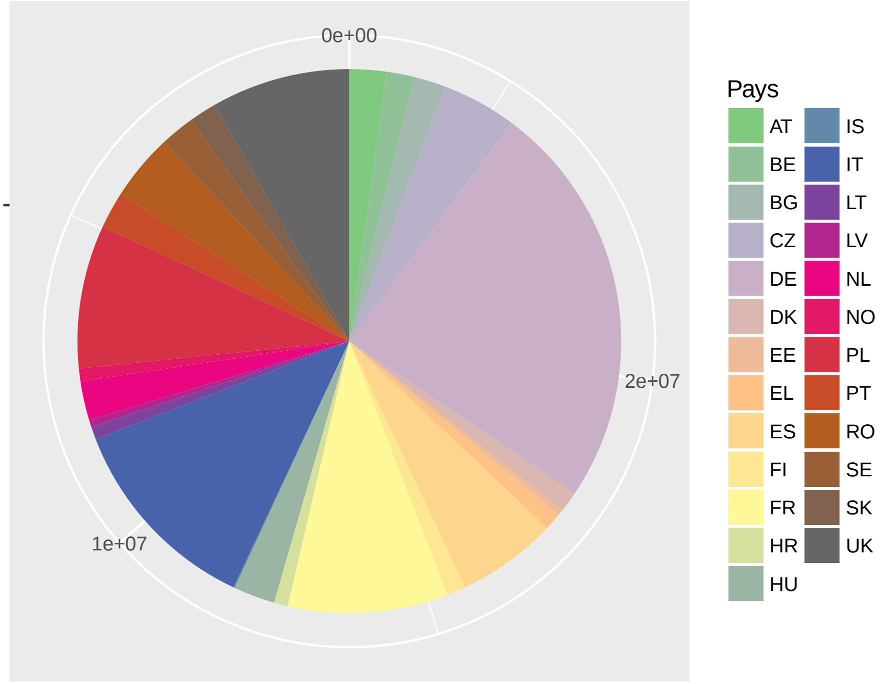


Figure 2: Taille relative des pays.

Figure 1

```
library("entropart")
# Profils d'ubiquité des secteurs C10, C20 et industrie entière
upC10 <- CommunityProfile(Diversity, as.AbdVector(ES02Cx["C10", ]), Correction = "None")
upC20 <- CommunityProfile(Diversity, as.AbdVector(ES02Cx["C20", ]), Correction = "None")
upC <- CommunityProfile(Diversity, colSums(ES02Cx), Correction = "None")
# Figure
plot(upC, ylim = c(min(upC20$y), max(upC20$y)), xlab = "Ordre", ylab = "Ubiquité absolue")
lines(upC10, col = "green", lty = 2, lwd = 2)
lines(upC20, col = "blue", lty = 3, lwd = 2)
```

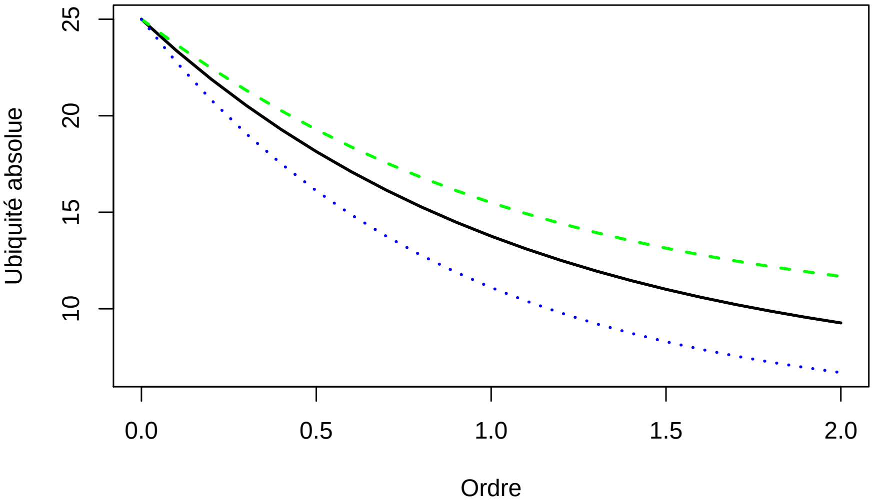


Figure 2

```
# Fonction intermédiaire pour la normalisation des profils
CPnormalize <- function(CProfile, Max) {
    # Copie du profil
    NormalizedCP <- CProfile
    # Normalisation des valeurs
    NormalizedCP$y <- (Max - CProfile$y)/(Max - 1)
    # Normalisation des bornes de l'enveloppe si elles existent
    if (!is.null(CProfile$high))
        NormalizedCP$low <- (Max - CProfile$high)/(Max - 1)
    if (!is.null(CProfile$low))
        NormalizedCP$high <- (Max - CProfile$low)/(Max - 1)
    return(NormalizedCP)
}
# Valeur maximale possible: nombre de pays
uMax <- ncol(ES02Cx)
# Profils de concentration: normalisation des profils d'ubiquité
cpC10 <- CPnormalize(upC10, uMax)
cpC20 <- CPnormalize(upC20, uMax)
cpC <- CPnormalize(upC, uMax)
# Figure
plot(cpC, ylim = c(min(cpC20$y), max(cpC20$y)), xlab = "Ordre", ylab = "Concentration absolue")
lines(cpC10, col = "green", lty = 2, lwd = 2)
```

```
lines(cpC20, col = "blue", lty = 3, lwd = 2)
```

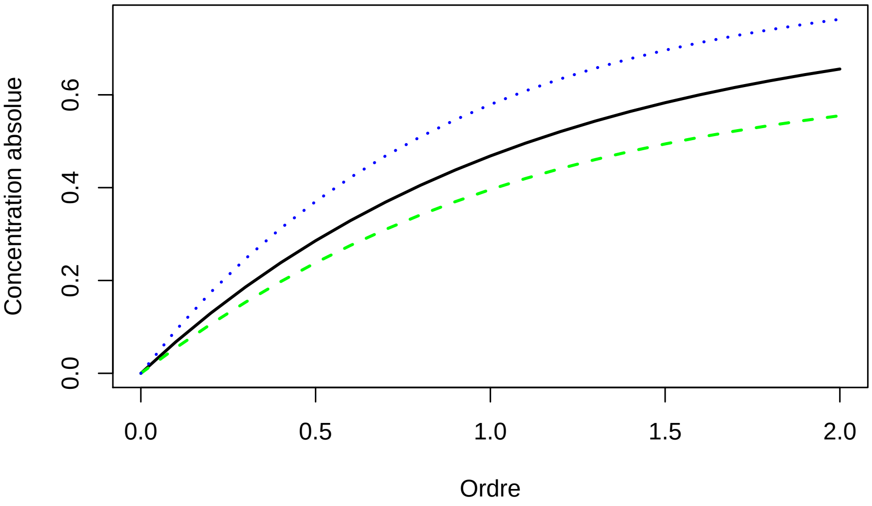


Figure 3

```
# Profils de diversité
dpIT <- CommunityProfile(Diversity, as.AbdVector(ES02Cx[, "IT"]), Correction = "None")
dpDE <- CommunityProfile(Diversity, as.AbdVector(ES02Cx[, "DE"]), Correction = "None")
dpFR <- CommunityProfile(Diversity, as.AbdVector(ES02Cx[, "FR"]), Correction = "None")
dpIS <- CommunityProfile(Diversity, as.AbdVector(ES02Cx[, "IS"]), Correction = "None")
dpEurope <- CommunityProfile(Diversity, rowSums(ES02Cx), Correction = "None")
# Figure
plot(dpEurope, ylim = c(min(dpIS$y), max(dpEurope$y)), xlab = "Ordre",
    ylab = "Diversité")
lines(dpIT, col = "green", lty = 2, lwd = 2)
lines(dpDE, col = "blue", lty = 3, lwd = 2)
lines(dpFR, col = "orange", lty = 4, lwd = 2)
lines(dpIS, col = "black", lty = 5, lwd = 2)
```

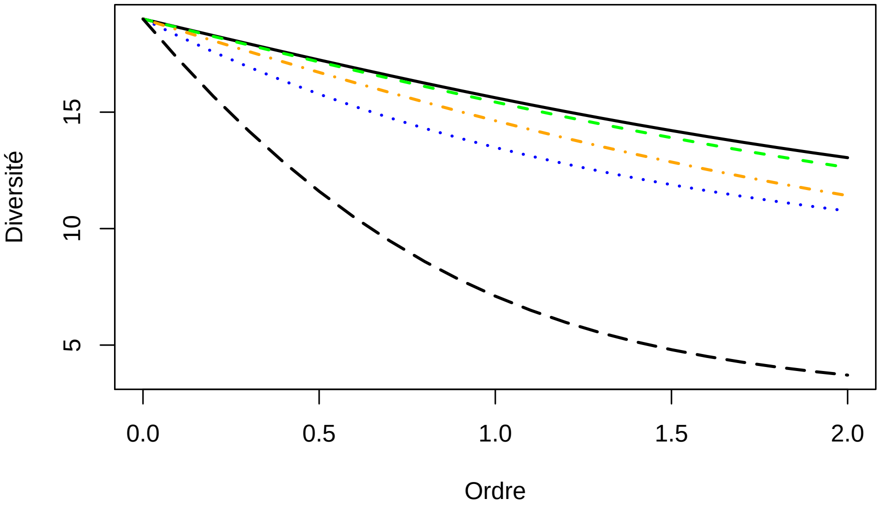


Figure 4:

```
# Valeur maximale possible
dMax <- nrow(ES02Cx)
# Profils de spécialisation : normalisation des profils de diversité
spIT <- CPnormalize(dpIT, dMax)
spDE <- CPnormalize(dpDE, dMax)
spFR <- CPnormalize(dpFR, dMax)
spIS <- CPnormalize(dpIS, dMax)
spEurope <- CPnormalize(dpEurope, dMax)
# Figure
plot(spEurope, ylim = c(0, 1), xlab = "Ordre", ylab = "Spécialisation absolue")
lines(spIT, col = "green", lty = 2, lwd = 2)
lines(spDE, col = "blue", lty = 3, lwd = 2)
lines(spFR, col = "orange", lty = 4, lwd = 2)
lines(spIS, col = "black", lty = 5, lwd = 2)
```

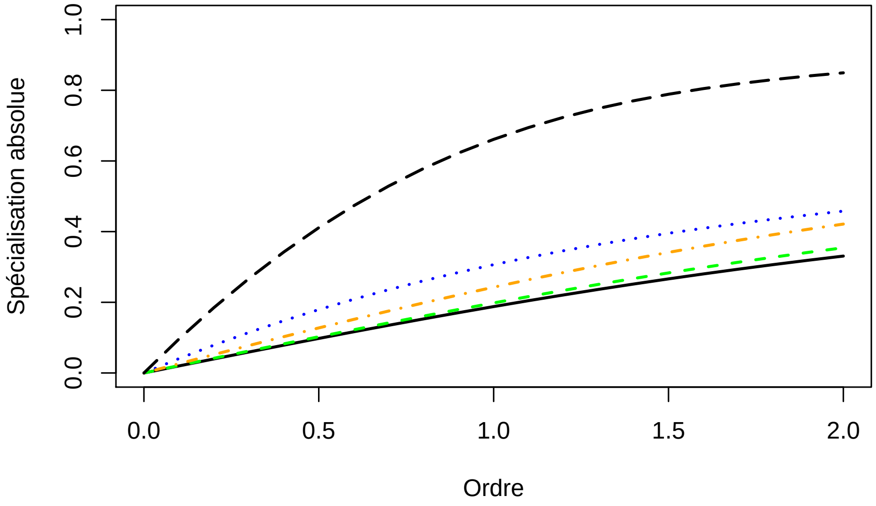


Figure 5

```
# Création d'une metacommunauté
ES02CMC <- MetaCommunity(ES02Cx, Weights = colSums(ES02Cx))
# Calcul des diversités alpha, beta, gamma
dpES02CMC <- DivProfile(, ES02CMC)
# Diversité jointe
Djointe <- CommunityProfile(Diversity, as.ProbaVector(ES02Cx))
# Redondance
RedondanceD <- Djointe$y/dpES02CMC$GammaDiversity
# Figure
plot(Djointe, log = "y", ylim = c(1, max(Djointe$y)), xlab = "Ordre", ylab = "Diversité")
lines(x = dpES02CMC$Order, y = dpES02CMC$TotalAlphaDiversity, col = "blue",
    lty = 2, lwd = 2)
lines(x = dpES02CMC$Order, y = dpES02CMC$TotalBetaDiversity, col = "red",
    lty = 3, lwd = 2)
lines(x = dpES02CMC$Order, y = dpES02CMC$GammaDiversity, col = "green",
    lty = 4, lwd = 2)
lines(x = dpES02CMC$Order, y = RedondanceD, col = "red", lty = 5, lwd = 2)
```

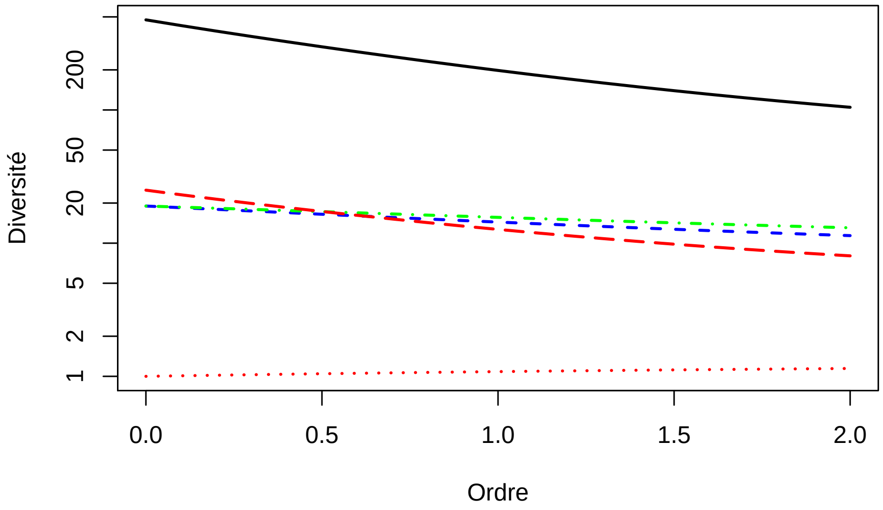
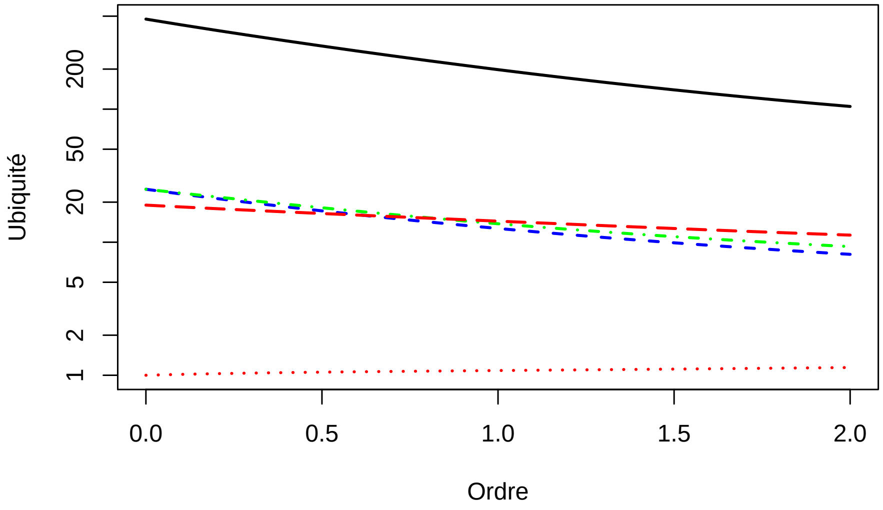


Figure 6

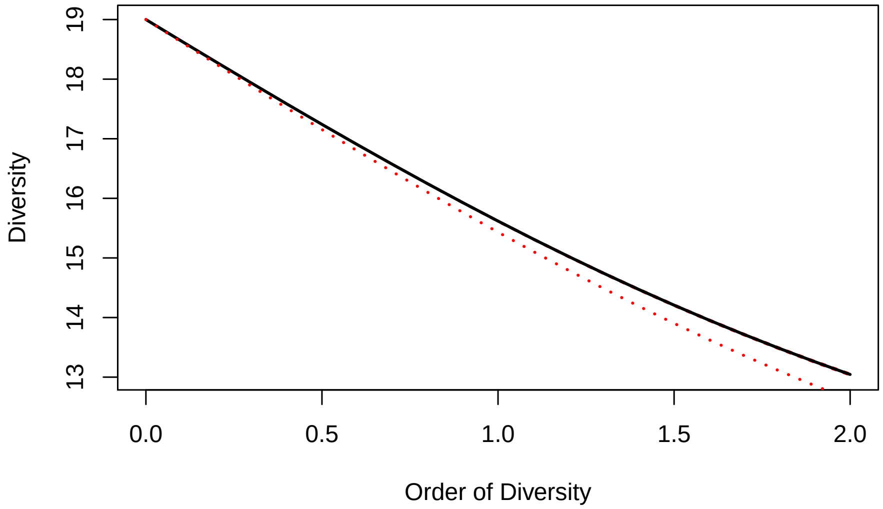
```
# Création d'une metacommunauté
ES02CtMC <- MetaCommunity(t(ES02Cx), Weights = rowSums(ES02Cx))
# Calcul des diversités alpha, beta, gamma
dpES02CtMC <- DivProfile(, ES02CtMC)
# Redondance
RedondanceU <- Djointe$y/dpES02CtMC$GammaDiversity
# Figure
plot(Djointe, log = "y", ylim = c(1, max(Djointe$y)), xlab = "Ordre", ylab = "Ubiquité")
lines(x = dpES02CtMC$Order, y = dpES02CtMC$TotalAlphaDiversity, col = "blue",
    lty = 2, lwd = 2)
lines(x = dpES02CtMC$Order, y = dpES02CtMC$TotalBetaDiversity, col = "red",
    lty = 3, lwd = 2)
lines(x = dpES02CtMC$Order, y = dpES02CtMC$GammaDiversity, col = "green",
    lty = 4, lwd = 2)
lines(x = dpES02CtMC$Order, y = RedondanceU, col = "red", lty = 5, lwd = 2)
```



Test de la spécialisation de l'Italie

Le test consiste à simuler 1000 distributions multinomiales respectant les probabilités des secteurs au niveau de l'Europe entière. La statistique de test est la diversité absolue. Sa valeur réelle, calculée pour l'Italie, est comparée aux quantiles de ses valeurs simulées.

```r
# Ordres à calculer
q.seq = seq(from = 0, to = 2, by = 0.1)
# Nombre de simulations
NbSimulations <- 1000
# Tirage
SimsIT <- rmultinom(NbSimulations, size = sum(ES02Cx[, "IT"]), prob = rowSums(ES02Cx))
# Profil de diversité de chaque simulation
Simulations <- apply(SimsIT, 2, function(Ns) sapply(q.seq, function(q) Diversity(Ns,
    q, Correction = "None", CheckArguments = FALSE)))
rownames(Simulations) <- seq(0, 2, 0.1)
# Seuil de risque
alpha <- 0.01
# Calcul des quantiles
Quantiles <- apply(Simulations, 1, quantile, probs = c(alpha/2, 1 - alpha/2))
Median <- apply(Simulations, 1, median)
# Création d'un profil
cpSimulations <- as.CommunityProfile(x = q.seq, y = Median, low = Quantiles[1,
    ], high = Quantiles[2, ])
# Figure
plot(cpSimulations)
CEnvelope(dpIT, col = "red", lty = 3)
```



La figure montre la distribution simulée de la diversité sur la courbe noire, qui en est la valeur médiane entourée de son intervalle de confiance à 99% (l'enveloppe au seuil de confiance de 95% est confondue avec l'épaisseur du trait de la valeur médiane). La courbe rouge pointillée correspond à la diversité observée de l'Italie, hors de l'enveloppe des simulations dès l'ordre $q = 0.1$.

Le test peut être appliqué à chaque valeur de q: l'hypothèse nulle est rejetée si la statistique observée est inférieure à la borne inférieure de l'enveloppe des simulations.

```r
# La diversité observée est-elle inférieure à la limite inférieure de
# l'envelope ?
dpIT$y < cpSimulations$low
```

```
##     0   0.1   0.2   0.3   0.4   0.5   0.6   0.7   0.8   0.9     1   1.1
## FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE
##   1.2   1.3   1.4   1.5   1.6   1.7   1.8   1.9     2
##  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE
```