

The Informational Content of Geographical Indications

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Abstract

This file contains the R codes associated with the paper "The informational content of geographical indications" AAWE Working Paper No XXX. The data used are under licence Creative Commons Attribution Share Alike 4.0 International, available on the INRA dataverse website: <https://data.inra.fr>. Some R functions are reported in the appendix to preserve the visibility of codes. Additional elements and last version of the document are available from <https://github.com/jsay/geoInd>.

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1 Descriptive Statistics

1.1 Data consistency

Data are available from the github repo, I put them in the folder /Inter

```
library(sp) ; load("Inter/PolyVine.Rda")
Reg.Rank <- subset(PolyVine, PolyVine$PAOC!= 0 &
  !is.na(PolyVine$DEM) & !is.na(PolyVine$LIBCOM))
Reg.Rank$AOCc <- ifelse(Reg.Rank$GCRU== 1, 5,
  ifelse(Reg.Rank$PCRU== 1, 4,
  ifelse(Reg.Rank$VILL== 1 | Reg.Rank$COMM== 1, 3,
  ifelse(Reg.Rank$BOUR== 1, 2, 1))))
tst <- Reg.Rank@data[, 12: 17]
tst$COMM <- ifelse(tst$VILL== 1 | tst$COMM== 1, 1, 0)
tst$VILL <- 0
table(rowSums(tst), Reg.Rank$AOCc)

tmp <- Reg.Rank$LIBCOM[order(Reg.Rank$YCHF, decreasing= TRUE)]
Reg.Rank$LIBCOM <- factor(Reg.Rank$LIBCOM, levels= unique(tmp))
Reg.Rank$RAYAT <- with(Reg.Rank@data, (SOLAR- mean(SOLAR))/ sd(SOLAR))
Reg.Rank$EXPO <- cut(Reg.Rank$ASPECT,
  breaks= c(-2, 45, 90, 135, 180, 225, 270, 315, 360))
sapply(Reg.Rank@data, function(x) sum(is.na(x)))
#table(Reg.Old$LIBCOM, Reg.Old$AOCc)
```

	1	2	3	4	5
0	657	0	0	0	0
1	9110	195	0	1	0
2	0	15300	0	1	0
3	0	0	24052	88	0
4	0	0	0	8499	0
5	0	0	0	0	1906

PAR2RAS	IDU	CODECOM	AREA	PERIM	MAXDIST
0	0	0	0	0	0
PAOC	ALIG	BPTG	CREM	MOUS	BGOR
0	0	0	0	0	0
BOUR	VILL	COMM	PCRU	GCRU	XL93
0	0	0	0	0	0
YL93	NOMOS	URBAN	FOREST	WATER	DEM
0	0	0	0	0	0
SLOPE	ASPECT	SOLAR	PERMEA	CODE	NOTATION
0	0	0	0	22	22
DESCR	TYPE_GEOL	AP_LOCALE	TYPE_AP	GEOL_NAT	ISOPIQUE
22	22	102	102	22	22
AGE_DEB	ERA_DEB	SYS_DEB	LITHOLOGIE	DURETE	ENVIRONMT
22	22	22	22	32	22

GEOCHIMIE	LITHO_COM	NOUC	NO_UC	NO_ETUDE	SURFUC
22	32	668	668	668	668
TARG	TSAB	TLIM	TEXTAG	EPAIS	TEG
668	668	668	668	668	668
TMO	RUE	RUD	NOUS	OCCUP	DESCRp
668	668	668	668	668	668
AOC36lab	AOC36lv1	LIEUDIT	CLDVIN	LIBCOM	XCHF
18	18	0	0	0	0
YCHF	ALTCOM	SUPCOM	POPCOM	CODECANT	REGION
0	0	0	0	0	0
X	Y	AOCc	RAYAT	EXPO	
0	0	0	0	0	

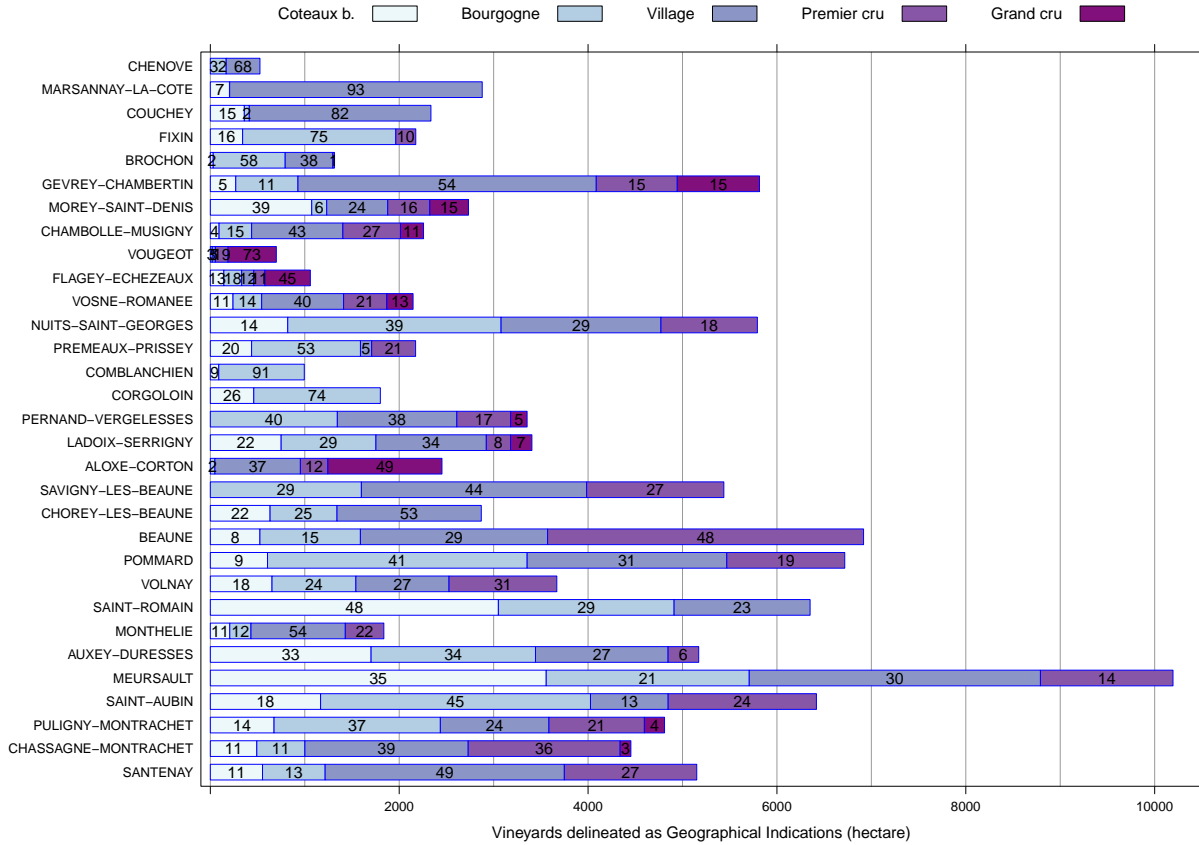
1.2 Crossing GIs dimensions

The interaction between the horizontal (*communes*) and the horizontal (*ranking*) dimension of GIs is assessed through the following Figure, which corresponds to Figure XX in the working paper.

```

library(lattice)
fig.dat <- aggregate(model.matrix(~0+ factor(Reg.Rank$AOCc))*
                     Reg.Rank$AREA/ 1000, by= list(Reg.Rank$LIBCOM), sum)
names(fig.dat) <- c("LIBCOM", "BGOR", "BOUR", "VILL", "PCRU", "GCRU")
fig.dat$LIBCOM <- factor(fig.dat$LIBCOM, levels= rev(levels(fig.dat$LIBCOM)))
fig.crd <- t(apply(fig.dat[, -1], 1, function(t) cumsum(t)- t/2))
fig.lab <- round(t(apply(fig.dat[, -1], 1, function(t) t/ sum(t)))* 100)
barchart(LIBCOM~ BGOR+ BOUR+ VILL+ PCRU+ GCRU, xlim= c(-100, 10500),
         xlab="Vineyards designated as Geographical Indications (hectare)",
         data= fig.dat, horiz= T, stack= T, col= my.pal, border= "blue",
         par.settings= list(superpose.polygon= list(col= my.pal)),
         auto.key= list(space= "top", points= F, rectangles= T, #corner= c(.85, 0.5)
                       columns= 5,
                       text=c("Coteaux b.", "Bourgogne",
                              "Village", "Premier cru", "Grand cru")),
         panel=function(x, y, ...) {
           panel.grid(h= 0, v = -11, col= "grey60")
           panel.barchart(x, y, ...)
           ltext(fig.crd, y,
                 lab= ifelse(fig.lab> 0, fig.lab, ""))} #paste0(fig.lab, "%")

```



2 Models of GI designation

2.1 Parametric ordered logit

Benchmark parametric ordered logistic model, `por1` corresponds to model (0) of Table XX in the working paper. Model `por1a` is the auxiliary regression used to test the presence of omitted *terroir* effect. Model `por1b` is also an auxiliary regression to compute the Fisher statistics associated to spatial smoothing terms in Table XX.

```
library(MASS)
por1 <- polr(factor(AOCc)~ 0+ LIBCOM+ EXPO
             + poly(DEM, 2)+ poly(SLOPE, 2)+ poly(RAYAT, 2)
             + poly(X, 3)* poly(Y, 3), data= Reg.Rank, Hess= TRUE)
por1a <- polr(factor(AOCc)~ 0 + EXPO
              + poly(DEM, 2)+ poly(SLOPE, 2)+ poly(RAYAT, 2)
              + poly(X, 3)* poly(Y, 3), data= Reg.Rank, Hess= TRUE)
por1b <- polr(factor(AOCc)~ 0+ LIBCOM+ EXPO
              + poly(DEM, 2)+ poly(SLOPE, 2)+ poly(RAYAT, 2)
              , data= Reg.Rank, Hess= TRUE)
```

Warning messages:

1: In `polr(factor(AOCc) ~ 0 + LIBCOM + EXPO + poly(DEM, 2) + poly(SLOPE, 2)` :

une coordonnée à l'origine est nécessaire et assumée
 2: In polr(factor(AOCc) ~ 0 + LIBCOM + EXPO + poly(DEM, 2) + poly(SLOPE, 2) :
 le plan ne semble pas de rang plein, des coefs seront ignorés

The warning messages are due to the lack of intercept that we force to compute the ordinal superiority measures for each *communes* below. This has no impact on the quality of the ML estimators.

2.2 Ordered generalized additive

The following code presents 2 loops that allow to estimate the OGAM models of GIs designations. Models (I) to (V) reported in Table XX are only a subset of all models estimated here. The `gamod` object contains the full models, the `gammod` object contains the auxiliary regression to test the omitted *terroir* effects. Because of the complexity of the models, each loop needs about 2 days to run (Dell Precision 7520, 64Go of RAM). I advice the reader to not run the loop entirely but pick some value of `listk` for the maximum degree of freedom and run the models individually. The objects `gamod.Rda` and `gammod.Rda` are available from the git repo mentioned in the first page.

```
library(mgcv)
listk <- c(50, 100, 200, 300, 400, 500, 600, 700, 800, 900)
gamod <- vector("list", length(listk))
system.time(
  for (i in 1: length(listk)){
    gamod[[ i]] <- gam(AOCc~ 0+ LIBCOM+ EXPO+ s(DEM)+ s(SLOPE)+ s(RAYAT)
                      + s(X, Y, k= listk[ i])
                      , data= Reg.Rank, family= ocat(R= 5))
  })
names(gamod) <- paste0("gam", listk)
save(gamod, file= "Inter/gamod.Rda")

gammod <- vector("list", length(listk))
system.time(
  for (i in 1: length(listk)){
    gammod[[ i]] <- gam(AOCc~ 0+ EXPO+ s(DEM)+ s(SLOPE)+ s(RAYAT)
                      + s(X, Y, k= listk[ i])
                      , data= Reg.Rank, family= ocat(R= 5))
  })
names(gammod) <- paste0("gam", listk)
save(gammod, file= "Inter/gammod.Rda")
```

utilisateur	système	écoulé
56177.4	384.9	56565
utilisateur	système	écoulé
42413.2	262.8	42679.6

3 Diagnostics

3.1 Significance

We first reports the Chi-square statistics for the joint significance of the model (0) of Table XX in the working paper.

```
library(car)
resla <- anova(por1, por1b)
(res1 <- Anova(por1))
```

Analysis of Deviance Table (Type II tests)

Response: factor(AOCc)

	LR	Chisq	Df	Pr(>Chisq)
LIBCOM	14609	31		<2e-16 ***
EXPO	1209	7		<2e-16 ***
poly(DEM, 2)	5308	2		<2e-16 ***
poly(SLOPE, 2)	400	2		<2e-16 ***
poly(RAYAT, 2)	1934	2		<2e-16 ***
poly(X, 3)	2484	3		<2e-16 ***
poly(Y, 3)	647	3		<2e-16 ***
poly(X, 3):poly(Y, 3)	9526	9		<2e-16 ***

codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Then, we compute the same statistics for the OGAMs, also reported in Table XX in the main paper.

```
load("Inter/gamod.Rda")
resume <- function(mod){
  tmp <- anova(mod)
  res <- c(as.vector(rbind(tmp$s.table[, 3], tmp$s.table[, 1])),
          as.vector(rbind(tmp$pTerms.tab[, 2], tmp$pTerms.tab[, 1])))
  names(res) <- c(as.vector(rbind(rownames(tmp$s.table), rep("", 4))),
                 as.vector(rbind(rownames(tmp$pTerms.tab), rep("", 2))))
  round(res, 1)
}
sapply(gamod[ 1: 5* 2], resume)
```

	gam100	gam300	gam500	gam700	gam900
s(DEM)	5020.2	2385.4	1677.7	1692.6	1766.8
	9.0	8.9	8.8	8.8	8.8
s(SLOPE)	1281.1	458.2	266.1	225.3	243.6
	8.5	8.5	8.5	8.4	8.4
s(RAYAT)	2491.6	1196.5	667.3	554.7	557.9
	8.3	8.2	7.7	7.6	7.5
s(X,Y)	41458.2	73705.5	94094.8	103941.0	107522.8

	98.7	295.2	483.1	666.7	844.7
LIBCOM	6793.2	6079.7	4594.7	3555.0	2894.5
	31.0	31.0	31.0	31.0	31.0
EXPO	110.3	123.2	222.3	153.5	160.8
	7.0	7.0	7.0	7.0	7.0

3.2 Goodness of fit

Here are the goodness-of-fit measures for model (0) also reported in Table XX: McFadden R^2 , Akaike information criteria, and percent of good predictions.

```
psR2 <- function(x) 1- (logLik(x)/ logLik(update(x, . ~ + 1)))
round(c(McFaddenR2= psR2(por1), AIC= AIC(por1)/ 1000,
        Pcgp= sum(diag(table(predict(por1), Reg.Rank$AOCc)))/nrow(Reg.Rank)), 2)
```

McFaddenR2	AIC	Pcgp
0.29	119.40	0.59

The same goodness of fit measures for OGAMs.

```
pcgp <- function(x){
  sum(diag(table(cut(x$line, c(-Inf, x$family$getTheta(TRUE), Inf)),
                    x$model[, 1])))/ nrow(x$model)* 100
}
rbind(Pcgp= sapply(gamod[ 1: 5* 2], pcgp), AIC= sapply(gamod[ 1: 5* 2], AIC))
#sapply(gamod, psR2)
```

	gam100	gam300	gam500	gam700	gam900
Pcgp	73.89	79.94	84.23	86.94	89.15
AIC	82412.10	64710.89	54941.54	48291.33	43535.14

3.3 Omitted variable

Bootstrapped statistics for the Fisher about omitted *terroir* variables, with 100 replications for parametric ordered logistic. The absence of correlated effects is strongly rejected. We use the *sure* package for surrogate residual.

```
library(lmtest) ; library(sandwich) ; library(sure)
wall <- 0 ; nsim= 100
for (i in 1: nsim){
  tmp <- surrogate(por1a)- por1a$lp
  wall[ i] <- waldtest(lm(tmp~ Reg.Rank$LIBCOM), . ~ 1, vcov= vcovHC)$F[ 2]
}
quantile(wall, c(.05, .5, .95))
```

5%	50%	95%
268.0	274.2	279.6

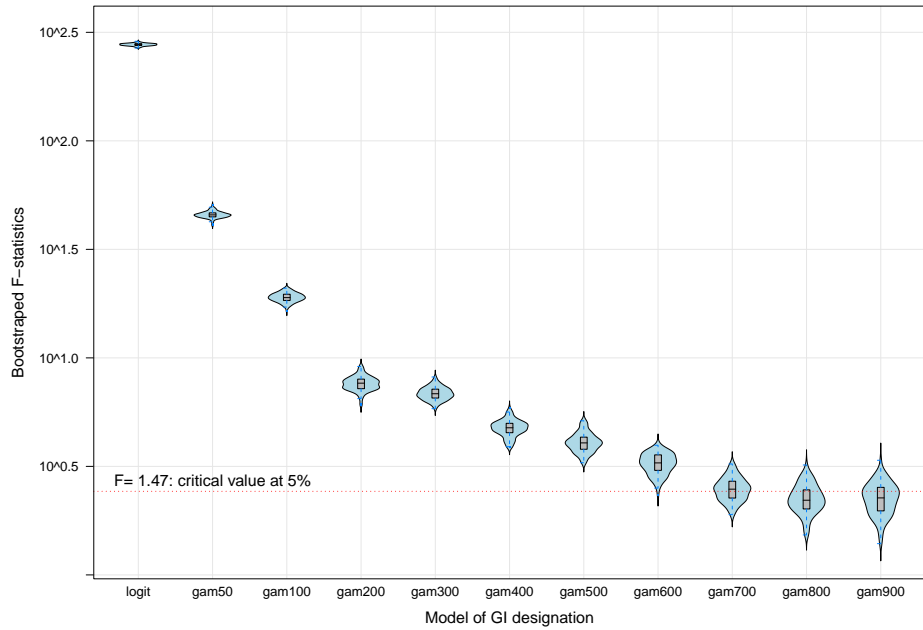
A passer en Reg.Rank, introduire la fonction sur les surrogate residuals des modèles gam en in the Appendix. Not exactly the same because of bootstrap.

```
load("Inter/gammod.Rda") ; source("myFcts.R")
omitVar <- function(mod, var, nsim= 100){
  usq <- 0
  for(i in 1: nsim) {
    RES <- sureOGAM(mod)
    tmp <- lm(I(RES- mod$linear.pred)~ factor(var))
    usq[ i] <- waldtest(tmp, . ~ 1, vcov= vcovHC)$F[ 2]
  }
  usq
}
wal2 <- sapply(gammod, function(x) omitVar(x, RRank$LIBCOM, nsim= 100))
apply(wal2[, 1: 5* 2], 2, function(x) quantile(x, c(.05, .5, .95)))
```

	gam100	gam300	gam500	gam700	gam900
5%	17.38	6.060	3.377	2.004	1.704
50%	18.94	6.806	4.130	2.525	2.181
95%	20.15	7.746	4.864	3.060	2.760

The following plot resumes the specification diagnostics and shows the relevance of OGAMs to control for omitted spatial effects. It corresponds to Figure XX in the working paper, the bootstrapped nature of the statistics individual values change.

```
library(lattice)
pltdat <- stack(data.frame(logit= wal1, wal2))
bwplot(values~ ind, data= pltdat, type=c("l","g"), horizontal= FALSE,
  xlab='Model of GI designation', ylab='Bootstraped F-statistics',
  par.settings = list(box.rectangle=list(col='black'),
    plot.symbol = list(pch='.', cex = 0.1)),
  scales=list(y= list(log= TRUE)),
  panel = function(..., box.ratio) {
    panel.grid(h= -1, v = -11)
    panel.violin(..., col = "lightblue",
      varwidth = FALSE, box.ratio = box.ratio)
    panel.bwplot(..., col='black',
      cex=0.8, pch='|', fill='gray', box.ratio = .1)
    panel.abline(h= log(1.47), col= "red", lty= 3)
    panel.text(2, log(1.55), "F= 1.47: critical value at 5%")})
```



3.4 Specification

Surrogate residuals can also be used to test specification, results not reported.

```
library(sure) ; library(ggplot2) ; library(gridExtra)
var <- c("DEM", "SLOPE", "RAYAT", "EXPO", "LIBCOM", "X", "Y")
plots <- lapply(var, function(.x)
  autoplot(por1, what= "covariate", x= Reg.Rank@data[, .x], xlab= .x))
do.call(grid.arrange, c(list(autoplot(por1, what= "qq")), plots))
restmp <- sureOGAM(gamod$gam900) - gamod$gam900$line
plot(qlogis(1: nrow(RRank)/ nrow(RRank), scale= 1), sort(restmp))
abline(0, 1)
pltSURE <- function(resid, xvar, lab){
  plot(xvar, resid, xlab= lab, main= paste("Surrogate Analysis", lab))
  abline(h= 0, col= "red", lty= 3, lwd= 2)
  lines(smooth.spline(resid ~ xvar), lwd= 3, col= "blue")
}
par(mfrow= c(3, 3)) ; for (i in var) pltSURE(restmp, RRank@data[, i], i)
```

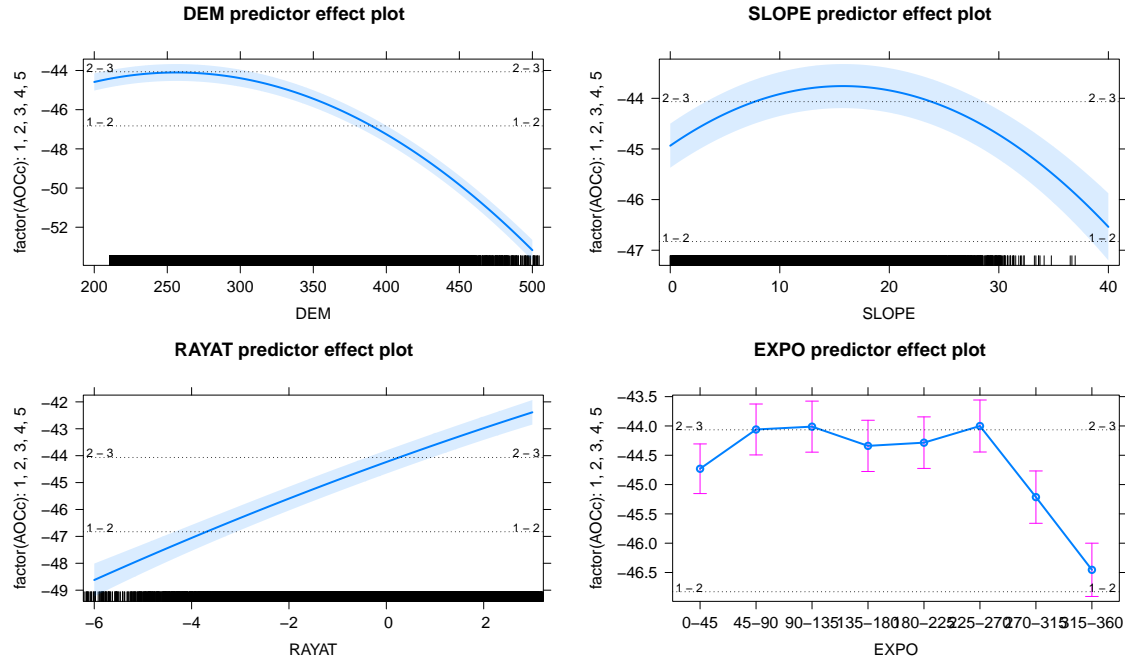
4 Marginal effects

4.1 Parametric ordered logit

Marginal effects from parametric models, corresponds to the dotted lines in Figure XX of the working paper.

```
library(effects)
plot(predictorEffects(por1, ~ DEM+ SLOPE+ RAYAT+ EXPO, latent= TRUE,
  xlevels=list(DEM= 200: 500,
```

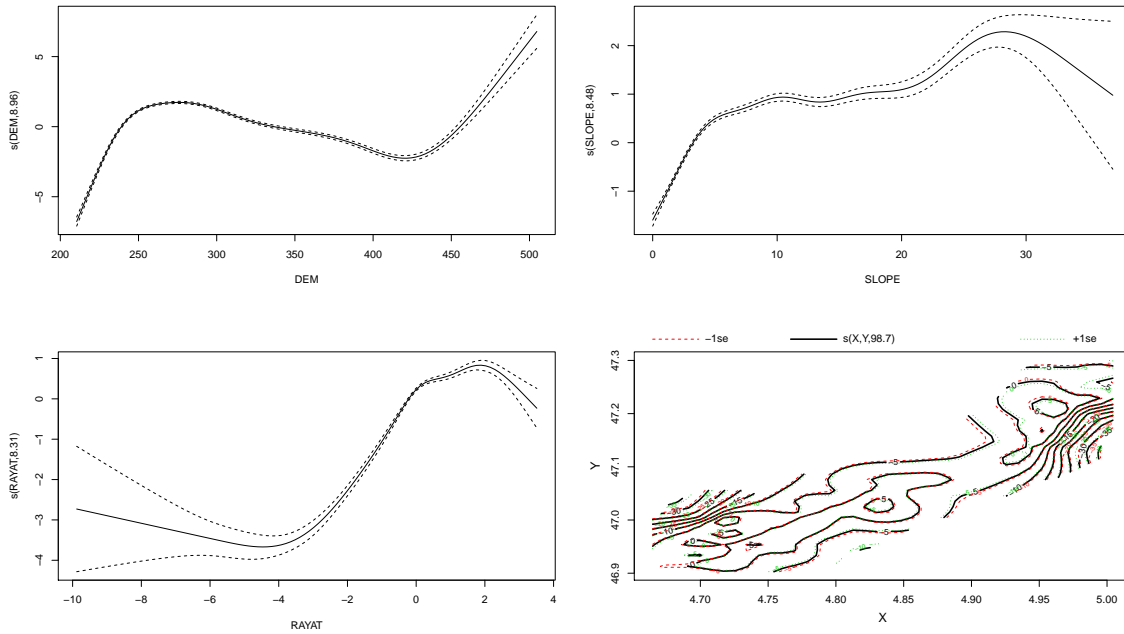
SLOPE= 0: 400 / 10, RAYAT= -60: 30 / 10)))



4.2 Ordered generalized additive

On voit bien que le lissage est le même que le papier. Can be changed by indexing the list gamod, below is the reported effect for a maximum effective degrees of freedom of 100. For all models of gamod, we obtain the grey curves of Figure XX of the working paper.

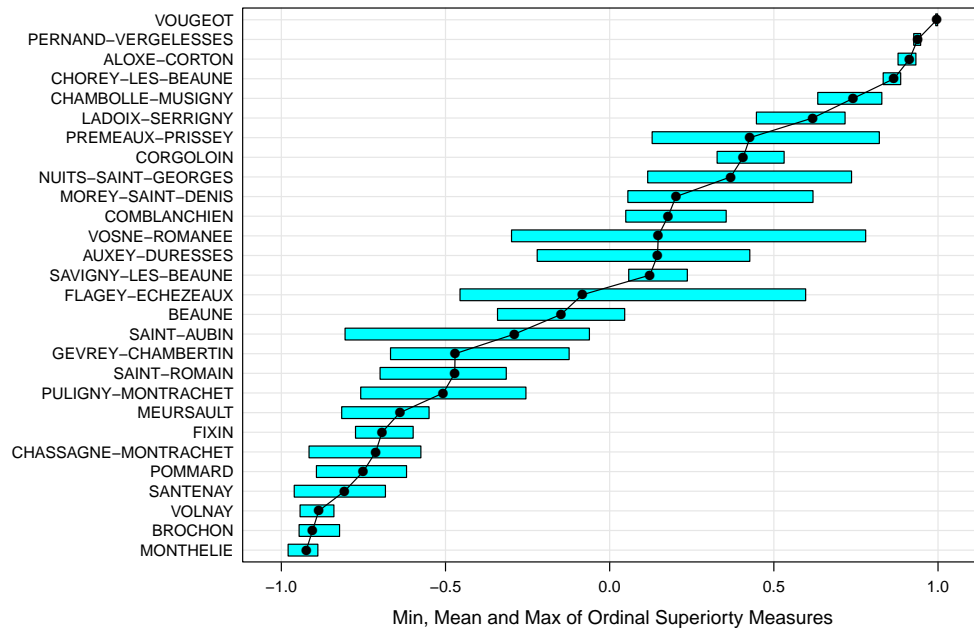
```
plot(gamod[[ 1]], pages= 1, scale= 0)
```



4.3 Ordinal superiority figure

From the equation XX of the working paper, we compute ordinal superiority measures for each OGAMs relatively to the average. It produces the Figure XX of the main text.

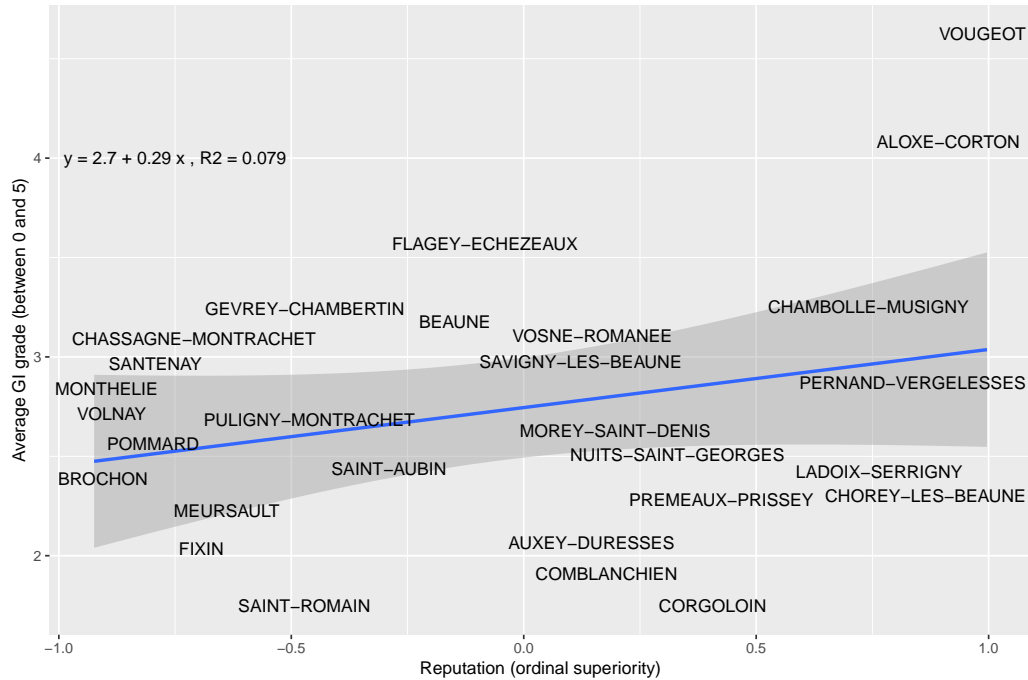
```
library(latticeExtra)
plogi <- function(x) exp(x/ sqrt(2))/ (1+ exp(x/ sqrt(2)))
xx <- data.frame(sapply(gamod, function(x)
  2* plogi(I(x$coeff[ 4: 31]- mean(x$coeff[ 4: 31]))- 1))
ww <- data.frame(xx,
  LIBCOM= substr(names(gamod[[1]]$coef[ 4: 31]), 7, 30),
  MIN= apply(xx[ 7: 10], 1, min),
  MAX= apply(xx[ 7: 10], 1, max),
  MEAN= apply(xx[ 7: 10], 1, mean))
segplot(reorder(factor(LIBCOM), MEAN)~ MIN+ MAX, length= 5, draw.bands= T,
  data= ww[order(ww$MEAN), ], center= MEAN, type= "o",
  unit = "mm", axis = axis.grid, col.symbol= "black", cex= 1,
  xlab= "Min, Mean and Max of Ordinal Superiority Measures")
```



4.4 Correlation between *Communes*

Below an unreported Figure to illustrate the claim that "*commune* with higher GIs do not have a preferential treatment" (p.XX) of the working paper. It correlates the average vertical GI score with the ordinal superiority measures from OGAM with XX maximum effective degrees of freedom.

```
library(plyr) ; library(ggrepel)
yy <- ddply(RRank@data, .(LIBCOM),
            function(x) weighted.mean(x$AOcc, x$Area))
zz <- merge(ww, yy, by= "LIBCOM")
m <- lm(V1~ MEAN, data= zz)
a <- signif(coef(m)[1], digits = 2)
b <- signif(coef(m)[2], digits = 2)
c <- signif(summary(m)$r.sq, digits = 2)
textlab <- paste("y = ", a, " + ", b, " x ", " ", R2 = " ", c, sep= "")
ggplot(zz, aes(MEAN, V1, label= LIBCOM)) +
  geom_smooth(method= lm, aes(MEAN, V1))+
  geom_text_repel(point.padding = NA) +
  annotate("text", x= -.75, y= 4, label= textlab, size= 4, parse= F)+
  xlab("Reputation (ordinal superiority)") +
  ylab("Average GI grade (between 0 and 5)")
```



5 Informational content

5.1 Decomposition table

see appendix for the detailed presentation of the R code to implement the decomposition decompositions. The following code for all OGAMs some computation times, allow the reader to compute the models individually.

```
load("Inter/gamod.Rda") ; source("myFcts.R")
ddtt <- data.frame(AOCc= RRank$AOCc, LIBCOM= RRank$LIBCOM,
  sapply(gamod[ 1: 5* 2], function(x)
    rowSums(predict(x, type= 'terms')[, -1])))
dcmp <- sapply(names(ddtt[, 3: 7]), function(x)
  c("Total Signal"= var(ddtt[, x]), "Total Noise"= pi^2/ 3,
    jointSignal(ddtt, x), jointNoise(ddtt, x),
    vertiSignal(ddtt, x), vertiResid(ddtt, x), vertiNoise(ddtt, x),
    horizSignal(ddtt, x), horizResid(ddtt, x), horizNoise(ddtt, x)))
round(t(apply(dcmp, 1, function(x) x/ (pi^2/ 3+ dcmp[1, ])* 100)), 1)
```

	gam100	gam300	gam500	gam700	gam900
Signal	84.8	94.7	95.9	96.8	97.6
Noise	15.2	5.3	4.1	3.2	2.4
Joint Signal	68.9	78.5	76.0	77.9	78.7
Joint Noise	16.0	16.2	20.0	18.9	18.9
Rank Signal	55.1	40.3	56.8	61.3	57.6
Rank Residual	13.8	38.2	19.2	16.5	21.2
Rank Noise	29.7	54.4	39.1	35.4	40.0
Com Signal	21.3	37.2	24.6	27.5	29.1

Com Residual	47.6	41.3	51.4	50.4	49.7
Com Noise	63.5	57.5	71.3	69.3	68.5

6 Models for GIs of 1936

6.1 Descriptive statistics

I present here the detail of the analysis with past GIs, to show that *communes* influences have decreased and informational content has increased since then. It typically makes the same analysis than for actual GIs, first some descriptive statistics.

```
Reg.Old <- subset(Reg.Rank, !is.na(Reg.Rank$AOC36lv1) &
                  !Reg.Rank$LIBCOM %in%
                  c("CHENOVE", "MARSANNAY-LA-COTE", "COUCHEY",
                    "COMBLANCHIEN", "CORGOLOIN", "SAINT-ROMAIN"))
Reg.Old$LIBCOM <- factor(Reg.Old$LIBCOM)
Reg.Old$AOC <- as.numeric(ifelse(Reg.Old$AOC36lv1== "0", 1,
                                ifelse(Reg.Old$AOC36lv1== "3", 2, 3)))
table(Reg.Old$AOC36lv1, Reg.Old$AOCc)
#table(Reg.Old$LIBCOM, Reg.Old$AOCc)
```

	1	2	3	4	5
0	7204	12605	4120	567	39
3	15	662	15378	8017	261
5	0	1	13	3	1604

6.2 Estimation

The estimation of both the parametric and OGAMs, long computation times for the latter, prefer to fit models individually.

```
library(MASS)
por2 <- polr(factor(AOCc)~ 0+ LIBCOM+ EXPO
             + poly(DEM, 2)+ poly(SLOPE, 2)+ poly(RAYAT, 2)
             + poly(X, 3)* poly(Y, 3), data= Reg.Old, Hess= T)
por2a <- polr(factor(AOCc)~ 0+ EXPO
             + poly(DEM, 2)+ poly(SLOPE, 2)+ poly(RAYAT, 2)
             + poly(X, 3)* poly(Y, 3), data= Reg.Old, Hess= T)
por2b <- polr(factor(AOCc)~ 0+ LIBCOM+ EXPO
             + poly(DEM, 2)+ poly(SLOPE, 2)+ poly(RAYAT, 2)
             , data= Reg.Old, Hess= T)

## A CHANGER WITH NEW DATA
library(mgcv)
listk <- c(50, 75, 100, 150, 200, 250, 300)
gamold <- vector("list", length(listk))
system.time(
  for (i in 1: length(listk)){
    gamold[[ i]] <- gam(AOCc~ 0+ LIBCOM+ EXPO+ s(DEM)+ s(SLOPE)+ s(RAYAT)
                      + s(X, Y, k= listk[ i])
```

```

, data= Reg.Old, family= ocat(R= 3))
})
names(gamold) <- paste0("gam", listk)
save(gamold, file= "Inter/gamold.Rda")

gamold <- vector("list", length(listk))
system.time(
for (i in 1: length(listk)){
  gamold[[ i]] <- gam(AOCo~ 0+ EXPO+ s(DEM)+ s(SLOPE)+ s(RAYAT)
    + s(X, Y, k= listk[ i])
    , data= Reg.Old, family= ocat(R= 3))
})
names(gamold) <- paste0("gam", listk)
save(gamold, file= "Inter/gamold.Rda")

```

utilisateur	système	écoulé
12259.5	144.1	12405.5
utilisateur	système	écoulé
9582.37	78.69	9661.62

6.3 Significance

Significance of all models of GIs designation, corresponds to Table XX in Appendix of the working paper.

```

load("Inter/gamold.Rda")
res2a <- anova(por2, por2b)
res2 <- Anova(por2)
sapply(gamold[ 3: 7], resume)

```

	gam100	gam150	gam200	gam250	gam300
s(DEM)	499.8	647.4	702.3	541.9	344.5
	8.5	8.2	8.8	8.4	7.7
s(SLOPE)	387.3	314.0	254.4	244.3	153.0
	8.7	8.7	8.6	8.6	8.3
s(RAYAT)	242.0	160.1	127.1	122.9	105.2
	8.5	8.3	8.1	5.0	5.9
s(X,Y)	17520.5	20194.2	22301.7	23507.2	23801.4
	98.3	146.3	194.4	239.8	286.6
LIBCOM	2782.5	1843.0	1642.4	1283.0	1049.4
	25.0	25.0	25.0	25.0	25.0
EXPO	119.8	91.8	91.9	96.1	90.2
	7.0	7.0	7.0	7.0	7.0

6.4 Goodness of fit

Goodness of fit measures from the same Table XX in Appendix.

```

round(c(McFaddenR2= psR2(por2), AIC= AIC(por2)/ 1000,
      Pcgp= sum(diag(table(predict(por2), Reg.Old$A0Co)))/ nrow(Reg.Old)), 2)
rbind(Pcgp= sapply(gamold, pcgp), AIC= sapply(gamold, AIC))
#sapply(gamold, psR2)

```

McFaddenR2	AIC	Pcgp					
0.38	51.29	0.79					
	gam50	gam75	gam100	gam150	gam200	gam250	gam300
Pcgp	84.34	85.9	87.08	89.26	90.28	91.4	92.54
AIC	40789.58	36833.3	33810.36	30271.01	27574.12	24526.6	22482.20

6.5 Omitted variable

Bootstrapped statistics for omitted variables, not reported in the working paper, mentioned at p.XX, .

```

library(lmtest) ; library(sandwich) ; library(sure)
wal3 <- 0 ; nsim= 100
for (i in 1: nsim){
  tmp <- surrogate(por2a)- por2a$lp
  wal3[ i] <- waldtest(lm(tmp~ Reg.Old$LIBCOM), . ~ 1, vcov= vcovHC)$F[ 2]
}
load("Inter/gammold.Rda") ; source("myFcts.R")
wal4 <- sapply(gammold, function(x) omitVar(x, SRank$LIBCOM, nsim= 100))
wold <- data.frame(logit= wal3, wal4)
apply(wold, 2, function(x) quantile(x, c(.05, .5, .95)))

```

	logit	gam50	gam75	gam100	gam150	gam200	gam250	gam300
5%	168.1	7.408	7.340	4.714	3.498	2.057	1.178	1.091
50%	173.6	8.553	8.843	5.894	4.310	2.709	1.832	1.488
95%	179.8	9.958	10.501	6.858	5.396	3.851	2.495	2.057

The same plot as for current GIs, same evidences about the relevance of spatial smoothing terms, the non significance is reach for smaller degrees of freedom (p.XX)

```

library(lattice)
poldat <- stack(wold)
bwplot(values~ ind, data= poldat, type=c("l","g"), horizontal= FALSE,
      xlab='Model of GI designation', ylab='Bootstraped F-statistics',
      par.settings = list(box.rectangle=list(col='black'),
        plot.symbol = list(pch='.', cex = 0.1)),
      scales=list(y= list(log= TRUE)),
      panel = function(..., box.ratio) {
        panel.grid(h= -1, v = -11)
        panel.violin(..., col = "lightblue",
          varwidth = FALSE, box.ratio = box.ratio)
        panel.bwplot(..., col='black',
          cex=0.8, pch='|', fill='gray', box.ratio = .1)
        panel.abline(h= log(1.47), col= "red", lty= 3)
        panel.text(2, log(1.55), "F= 1.47: critical value at 5%")})

```

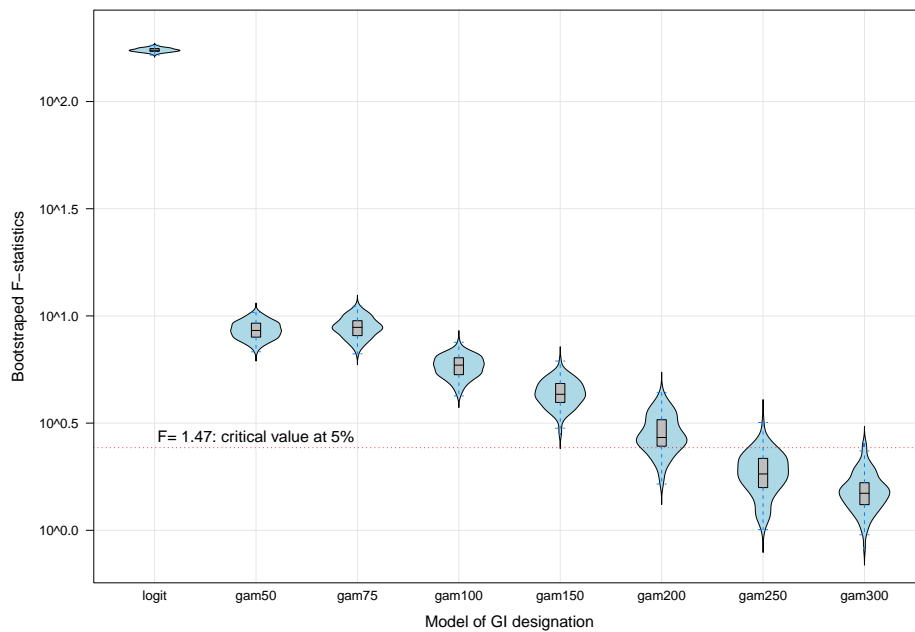


Figure 1: Effects of model XX

6.6 Specification

results not reported, parler de ce qu'il se passe moins bien mais qui n'est pas grave. Dans le gam 300 il y a un point qui fait n'imp, probablement un trou dans la carte de Florian.

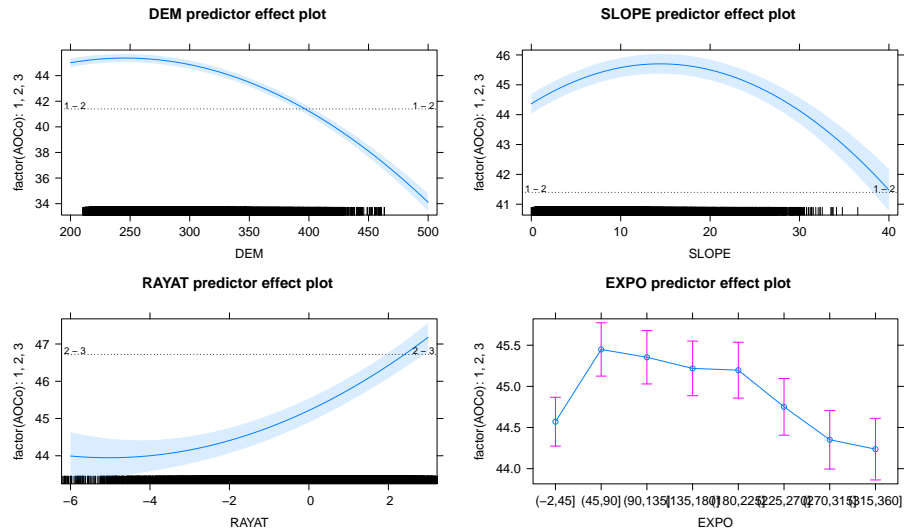
```
library(sure) ; library(ggplot2) ; library(gridExtra)
var <- c("DEM", "SLOPE", "RAYAT", "EXPO", "LIBCOM", "X", "Y")
plots <- lapply(var, function(.x)
  autoplot(por2, what= "covariate", x= Reg.Old@data[, .x], xlab= .x))
do.call(grid.arrange, c(list(autoplot(por2, what= "qq")), plots))

restmp <- sureOGAM(gamold$gam300)- gamold$gam300$line
plot(qlogis(1: nrow(SRank)/ nrow(SRank), scale= 1), sort(restmp))
abline(0, 1)
var <- c("DEM", "SLOPE", "RAYAT", "EXPO", "LIBCOM", "X", "Y")
par(mfrow= c(3, 3)) ; for (i in var) pltSURE(restmp, SRank@data[, i], i)
```

6.7 Marginal effects

Marginal effect ca be assessed, corresponds to Figure XX in the appendix in the working paper.

```
library(effects)
plot(predictorEffects(por2, ~ DEM+ SLOPE+ RAYAT+ EXPO, latent= TRUE,
  xlevels=list(DEM= 200: 500,
    SLOPE= 0: 400/ 10, RAYAT= -60: 30/ 10)))
plot(gamold$gam300, pages= 1, scale= 0)
```



6.8 Ordinal superiority

Ordinal superiority of *commune* from the GIs of 1936, same equation XX of the working paper and Figure XX in the appendix.

```
xxx <- data.frame(sapply(gamold, function(x)
  2* plogi(I(x$coeff[ 1: 25]- mean(x$coeff[ 1: 25]))- 1))
www <- data.frame(xxx,
  LIBCOM= substr(names(gamold[[ 1]]$coef[ 1: 25]), 7, 30),
  MIN= apply(xxx[ 6: 7], 1, min),
  MAX= apply(xxx[ 6: 7], 1, max),
  MEAN= apply(xxx[ 6: 7], 1, mean))
segplot(reorder(factor(LIBCOM), MEAN)~ MIN+ MAX, length= 5, draw.bands= T,
  data= www[order(www$MEAN), ], center= MEAN, type= "o",
  unit = "mm", axis = axis.grid, col.symbol= "black", cex= 1,
  xlab= "Min, Mean and Max of Ordinal Superiority Measures")
```

6.9 Correlation between models

An additional unreported Figure to show the claim that "the importance of *communes* has decreased since the 1936 scheme" (p.XX)

```
zzz <- merge(ww, www, by= "LIBCOM")
segplot(reorder(factor(LIBCOM), MEAN.x)~ MEAN.y+ MEAN.x, data= zzz,
  segments.fun = panel.arrows, length = 2, unit = "mm",
  draw.bands= F, axis = axis.grid,
  xlab= "Rate of variation for ordinal superiority")
```

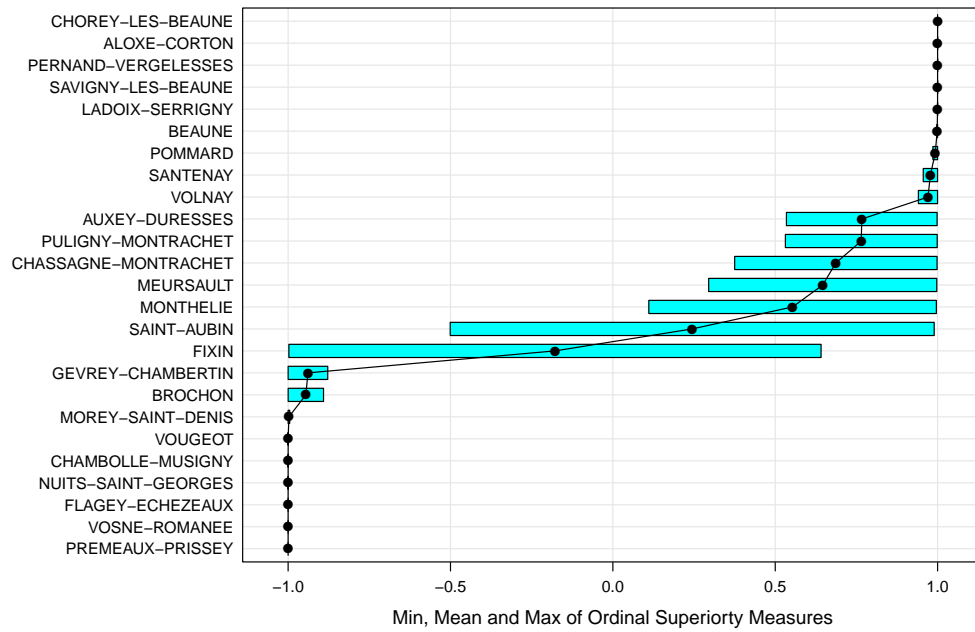
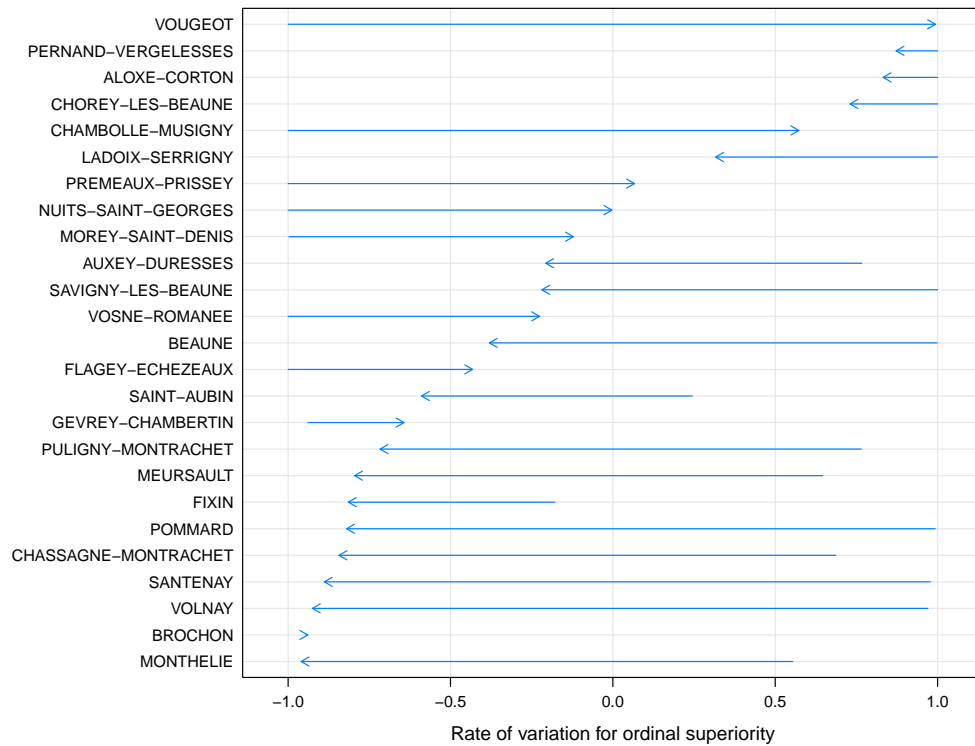


Figure 2: Effects of model XX



6.10 Decomposition table

And then the decomposition table unreported in the main text that show the "smaller joint informational content of GIs in 1936" (p.XX).

```
load("Inter/gamold.Rda") ; source("myFcts.R")
ddoo <- data.frame(AOCavt= SRank$AOCavt, LIBCOM= SRank$LIBCOM,
                  sapply(gamold, function(x)
                        rowSums(predict(x, type= 'terms')[, -1])))
dcop <- sapply(names(ddoo[, 3: 9]), function(x)
  c("Total Signal"= var(ddoo[, x]), "Total Noise"= pi^2/ 3,
    jointSignal(ddoo, x, "AOCavt"), jointNoise(ddoo, x, "AOCavt"),
    vertiSignal(ddoo, x, "AOCavt"), vertiResid(ddoo, x, "AOCavt"), vertiNoise(ddoo, x, "AOCavt"),
    horizSignal(ddoo, x, "AOCavt"), horizResid(ddoo, x, "AOCavt"), horizNoise(ddoo, x, "AOCavt")))
round(t(apply(dcop, 1, function(x) x/ (pi^2/ 3+ dcop[1, ]* 100)), 1)
```

	gam50	gam75	gam100	gam150	gam200	gam250	gam300
Signal	95.6	93.1	95.4	98.7	98.1	99.5	99.5
Noise	4.4	6.9	4.6	1.3	1.9	0.5	0.5
Joint Signal	78.7	63.2	55.3	75.2	47.9	75.0	45.1
Joint Noise	16.9	29.9	40.2	23.5	50.3	24.5	54.5
Rank Signal	5.8	18.1	24.1	16.4	20.6	14.9	22.7
Rank Noise	89.8	75.0	71.3	82.4	77.5	84.6	76.8
Rank Residual	72.9	45.1	31.2	58.8	27.3	60.1	22.4
Com Signal	67.5	39.6	29.4	62.3	24.0	62.7	22.6
Com Noise	28.1	53.5	66.0	36.4	74.1	36.8	77.0
Com Residual	16.0	33.3	43.7	20.9	35.3	20.6	43.7

7 Alternative GI designations

7.1 Change latent vineyard quality

We conclude this work with the simulations of alternative GIs designations schemes. Below are scenarios XX from XX, need to run the code. Put the equations here.

```
load("Inter/gamod.Rda")
prdd <- predict(gamod$gam900, type= 'terms')
thsld <- c(-Inf, gamod$gam900$family$getTheta(TRUE), Inf)
l1t0 <- rowSums(prdd)- (sureOGAM(gamod$gam900)- gamod$gam900$line)
l1t1 <- rowSums(prdd)
l1t2 <- mean(prdd[, 1])+ rowSums(prdd[, -1])-
  (sureOGAM(gamod$gam900)- gamod$gam900$line)
l1t3 <- mean(prdd[, 1])+ rowSums(prdd[, -1])
## CHANGER RRank$AOCavt
Simu <- data.frame(RRank, l1t= rowSums(prdd[, -1]),
                  OLD= RRank$AOCavt, S0= cut(l1t0, thsld),
                  SI= cut(l1t1, thsld), SII= cut(l1t2, thsld),
                  SIII= cut(l1t3, thsld))
table(Simu$AOCc, Simu$S0) ; table(Simu$AOCc, Simu$SI)
table(Simu$AOCc, Simu$SII) ; table(Simu$AOCc, Simu$SIII)
```

	OLD	CF1	CF2	CF3	CF4	CF5	CF6
Signal	97.1	97.1	97.1	97.1	97.1	97.1	97.1
Noise	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Joint Signal	51.4	80.1	81.2	82.2	79.4	80.0	79.2
Joint Noise	45.8	17.1	15.9	15.0	17.7	17.1	18.0
Rank Signal	38.9	70.7	64.5	73.5	62.2	62.8	62.0
Rank Noise	58.2	26.4	32.6	23.6	34.9	34.3	35.1
Rank Residual	12.5	9.4	16.7	8.7	17.2	17.2	17.2
Com Signal	28.5	28.5	28.5	28.5	28.5	28.5	28.5
Com Noise	68.6	68.6	68.6	68.6	68.6	68.6	68.6
Com Residual	22.9	51.6	52.7	53.7	50.9	51.5	50.7

7.2 Add a vertical level in GIs

Below are the simulations from scenarios XX, XX, and XX, according to changing XX. Put the equations here.

```

thrldBOUR <- mean(ltt1[RRank$AOCc== 2])
thrldVILL <- mean(ltt1[RRank$AOCc== 3])
thrldPCRU <- mean(ltt1[RRank$AOCc== 4])
Simv <- data.frame(Simu,
  SIV= ifelse(RRank$AOCc< 2, RRank$AOCc,
    ifelse(RRank$AOCc== 2 & ltt1< thrldBOUR, 2,
      ifelse(RRank$AOCc== 2 & ltt1>= thrldBOUR, 3,
        RRank$AOCc+ 1))),
  SV = ifelse(RRank$AOCc< 3, RRank$AOCc,
    ifelse(RRank$AOCc== 3 & ltt1< thrldVILL, 3,
      ifelse(RRank$AOCc== 3 & ltt1>= thrldVILL, 4,
        RRank$AOCc+ 1))),
  SVI= ifelse(RRank$AOCc< 4, RRank$AOCc,
    ifelse(RRank$AOCc== 4 & ltt1< thrldPCRU, 4,
      ifelse(RRank$AOCc== 4 & ltt1>= thrldPCRU, 5,
        RRank$AOCc+ 1))))
table(Simv$AOCc, Simv$SIV)
table(Simv$AOCc, Simv$SV) ; table(Simv$AOCc, Simv$SVI)

```

	1	2	3	4	5	6
1	9759	0	0	0	0	0
2	0	8931	6577	0	0	0
3	0	0	0	24151	0	0
4	0	0	0	0	8577	0
5	0	0	0	0	0	1906

	1	2	3	4	5	6
1	9759	0	0	0	0	0
2	0	15508	0	0	0	0

3	0	0	13275	10876	0	0
4	0	0	0	0	8577	0
5	0	0	0	0	0	1906

	1	2	3	4	5	6
1	9759	0	0	0	0	0
2	0	15508	0	0	0	0
3	0	0	24151	0	0	0
4	0	0	0	4970	3607	0
5	0	0	0	0	0	1906

7.3 Decomposition table

And the decomposition Table which corresponds to Table XX in the working paper.

```

decf <- sapply(names(Simv[, 100: 107]), function(x)
  c("Total Signal"= var(Simv[, "ltt"]), "Total Noise"= pi^2/ 3,
    jointSignal(Simv, "ltt", vt= x), jointNoise(Simv, "ltt", vt= x),
    vertiSignal(Simv, "ltt", vt= x), vertiResid(Simv, "ltt", vt= x), vertiNoise(Simv, "ltt", vt= x),
    horizSignal(Simv, "ltt", vt= x), horizResid(Simv, "ltt", vt= x), horizNoise(Simv, "ltt", vt= x)))
round(t(apply(decf, 1, function(x) x/ (pi^2/ 3+ decf[1, ]* 100)), 1)

```

	OLD	S0	SI	SII	SIII	SIV	SV	SVI
Total Signal	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6
Total Noise	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Joint Signal	50.7	78.4	80.7	81.1	82.8	79.2	79.7	79.0
Joint Noise	46.9	19.2	16.8	16.5	14.8	18.4	17.9	18.6
Vertical Signal	35.9	56.8	59.8	70.7	73.1	58.1	58.5	58.0
Vertical Residual	14.9	21.6	21.0	10.4	9.7	21.1	21.2	21.1
Vertical Noise	61.7	40.8	37.8	26.9	24.5	39.4	39.1	39.6
Horizontal Signal	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
Horizontal Residual	21.6	49.3	51.7	52.0	53.7	50.1	50.6	50.0
Horizontal Noise	68.5	68.5	68.5	68.5	68.5	68.5	68.5	68.5

8 Session information

```
sessionInfo()
```

```
R version 3.5.3 (2019-03-11)
```

```
Platform: x86_64-pc-linux-gnu (64-bit)
```

```
Running under: Ubuntu 18.04.2 LTS
```

```
Matrix products: default
```

```
BLAS: /usr/lib/x86_64-linux-gnu/blas/libblas.so.3.7.1
```

```
LAPACK: /usr/lib/x86_64-linux-gnu/lapack/liblapack.so.3.7.1
```

```
locale:
```

```
[1] LC_CTYPE=fr_FR.UTF-8      LC_NUMERIC=C
[3] LC_TIME=fr_FR.UTF-8      LC_COLLATE=fr_FR.UTF-8
[5] LC_MONETARY=fr_FR.UTF-8  LC_MESSAGES=fr_FR.UTF-8
[7] LC_PAPER=fr_FR.UTF-8     LC_NAME=C
[9] LC_ADDRESS=C             LC_TELEPHONE=C
[11] LC_MEASUREMENT=fr_FR.UTF-8 LC_IDENTIFICATION=C
```

```
attached base packages:
```

```
[1] stats4      stats      graphics  grDevices  utils      datasets
[7] methods     base
```

```
other attached packages:
```

```
[1] gridExtra_2.3      xtable_1.8-3      ggrepel_0.8.0
[4] ggplot2_3.1.0      plyr_1.8.4        latticeExtra_0.6-28
[7] RColorBrewer_1.1-2 effects_4.0-3      lattice_0.20-38
[10] truncdist_1.0-2    evd_2.3-3         sure_0.2.0
[13] sandwich_2.5-0     lmtest_0.9-36     zoo_1.8-4
[16] mgcv_1.8-28        nlme_3.1-137      car_3.0-2
[19] carData_3.0-1      MASS_7.3-51.1     sp_1.3-1
```

```
loaded via a namespace (and not attached):
```

```
[1] Rcpp_1.0.0          assertthat_0.2.0  R6_2.3.0
[4] cellranger_1.1.0    survey_3.33-2     pillar_1.3.0
[7] rlang_0.3.0.1       lazyeval_0.2.1    curl_3.2
[10] readxl_1.1.0        minqa_1.2.4       data.table_1.11.4
[13] nloptr_1.0.4        Matrix_1.2-17     labeling_0.3
[16] splines_3.5.3       rgdal_1.3-6       lme4_1.1-18-1
[19] foreign_0.8-71      munsell_0.5.0     compiler_3.5.3
[22] pkgconfig_2.0.2     nnet_7.3-12       tidyselect_0.2.5
[25] tibble_1.4.2        rio_0.5.10        crayon_1.3.4
[28] dplyr_0.7.8         withr_2.1.2       grid_3.5.3
[31] gtable_0.2.0        magrittr_1.5      scales_1.0.0
[34] zip_1.0.0           bindrcpp_0.2.2    openxlsx_4.1.0
```

```
[37] tools_3.5.3      forcats_0.3.0    glue_1.3.0
[40] purrr_0.2.5      hms_0.4.2        abind_1.4-5
[43] survival_2.43-3  colorspace_1.3-2 bindr_0.1.1
[46] haven_1.1.2
```

A Custom functions

A.1 Surrogate Residuals

We use the package `sure` to simulate the surrogate residuals from the parametric ordered logistic, then we code a custom function for that to show that it works, then we implemented a custom function from OGAM models fitted with `mgcv`. We use `truncdist` to simulate truncated distribution.

Implementing the function for the ordered logistic from the `polr` function of the `MASS` package.

```
truncLogis <- function(n, spec, a = -Inf, b = Inf, ...) {
  p <- runif(n, min = 0, max = 1)
  G <- get(paste("p", spec, sep = ""), mode = "function")
  Gin <- get(paste("q", spec, sep = ""), mode = "function")
  G.a <- G(a, ...)
  G.b <- G(b, ...)
  pmin(pmax(a, Gin(G(a, ...) + p * (G(b, ...) - G(a, ...)), ...)), b)
}

surePOLR <- function(mod, newd= NULL){
  if (mod$method!= "logistic") stop("Logistic required")
  gg <- as.numeric(mod$zeta)
  if (is.null(newd)){
    g1 <- as.integer(model.response(model.frame(mod)))
    g6 <- mod$lp
  } else {
    g1 <- as.integer(newd[, "AOCc"])
    g6 <- gg[ 1]-qlogis(predict(mod, newdata= newd, type= 'probs')[, 1])
  }
  nn <- length(g1)
  suls <- sapply(g1, switch,
    "1"= c(-Inf , gg[ 1]), "2"= c(gg[ 1], gg[ 2]),
    "3"= c(gg[ 2], gg[ 3]), "4"= c(gg[ 3], gg[ 4]),
    "5"= c(gg[ 4], Inf ))
  sls <- data.frame(unlist(t(suls)))
  truncLogis(nn, spec= "logis", a= sls[, 1], b= sls[, 2],
    location= g6, scale= 1)
}
```

Now the same structure for the OGAM, from the `mgcv` package

```
sureOGAM <- function(mod, newd= NULL){
  if (is.null(newd)){
    g1 <- as.integer(mod$y)
    g6 <- mod$linear.predictors
  } else {
    g1 <- as.integer(newd[, names(mod$model[ 1])])
    g6 <- predict(mod, newdata= newd)
  }
}
```

```

}
nn <- length(g1)
gt <- data.frame(rep(NA, nn), rep(NA, nn))
gg <- c(mod$family$getTheta(TRUE), Inf)
kk <- c(- Inf, gg[ 1])
for (j in 2: length(unique(g1))) kk <- rbind(kk, c(gg[ j- 1], gg[ j]))
gt <- data.frame(t(sapply(g1, function(x) kk[x, ])))
truncLogis(nn, spec= "logis", a= gt[, 1], b= gt[, 2], location= g6)
}

surlGAM <- function(mod, newd= NULL){
  gg <- as.numeric(mod$family$getTheta(TRUE))
  if (is.null(newd)){
    g1 <- as.integer(mod$y)
    g6 <- mod$linear.predictors
  } else {
    g1 <- as.integer(newd[, names(mod$model[ 1])])
    g6 <- predict(mod, newdata= newd)
  }
  nn <- length(g1)
  suls <- sapply(g1, switch,
    "1"= c(-Inf , gg[ 1]), "2"= c(gg[ 1], gg[ 2]),
    "3"= c(gg[ 2], gg[ 3]), "4"= c(gg[ 3], gg[ 4]),
    "5"= c(gg[ 4], Inf ))
  sls <- data.frame(unlist(t(suls)))
  rtrunc(nn, spec= "logis", a= sls[, 1], b= sls[, 2], location= g6)
}

```

Equivalence between OGAM and polr, for surrogate and residuals.

```

library(mgcv) ; library(MASS) ; library(sure) ; library(truncdist)
fit.ogam <- gam(AOCc~ poly(DEM, 2)+ poly(SLOPE, 2)
  + poly(RAYAT, 2)+ poly(ASPECT, 2)+ poly(PERMEA, 2)
  , family= ocat(R= 5), data= Reg.Rank)
fit.polr <- polr(factor(AOCc)~ poly(DEM, 2)+ poly(SLOPE, 2)
  + poly(RAYAT, 2)+ poly(ASPECT, 2)+ poly(PERMEA, 2)
  , data= Reg.Rank)

sure1 <- surrogate(fit.polr)+ fit.oglm$zeta[ 1]
sure2 <- resids(fit.polr)
polr1 <- surePOLR(fit.polr)
polr2 <- surePOLR(fit.polr)- fit.polr$lp
ogam1 <- sureOGAM(fit.ogam)
ogam2 <- sureOGAM(fit.ogam)- fit.ogam$linear.pred

par(mfrow= c(3, 2))
plot(sure1, polr1)
abline(h= fit.oglm$zeta, v= fit.oglm$zeta, lty= 2, col= "blue")
abline(0, 1, col= "orange")
plot(sure2, polr2)
abline(0, 1, col= "orange")

plot(polr1, ogam1- mean(ogam1))
abline(h= fit.ogam$family$getTheta(TRUE)- mean(ogam1),
  v= fit.oglm$zeta, lty= 2, col= "blue")
abline(0, 1, col= "orange")
plot(polr2, ogam2)

```

```
abline(0, 1, col= "orange")

plot(sure1, ogam1- mean(ogam1))
abline(h= fit.ogam$family$getTheta(TRUE)- mean(ogam1),
       v= fit.oglm$zeta, lty= 2, col= "blue")
abline(0, 1, col= "orange")
plot(sure2, ogam2)
abline(0, 1, col= "orange")
```

A.2 Decomposition terms

We code different functions for the terms.

The **joint signal** terms is the variance of the expected quality conditionally on vertical and horizontal dummies:

$$\mathbb{V}\{\mathbb{E}[q(X^*) | y, c]\} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (1)$$

```
jointSignal <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  jS <- rep(0, nrow(dat))
  for (i in unique(dat[, vt])){
    for (j in unique(dat[, hz])){
      tmp <- dat[, vt]== i & dat[, hz]== j
      jS[ tmp] <- mean(dat[tmp, lt])
    }
  }
  c("Joint Signal"= var(jS))
}
```

The **joint noise** terms is the expectation of the variance quality conditionally on vertical and horizontal dummies:

$$\mathbb{E}\{\mathbb{V}[q(X^*) | y, c]\} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (2)$$

```
jointNoise <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  jN <- 0
  for (i in unique(dat[, vt])){
    for (j in unique(dat[, hz])){
      tmp <- dat[, vt]== i & dat[, hz]== j
      if (sum(tmp) > 1) jN <- jN+ var(dat[ tmp, lt])* mean(tmp)
    }
  }
  c("Joint Noise"= jN)
}
```

The **vertical signal** terms is the variance of the expectation quality conditionally on vertical GI dummies:

$$\mathbb{V}\{\mathbb{E}[q(X^*) | y]\} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (3)$$

```
vertiSignal <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  vS <- rep(0, nrow(dat))
  for (i in unique(dat[, vt])){
    vS[ dat[, vt]== i] <- mean(dat[dat[, vt]== i, lt])
  }
}
```

```

}
c("Vertical Signal"= var(vS))
}

```

The **vertical residual** terms is the expectation of the conditional on horizontal variance of the expectation quality conditionally on vertical GI dummies:

$$\mathbb{E}\{\mathbb{V}[\mathbb{E}(q(X^*) | y, c) | y]\} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (4)$$

```

vertiResid <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  sig <- rep(0, nrow(dat)) ; vR <- 0
  for (i in unique(dat[, vt])){
    for (j in unique(dat[, hz])){
      tmp <- dat[, vt]== i & dat[, hz]== j
      sig[ tmp] <- mean(dat[ tmp, lt])
    }
  }
  for (i in unique(dat[, vt])){
    vR <- vR+ var(sig[dat[, vt]== i])* mean(dat[, vt]== i)
  }
  c("Vertical Residual"= vR)
}

```

The **vertical Noise** terms is the expectation of the variance of the quality conditionally on vertical GI dummies:

$$\mathbb{E}\{\mathbb{V}[q(X^*) | y]\} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (5)$$

```

vertiNoise <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  vN <- 0
  for (i in unique(dat[, vt])){
    vN <- vN+ var(dat[dat[, vt]== i, lt])* mean(dat[, vt]== i)
  }
  c("Vertical Noise"= vN)
}

```

The **horizontal signal** terms is the variance of the expectation quality conditionally on horizontal GI dummies:

$$\mathbb{V}\{\mathbb{E}[q(X^*) | c]\} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (6)$$

```

horizSignal <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  hS <- rep(0, nrow(dat))
  for (j in unique(dat[, hz])){
    hS[ dat[, hz]== j] <- mean(dat[dat[, hz]== j, lt])
  }
  c("Horizontal Signal"= var(hS))
}

```

The **horizontal residual** terms is the expectation of the conditional on vertical variance of the expectation quality conditionally on horizontal GI dummies:

$$\mathbb{E}\{ \mathbb{V}[\mathbb{E}(q(X^*) | y, c) | y] \} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (7)$$

```

horizResid <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  sig <- rep(0, nrow(dat)) ; hR <- 0
  for (i in unique(dat[, vt])){
    for (j in unique(dat[, hz])){
      tmp <- dat[, vt]== i & dat[, hz]== j
      sig[ tmp] <- mean(dat[ tmp, lt])
    }
  }
  for (j in unique(dat[, hz])){
    hR <- hR+ var(sig[dat[, hz]== j])* mean(dat[, hz]== j)
  }
  c("Horizontal Residual"= hR)
}

```

The **horizontal Noise** terms is the expectation of the variance of the quality conditionally on horizontal GI dummies:

$$\mathbb{E}\{ \mathbb{V}[q(X^*) | c] \} = \frac{1}{N + J + H} \sum_{i=1}^N \sum_{j=1}^J \sum_{h=1}^H [\mathbb{E}(q(X^*) | y = j, c = h) - \bar{q}_{jh}]^2 \quad (8)$$

```

horizNoise <- function(dat, lt, vt= "AOCc", hz= "LIBCOM"){
  hN <- 0
  for (j in unique(dat[, hz])){
    hN <- hN+ (var(dat[dat[, hz]== j, lt])* mean(dat[, hz]== j))
  }
  c("Horizontal Noise"= hN)
}

```
