Complementarity in Alliances - logfile

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This log file was last compiled on 2025-02-20 using the following system:

```
Sys.info()
```

```
                                                    sysname
                                                    "Linux"
                                                    release
                                             "6.11.0-18-generic"
                                                    version
"#18-Ubuntu SMP PREEMPT_DYNAMIC Fri Feb  7 22:34:25 UTC 2025"
                                                   nodename
                                                    "fuego"
                                                    machine
                                                   "x86_64"
                                                      login
                                               "andres-gannon"
                                                       user
```

```
                                                    "andres-gannon"
                                                     effective_user
                                                    "andres-gannon"
```

```
1 sessionInfo()
```

```
R version 4.4.2 (2024-10-31)
Platform: x86_64-pc-linux-gnu
Running under: Ubuntu 24.10

Matrix products: default
BLAS:   /usr/lib/x86_64-linux-gnu/blas/libblas.so.3.12.0
LAPACK: /usr/lib/x86_64-linux-gnu/lapack/liblapack.so.3.12.0

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

time zone: America/Chicago
tzcode source: system (glibc)

attached base packages:
```

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

loaded via a namespace (and not attached):
 [1] compiler_4.4.2    fastmap_1.2.0     cli_3.6.3         tools_4.4.2
 [5] htmltools_0.5.8.1 rstudioapi_0.17.1 yaml_2.3.10       rmarkdown_2.29
 [9] knitr_1.49        jsonlite_1.8.9    xfun_0.50         digest_0.6.37
[13] rlang_1.1.5       evaluate_1.0.3
```

```r
library(knitr)
library(kableExtra)
library(ggplot2)
library(ggtext)
library(magrittr)
library(rstan)
```

```
Loading required package: StanHeaders


rstan version 2.32.6 (Stan version 2.32.2)

For execution on a local, multicore CPU with excess RAM we recommend calling
options(mc.cores = parallel::detectCores()).
To avoid recompilation of unchanged Stan programs, we recommend calling
rstan_options(auto_write = TRUE)
For within-chain threading using `reduce_sum()` or `map_rect()` Stan functions,
change `threads_per_chain` option:
rstan_options(threads_per_chain = 1)
```

```
Attaching package: 'rstan'

The following object is masked from 'package:magrittr':

    extract
```

Load data

```
df_raw <- readRDS(file = paste0(here::here(), "/data/rDMC_raw_v1.rds"))
df_long <- readRDS(file = paste0(here::here(), "/data/rDMC_long_v1.rds"))
df_wide <- readRDS(file = paste0(here::here(), "/data/rDMC_wide_v1.rds"))

df <- readRDS(file = paste0(here::here(), "/data/03_df-full.rds"))

df_m1 <- df |>
  dplyr::rename(dv = dol_nicheolap,
                strcomp = strcomp_cinc_total_scaled,
                hier = hier_laplace_scaled)
```

Figure 1

```r
# ANZUS = 3215 and CSTO = 4220

df |>
  ggplot(aes(x = dol_nicheolap)) +
  geom_histogram(bins = 30, color = "black", fill = "gray") +
  geom_vline(aes(xintercept = mean(dol_nicheolap, na.rm = TRUE)),
             linetype = "dashed", linewidth = 1) +
  annotate("text",
           x = mean(df$dol_nicheolap, na.rm = TRUE) + 0.075,
           y = 200,
           size = 2,
           label = paste("Mean =", round(mean(df$dol_nicheolap, na.rm =
            ↪  TRUE), 2))) +
  geomtextpath::geom_labelvline(xintercept = 0.57, label = "ANZUS (2002)",
 ↪  linetype = 3, hjust = 0.55, size = 2) +
  geomtextpath::geom_labelvline(xintercept = 0.063, label = "CSTO (2002)",
 ↪  linetype = 3, hjust = 0.55, size = 2) +
  scale_x_continuous(breaks = scales::pretty_breaks()) +
  labs(title = "",
       x = "\nDivision of labor",
       y = "Number of observations\n") +
  theme_classic() +
  theme(text = element_text(size = 10),
        axis.text = element_text(color = "black"))
```

```
Warning in geomtextpath::geom_labelvline(xintercept = 0.57, label = "ANZUS (2002)", : All aes
i Please consider using `annotate()` or provide this layer with data containing
  a single row.

Warning in geomtextpath::geom_labelvline(xintercept = 0.063, label = "CSTO (2002)", : All aes
i Please consider using `annotate()` or provide this layer with data containing
  a single row.

Warning: Removed 111 rows containing non-finite outside the scale range
(`stat_bin()`).
```

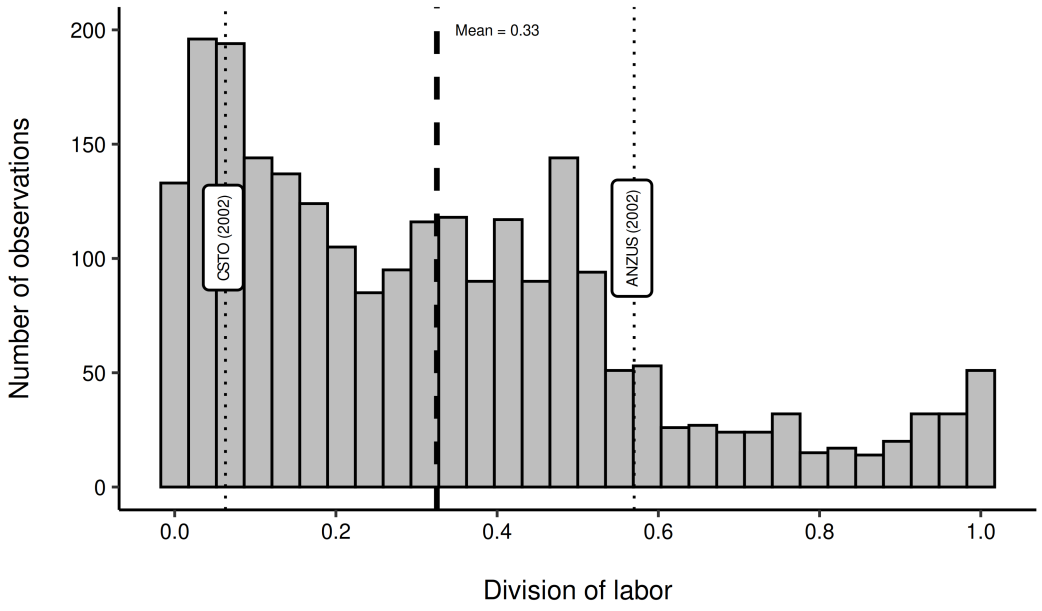


Figure 2

```
# US-Japan (3375)

df |>
  dplyr::filter(atopid == 3375) |>
  dplyr::select(year, dol_nicheolap, strcomp_cinc_total) |>
  ggplot(aes(y = strcomp_cinc_total, x = year)) +
  geom_line() +
  scale_x_continuous(breaks = seq(1970, 2015, 5), minor_breaks = NULL) +
  theme_classic() +
  labs(y = "Strategic compatibility\n",
       x = "",
       title = "") +
  theme(text = element_text(size = 10),
        axis.text = element_text(color = "black"))
```


```r
shared <- readRDS(file = paste0(here::here(), '/data/dyad_threat.rds')) |>
  dplyr::filter(year == 1995 & ccode1 %in% c(2, 740) & threatenviro == 1) |>
  dplyr::select(ccode1, rival, threatenviro, cinc2) |>
  dplyr::mutate(threat_ccode1 = dplyr::if_else(ccode1 == 2 & threatenviro ==
  ↪  1, cinc2, 0),
                threat_ccode2 = dplyr::if_else(ccode1 == 740 & threatenviro
                 ↪  == 1, cinc2, 0)) |>
  dplyr::filter(threat_ccode1 > 0 | threat_ccode2 > 0) |>
  dplyr::select(-ccode1, -threatenviro) |>
  tidyr::pivot_longer(cols = c(threat_ccode1, threat_ccode2)) |>
  dplyr::filter(value > 0) |>
  tidyr::pivot_wider(id_cols = rival, names_from = name) |>
  dplyr::mutate(threat_shared = dplyr::if_else(threat_ccode1 > 0 &
  ↪  threat_ccode2 > 0, 1, 0),
```

```
12                dplyr::across(dplyr::everything(), ~tidyr::replace_na(.x,
↪  0)))
```

Figure 3

```
network <- readRDS(paste0(here::here(), "/data/sipri_dyad-year.rds")) |>
  dplyr::filter(year == 1975) |>
  dplyr::select(ccode1, ccode2, value)

sipri <- readRDS(paste0(here::here(), "/data/sipri_dyad-year.rds")) |>
  dplyr::filter(year == 1975) |>
  dplyr::select(ccode1, ccode2, value) |>
  dplyr::rename(weight = value) |>
  igraph::graph_from_data_frame(directed = TRUE) |>
  centiserve::laplacian(mode = "out") |>
  as.data.frame() |>
  dplyr::rename(laplace = 1) |>
  tibble::rownames_to_column(var = "ccode") |>
  dplyr::mutate(ccode = as.integer(ccode))

nato <- rio::import(paste0(here::here(), "/inst/extdata/ATOP/atop5_1m.csv"))
 ↪  |>
  dplyr::filter(yrexit > 1970 |
                  yrexit == 0) |>
  dplyr::mutate(yrexit = dplyr::if_else(yrexit == 0,
                                        2023,
                                        yrexit)) |>
  dplyr::select(atopid, member, yrent, yrexit) |>
  dplyr::distinct() |>
```

```r
  dplyr::mutate(row = dplyr::row_number()) |>
  dplyr::group_by(row, atopid, member) |>
  dplyr::reframe(year = seq(yrent, yrexit)) |>
  dplyr::ungroup() |>
  dplyr::select(-row) |>
  dplyr::rename(ccode = 'member') |>
  dplyr::filter(year == 1975 & atopid == 3180) |>
  dplyr::distinct() |>
  dplyr::select(-atopid, -year) |>
  dplyr::mutate(nato = 1)

## Network plot
library(igraph)
```

```
Attaching package: 'igraph'

The following objects are masked from 'package:stats':

    decompose, spectrum

The following object is masked from 'package:base':

    union
```

```r
library(ggraph)
library(tidygraph)
```

```
Attaching package: 'tidygraph'
```

```
The following object is masked from 'package:igraph':

    groups
```

```
The following object is masked from 'package:stats':

    filter
```

```r
edgelist <- dplyr::left_join(network, nato, by = c("ccode1" = "ccode")) |>
  dplyr::rename(nato_sender = nato) %>%
  dplyr::left_join(., nato, by = c("ccode2" = "ccode")) |>
  dplyr::rename(nato_receiver = nato) |>
  dplyr::filter(nato_sender == 1 & nato_receiver == 1) |>
  dplyr::select(!dplyr::starts_with("nato_")) |>
  dplyr::mutate(cown1 = countrycode::countrycode(ccode1, origin = "cown",
  ↪  destination = "cowc"),
                cown1 = dplyr::if_else(ccode1 == 260, "GFR", cown1),
                cown2 = countrycode::countrycode(ccode2, origin = "cown",
                 ↪  destination = "cowc"),
```

```
                cown2 = dplyr::if_else(ccode2 == 260, "GFR", cown2)) |>
  dplyr::select(cown1, cown2, value)
```

```
Warning: There were 2 warnings in `dplyr::mutate()`.
The first warning was:
i In argument: `cown1 = countrycode::countrycode(ccode1, origin = "cown",
  destination = "cowc")`.
Caused by warning:
! Some values were not matched unambiguously: 260
i Run `dplyr::last_dplyr_warnings()` to see the 1 remaining warning.
```

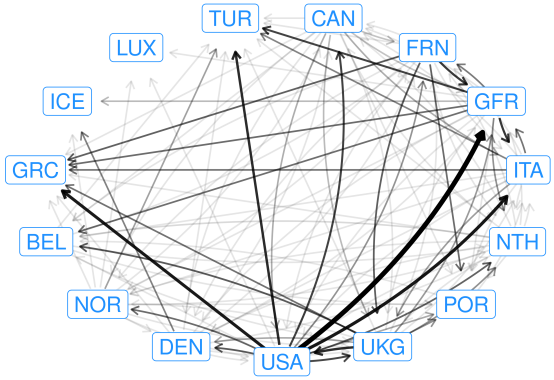
```
network <- igraph::graph_from_data_frame(edgelist, directed = TRUE)
tbl_graph <- tidygraph::as_tbl_graph(network)

ggraph(tbl_graph,
       layout = 'linear',
       circular = TRUE) +
  geom_edge_fan(aes(edge_alpha = log(value + 1),
                    edge_width = value),
                arrow = arrow(length = unit(2, "mm")),
                start_cap = circle(4, 'mm'),
                end_cap = circle(8, 'mm'),
                show.legend = FALSE,) +
  geom_node_label(aes(label = name),
                  size = 5,
                  repel = FALSE,
```

```
                color = 'dodgerblue') +
  scale_edge_width(range = c(0.5, 1.5)) +
  scale_edge_alpha('Edge direction',
                   guide = 'edge_direction') +
  scale_x_continuous(expand = expansion(mult = .1)) +
  theme_void()
## Bar plot
dplyr::left_join(nato, sipri) |>
  dplyr::select(-nato) |>
  dplyr::mutate(cname = countrycode::countrycode(ccode, origin = "cown",
 ↪  destination = "country.name"),
                cname = dplyr::if_else(ccode == 260, "West Germany", cname))
                 ↪  |>
  dplyr::arrange(laplace) |>
  dplyr::mutate(cname = factor(cname, levels = cname)) |>
  ggplot(aes(x = laplace,
             y = cname)) +
  geom_segment(aes(xend = 0, yend = cname)) +
  geom_point(size = 3, color = "dodgerblue") +
  labs(title = "",
       x = "\nLaplacian entropy",
       y = "") +
  scale_x_continuous(labels = scales::label_comma()) +
  theme_classic() +
  theme(text = element_text(size = 14),
        axis.text = element_text(color = "black"))
```

```
Joining with `by = join_by(ccode)`


Warning: There was 1 warning in `dplyr::mutate()`.
i In argument: `cname = countrycode::countrycode(ccode, origin = "cown",
  destination = "country.name")`.
Caused by warning:
! Some values were not matched unambiguously: 260
```



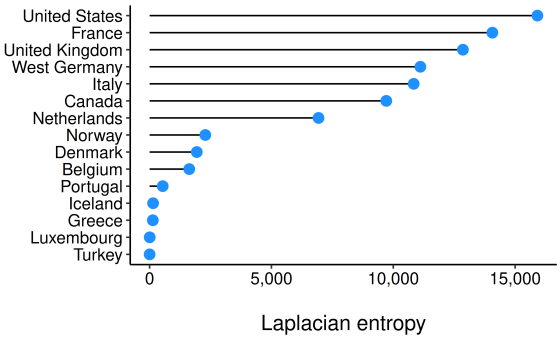


Table 1

```
df_m1 <- df |>
  dplyr::rename(dv = dol_nicheolap,
                strcomp = strcomp_cinc_total_scaled,
                hier = hier_laplace_scaled)

models <- list(fixest::feols(dv ~ strcomp + hier +
                               year_norm + year_sq + year_cube,
                             cluster = "atopid",
                             data = df_m1),
               fixest::feols(dv ~ strcomp + hier + milinst + demo_polityprop
 ↪  + dist_contigprop + dist_maxlog + rivals_log + members_log +
 ↪  allianceage_avg +
                               year_norm + year_sq + year_cube,
                             cluster = "atopid",
                             data = df_m1),
               fixest::feols(dv ~ strcomp + hier
                             | year_norm,
                             cluster = "atopid",
                             data = df_m1),
               fixest::feols(dv ~ strcomp + hier + milinst + demo_polityprop
 ↪  + dist_contigprop + dist_maxlog + rivals_log + members_log +
 ↪  allianceage_avg
                             | year_norm,
                             cluster = "atopid",
```

```
                                data = df_m1),
              lmerTest::lmer(dv ~ strcomp + hier +
                                  (1 | year_norm),
                                data = df_m1),
              lmerTest::lmer(dv ~ strcomp + hier + milinst + demo_polityprop
  ↪  + dist_contigprop + dist_maxlog + rivals_log + members_log +
  ↪  allianceage_avg +
                                  (1 | year_norm),
                                data = df_m1))
```

```
NOTE: 113 observations removed because of NA values (LHS: 111, RHS: 3).
```

```
NOTE: 231 observations removed because of NA values (LHS: 111, RHS: 156).
```

```
NOTE: 113 observations removed because of NA values (LHS: 111, RHS: 3).
```

```
NOTE: 231 observations removed because of NA values (LHS: 111, RHS: 156).
```

```
coefs <- c("strcomp" = "Strategic compatibility",
           "hier" = "Hierarchy",
           "milinst" = "Alliance institutionalization",
           "demo_polityprop" = "Democracy ratio",
           "dist_contigprop" = "Contiguity ratio",
           "dist_maxlog" = "Maximum distance (log)",
           "rivals_log" = "Number of rivals (log)",
```

```
            "members_log" = "Number of members (log)",
            "allianceage_avg" = "Alliance age (average)")

modelsummary::modelsummary(models,
                           stars = c('+' = .10, '*' = .05, '**' = .01),
                           coef_map = coefs,
                           coef_omit = "Intercept",
                           gof_map = c("nobs", "r.squared", 'adj.r.squared',
                            ↪  'r2.marginal', 'r2.conditional', 'aic', 'bic',
                            ↪  'rmse'),
                           output = "tinytable") |>
  tinytable::group_tt(j = list("Year polynomials" = 2:3, "Year fixed effects"
 ↪  = 4:5, "Multilevel model" = 6:7)) |>
  tinytable::theme_tt("resize")
```

	Year polynomials		Year fixed effects		Multilevel model	
	(1)	(2)	(3)	(4)	(5)	(6)
Strategic compatibility	0.186**	0.153*	0.192**	0.165*	0.197**	0.168**
	(0.046)	(0.061)	(0.048)	(0.064)	(0.019)	(0.024)
Hierarchy	0.403**	0.320**	0.397**	0.313*	0.396**	0.327**
	(0.067)	(0.119)	(0.067)	(0.121)	(0.021)	(0.039)
Alliance institutionalization		0.039*		0.039*		0.035**
		(0.017)		(0.017)		(0.006)
Democracy ratio		0.118*		0.116*		0.116**
		(0.046)		(0.047)		(0.017)
Contiguity ratio		-0.127		-0.140		-0.142**
		(0.106)		(0.106)		(0.045)
Maximum distance (log)		-0.025+		-0.026+		-0.026**
		(0.015)		(0.015)		(0.006)
Number of rivals (log)		0.064*		0.060*		0.066**
		(0.027)		(0.027)		(0.009)
Number of members (log)		-0.029		-0.027		-0.031**
		(0.019)		(0.019)		(0.008)
Alliance age (average)		0.000		0.000		0.000
		(0.001)		(0.001)		(0.000)
Num.Obs.	2398	2280	2398	2280	2398	2280
R2	0.206	0.284	0.232	0.307		
R2 Adj.	0.204	0.281	0.217	0.290		
R2 Marg.					0.127	0.201
R2 Cond.					0.217	0.289
AIC	-226.4	-482.2	-226.2	-472.2	-158.4	-341.9
BIC	-191.8	-407.7	45.5	-162.7	-129.4	-273.1
RMSE	0.23	0.22	0.23	0.21	0.23	0.21

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$

Figure 4 (in-text results)

```
m1_obr <- ordbetareg::ordbetareg(dv ~
                                   strcomp + hier +
                                   milinst + latent.depth.mean +
 ↪  demo_polityprop + dist_contigprop + dist_maxlog + rivals_log +
 ↪  members_log + allianceage_avg +
                                   (1 | year_norm),
                                 data = df_m1,
                                 cores = 6,
                                 chains = 6,
                                 iter = 2000,
                                 backend = "cmdstanr",
                                 refresh = 0,
                                 file = "ordbeta",
                                 file_refit = "on_change")
```

```
Warning: Rows containing NAs were excluded from the model.
```

```
ordpred_strcomp <- brms::conditional_effects(m1_obr)[[1]]
ordpred_hier <- brms::conditional_effects(m1_obr)[[2]]

# Figure 4(a) in-text description
marginaleffects::avg_comparisons(m1_obr, variables = list(strcomp = "sd")) |>
 ↪  broom::tidy() |> dplyr::pull(estimate) |> round(3)
```

```
[1] 0.039
```

```
# Figure 4(b) in-text description
marginaleffects::avg_comparisons(m1_obr, variables = list(hier = "sd")) |>
  broom::tidy() |> dplyr::pull(estimate) |> round(3)
```

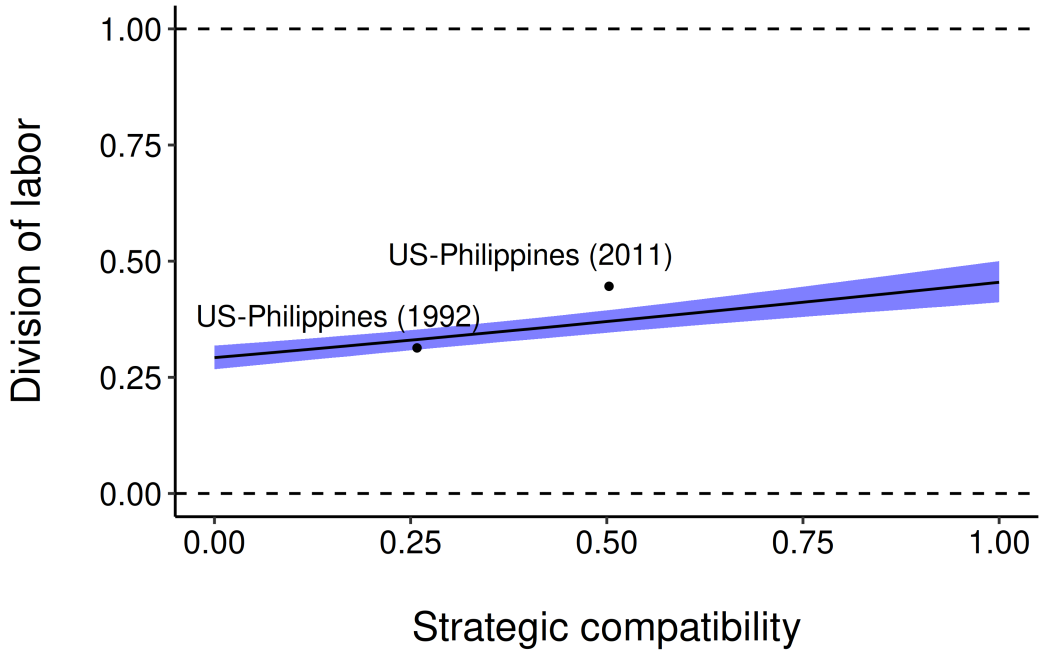
```
[1] 0.083
```

Figure 4

```
# Strategic compatibility predicted values with example
ex_strcomp <- df |>
  dplyr::filter(year %in% c(1992, 2011), atopid == 3375) |>
  dplyr::select(year, atopid, dol_nicheolap, strcomp_cinc_total_scaled) |>
  dplyr::mutate(year = dplyr::recode(year, "1992" = "US-Philippines (1992)",
  ↪  "2011" = "US-Philippines (2011)"))

ordpred_strcomp |>
  ggplot(aes(y = estimate__, x = strcomp)) +
  geom_ribbon(aes(ymin = lower__,
                  ymax = upper__), fill="blue",
              alpha = 0.5) +
  geom_hline(yintercept = 1, linetype = 2) +
  geom_hline(yintercept = 0, linetype = 2) +
  geom_line() +
  geom_point(data = ex_strcomp,
             aes(x = strcomp_cinc_total_scaled, y = dol_nicheolap),
             size = 1) +
  geom_text(data = ex_strcomp,
            aes(x = strcomp_cinc_total_scaled - 0.1, y = dol_nicheolap, label
             ↪  = year),
            vjust = -1) +
  theme_classic() +
  theme(text = element_text(size = 15),
```

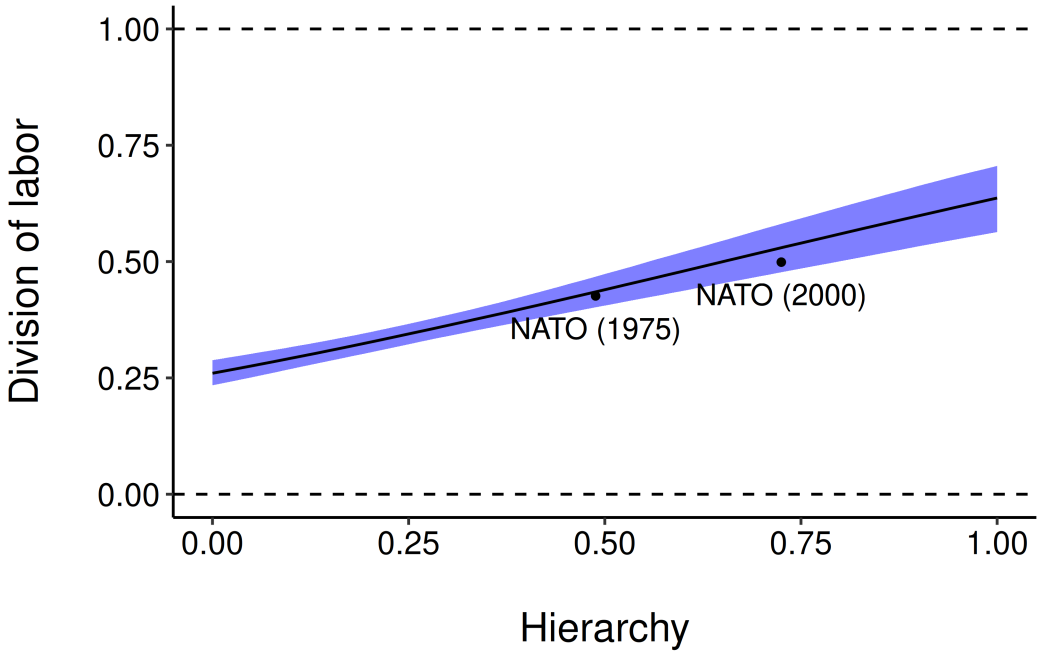
```
        axis.text = element_text(color = "black")) +
  labs(y = "Division of labor\n",
       x = "\nStrategic compatibility")
```




```
# Hierarchy predicted values with example
ex_hier <- df |>
  dplyr::filter(year %in% c(1975, 2000) & atopid == 3180) |>
  dplyr::select(year, dol_nicheolap, hier_laplace_scaled) |>
  dplyr::mutate(year = dplyr::recode(year,
                                     "1975" = "NATO (1975)",
                                     "2000" = "NATO (2000)"))

ordpred_hier |>
```

```
  ggplot(aes(y = estimate__, x = hier)) +
  geom_ribbon(aes(ymin = lower__,
                  ymax = upper__), fill="blue",
              alpha = 0.5) +
  geom_hline(yintercept = 1, linetype = 2) +
  geom_hline(yintercept = 0, linetype = 2) +
  geom_line() +
  geom_point(data = ex_hier,
             aes(x = hier_laplace_scaled, y = dol_nicheolap),
             size = 1) +
  geom_text(data = ex_hier,
            aes(x = hier_laplace_scaled, y = dol_nicheolap, label = year),
            vjust = 2) +
  theme_classic() +
  theme(text = element_text(size = 15),
        axis.text = element_text(color = "black")) +
  labs(y = "Division of labor\n",
       x = "\nHierarchy")
```


1.00
0.75
0.50
0.25
0.00
Division of labor
0.00
0.25
0.50
0.75
1.00
Hierarchy
NATO (1975)
NATO (2000)