NCEE

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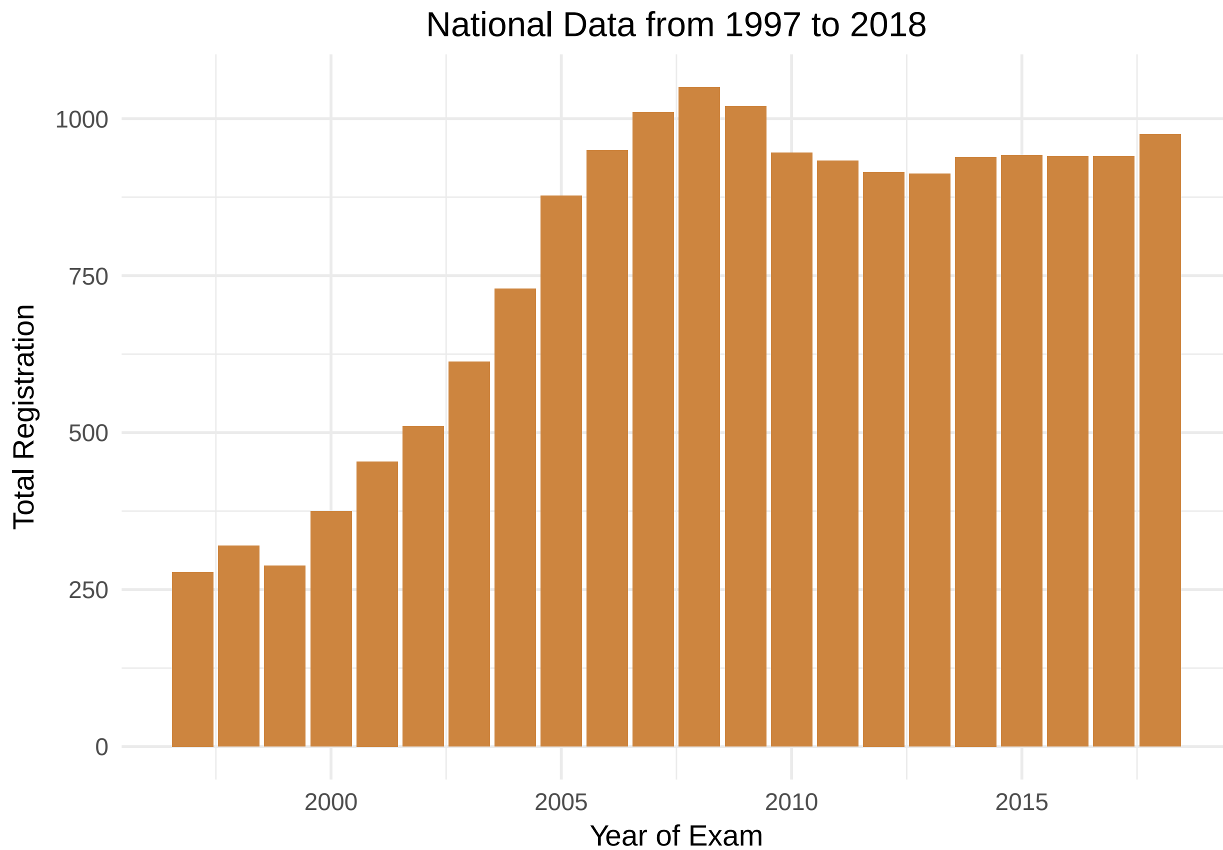
```
setwd("~/NCEE")
library(ggplot2)
library(gridExtra)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
## The following object is masked from 'package:gridExtra':
##
##     combine
## The following objects are masked from 'package:stats':
##
##     filter, lag
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(wesanderson)
library(maps)
library(mapdata)
library(sp)

NCEE_reg <- read.csv("NCEE_reg.csv")[1:31, ]
province <<- c(as.character(NCEE_reg[, 1]))
rownames(NCEE_reg) <- province
NCEE_reg <- NCEE_reg[, -1]

NCEE_JHS <- read.csv("NCEE_JHS.csv")
```

```
# =====Plot for National Data Trend 1987~2018===== #
NCEE_national <- read.csv("national data.csv")
national_reg <- NCEE_national$Reg[1:14]
national_JHS <- NCEE_national$JHS[7:20]/30000
year_born <- c(2000:1987)
year_test <- c(2018:1997)
national_reg_full <- NCEE_national$Reg[1:22]

reg_full <- data.frame(year_test, national_reg_full)

ggplot(data = reg_full, aes(x = year_test, y = national_reg_full)) + geom_bar(stat = "identity",
    fill = "tan3", position = position_dodge()) + theme_minimal() + ggtitle("National Data from 1997 to
    theme(plot.title = element_text(hjust = 0.5)) + xlab("Year of Exam") + ylab("Total Registration")
```




```r
# =====Plot for National Data Trend===== #

population <- c(national_JHS, national_reg)
label <- c(rep("JHS", 14), rep("NCEE Reg", 14))
year_birth <- rep(year_born, 2)
plot_df <- data.frame(population, label, year_birth)

p1 <- ggplot(data = plot_df, aes(x = year_birth, y = population, fill = label)) +
    geom_bar(stat = "identity", color = "grey", position = position_dodge()) +
    theme_minimal() + scale_fill_brewer(palette = "Blues") + ggtitle("Total-Cohort from 1987 to 2000")
    theme(plot.title = element_text(hjust = 0.5)) + xlab("Year of Birth")

# =====Plot for Beijing Data Trend===== #

Beijing_JHS <- as.numeric(NCEE_JHS[1, 7:19])/30000  #2012-2000
Beijing_reg <- as.numeric(NCEE_reg[1, 1:13])/10000  # 2018-2006
label_city <- c(rep("JHS", 13), rep("NCEE Reg", 13))
year_born <- c(2000:1988)
year_birth <- rep(year_born, 2)
Beijing_population <- c(Beijing_JHS, Beijing_reg)
plot_beijing <- data.frame(Beijing_population, label_city, year_birth)

p2 <- ggplot(data = plot_beijing, aes(x = year_birth, y = Beijing_population,
    fill = label_city)) + geom_bar(stat = "identity", color = "grey", position = position_dodge()) +
    theme_minimal() + scale_fill_brewer(palette = "Reds") + ggtitle("Beijing-Cohort from 1987 to 2000")
    theme(plot.title = element_text(hjust = 0.5)) + xlab("Year of Birth")
```

```r
# =====Plot for Henan Data Trend===== #

Henan_JHS <- as.numeric(NCEE_JHS[16, 7:19])/30000  #2012-2000
Henan_reg <- as.numeric(NCEE_reg[16, 1:13])/10000  # 2018-2006
label_city <- c(rep("JHS", 13), rep("NCEE Reg", 13))
year_born <- c(2000:1988)
year_birth <- rep(year_born, 2)
Henan_population <- c(Henan_JHS, Henan_reg)
plot_Henan <- data.frame(Henan_population, label_city, year_birth)

p3 <- ggplot(data = plot_Henan, aes(x = year_birth, y = Henan_population, fill = label_city)) +
    geom_bar(stat = "identity", color = "grey", position = position_dodge()) +
    theme_minimal() + scale_fill_brewer(palette = "Greens") + ggtitle("Henan-Cohort from 1987 to 2000")
    theme(plot.title = element_text(hjust = 0.5)) + xlab("Year of Birth")

# =====Plot for Shanxi Data Trend===== #

Xinjiang_JHS <- as.numeric(NCEE_JHS[31, 7:19])/30000  #2012-2000
Xinjiang_reg <- as.numeric(NCEE_reg[31, 1:13])/10000  # 2018-2006
label_city <- c(rep("JHS", 13), rep("NCEE Reg", 13))
year_born <- c(2000:1988)
year_birth <- rep(year_born, 2)
Xinjiang_population <- c(Xinjiang_JHS, Xinjiang_reg)
plot_Xinjiang <- data.frame(Xinjiang_population, label_city, year_birth)

p4 <- ggplot(data = plot_Xinjiang, aes(x = year_birth, y = Xinjiang_population,
    fill = label_city)) + geom_bar(stat = "identity", color = "grey", position = position_dodge()) +
    theme_minimal() + scale_fill_brewer(palette = "OrRd") + ggtitle("Xinjiang-Cohort from 1987 to 2000"
    theme(plot.title = element_text(hjust = 0.5)) + xlab("Year of Birth")

# =====Display===== #
grid.arrange(p1, p2, p3, p4, nrow = 2)
```

```
## Warning: Removed 1 rows containing missing values (geom_bar).

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```
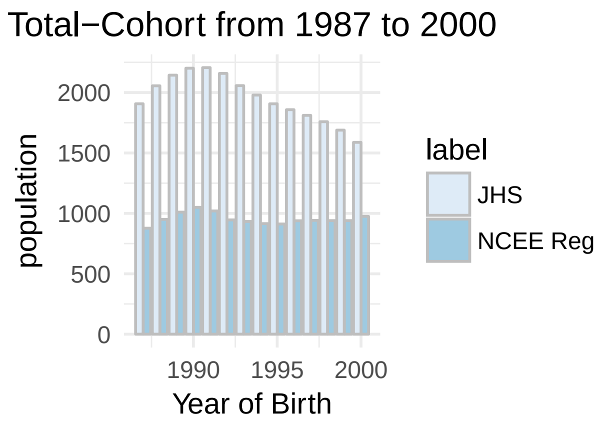
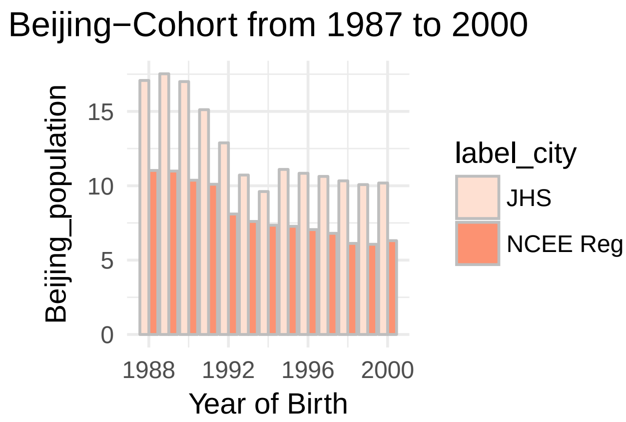
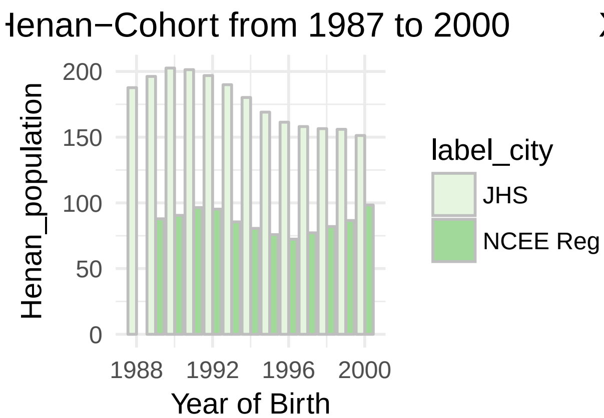
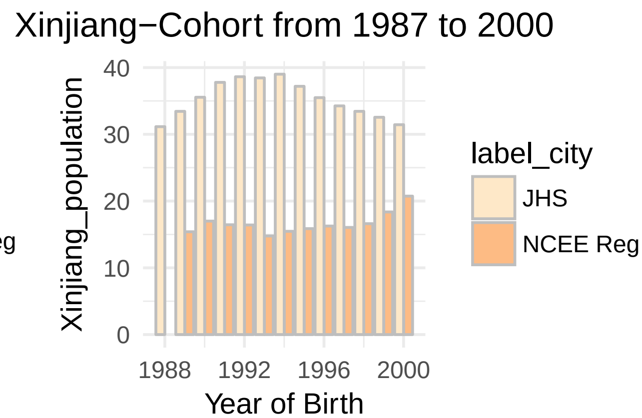










```r
# =====Fit linear model for 31 provinces===== #
NCEE_JHS
```

```
##                X   X2017   X2016   X2015   X2014   X2013   X2012   X2011
## 1        Beijing  266404  268273  283366  306789  310568  305510  302269
## 2        Tianjin  262243  256383  261474  267214  260710  256541  261954
## 3          Hebei 2600675 2436810 2361330 2288195 2088470 2173677 2150335
## 4         Shanxi 1082430 1092739 1126849 1218952 1291442 1502433 1643113
## 5      Neimenggu  618655  612376  639648  669657  688464  746308  791411
## 6       Liaoning  963450  978298 1012944 1055661 1057488 1134585 1195997
## 7          Jilin  618704  604277  595518  622883  644993  696588  751532
## 8   Heilongjiang  903983  903883  899803  916293  932839 1204786 1223979
## 9       Shanghai  411712  413298  412345  426789  436696  432686  430585
## 10       Jiangsu 2086934 1949456 1867166 1852029 1857469 1970169 2111249
## 11      Zhejiang 1558460 1504118 1479353 1499062 1482649 1492985 1546002
## 12         Anhui 2021627 1941986 1900786 1924134 1997091 2130347 2498800
## 13        Fujian 1215717 1154758 1133458 1125729 1108226 1120356 1157266
## 14       Jiangxi 1910421 1802080 1763985 1750083 1754361 1945486 2009641
## 15      Shandong 3294601 3159129 3108127 3147954 3179800 3281023 3451577
## 16         Henan 4291617 4158272 4048103 3993606 3850493 4537868 4679780
## 17         Hubei 1487131 1414864 1365319 1375940 1483710 1577701 2040702
## 18         Hunan 2296294 2260603 2224138 2206344 2142847 2111100 2163402
## 19     Guangdong 3561001 3478440 3553170 3767505 4047906 4424650 4790565
## 20       Guangxi 2034632 1987540 1963062 1950844 1950761 1966202 2008317
## 21        Hainan  333342  323736  328889  337350  346790  364677  392397
## 22     Chongqing  990403  966021  960383  979386 1017592 1087258 1190197
## 23       Sichuan 2491364 2448234 2463860 2583315 2717198 3041867 3266108
```

```
## 24       Guizhou 1829870 1891411 1979699 2068326 2103033 2100850 2138054
## 25        Yunnan 1872808 1873150 1894282 1897966 1874418 1954348 2052586
## 26        Xizang  124571  120283  117520  124295  126117  130226  136371
## 27       Shaanxi 1049654 1051036 1070779 1117284 1201851 1315464 1498841
## 28         Gansu  856127  876171  909255  970919 1035940 1180171 1285392
## 29       Qinghai  205814  207937  213165  211993  208095  208723  223398
## 30       Ningxia  279180  273696  274333  278323  284758  292813  299635
## 31      Xinjiang  901806  894798  907400  911477  918473  943169  976569
##       X2010   X2009   X2008   X2007   X2006   X2005   X2004   X2003   X2002
## 1    309912  318874  325117  332959  288298  321585  386511  453446  510055
## 2    273408  287031  303492  320840  335783  359110  400568  432505  447288
## 3   2212343 2418637 2741801 3062442 3368253 3704263 4035302 4294874 4332543
## 4   1713779 1726832 1772798 1851469 1892237 1897840 1927068 1932486 1830745
## 5    814686  832216  862276  918851  990473 1031241 1092223 1123586 1128267
## 6   1272295 1359494 1437573 1478469 1499946 1570269 1675350 1808303 1880118
## 7    817462  869037  905738  941553  977306 1057933 1148001 1196226 1222597
## 8   1290892 1338839 1393338 1462655 1559789 1695823 1863607 1987827 2147936
## 9    425463  426081  425141  427037  440011  466962  522475  463261  523521
## 10 2329518 2562224 2782784 2981844 3187076 3462294 3677793 3703519 3524050
## 11 1671286 1767195 1849851 1794725 1729981 1710877 1800749 1919386 2015585
## 12 2789866 2974241 3098582 3217399 3414456 3439620 3540957 3383157 3239091
## 13 1275763 1415209 1512936 1560270 1650310 1769284 1861259 1896759 1899852
## 14 1999946 1892398 1744883 1697941 1807153 2012287 2178942 2286573 2284226
## 15 3485570 3418475 3337815 3368280 3608673 3959117 4392406 4852715 5422262
## 16 4694044 4742528 4841994 5072021 5406380 5698301 5906674 6040927 6077986
## 17 2180937 2363351 2612455 2840700 3010769 3172392 3319842 3341801 3224319
## 18 2149204 2143515 2143743 2235833 2489107 2972610 3528584 3822026 3754394
## 19 5001040 5036732 4978825 4829437 4758296 4627044 4495533 4321843 4149939
## 20 2003911 2065476 2119362 2219760 2290412 2339138 2410467 2449891 2471312
## 21  421593  445840  463780  474705  475365  466186  439092  418940  397982
## 22 1281724 1328175 1350451 1316698 1288052 1253778 1254784 1255823 1240367
## 23 3438646 3554513 3615083 3632702 3595157 3470817 3614111 3679899 3660933
## 24 2136599 2112917 2055674 2014110 2032209 2054382 2049364 1969955 1814034
## 25 2073500 2038185 2000076 1941244 1901616 1905763 1930879 1921251 1835840
## 26  138992  143187  139920  135995  127882  120706  109148   92060   72048
## 27 1643225 1802742 1941810 2037632 2118803 2139326 2192280 2212732 2140604
## 28 1384027 1410974 1420194 1422734 1444489 1377671 1344797 1306024 1260298
## 29  219463  214883  207231  219542  224954  226991  223162  214090  200474
## 30  306755  298922  291970  283505  290375  280950  269277  268948  265488
## 31 1003278 1027697 1064849 1115640 1170181 1153519 1158801 1133353 1066455
##       X2001   X2000   X1999
## 1    525844  512351  473422
## 2    450938  446430  428334
## 3   4213686 4117058 3844420
## 4   1740518 1660337 1590282
## 5   1085032 1040857  995456
## 6   1859905 1737624 1562444
## 7   1201895 1168514 1094484
## 8   2158178 2158672 2046920
## 9    557948  562129  539780
## 10 3246164 2934647 2666953
## 11 2028231 1941184 1786620
## 12 3083280 3041774 2944687
## 13 1942569 1962632 1973559
```

```
## 14 2246158 2206902 2146164
## 15 5780665 5699640 5264908
## 16 5886532 5629942 5077959
## 17 2997821 2810909 2587432
## 18 3503279 3291607 3028566
## 19 4054225 3881614 3797987
## 20 2450923 2487034 2360700
## 21  377803  375932  359666
## 22 1284945 1267003 1095743
## 23 3587236 3356703 2856294
## 24 1601444 1380966 1228515
## 25 1739587 1637575 1480201
## 26   56344   43121   34756
## 27 2016476 1877944 1693914
## 28 1183272 1085210  984753
## 29  188597  175269  160155
## 30  257889  250605  237254
## 31 1003155  934273  873343
```

```r
NCEE_function <- function(JHS, reg) {
    intercept <- rep(NA, 31)
    slope <- rep(NA, 31)
    cor <- rep(NA, 31)
    predict_year <- c("2023", "2022", "2021", "2020", "2019")
    prd_df <- data.frame(predict_year)
    prd_low <- data.frame(predict_year)
    prd_high <- data.frame(predict_year)

    for (i in 1:31) {
        city_JHS <- as.numeric(JHS[i, 7:18])/30000  # 2012-2001
        city_reg <- as.numeric(reg[i, 1:12])/10000  # 2018-2007
        city_lm.i <- lm(city_reg ~ city_JHS)

        intercept[i] <- as.numeric(city_lm.i$coefficients[1])
        slope[i] <- as.numeric(city_lm.i$coefficients[2])
        cor[i] <- cor(city_JHS, city_reg)

        predict_city <- predict(city_lm.i, newdata = data.frame(city_JHS = as.numeric(NCEE_JHS[i,
            2:6])/30000))
        predict_city_low <- predict(city_lm.i, newdata = data.frame(city_JHS = as.numeric(NCEE_JHS[i,
            2:6])/30000), interval = "confidence")[, 2]
        predict_city_high <- predict(city_lm.i, newdata = data.frame(city_JHS = as.numeric(NCEE_JHS[i,
            2:6])/30000), interval = "confidence")[, 3]

        prd_df <- data.frame(prd_df, predict_city)
        prd_low <- data.frame(prd_low, predict_city_low)
        prd_high <- data.frame(prd_high, predict_city_high)

    }

    colnames(prd_df) <- c("year", province)
    colnames(prd_low) <- c("year", province)
    colnames(prd_high) <- c("year", province)
```

```
    summm <- data.frame(province, intercept, slope, cor)

    return(list(summ, prd_df, prd_low, prd_high))
}


# Sum up all province prediction as the national total
predict_national <- rep(NA, 5)
for (i in 1:5) {
    predict_national[i] <- sum(as.numeric(NCEE_function(NCEE_JHS, NCEE_reg)[[2]][i,
        ]))
}  # 2023-2019
```

```
# =====Use National JHS as Predictors===== #

JHS_total <- NCEE_national$JHS[7:17]/30000
Reg_total <- NCEE_national$Reg[1:11]
new.data <- NCEE_national$JHS[2:6]/30000

test <- data.frame(JHS_total, Reg_total)

predict_national2 <- predict(lm(Reg_total ~ JHS_total, data = test), newdata = data.frame(JHS_total = ne
    interval = "confidence")
predict_national
```

```
## [1] 838.4952 830.3795 831.1387 839.2643 843.9974
```

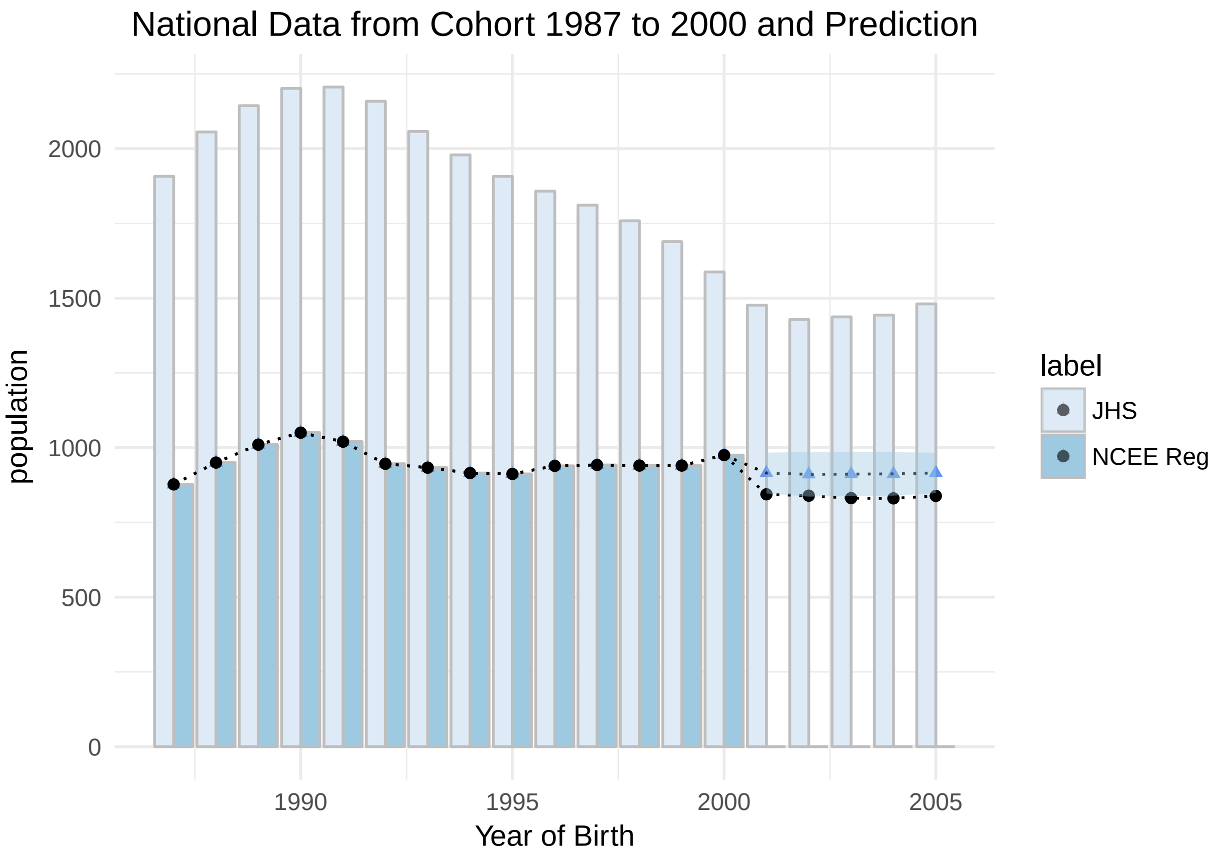
```
predict_national2
```

```
##        fit      lwr      upr
## 1 915.4487 847.6075 983.2899
## 2 912.1054 839.5374 984.6734
## 3 911.5534 838.1994 984.9074
## 4 910.7361 836.2158 985.2563
## 5 915.0885 846.7411 983.4360
```

```
# =====Plot prediction result===== #

national_reg <- c(rep(0, 5), NCEE_national$Reg[1:14])
national_JHS <- NCEE_national$JHS[2:20]/30000
year_born <- c(2005:1987)
predict_national_t <- c(rep(NA, 19), predict_national, national_reg[6:19])

predict_national_pf <- c(rep(NA, 19), prd_fit <- predict_national2[, 1], national_reg[6:19])
predict_national_pl <- c(rep(NA, 19), prd_fit <- predict_national2[, 2], rep(NA,
    14))
predict_national_ph <- c(rep(NA, 19), prd_fit <- predict_national2[, 3], rep(NA,
    14))

population <- c(national_JHS, national_reg)
label <- c(rep("JHS", 19), rep("NCEE Reg", 19))
year_birth <- rep(year_born, 2)

plot_df <- data.frame(population, label, year_birth, predict_national_t, predict_national_pf,
    predict_national_pl, predict_national_ph)
```

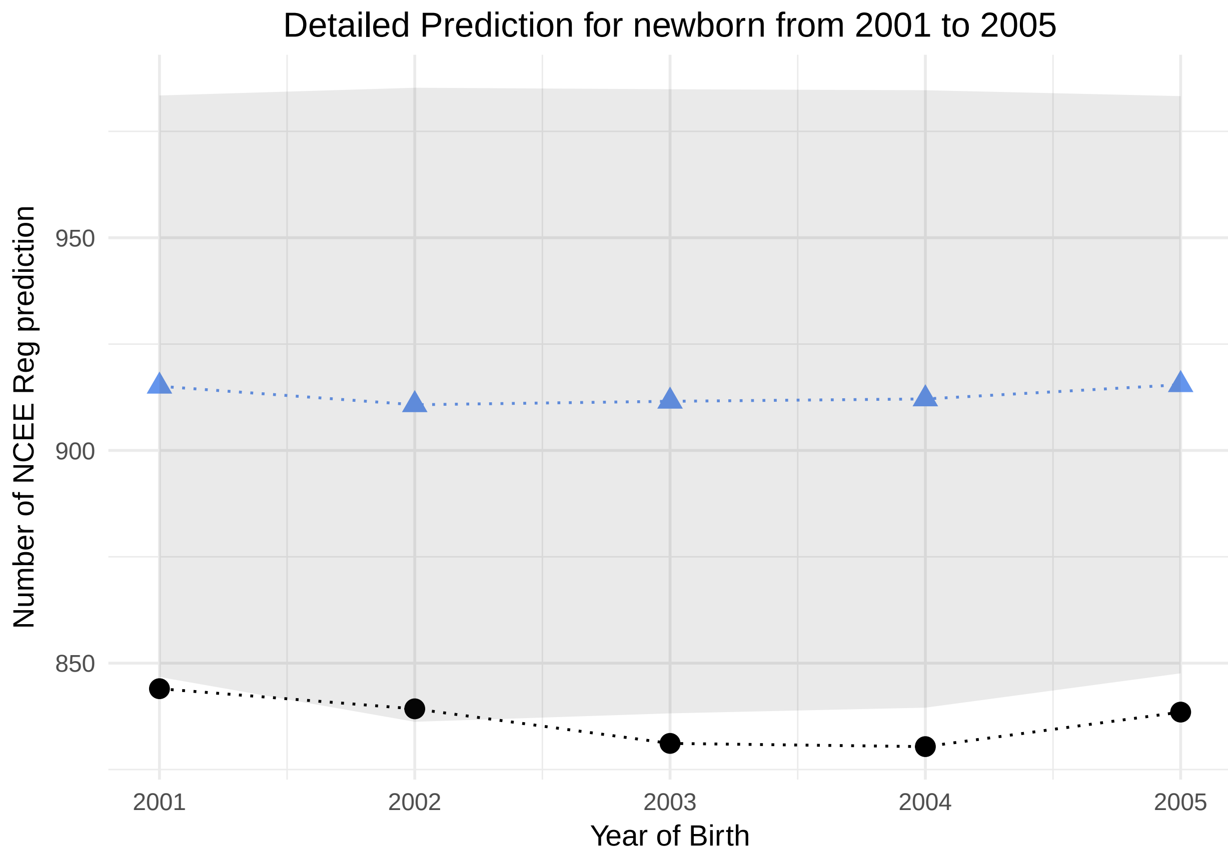
```r
ggplot(data = plot_df, aes(x = year_birth, y = population, fill = label)) +
    geom_bar(stat = "identity", color = "grey", position = position_dodge()) +
    geom_point(aes(x = year_birth, y = predict_national_pf), color = "cornflowerblue",
        shape = 17) + geom_point(aes(x = year_birth, y = predict_national_t)) +
    geom_line(aes(x = year_birth, y = predict_national_pf), linetype = "dotted") +
    geom_line(aes(x = year_birth, y = predict_national_t), linetype = "dotted") +
    geom_ribbon(aes(ymin = predict_national_pl, ymax = predict_national_ph,
        x = year_birth), linetype = 2, alpha = 0.4) + theme_minimal() + scale_fill_brewer(palette = "Bl
    ggtitle("National Data from Cohort 1987 to 2000 and Prediction") + theme(plot.title = element_text(
    xlab("Year of Birth")
```

```
## Warning: Removed 19 rows containing missing values (geom_point).

## Warning: Removed 19 rows containing missing values (geom_point).
```



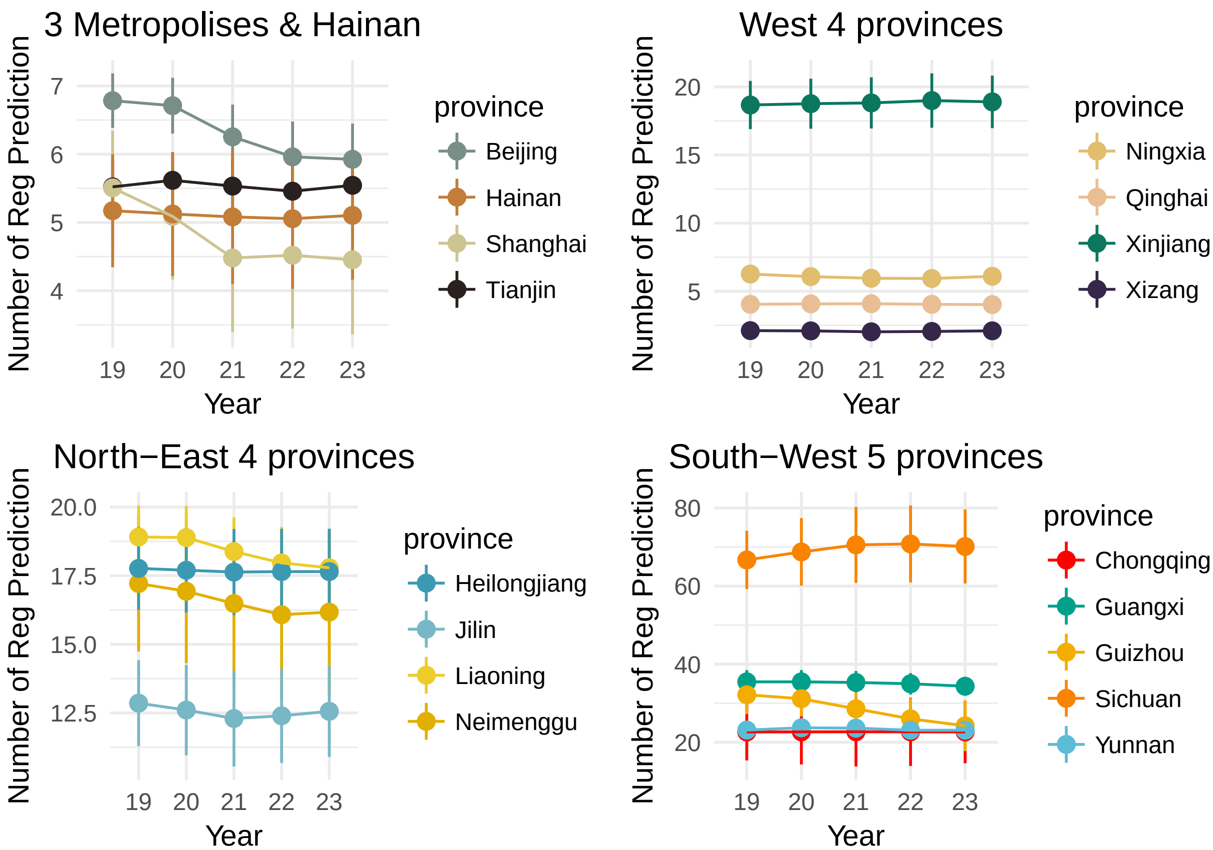

```r
new_born <- c(2005:2001)
new_plot <- data.frame(new_born, predict_national, predict_national2[, 1], predict_national2[,
    2], predict_national2[, 3])

ggplot(data = new_plot) + geom_line(aes(x = new_born, y = predict_national2[,
    1]), linetype = "dotted", color = "cornflowerblue") + geom_line(aes(x = new_born,
    y = predict_national), linetype = "dotted") + geom_point(aes(x = new_born,
    y = predict_national2[, 1]), color = "cornflowerblue", shape = 17, size = 3) +
    geom_point(aes(x = new_born, y = predict_national), size = 3) + geom_ribbon(aes(ymin = predict_nati
    2], ymax = predict_national2[, 3], x = new_born), linetype = 2, alpha = 0.1) +
    xlab("Year of Birth") + ylab("Number of NCEE Reg prediction") + ggtitle("Detailed Prediction for ne
```

```
    theme_minimal() + theme(plot.title = element_text(hjust = 0.5))
```

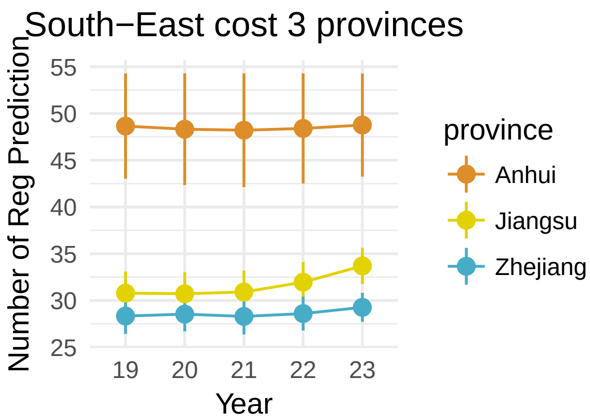


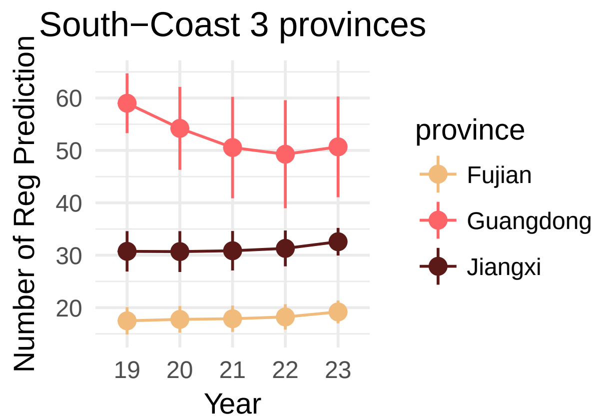

```
city.low <- NCEE_function(NCEE_JHS, NCEE_reg)[[3]]
city.low.nu <- as.vector(t(city.low[, 2:32]))
city.fit <- NCEE_function(NCEE_JHS, NCEE_reg)[[2]]
city.fit.nu <- as.vector(t(city.fit[, 2:32]))
city.high <- NCEE_function(NCEE_JHS, NCEE_reg)[[4]]
city.high.nu <- as.vector(t(city.high[, 2:32]))

year_prd <- c(rep("23", 31), rep("22", 31), rep("21", 31), rep("20", 31), rep("19",
    31))

pro_bind <- data.frame(year_prd, province = rep(province, 5), city.low.nu, city.fit.nu,
    city.high.nu)

pl1 <- pro_bind %>% subset(province %in% c("Beijing", "Tianjin", "Shanghai",
    "Hainan")) %>% ggplot(aes(year_prd, city.fit.nu, color = province)) + geom_pointrange(aes(ymin = ci
    ymax = city.high.nu)) + scale_color_manual(values = wes_palette("Moonrise2",
    4)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
    ylab("Number of Reg Prediction") + ggtitle("3 Metropolises & Hainan") +
    theme(plot.title = element_text(hjust = 0.5))

pl2 <- pro_bind %>% subset(province %in% c("Qinghai", "Ningxia", "Xizang", "Xinjiang")) %>%
    ggplot(aes(year_prd, city.fit.nu, color = province)) + geom_pointrange(aes(ymin = city.low.nu,
    ymax = city.high.nu)) + scale_color_manual(values = wes_palette("Rushmore1",
    4)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
```

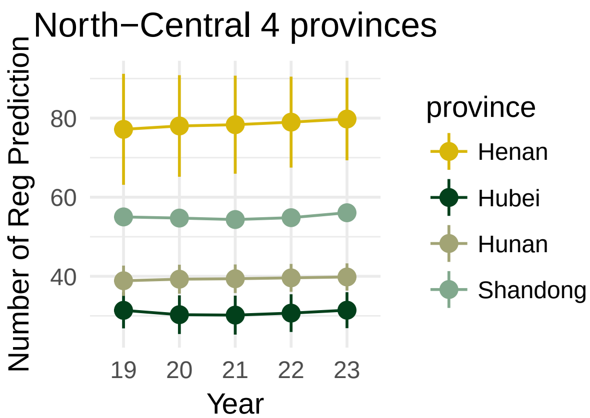
```
    ylab("Number of Reg Prediction") + ggtitle("West 4 provinces") + theme(plot.title = element_text(hju

pl3 <- pro_bind %>% subset(province %in% c("Heilongjiang", "Jilin", "Liaoning",
    "Neimenggu")) %>% ggplot(aes(year_prd, city.fit.nu, color = province)) +
    geom_pointrange(aes(ymin = city.low.nu, ymax = city.high.nu)) + scale_color_manual(values = wes_pale
    4)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
    ylab("Number of Reg Prediction") + ggtitle("North-East 4 provinces") + theme(plot.title = element_te

pl4 <- pro_bind %>% subset(province %in% c("Sichuan", "Guizhou", "Yunnan", "Guangxi",
    "Chongqing")) %>% ggplot(aes(year_prd, city.fit.nu, color = province)) +
    geom_pointrange(aes(ymin = city.low.nu, ymax = city.high.nu)) + scale_color_manual(values = wes_pale
    5)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
    ylab("Number of Reg Prediction") + ggtitle("South-West 5 provinces") + theme(plot.title = element_te

pl5 <- pro_bind %>% subset(province %in% c("Zhejiang", "Jiangsu", "Anhui")) %>%
    ggplot(aes(year_prd, city.fit.nu, color = province)) + geom_pointrange(aes(ymin = city.low.nu,
    ymax = city.high.nu)) + scale_color_manual(values = wes_palette("FantasticFox1",
    3)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
    ylab("Number of Reg Prediction") + ggtitle("South-East cost 3 provinces") +
    theme(plot.title = element_text(hjust = 0.5))

pl6 <- pro_bind %>% subset(province %in% c("Guangdong", "Fujian", "Jiangxi")) %>%
    ggplot(aes(year_prd, city.fit.nu, color = province)) + geom_pointrange(aes(ymin = city.low.nu,
    ymax = city.high.nu)) + scale_color_manual(values = wes_palette("GrandBudapest1",
    3)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
    ylab("Number of Reg Prediction") + ggtitle("South-Coast 3 provinces") +
    theme(plot.title = element_text(hjust = 0.5))

pl7 <- pro_bind %>% subset(province %in% c("Hunan", "Hubei", "Henan", "Shandong")) %>%
    ggplot(aes(year_prd, city.fit.nu, color = province)) + geom_pointrange(aes(ymin = city.low.nu,
    ymax = city.high.nu)) + scale_color_manual(values = wes_palette("Cavalcanti1",
    4)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
    ylab("Number of Reg Prediction") + ggtitle("North-Central 4 provinces") +
    theme(plot.title = element_text(hjust = 0.5))

pl8 <- pro_bind %>% subset(province %in% c("Shanxi", "Shaanxi", "Hebei", "Gansu")) %>%
    ggplot(aes(year_prd, city.fit.nu, color = province)) + geom_pointrange(aes(ymin = city.low.nu,
    ymax = city.high.nu)) + scale_color_manual(values = wes_palette("Rushmore",
    4)) + geom_line(aes(group = province)) + theme_minimal() + xlab("Year") +
    ylab("Number of Reg Prediction") + ggtitle("West-Central 4 provinces") +
    theme(plot.title = element_text(hjust = 0.5))

# =====Display===== #

grid.arrange(pl1, pl2, pl3, pl4, nrow = 2)
```

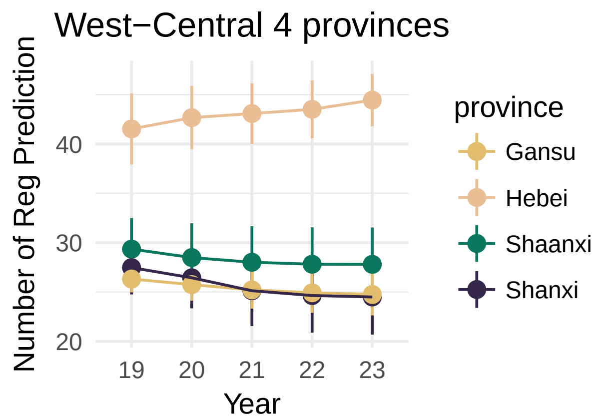



```
grid.arrange(pl5, pl6, pl7, pl8, nrow = 2)
```










```r
# ggplot(map('china', plot=F), aes(long, lat, group=group, fill=region)) +
# geom_path(show.legend = F) + ggtitle('Map of China') + geom_polygon()

# chinamap <- readRDS('gadm36_CHN_0_sp.rds')

# ggplot(chinamap, aes(long, lat, group=group)) + geom_polygon(fill='white',
# colour='gray') + ggtitle('Map of China')
```