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Create a scatterplot showing population size on the y axis and year on the x axis. Add lines to show three different model fits for the data: a linear model, a LOESS model, and a cubic spline model.

```
model_colors <- brewer.pal(3,"Dark2")
#model_colors
```

```
one_country <- gapminder %>%
  filter(country == "New Zealand")
p <- ggplot(data = one_country, mapping = aes(x = year, y = pop))

ggplotly(p + geom_point() +
    geom_smooth(method = "lm",
                aes(color = "Linear Model", fill = "Linear Model")) +
    geom_smooth(method = "loess",
                aes(color = "LOESS", fill = "LOESS")) +
    geom_smooth(method = "lm", formula = y ~ splines::bs(x, df = 3),
                aes(color = "Cubic Spline", fill = "Cubic Spline")) +
    scale_color_manual(name = "Models", values = model_colors) +
    scale_fill_manual(name = "Models", values = model_colors) +
    theme(legend.position = "top") +
    labs(x = "Year", y = "Population", title = "New Zealand Population Growth"))
```

```
reg <- lm(data=one_country, year~pop)
#summary(reg)
#reg$coefficients[1]
#reg$coefficients[2]
pred.y <- reg$coefficients[1] + reg$coefficients[2]*one_country$pop
```

Using the gapminder data, looking at only data from the Americas, fit a linear regression to predict population as a function of year and country. Calculate predicted values for years ranging from 1950 to 2025, in intervals of five years. Include a 95% prediction interval. Plot your predictions for two countries of your choosing. In addition, create a plot of the residuals versus the fitted values.

```
# Data from the Americas only
smaller_gapminder <- gapminder %>%
  filter(continent == "Americas")

# Predict population as a function of year and country
Americas_pop <- lm(formula = pop ~ year * country,
                   data = smaller_gapminder)
#summary(Americas_pop)
```

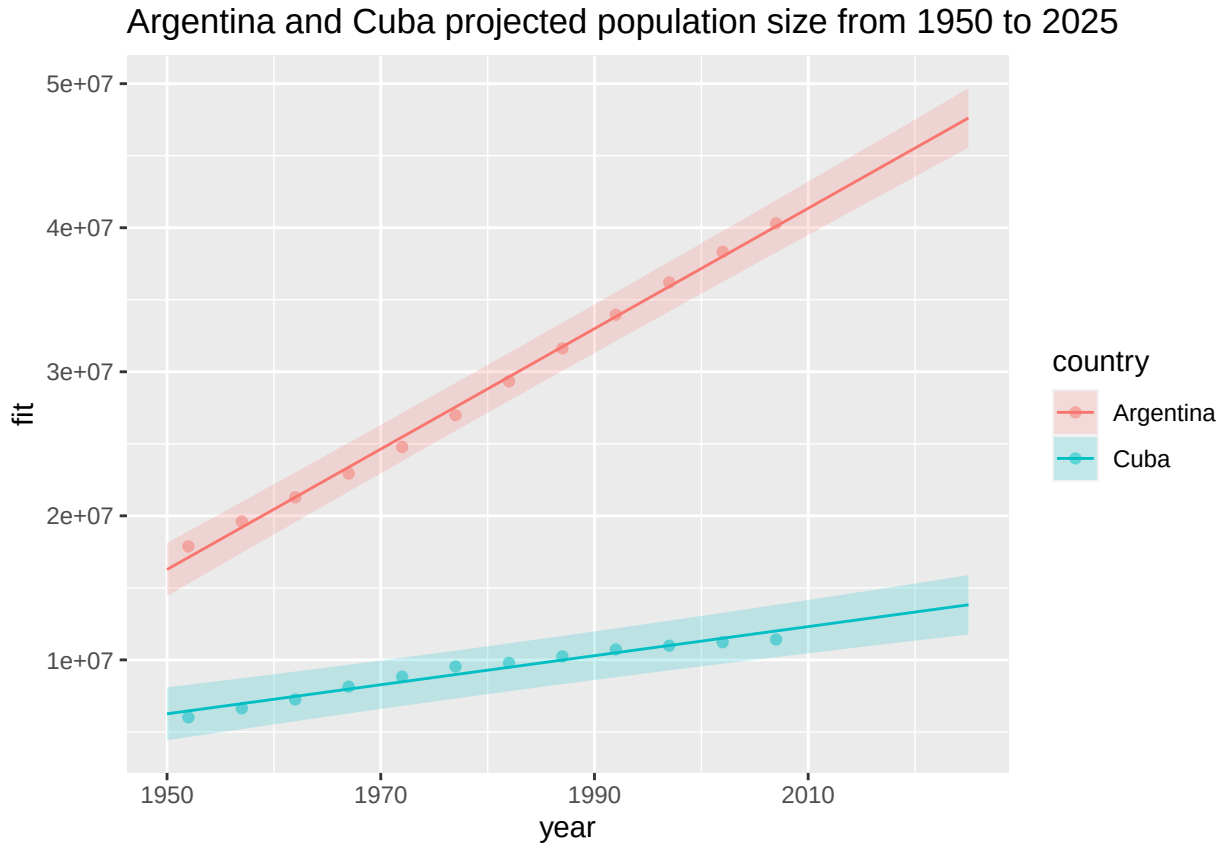
```
# Predict values for years ranging from 1950 to 2025 in intervals of 5 years
min_year <- 1950
max_year <- 2025
```

```r
pred_df <- expand.grid(year = (seq(from = 1950,
                                   to = 2025,
                                   # intervals of 5 years, [(2016 - 1950)/5 + 1]
                                   length.out = 16)),
                       country = c( "Argentina","Cuba"))
#pred_df

pred_Americas_pop <- predict(object = Americas_pop,
                             newdata = pred_df,
                             interval = "predict") #95% prediction interval
pred_df <- cbind(pred_df, pred_Americas_pop)

p <- ggplot(data = pred_df,
            aes(x = year,
                y = fit, ymin = lwr, ymax = upr,
                color = country,
                fill = country,
                group = country))

p + geom_point(data = subset(smaller_gapminder,
                             country %in% c("Cuba", "Argentina")),
               aes(x = year, y = pop,
                   color = country),
               alpha = 0.5,
               inherit.aes = FALSE) +
    geom_line() +
    geom_ribbon(alpha = 0.2, color = FALSE) +
    labs(title = "Argentina and Cuba projected population size from 1950 to 2025")
```




```
# Data from Argentina and Cuba only
smaller_gapminder1 <- gapminder %>%
  filter(country %in% c( "Cuba", "Argentina"))
Americas_pop1 <- lm(formula = pop ~ year * country,
                    data = smaller_gapminder1)

Americas_pop1_aug <- augment(Americas_pop1)
head(Americas_pop1_aug) %>% round_df()
```

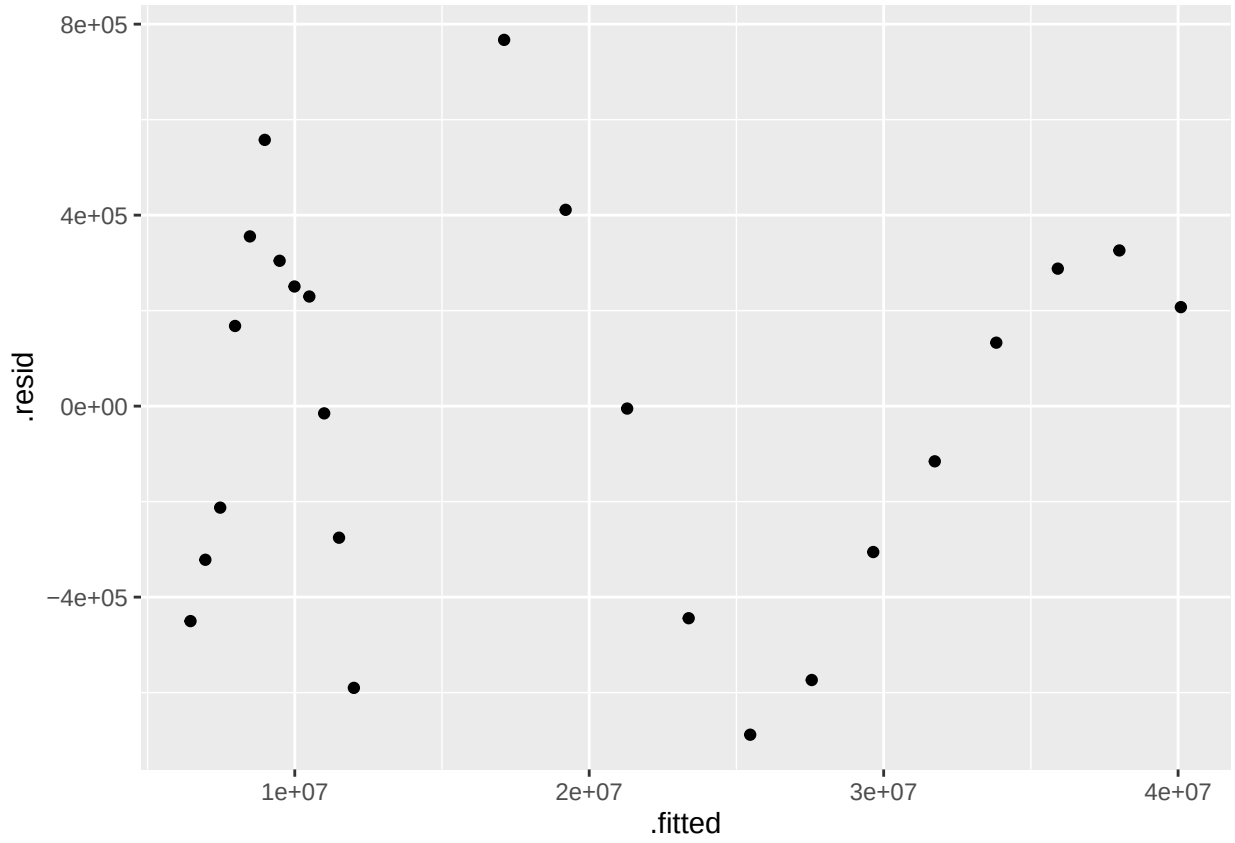
```
## # A tibble: 6 x 9
##        pop  year country     .fitted   .resid  .hat  .sigma .cooksd .std.resid
##      <dbl> <dbl> <fct>         <dbl>    <dbl> <dbl>   <dbl>   <dbl>      <dbl>
## 1 17876956  1952 Argentina 17109890.  767066. 0.290 378998.    0.49       2.16
## 2 19610538  1957 Argentina 19199408.  411130. 0.22  419618.    0.09       1.11
## 3 21283783  1962 Argentina 21288926.   -5143. 0.17  433077.    0         -0.01
## 4 22934225  1967 Argentina 23378444. -444219. 0.13  419119.    0.05      -1.13
## 5 24779799  1972 Argentina 25467963. -688164. 0.1   399865.    0.08      -1.72
## 6 26983828  1977 Argentina 27557481. -573653. 0.09  410642.    0.05      -1.42
```

```
Americas_pop1_aug <- augment(Americas_pop1, data = smaller_gapminder1)
head(Americas_pop1_aug) %>% round_df()
```

```
## # A tibble: 6 x 12
##   country  continent  year lifeExp    pop gdpPercap .fitted  .resid  .hat .sigma
##   <fct>    <fct>     <dbl>   <dbl>  <dbl>     <dbl>   <dbl>   <dbl> <dbl>  <dbl>
```

```
## 1 Argenti~ Americas   1952    62.5 1.79e7     5911.  1.71e7  7.67e5 0.290 3.79e5
## 2 Argenti~ Americas   1957    64.4 1.96e7     6857.  1.92e7  4.11e5 0.22  4.20e5
## 3 Argenti~ Americas   1962    65.1 2.13e7     7133.  2.13e7 -5.14e3 0.17  4.33e5
## 4 Argenti~ Americas   1967    65.6 2.29e7     8053.  2.34e7 -4.44e5 0.13  4.19e5
## 5 Argenti~ Americas   1972    67.1 2.48e7     9443.  2.55e7 -6.88e5 0.1   4.00e5
## 6 Argenti~ Americas   1977    68.5 2.70e7    10079.  2.76e7 -5.74e5 0.09  4.11e5
## # ... with 2 more variables: .cooksd <dbl>, .std.resid <dbl>
```

```
p <- ggplot(data = Americas_pop1_aug,
mapping = aes(x = .fitted, y = .resid))
p + geom_point()
```



Using the gapminder data, use the nest function to fit a separate regression model for every country in the Americas, predicting population size as a function of year. Use geom_pointrange() to display the slopes for each of these models, with error bars based on two standard errors.

```
out_le <- smaller_gapminder %>%
    group_by(country) %>%
    nest()

#out_le
fit_ols <- function(df) {
    lm(pop ~ year, data = df)
}
```

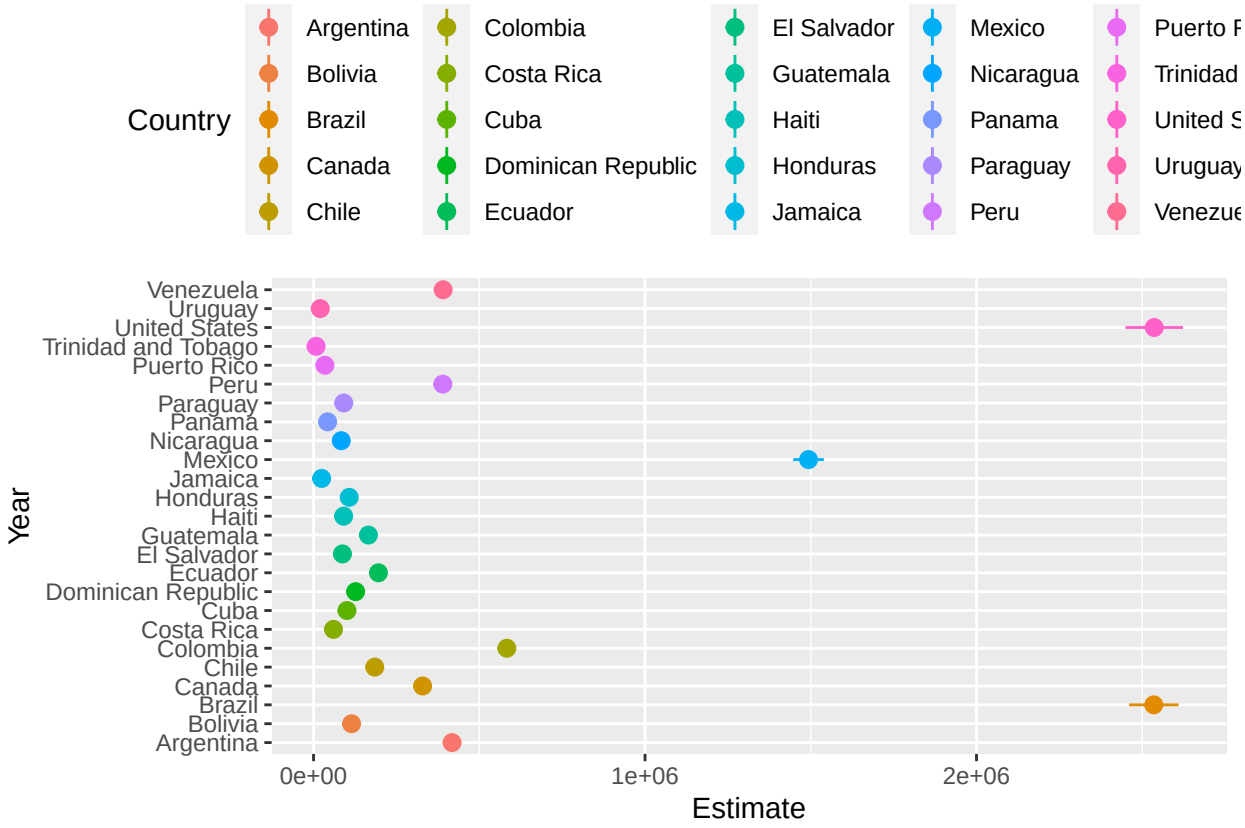
```r
out_le <- smaller_gapminder %>%
    group_by(country) %>%
    nest() %>%
    mutate(model = map(data, fit_ols))

#out_le
fit_ols <- function(df) {
    lm(pop ~ year, data = df)
}

out_tidy <- smaller_gapminder %>%
    group_by(country) %>%
    nest() %>%
    mutate(model = map(data, fit_ols),
           tidied = map(model, tidy)) %>%
    unnest(tidied, .drop = TRUE) %>%
    filter(term %nin% "(Intercept)")

#out_tidy
p <- ggplot(data = out_tidy,
            mapping = aes(x = country, y = estimate,
                          ymin = estimate - 2*std.error,
                          ymax = estimate + 2*std.error,
                          group = country, color = country))

p + geom_pointrange(position = position_dodge(width = 1)) +
    scale_x_discrete(breaks = unique(smaller_gapminder$country)) +
    coord_flip() +
    theme(legend.position = "top") +
    labs(x = "Year", y = "Estimate", color = "Country")
```


Country
Argentina
Bolivia
Brazil
Canada
Chile
Colombia
Costa Rica
Cuba
Dominican Republic
Ecuador
El Salvador
Guatemala
Haiti
Honduras
Jamaica
Mexico
Nicaragua
Panama
Paraguay
Peru
Puerto R
Trinidad
United S
Uruguay
Venezue
Year
Venezuela
Uruguay
United States
Trinidad and Tobago
Puerto Rico
Peru
Paraguay
Panama
Nicaragua
Mexico
Jamaica
Honduras
Haiti
Guatemala
El Salvador
Ecuador
Dominican Republic
Cuba
Costa Rica
Colombia
Chile
Canada
Brazil
Bolivia
Argentina
0e+00
1e+06
2e+06
Estimate