Gender Pay Inequality in the EU: Sectoral and Regional Analysis

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Part 1 - Identify a Social Problem

1.1 Describe the Social Problem

ALIYA

References:
ALIYA

Part 2 - Data Sourcing

2.1 Load in the Data

```
# Read CSVs from project GitHub repo structure
TableCountries = read_csv("data/TableCountries.csv")
Germany_subgroup = read_csv("data/Germany_subgroup/Germany_subgroup.csv")
```

2.2 Summary of the Dataset

```
head(TableCountries)
```

```
## # A tibble: 6 x 7
##    ...1 country  year gender_pay_gap monthly_income p_female p_male
##   <dbl> <chr>   <dbl>          <dbl>          <dbl>    <dbl>  <dbl>
## 1     1 Austria  2021           19.1          4014.    0.410  0.590
## 2     2 Austria  2022           18.7          4228.    0.414  0.586
## 3     3 Austria  2023           18.3          4542.    0.412  0.588
## 4     4 Belgium  2021            1.8          4141.    0.429  0.571
## 5     5 Belgium  2022            0.7          4452.    0.434  0.566
## 6     6 Belgium  2023            0.7          4832.    0.432  0.568
```

The EU-wide data set includes country-level variables such as the gender pay gap, average monthly income, and male and female share in workforce for 2021–2023. The Germany subgroup includes sector-level earnings, gender pay gaps, and gender share in workforce.

2.3 Describe the Type of Variables

The data sets are compiled from administrative sources such as Eurostat and Destatis. Variables include: - **gender_pay_gap**: percentage difference in male vs female income - **monthly_income**: average monthly gross pay (€) - **p_female / p_male**: employment shares by gender - **income_eur**: average monthly income by sector in Germany - **gpg_2023**: sector-specific gender pay gap

Part 3 - Quantifying

3.1 Data Cleaning

```
TableCountries$year = as.factor(TableCountries$year)
Germany_subgroup$income_quartile = cut(Germany_subgroup$income_eur,
  breaks = quantile(Germany_subgroup$income_eur, probs = seq(0, 1, 0.25), na.rm = TRUE),
  include.lowest = TRUE,
  labels = c("Q1 (lowest)", "Q2", "Q3", "Q4 (highest)"))
```

3.2 Generate Necessary Variables

```
# EU country-level income estimation
male_income = numeric(nrow(TableCountries))
female_income = numeric(nrow(TableCountries))
for (i in 1:nrow(TableCountries)) {
  income = TableCountries$monthly_income[i]
  gpg = TableCountries$gender_pay_gap[i] / 100
  p_f = TableCountries$p_female[i]
  p_m = TableCountries$p_male[i]

  if (any(is.na(c(income, gpg, p_f, p_m))) || (p_m + p_f * (1 - gpg) == 0)) {
    male_income[i] = NA
    female_income[i] = NA
  } else {
    male_income[i] = income / (p_m + p_f * (1 - gpg))
    female_income[i] = male_income[i] * (1 - gpg)
  }
}
TableCountries$male_income = round(male_income, 2)
TableCountries$female_income = round(female_income, 2)
```

```
# Germany sectoral level
male_income = numeric(nrow(Germany_subgroup))
female_income = numeric(nrow(Germany_subgroup))
for (i in 1:nrow(Germany_subgroup)) {
  income = Germany_subgroup$income_eur[i]
  gpg = Germany_subgroup$gpg_2023[i] / 100
  p_f = Germany_subgroup$p_female[i]
  p_m = Germany_subgroup$p_male[i]
  male_income[i] = income / (p_m + p_f * (1 - gpg))
  female_income[i] = male_income[i] * (1 - gpg)
}
Germany_subgroup$male_income = round(male_income, 2)
Germany_subgroup$female_income = round(female_income, 2)
```

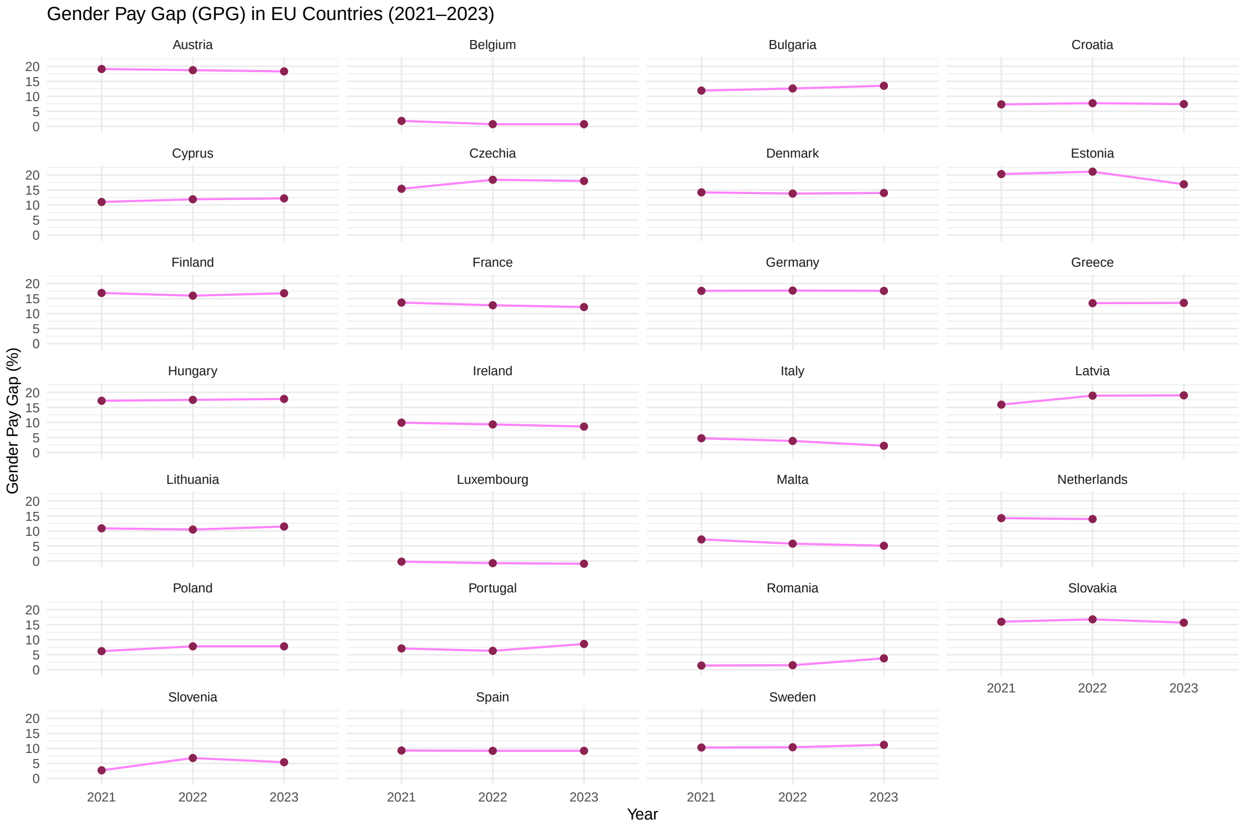
3.3 Visualize Temporal Variation

```
eu_countries = c("Austria", "Belgium", "Bulgaria", "Croatia", "Cyprus", "Czechia", "Denmark", "Estonia"

TableCountries_filtered = TableCountries %>%
  filter(country %in% eu_countries) %>%
  arrange(factor(country, levels = eu_countries))

ggplot(TableCountries_filtered, aes(x = year, y = gender_pay_gap, group = 1)) +
  geom_line(color = "orchid1", linewidth = 0.7) +
  geom_point(color = "violetred4", size = 2) +
  facet_wrap(~ country, ncol = 4, nrow = 7) +
  scale_y_continuous(limits = c(-1, 22)) +
  labs(
    title = "Gender Pay Gap (GPG) in EU Countries (2021-2023)",
    x = "Year", y = "Gender Pay Gap (%)"
  ) +
  theme_minimal(base_size = 11)
```

```
## Warning: Removed 2 rows containing missing values or values outside the scale range
## (‘geom_point()‘).
```



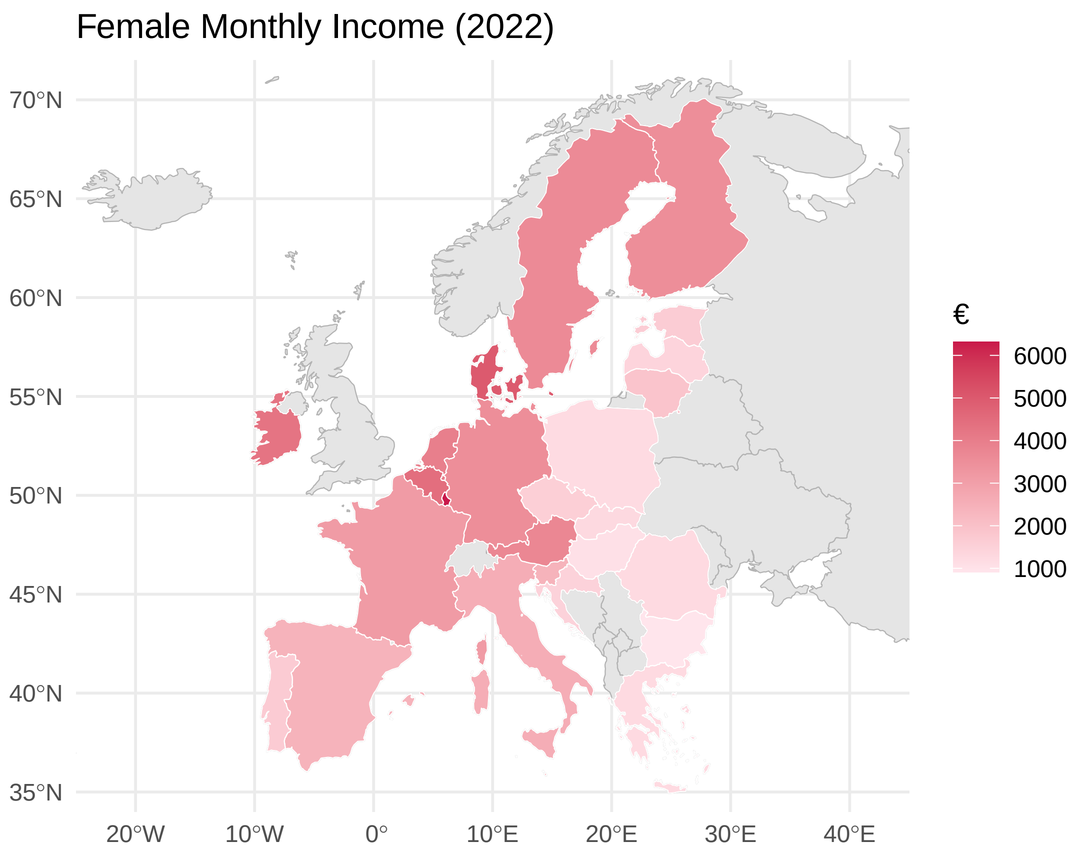
```
ggsave("gpg_eu_2021_2023.png", width = 12, height = 9, dpi = 300)
```

```
## Warning: Removed 2 rows containing missing values or values outside the scale range
## (‘geom_point()‘).
```

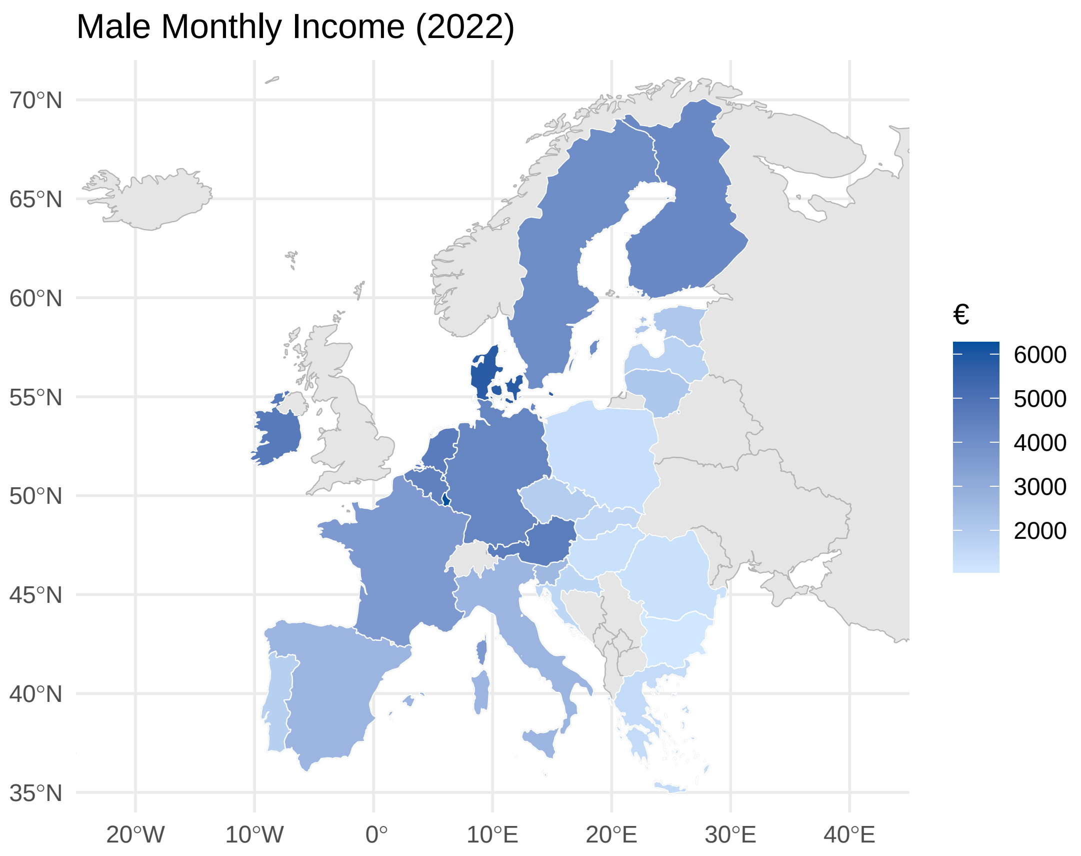
3.4 Visualize Spatial Variation

```
all_europe = rnaturalearth::ne_countries(scale = "medium", returnclass = "sf") %>%
  filter(region_un == "Europe")
eu_data_2022 = TableCountries %>% filter(year == 2022)
europe_map = all_europe %>%
  left_join(eu_data_2022, by = c("name" = "country")) %>%
  filter(!is.na(monthly_income))

ggplot() +
  geom_sf(data = all_europe, fill = "grey90", color = "grey70", size = 0.2) +
  geom_sf(data = europe_map, aes(fill = female_income), color = "white", size = 0.3) +
  scale_fill_gradient(low = "#FFE5EC", high = "#C9184A", name = "€") +
  labs(title = "Female Monthly Income (2022)") +
  coord_sf(xlim = c(-25, 45), ylim = c(34, 72), expand = FALSE) +
  theme_minimal()
```



```
ggplot() +
  geom_sf(data = all_europe, fill = "grey90", color = "grey70", size = 0.2) +
  geom_sf(data = europe_map, aes(fill = male_income), color = "white", size = 0.3) +
  scale_fill_gradient(low = "#D0E8FF", high = "#00509D", name = "€") +
  labs(title = "Male Monthly Income (2022)") +
  coord_sf(xlim = c(-25, 45), ylim = c(34, 72), expand = FALSE) +
  theme_minimal()
```

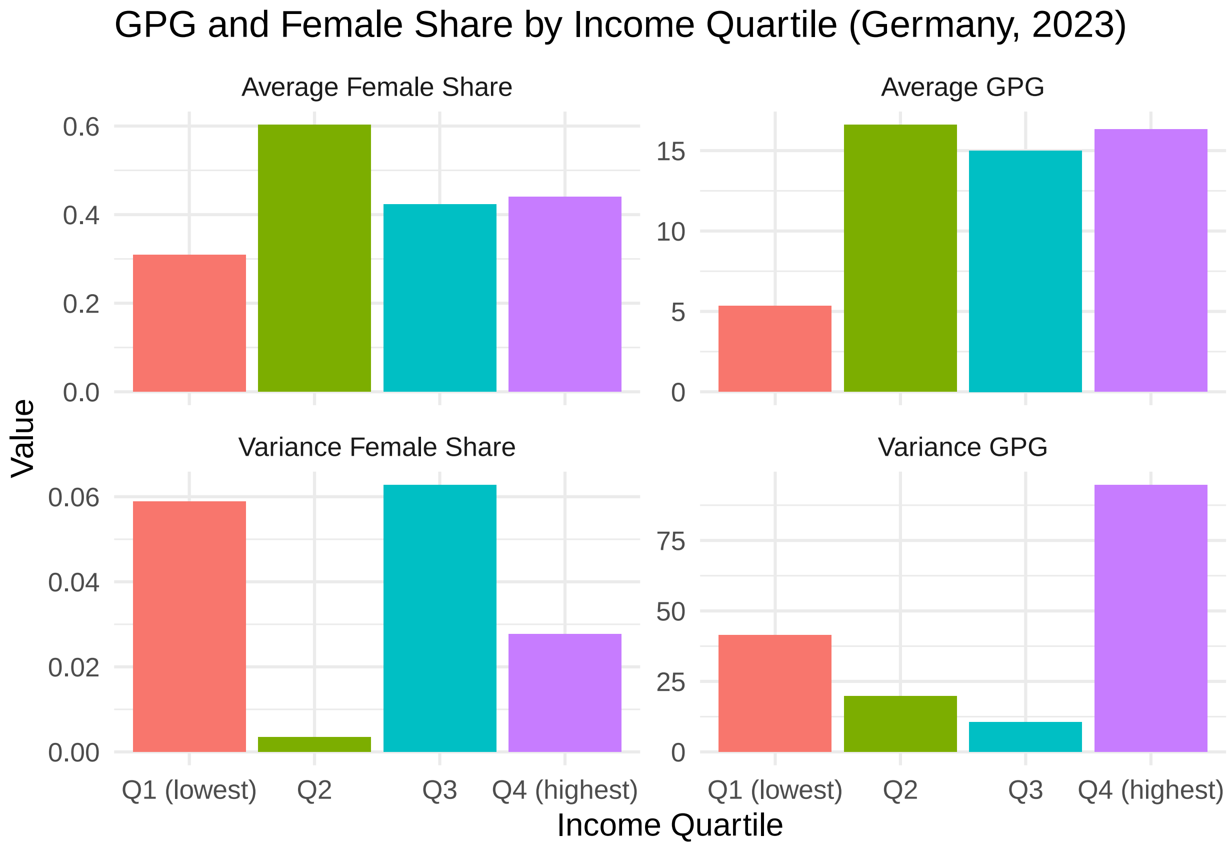


3.5 Visualize Sub-Population Variation

```r
quartile_summary = Germany_subgroup %>%
  group_by(income_quartile) %>%
  summarise(
    avg_income = mean(income_eur),
    avg_gpg = mean(gpg_2023),
    var_gpg = var(gpg_2023),
    avg_p_female = mean(p_female),
    var_p_female = var(p_female),
    n_sectors = n()
  )

quartile_long = quartile_summary %>%
  select(income_quartile, avg_gpg, var_gpg, avg_p_female, var_p_female) %>%
  pivot_longer(cols = -income_quartile, names_to = "metric", values_to = "value") %>%
  mutate(metric = recode(metric,
    avg_gpg = "Average GPG",
    var_gpg = "Variance GPG",
    avg_p_female = "Average Female Share",
    var_p_female = "Variance Female Share"
  ))

ggplot(quartile_long, aes(x = income_quartile, y = value, fill = income_quartile)) +
  geom_col(show.legend = FALSE) +
  facet_wrap(~ metric, ncol = 2, scales = "free_y") +
  labs(
    title = "GPG and Female Share by Income Quartile (Germany, 2023)",
    x = "Income Quartile", y = "Value"
  ) +
  theme_minimal(base_size = 12)
```

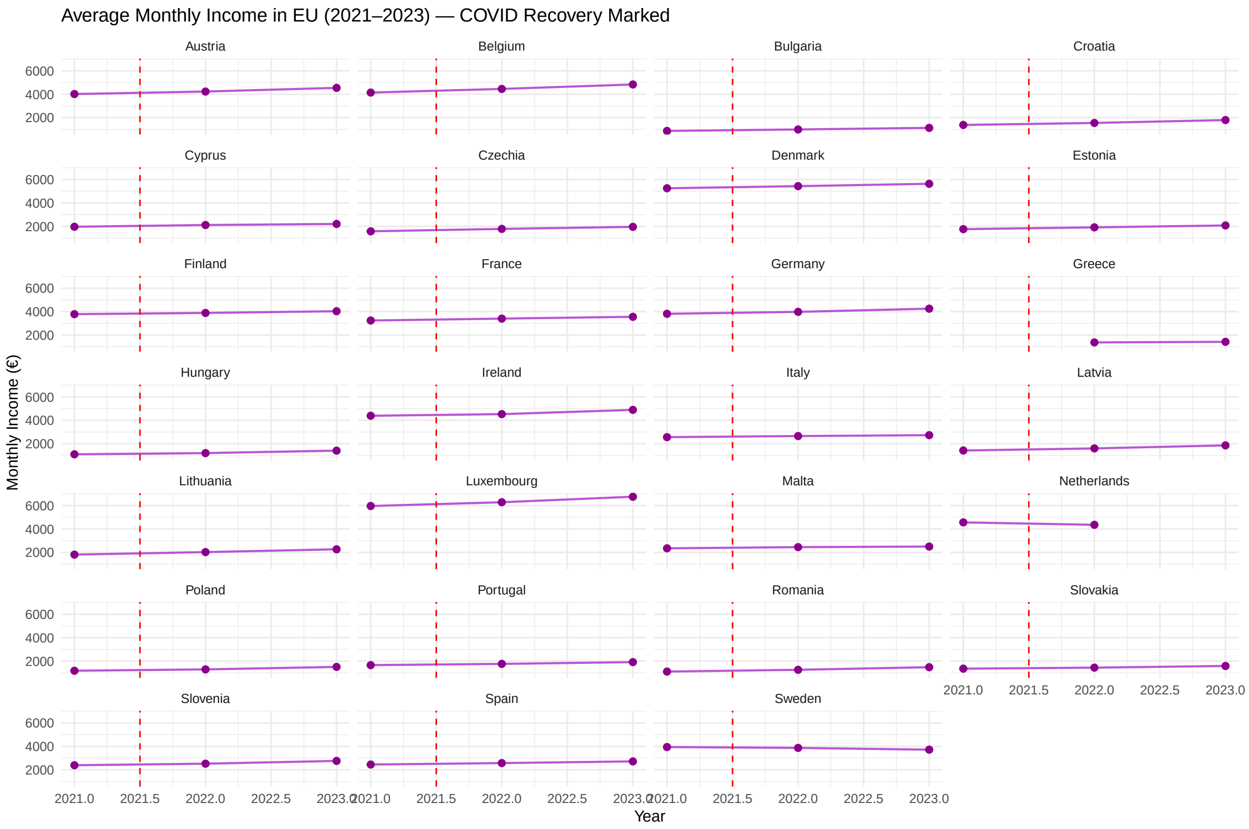


3.6 Event Analysis

```r
filtered_data = TableCountries %>%
  filter(country %in% eu_countries) %>%
  mutate(year_numeric = as.numeric(as.character(year)))

ggplot(filtered_data, aes(x = year_numeric, y = monthly_income, group = 1)) +
  geom_line(color = "mediumorchid", linewidth = 0.7) +
  geom_point(color = "darkmagenta", size = 2) +
  geom_vline(xintercept = 2021.5, linetype = "dashed", color = "red", linewidth = 0.5) +
  facet_wrap(~ country, ncol = 4, nrow = 7) +
  labs(
    title = "Average Monthly Income in EU (2021-2023) - COVID Recovery Marked",
    x = "Year", y = "Monthly Income (€)"
  ) +
  theme_minimal(base_size = 11)
```

```
## Warning: Removed 2 rows containing missing values or values outside the scale range
## (‘geom_point()‘).
```



Part 4 - Discussion

4.1 Discuss Your Findings

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Part 5 - Reproducibility

5.1 Github Repository Link

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5.2 Reference List

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