

# Productivity versus Participation: Divergent Growth Paths in North America and East Asia

Kei Nie, Felix Huang, Yunqing Chen, Jackson Fang

```
import sys, os
print("sys.executable:", sys.executable)
print("CONDA_DEFAULT_ENV:", os.environ.get("CONDA_DEFAULT_ENV"))
```

```
sys.executable: /Users/jackson/anaconda3/bin/python
CONDA_DEFAULT_ENV: base
```

## Introduction

Our study examines how labour-force utilization, income levels and short-run growth interact in two North-American economies—the United States and Canada—and two large East-Asian economies—China and Japan—during the period 1990 to 2023.

## Data

```
→ Loading raw table: gdp_raw from '../data/gdp.csv'
→ Loading raw table: emp_raw from '../data/emp.csv'
→ Loading raw table: gdp_growth_raw from '../data/gdp_growth.csv'
All raw tables loaded into SQLite.
```

```

--- gdp_raw ---
['Country Name', 'Indicator Name', '1990', '1991', '1992', '1993', '1994', '1995', '1996', '1997', '1998', '1999', '2000', '2001', '2002', '2003', '2004', '2005', '2006', '2007', '2008', '2009', '2010', '2011', '2012', '2013', '2014', '2015', '2016', '2017', '2018', '2019', '2020', '2021', '2022', '2023', '2024', '2025', '2026', '2027', '2028', '2029', '2030', '2031', '2032', '2033', '2034', '2035', '2036', '2037', '2038', '2039', '2040', '2041', '2042', '2043', '2044', '2045', '2046', '2047', '2048', '2049', '2050', '2051', '2052', '2053', '2054', '2055', '2056', '2057', '2058', '2059', '2060', '2061', '2062', '2063', '2064', '2065', '2066', '2067', '2068', '2069', '2070', '2071', '2072', '2073', '2074', '2075', '2076', '2077', '2078', '2079', '2080', '2081', '2082', '2083', '2084', '2085', '2086', '2087', '2088', '2089', '2090', '2091', '2092', '2093', '2094', '2095', '2096', '2097', '2098', '2099', '2100']
('Canada', 'GDP per capita (constant 2015 US$)', 31700.54627, 30654.33314, 30563.37882, 31030.12345, 31123.45678, 31234.56789, 31345.67890, 31456.78901, 31567.89012, 31678.90123, 31789.01234, 31890.12345, 31901.23456, 32012.34567, 32123.45678, 32234.56789, 32345.67890, 32456.78901, 32567.89012, 32678.90123, 32789.01234, 32890.12345, 32901.23456, 33012.34567, 33123.45678, 33234.56789, 33345.67890, 33456.78901, 33567.89012, 33678.90123, 33789.01234, 33890.12345, 33901.23456, 34012.34567, 34123.45678, 34234.56789, 34345.67890, 34456.78901, 34567.89012, 34678.90123, 34789.01234, 34890.12345, 34901.23456, 35012.34567, 35123.45678, 35234.56789, 35345.67890, 35456.78901, 35567.89012, 35678.90123, 35789.01234, 35890.12345, 35901.23456, 36012.34567, 36123.45678, 36234.56789, 36345.67890, 36456.78901, 36567.89012, 36678.90123, 36789.01234, 36890.12345, 36901.23456, 37012.34567, 37123.45678, 37234.56789, 37345.67890, 37456.78901, 37567.89012, 37678.90123, 37789.01234, 37890.12345, 37901.23456, 38012.34567, 38123.45678, 38234.56789, 38345.67890, 38456.78901, 38567.89012, 38678.90123, 38789.01234, 38890.12345, 38901.23456, 39012.34567, 39123.45678, 39234.56789, 39345.67890, 39456.78901, 39567.89012, 39678.90123, 39789.01234, 39890.12345, 39901.23456, 40012.34567, 40123.45678, 40234.56789, 40345.67890, 40456.78901, 40567.89012, 40678.90123, 40789.01234, 40890.12345, 40901.23456, 41012.34567, 41123.45678, 41234.56789, 41345.67890, 41456.78901, 41567.89012, 41678.90123, 41789.01234, 41890.12345, 41901.23456, 42012.34567, 42123.45678, 42234.56789, 42345.67890, 42456.78901, 42567.89012, 42678.90123, 42789.01234, 42890.12345, 42901.23456, 43012.34567, 43123.45678, 43234.56789, 43345.67890, 43456.78901, 43567.89012, 43678.90123, 43789.01234, 43890.12345, 43901.23456, 44012.34567, 44123.45678, 44234.56789, 44345.67890, 44456.78901, 44567.89012, 44678.90123, 44789.01234, 44890.12345, 44901.23456, 45012.34567, 45123.45678, 45234.56789, 45345.67890, 45456.78901, 45567.89012, 45678.90123, 45789.01234, 45890.12345, 45901.23456, 46012.34567, 46123.45678, 46234.56789, 46345.67890, 46456.78901, 46567.89012, 46678.90123, 46789.01234, 46890.12345, 46901.23456, 47012.34567, 47123.45678, 47234.56789, 47345.67890, 47456.78901, 47567.89012, 47678.90123, 47789.01234, 47890.12345, 47901.23456, 48012.34567, 48123.45678, 48234.56789, 48345.67890, 48456.78901, 48567.89012, 48678.90123, 48789.01234, 48890.12345, 48901.23456, 49012.34567, 49123.45678, 49234.56789, 49345.67890, 49456.78901, 49567.89012, 49678.90123, 49789.01234, 49890.12345, 49901.23456, 50012.34567, 50123.45678, 50234.56789, 50345.67890, 50456.78901, 50567.89012, 50678.90123, 50789.01234, 50890.12345, 50901.23456, 51012.34567, 51123.45678, 51234.56789, 51345.67890, 51456.78901, 51567.89012, 51678.90123, 51789.01234, 51890.12345, 51901.23456, 52012.34567, 52123.45678, 52234.56789, 52345.67890, 52456.78901, 52567.89012, 52678.90123, 52789.01234, 52890.12345, 52901.23456, 53012.34567, 53123.45678, 53234.56789, 53345.67890, 53456.78901, 53567.89012, 53678.90123, 53789.01234, 53890.12345, 53901.23456, 54012.34567, 54123.45678, 54234.56789, 54345.67890, 54456.78901, 54567.89012, 54678.90123, 54789.01234, 54890.12345, 54901.23456, 55012.34567, 55123.45678, 55234.56789, 55345.67890, 55456.78901, 55567.89012, 55678.90123, 55789.01234, 55890.12345, 55901.23456, 56012.34567, 56123.45678, 56234.56789, 56345.67890, 56456.78901, 56567.89012, 56678.90123, 56789.01234, 
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[('Country Name', 'Indicator Name', '1990', '1991', '1992', '1993', '1994', '1995', '1996', '1997', '1998', '1999', '2000'), ('Canada', 'Employment to population ratio, 15+, total (%) (modeled ILO estimate)', None, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0), ('China', 'Employment to population ratio, 15+, total (%) (modeled ILO estimate)', None, 76.8, 76.8, 76.8, 76.8, 76.8, 76.8, 76.8, 76.8, 76.8, 76.8), ('United Kingdom', 'Employment to population ratio, 15+, total (%) (modeled ILO estimate)', None, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4), ('Japan', 'Employment to population ratio, 15+, total (%) (modeled ILO estimate)', None, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4, 62.4), ('United States', 'Employment to population ratio, 15+, total (%) (modeled ILO estimate)', None, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0, 59.0)]
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[('Country Name', 'Indicator Name', '1990', '1991', '1992', '1993', '1994', '1995', '1996', '1997', '1998', '1999', '2000', '2001', '2002', '2003', '2004', '2005', '2006', '2007', '2008', '2009', '2010', '2011', '2012', '2013', '2014', '2015', '2016', '2017', '2018', '2019', '2020', '2021', '2022'), ('Canada', 'GDP growth (annual %)', 0.202947863, -2.091055179, 0.890466255, 2.657706883, 4.424111111, 3.920251368, 9.262786085, 14.22452959, 13.8837293, 13.03681111, 12.72222222, 12.40740741, 12.09259259, 11.77777778, 11.46296296, 11.14814815, 10.83333333, 10.51851852, 10.2037037, 9.88888889, 9.57407407, 9.25925926, 8.94444444, 8.62962963, 8.31481481, 8.0, 7.68518519, 7.37037037, 7.05555556, 6.74074074, 6.42592593, 6.11111111, 5.7962963, 5.48148148, 5.16666667, 4.85185185, 4.53703704, 4.22222222, 3.90740741, 3.59259259, 3.27777778, 2.96296296, 2.64814815, 2.33333333, 2.01851852, 1.7037037, 1.38888889, 1.07407407, 0.75925926, 0.44444444, 0.12962963, -0.18518519, -0.5, -0.81481481, -1.12962963, -1.44444444, -1.75925926, -2.07407407, -2.38888889, -2.7037037, -3.01851852, -3.33333333, -3.64814815, -3.96296296, -4.27777778, -4.59259259, -4.90740741, -5.22222222, -5.53703704, -5.85185185, -6.16666667, -6.48148148, -6.8, -7.11481481, -7.42962963, -7.75, -8.06944444, -8.38888889, -8.70740741, -9.02592593, -9.34444444, -9.66296296, -9.98148148, -10.3, -10.61481481, -10.92962963, -11.24444444, -11.55925926, -11.87407407, -12.18888889, -12.5037037, -12.81851852, -13.13333333, -13.44814815, -13.76296296, -14.07777778, -14.39259259, -14.70740741, -15.02222222, -15.33703704, -15.65185185, -15.96666667, -16.28148148, -16.5962963, -16.91111111, -17.22592593, -17.54444444, -17.86296296, -18.18148148, -18.5, -18.81481481, -19.12962963, -19.44444444, -19.75925926, -20.07407407, -20.38888889, -20.7037037, -21.01851852, -21.33333333, -21.64814815, -21.96296296, -22.27777778, -22.59259259, -22.90740741, -23.22222222, -23.53703704, -23.85185185, -24.16666667, -24.48148148, -24.8, -25.11481481, -25.42962963, -25.74444444, -26.05925926, -26.37407407, -26.68888889, -27.0037037, -27.31851852, -27.63333333, -27.94814815, -28.26296296, -28.57777778, -28.89259259, -29.20740741, -29.52222222, -29.83703704, -30.15185185, -30.46666667, -30.78148148, -31.0962963, -31.41111111, -31.72592593, -32.04444444, -32.35925926, -32.67407407, -32.98888889, -33.3037037, -33.61851852, -33.93333333, -34.24814815, -34.56296296, -34.87777778, -35.19259259, -35.50740741, -35.82222222, -36.13703704, -36.45185185, -36.76666667, -37.08148148, -37.3962963, -37.71111111, -38.02592593, -38.34444444, -38.65925926, -38.97407407, -39.28888889, -39.6037037, -39.91851852, -40.23333333, -40.54814815, -40.86296296, -41.17777778, -41.49259259, -41.80740741, -42.12222222, -42.43703704, -42.75185185, -43.06666667, -43.38148148, -43.6962963, -44.01111111, -44.32592593, -44.64444444, -44.95925926, -45.27407407, -45.58888889, -45.9037037, -46.21851852, -46.53333333, -46.84814815, -47.16296296, -47.47777778, -47.79259259, -48.10740741, -48.42222222, -48.73703704, -49.05185185, -49.36666667, -49.68148148, -49.9962963, -50.31111111, -50.62592593, -50.94444444, -51.25925926, -51.57407407, -51.88888889, -52.2037037, -52.51851852, -52.83333333, -53.14814815, -53.46296296, -53.77777778, -54.09259259, -54.40740741, -54.72222222, -55.03703704, -55.35185185, -55.66666667, -55.98148148, -56.2962963, -56.61111111, -56.92592593, -57.24444444, -57.55925926, -57.87407407, -58.18888889, -58.5037037, -58.81851852, -59.13333333, -59.44814815, -59.76296296, -60.07777778, -60.39259259, -60.70740741, -61.02222222, -61.33703704, -61.65185185, -61.96666667, -62.28148148, -62.5962963, -62.91111111, -63.22592593, -63.54444444, -63.85925926, -64.17407407, -64.48888889, -64.8037037, -65.11851852, -65.43333333, -65.74814815, -66.06296296, -66.37777778, -66.69259259, -67.00740741, -67.32222222, -67.63703704, -67.95185185, -68.26666667, -68.58148148, -68.8962963, -69.21111111, -69.52592593, -69.84444444, -70.15925926, -70.47407407, -70.78888889, -71.1037037, -71.41851852, -71.73333333, -72.04814815, -72.36296296, -72.67777778, -72.99259259, -73.30740741, -73.62222222, -73.93703704, -74.25185185, -74.56666667, -74.88148148, -75.1962963, -75.51111111, -75.82592593, -76.14444444, -76.45925926, -76.77407407, -77.08888889, -77.4037037, -77.71851852, -78.03333333, -78.34814815, -78.66296296, -78.97777778, -79.29259259, -79.60740741, -79.92222222, -80.23703704, -80.55185185, -80.86666667, -81.181481
```

Cleaning data...

Saving merged cleaned data into database as 'econ\_cleaned'...

	GDP_count	GDP_mean	GDP_std	GDP_min \
Country Name				
Canada	34	39357.078405	4856.836357	30563.378820
China	34	5073.229508	3583.630683	905.032457
Japan	34	32770.738504	2371.821778	28422.213120
United Kingdom	34	40583.327987	5456.617589	30441.481350
United States	34	51521.551093	7640.364126	38637.839810

Country	GDP_max	Employment_count	Employment_mean
Canada	45227.14474	33	60.712303
China	12175.19611	33	69.123242
Japan	36990.33011	33	59.238939
United Kingdom	47551.22966	33	57.831939
United States	65875.17788	33	60.468424

2

China	4.132756	62.523	76.840
Japan	1.957756	56.440	62.608
United Kingdom	1.511241	54.713	60.335
United States	1.872493	56.598	63.506

	GDP_Growth_count	GDP_Growth_mean	GDP_Growth_std \
Country Name			
Canada	34	2.135410	2.185206
China	34	8.797740	2.924949
Japan	34	0.963596	2.050458
United Kingdom	34	1.859416	2.990588
United States	34	2.491121	1.757601

	GDP_Growth_min	GDP_Growth_max
Country Name		
Canada	-5.038233	5.286957
China	2.238638	14.230861
Japan	-5.693236	4.840929
United Kingdom	-10.296919	8.575951
United States	-2.576500	6.055053

All tasks completed!

## Income levels and their growth paths Income levels and their growth paths

```
import os

# show the current working directory
print("CWD:", os.getcwd())

# list files/folders there so you can see where your .db lives
print("Contents:", os.listdir("."))

#| echo: false
#| message: false
# ===== 0.  SETUP =====

!pwd
import sqlite3
import pandas as pd
```

```

import numpy as np
import matplotlib.pyplot as plt
from pathlib import Path
import pycountry                                # pip install pycountry

# ---- output folders -----
OUT_FIG = Path("figures")
OUT_DAT = Path("processed")
OUT_FIG.mkdir(exist_ok=True, parents=True)
OUT_DAT.mkdir(exist_ok=True, parents=True)

INDICATORS = ["GDP", "Employment", "GDP_Growth"]

# ===== 1.  LOAD CLEAN PANEL =====
DB_PATH = "economic_data.db"
with sqlite3.connect(DB_PATH) as con:
    df = pd.read_sql_query("SELECT * FROM econ_cleaned", con)

if df.empty:
    raise RuntimeError("econ_cleaned table is empty - check SQL pipeline.")

# ===== 2.  ENRICH  - add ISO-3 codes =====
def name_to_iso3(name):
    try:
        return pycountry.countries.lookup(name).alpha_3
    except LookupError:
        # handle special cases
        mapping = {
            "South Korea": "KOR",
            "United States": "USA",
            "United Kingdom": "GBR"
        }
        return mapping.get(name, None)

df["iso3"] = df["Country Name"].apply(name_to_iso3)
if df["iso3"].isna().any():
    missing = df[df["iso3"].isna()]["Country Name"].unique()
    raise ValueError(f"ISO-3 lookup failed for: {missing}")

# ===== 3.  BASIC CLEANING =====
df[INDICATORS] = df[INDICATORS].apply(pd.to_numeric, errors="coerce")

```

```
# forward-fill within each country to patch occasional NaNs
df = (df.sort_values(["iso3", "Year"])
      .groupby("iso3")
      .apply(lambda g: g.ffill())
      .reset_index(drop=True))

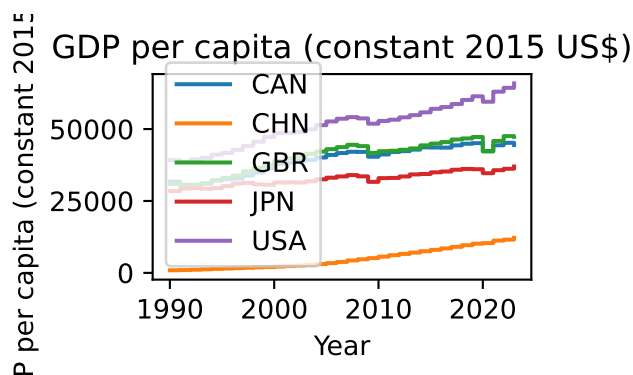
#| echo: true
def lineplot(ind_col, ylab):
    plt.figure()
    for iso, g in df.groupby("iso3"):
        plt.plot(g["Year"], g[ind_col], label=iso)
    plt.title(ylab)
    plt.xlabel("Year")
    plt.ylabel(ylab)
    plt.legend()
    plt.tight_layout()
    plt.savefig(OUT_FIG / f"{ind_col}_trend.png", dpi=300)
    plt.plot()

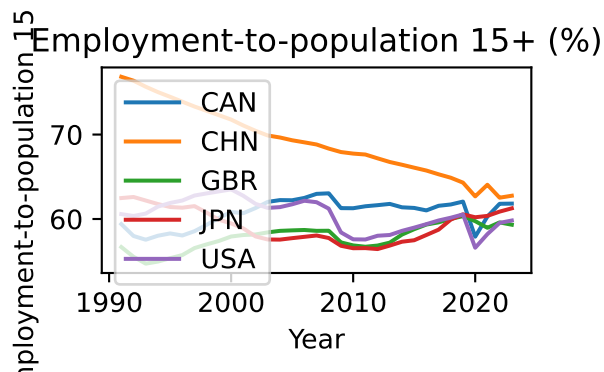
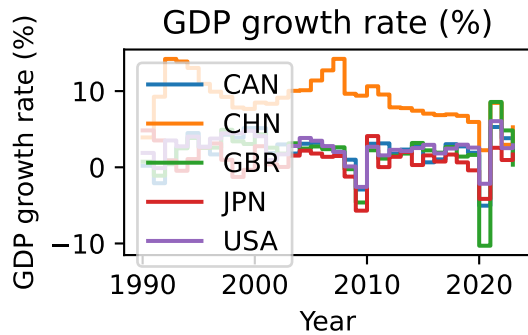
lineplot("GDP", "GDP per capita (constant 2015 US$)")
lineplot("GDP_Growth", "GDP growth rate (%)")
lineplot("Employment", "Employment-to-population 15+ (%)")
```

CWD: /Users/jackson/Documents/emory/emory2025Spring/QT350/finalnew/350FinalQuarto  
 Contents: ['350FinalQuarto.quarto\_ipynb', '\_quarto.yml', '350FinalQuarto.qmd', '.DS\_Store',  
 /Users/jackson/Documents/emory/emory2025Spring/QT350/finalnew/350FinalQuarto

/var/folders/6m/wlb3j20s32q0624t09s3bf7w0000gn/T/ipykernel\_40436/1336997099.py:62: Deprecati

DataFrameGroupBy.apply operated on the grouping columns. This behavior is deprecated, and in





The GDP-per-capita plot underscores the prosperity gap that separates North America from East Asia. Real income in the United States rises from roughly thirty-nine thousand dollars in 1990 to about sixty-six thousand in 2023, widening its lead over all other cases. Canada mirrors the American path but remains seven to ten thousand dollars lower throughout. China, starting from a base of just over one thousand dollars, multiplies its income almost ten-fold, yet still reaches only about twelve thousand dollars by the end of the sample. Japan's income climbs during the 1990s but plateaus at approximately thirty-six thousand dollars after 2010. The corresponding growth-rate figures reveal that China's rapid expansion, once firmly in double digits, decelerates to mid-single-digit territory in the 2010s. Japan's growth oscillates around zero, reflecting its long struggle with deflation and demographic ageing. The United States and Canada exhibit more moderate booms and busts, rarely exceeding four percent on the upside or falling much below minus two percent except in the global crises of 2009 and 2020, which strike all four economies simultaneously.

## Quarto

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