World development indicators

Which country will develop more

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April-May 2017

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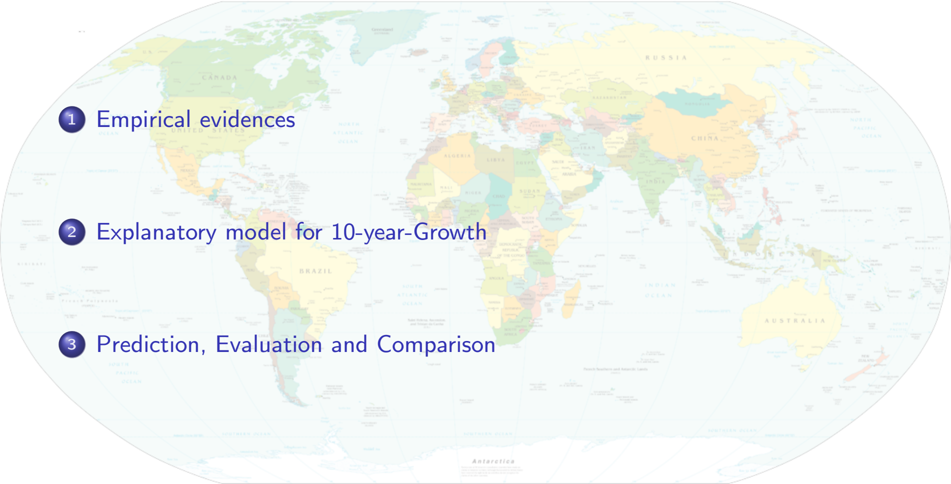
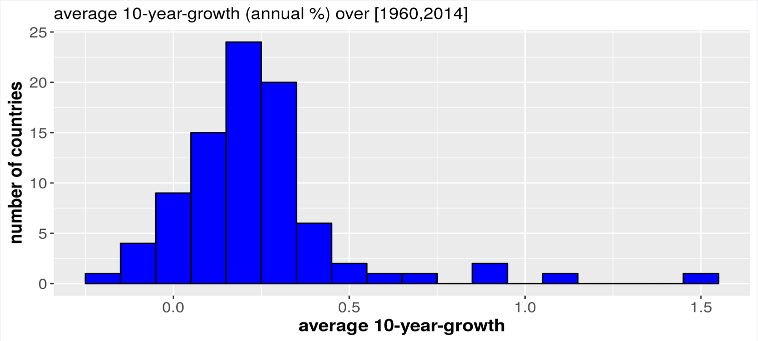


10-year-Growth definition and average



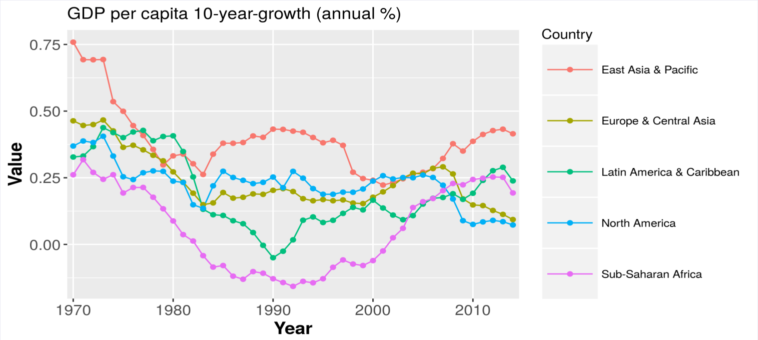
Definition

The 10-year-Growth is the 10-year percentage variation of the GDP per capita in local currency. More formally,

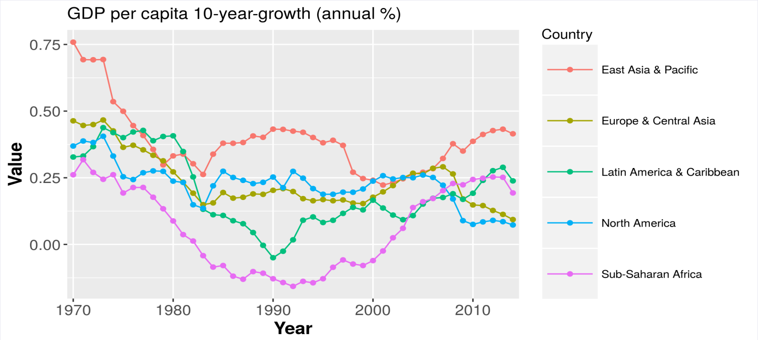
$$Growth_t := \frac{GDP_t - GDP_{t-10}}{GDP_{t-10}} \tag{1}$$

where GDP is the Gross Domestic Product per capita

10-year-growth by region



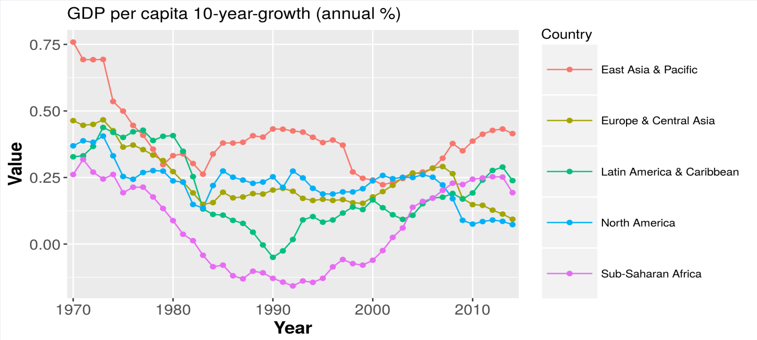
10-year-growth by region



Remark 1

significant differences between decades $\Longrightarrow$ dummy for decades

10-year-growth by region

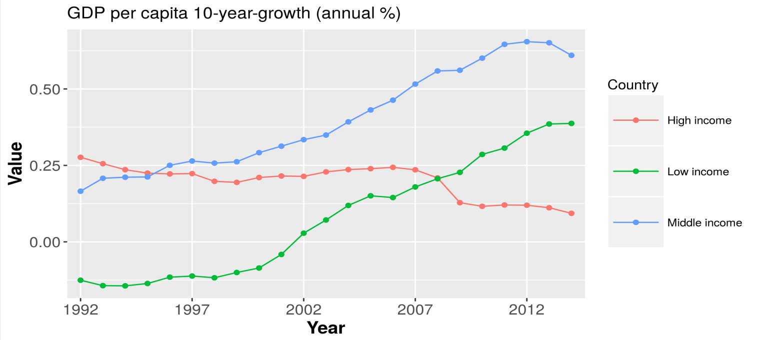


Remark 1

significant differences between decades $\Longrightarrow$ dummy for decades

Remark 2

different growth patterns for different regions $\Longrightarrow$ dummy for Asia and dummy for Africa



Remark 3

different growth patterns for different Income groups $\implies$ dummy for High Income and dummy for Low Income

The Regressors: State and Environmental variables

State variables

- Education $:= \dfrac{\text{tot enrolment primary school}}{\text{population}}$ $[\%]$
- Health $:= \dfrac{1}{\text{life expectancy at birth}}$ $[\text{year}]^{-1}$
- Fertility $:=$ average number of births per woman

The Regressors: State and Environmental variables

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- Fertility := average number of births per woman

Envirnonmental variables

- Inflation [%]
- GDP := log(GDP)
- FDI := financial capital owned by foreign investors [% of GDP]
- Openess $:= \frac{\text{Inport+Export}}{\text{GDP}}$
- Consumption := households consumption expenditure [% of GDP]
- Investment := government expenditures for goods and services [% of GDP]

The Dummies: decade, income and region

Let $X = [\underline{x}_1, \underline{x}_2, \ldots, \underline{x}_{3n}]^T$ be the design matrix

Dummies for decades

$$D_1 = \begin{cases} 1 & \text{if } \underline{x}_i \in [1983, 1993) \\ 0 & \text{otherwise} \end{cases} \qquad D_2 = \begin{cases} 1 & \text{if } \underline{x}_i \in [1993, 2003) \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

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Dummies for Income

$$I_1 = \begin{cases} 1 & \text{if } \underline{x}_i \in \text{High Income} \\ 0 & \text{otherwise} \end{cases} \qquad I_2 = \begin{cases} 1 & \text{if } \underline{x}_i \in \text{Low Income} \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

The Dummies: decade, income and region

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Dummies for Region

$$R_1 = \begin{cases} 1 & \text{if } \underline{x}_i \in \text{East Asia} \\ 0 & \text{otherwise} \end{cases} \qquad R_2 = \begin{cases} 1 & \text{if } \underline{x}_i \in \text{Sub-Saharan Africa} \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

Linear Model: complete model

Let $\epsilon \sim N(0, \sigma^2)$

complete model

$$
\begin{aligned}
Growth = {} & \beta_0 + \beta_1 \text{fertility} + \beta_2 \text{FDI} + \beta_3 \text{GDP} + \beta_4 \text{education} + \beta_5 \text{consumption} + \\
& \beta_6 \text{inflation} + \beta_7 \text{health} + \beta_8 \text{investment} + \beta_9 \text{openess} + \\
& \beta_{10} D_1 + \beta_{11} D_2 + \beta_{12} R_1 + \beta_{13} R_2 + \beta_{14} I_1 + \beta_{15} I_2 + \\
& D_1(\beta_{16} \text{GDP} + \beta_{17} \text{fertility} + \beta_{18} \text{investment}) + \\
& D_2(\beta_{19} \text{GDP} + \beta_{20} \text{fertility} + \beta_{21} \text{investment}) + \\
& I_1(\beta_{22} \text{GDP} + \beta_{23} \text{fertility} + \beta_{24} \text{investment}) + \\
& I_2(\beta_{25} \text{GDP} + \beta_{26} \text{fertility} + \beta_{27} \text{investment}) + \\
& R_1(\beta_{28} \text{GDP} + \beta_{29} \text{fertility} + \beta_{30} \text{investment}) + \\
& R_2(\beta_{31} \text{GDP} + \beta_{32} \text{fertility} + \beta_{33} \text{investment}) + \epsilon
\end{aligned}
$$

Linear Model: reduced model

Let $\epsilon \sim N(0, \sigma^2)$

reduced model

$$
\begin{aligned}
Growth = {} & \beta_0 + \beta_1 \text{fertility} + \beta_2 \text{GDP} + \beta_3 \text{consumption} + \beta_4 \text{investment} + \\
& \beta_5 \text{education} + \beta_6 \text{FDI} \\
& \beta_7 D_1 + \beta_8 D_2 + \beta_9 R_1 + \beta_{10} R_2 + \beta_{11} I_1 + \beta_{12} I_2 + \\
& D_1(\beta_{13} \text{GDP} + \beta_{14} \text{investment}) + \\
& D_2(\beta_{15} \text{GDP}) + \\
& I_1(\beta_{16} \text{GDP} + \beta_{17} \text{fertility} + \beta_{18} \text{investment}) \\
& I_2(\beta_{19} \text{investment}) + \\
& R_1(\beta_{20} \text{GDP} + \beta_{21} \text{fertility}) + \\
& R_2(\beta_{22} \text{fertility} + \beta_{23} \text{investment}) + \epsilon
\end{aligned}
$$

lm output

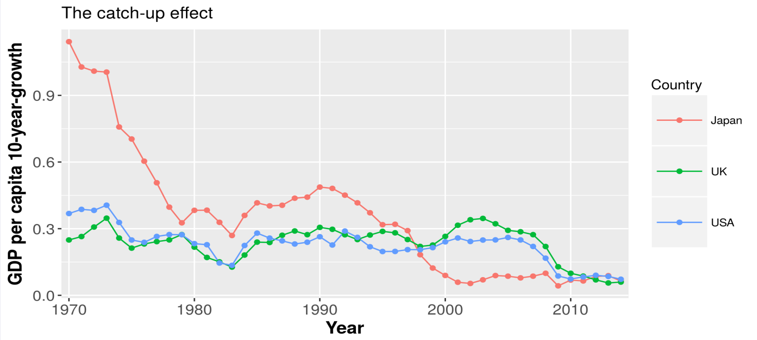
	Model 1
(Intercept)	$0.9531\ (0.3791)^{*}$
fertility	$-0.0849\ (0.0244)^{***}$
FDI	$-0.0085\ (0.0063)$
GDP	$-0.0903\ (0.0305)^{**}$
education	$-0.0025\ (0.0010)^{*}$
consumption	$0.0047\ (0.0010)^{***}$
health	$-21.0428\ (11.8102)$
R1	$3.8459\ (0.3718)^{***}$
R2	$0.8626\ (0.1585)^{***}$
I1	$1.0546\ (0.4503)^{*}$
I2	$-0.4912\ (0.1445)^{**}$
investment	$0.0407\ (0.0063)^{***}$
D1	$-0.3408\ (0.1521)^{*}$
D2	$-0.4913\ (0.1369)^{***}$
GDP:D1	$0.0841\ (0.0182)^{***}$
investment:D1	$-0.0189\ (0.0048)^{***}$
GDP:D2	$0.0640\ (0.0163)^{***}$
GDP:I1	$-0.0783\ (0.0474)$
fertility:I1	$0.0804\ (0.0297)^{**}$
investment:I1	$-0.0354\ (0.0073)^{***}$
investment:I2	$0.0327\ (0.0088)^{***}$
GDP:R1	$-0.3070\ (0.0348)^{***}$
fertility:R1	$-0.3880\ (0.0362)^{***}$
fertility:R2	$-0.0527\ (0.0274)$
investment:R2	$-0.0425\ (0.0073)^{***}$
R^2	0.8705
Adj. R^2	0.8364
Num. obs.	116
RMSE	0.1134

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Legend:

- D1 = [1983,1993) D2 = [1993,2003)
- R1 = Asia R2 = Africa
- I1 = high income
- I2 = low income

Results analysis: Conditional Convergence



Definition

the following principle is called **conditional convergence**: the lower the initial GDP the higher the growth over the next decade

Prediction model: no dummies for decades

Let $\epsilon \sim N(0, \sigma^2)$

prediction model: timeless

$$
\begin{aligned}
Growth = \beta_0 &+ \beta_1 \text{fertility} + \beta_2 \text{GDP} + \beta_3 \text{consumption} + \beta_4 \text{investment} + \\
&\beta_5 R_1 + \beta_6 R_2 + \beta_7 I_1 + \beta_8 I_2 + \\
&I_1(\beta_9 \text{GDP} + \beta_{10} \text{fertility} + \beta_{11} \text{investment}) \\
&I_2(\beta_{12} \text{investment} + \beta_{13} \text{fertility}) + \\
&R_1(\beta_{14} \text{GDP} + \beta_{15} \text{fertility}) + \\
&R_2(\beta_{16} \text{fertility} + \beta_{17} \text{investment}) + \epsilon
\end{aligned}
$$

predictor evaluation

fitting sample = [1983,2003] test sample = [2003,2013]

Definition

- F_t = prediction for the growth in t with our model
- Y_t = realization of growth in t
- e_t = prediction error
- $ME = \sum_{t=0}^{n} \frac{1}{n} e_t$ = mean error
- $MAD = \sum_{t=0}^{n} \frac{1}{n} \|e_t\|$ = mean absolute deviation
- $RMSE = \sqrt{\sum_{t=0}^{n} \frac{1}{n} e_t^2}$ = root mean square error

predictor evaluation

fitting sample $= [1983,2003]$ test sample $= [2003,2013]$

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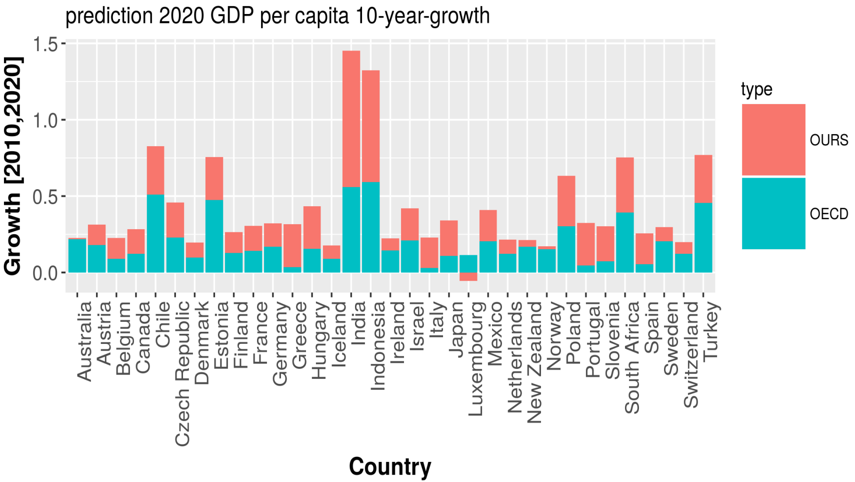
predictor performances

	same countries	new countries
ME	-0.014	0.022
MAD	0.099	0.182
RMSE	0.1361	0.2823

- slightly overestimating
- inaccurate out-of-sample

2020 growth prediction comparison



OECD = The Organisation for Economic Co-operation and Development is an intergovernmental economic organisation with 35 member countries, founded in 1960 to stimulate economic progress and world trade