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Efficient development portfolio design for Sub-Saharan Africa

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Development

- Multi-dimensional measures of development
  - Human Development Index (HDI)
    Education, health, standard of living

- Options for policy makers
  - Government expenditures on
    Education, health, others

Objective

Maximize development through optimal allocation of the government budget

Portfolio Theory

Optimum Portfolio Theory (Markovitz, 1952)

$$\max \quad \Theta = R - \alpha V$$

$$s.t. \quad R = r'y$$

$$1 = i'y$$

$$V = y' S y$$

R	expected portfolio return
α	degree of risk aversion
r	vector of expected return of individual assets
y	vector of asset shares
V	variance of portfolio return
S	covariance matrix of rates of return

Efficient Development Portfolio

$$\max \quad \Theta = \hat{H} - \alpha \cdot \hat{V}$$

$$s.t. \quad \hat{H} = i' \cdot \hat{t} / T$$

$$B = \sum_{i=1}^{Y} \exp(y_i)$$ Non-linearity

$$\hat{t} = \hat{J} \cdot y + \hat{K} \cdot x$$ Additional constraint

$$V = 1/T^2 \sum_{i=1}^{T} \sum_{j=1}^{T} \left(y' \Omega_{i,j}^{YY} y + y' \Omega_{i,j}^{YX} x + x' \Omega_{i,j}^{XY} y + x' \Omega_{i,j}^{XX} x \right)$$

H HDI

$t = (lex, edu, gdp)'$ ⇨ $T = 3$ targets

$y = (lngeh, lnged, lngeg)'$ ⇨ $Y = 3$ policy instruments

x = vector of X control variables

⇨ $t = Jy + Kx$

⇨ $H = \sum_{i=1}^{T} t_i / T$

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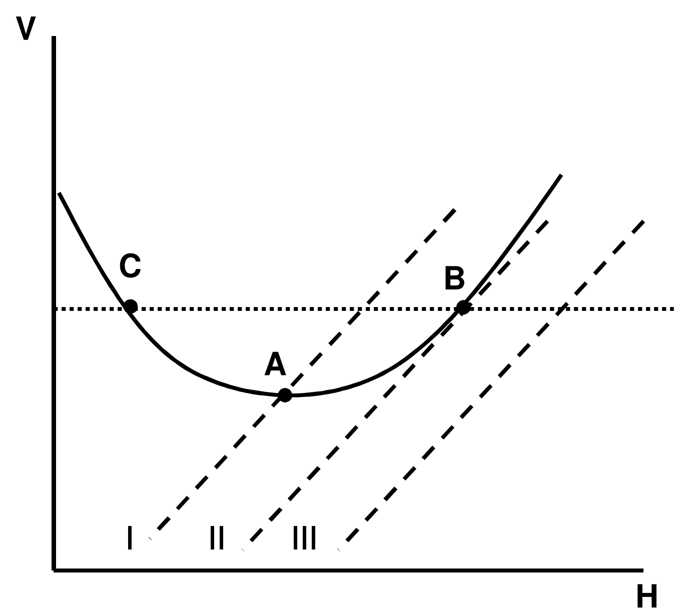
Portfolio Theory

- F.O.C.s implicitly define portfolio through budget shares & variance

$$y = y(t', \Omega, H)$$

$$V = V(t', \Omega, H)$$



- Optimum portfolio

$$\partial\Theta / \partial H = 1 - \alpha \cdot \partial V / \partial H = 0 \Rightarrow \partial V / \partial H = 1 / \alpha$$

Modelling steps

1. Estimate $t = Jy + Kx + \varepsilon$ using *Seemingly Unrelated Regression* (Zellner, 1962)

2. Get variance-covariance matrix of parameter estimates

3. Calculate expected H and corresponding $Var(H)$

4. Solve non-linear optimization problem for varying α

Data

- 5-year average data: 1995, 2000, 2005
- 29 Sub-Saharan African countries

Human Development Index

$$HDI = \frac{1}{3} lex + \frac{1}{3} edu + \frac{1}{3} gdp$$

- ***lex*** health component
  - LEXB life expectancy at birth

$$lex = \frac{85 - LEXB}{85 - 25}$$

- ***edu*** education component
  - LITR literacy rate
  - GSER gross school enrolment rate

$$edu = \frac{2}{3} LITR + \frac{1}{3} GSER$$

- ***gdp*** standard of living component
  - GDPC GDP per capita

$$gdp = \frac{\log(GDPC/100)}{\log(40000/100)}$$

Data: Government expenditures

- **WHO**
  - Health expenditures per capita in int. PPP$: ***geh***
  - Health expenditures as % of total government expenditures

⇨ Calculate total government expenditures per capita in PPP$: ***get***

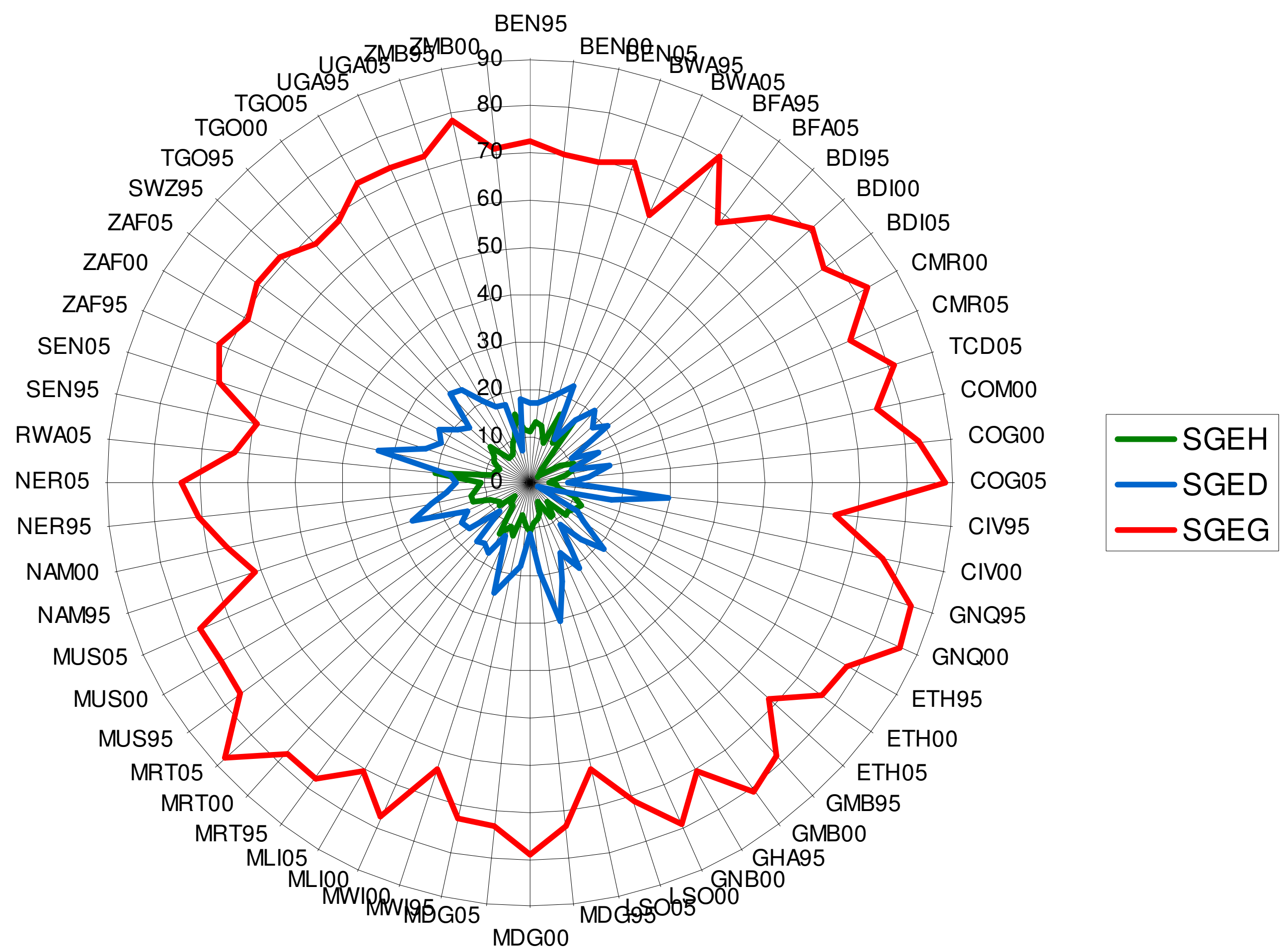
- **WDI**
  - Education expenditures per capita as % of total government expenditures

⇨ Calculate education expenditures per capita in PPP$: ***ged***

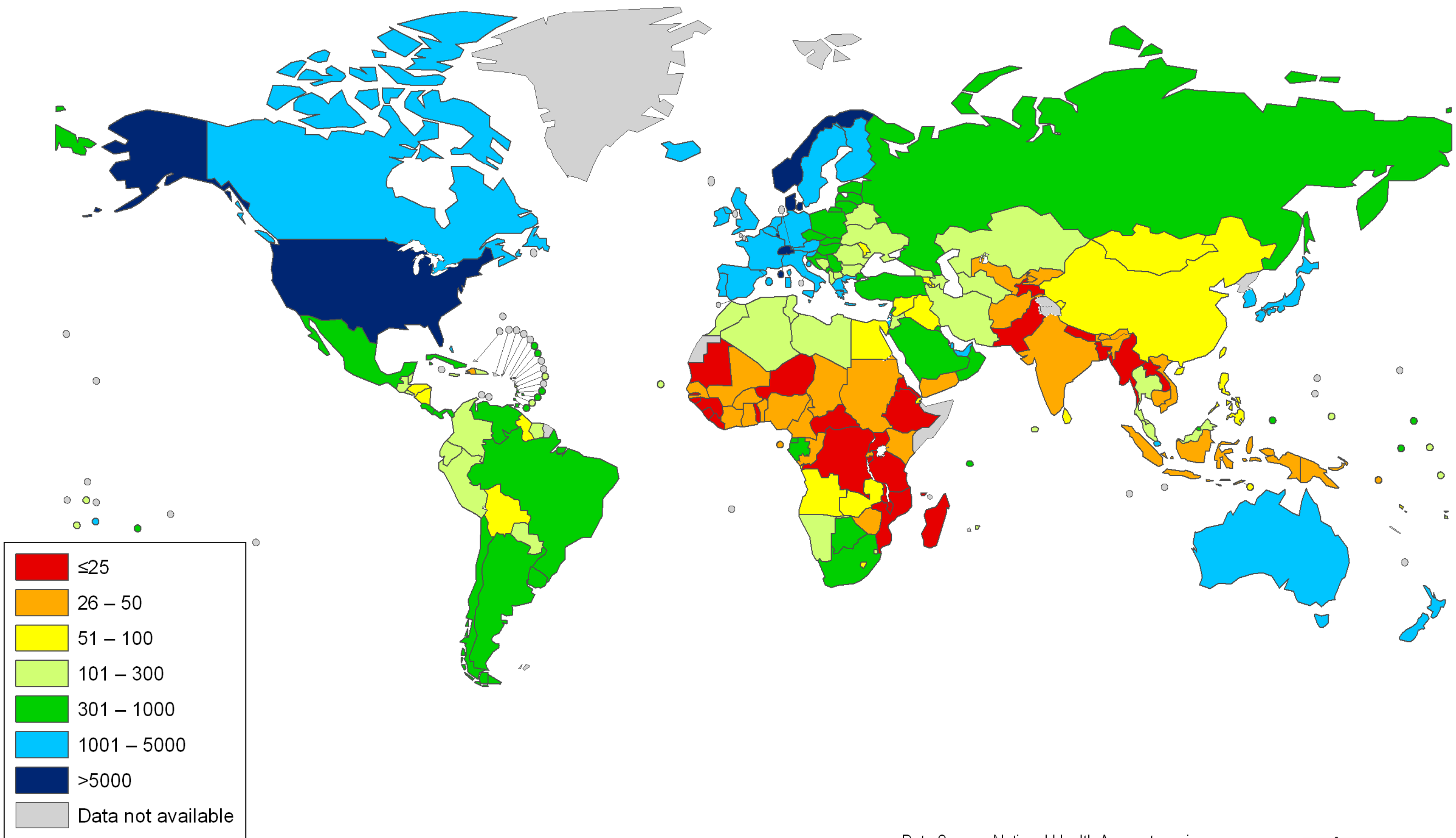
⇨ Government expenditures associated with GDP component of HDI is residual: ***geg = get – ged – geh***

Budget redistribution

Actual budget distribution (% shares)



Total expenditure on health per capita, 2006
(in US$)



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

Data Source: National Health Accounts series, World Health Organization
Map Production: Public Health Information and Geographic Information Systems (GIS)
World Health Organization

World Health Organization

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Estimation results

	lex		edu		gdp	
lngeh	0.0205	*	0.0722	***	0.0431	***
lnged			0.0379			
lngeg					0.0797	***
lnurbr	0.0578	**			0.0328	**
lnpopd	0.0163	*			0.0099	**
lnempr			0.2985	***		
lneind			0.1375	***		
lneser	0.1002	***				
lntrad	0.0418					
lntbpr	-0.0420	**				
lnhivr	-0.0266	***				
gbcd	-0.0418		0.0307		-0.0180	
lnatss			0.0685	***		
const	-0.1840		-1.7606	***	-0.2513	***
RMSE	0.0751		0.1068		0.0483	
R-squared	0.6549		0.6857		0.8923	
Number of obs.		60	AIC	-395		
D o F		22	BIC	-349		

** significant at 10% , ** significant at 5% , *** significant at 1%*

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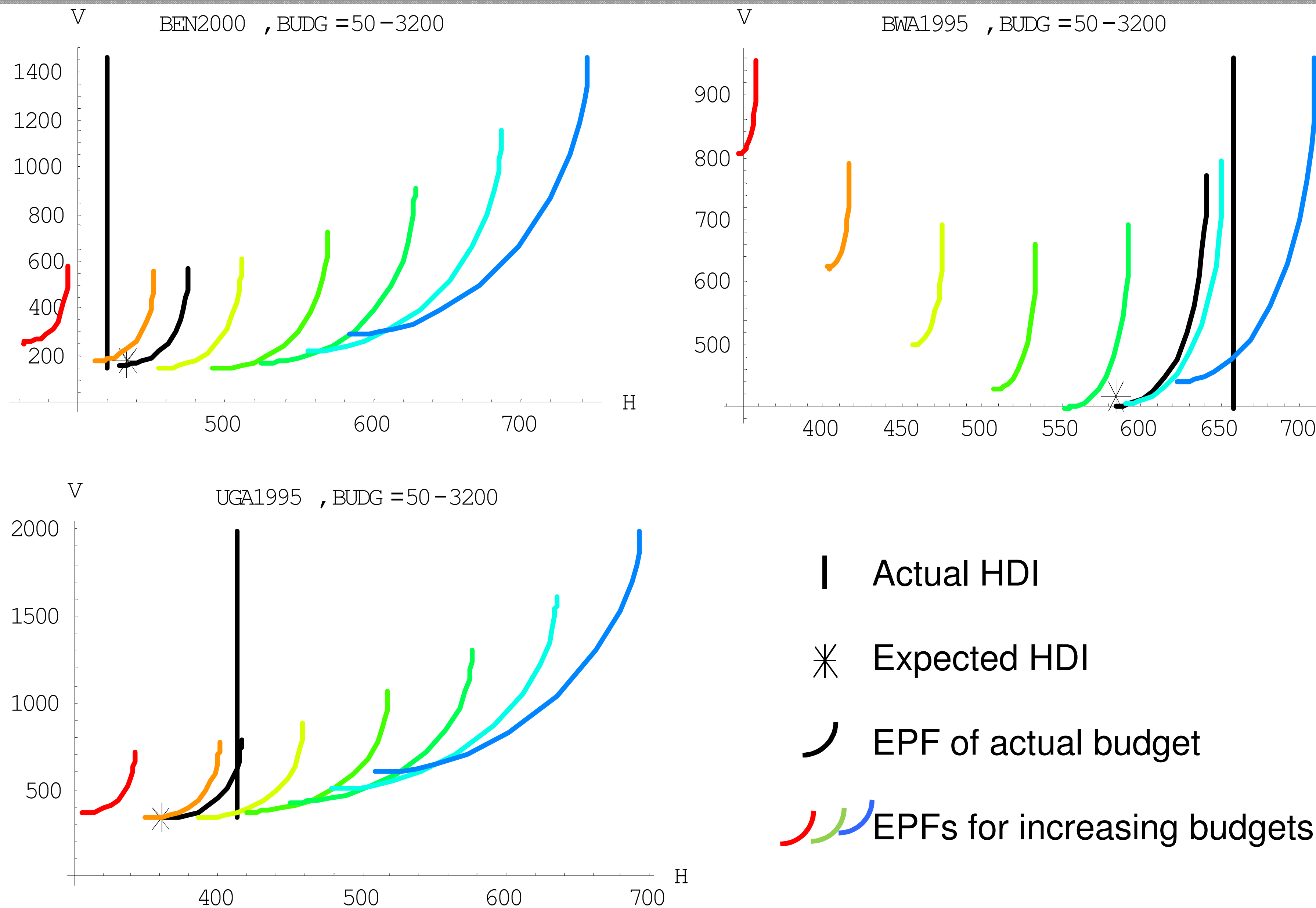
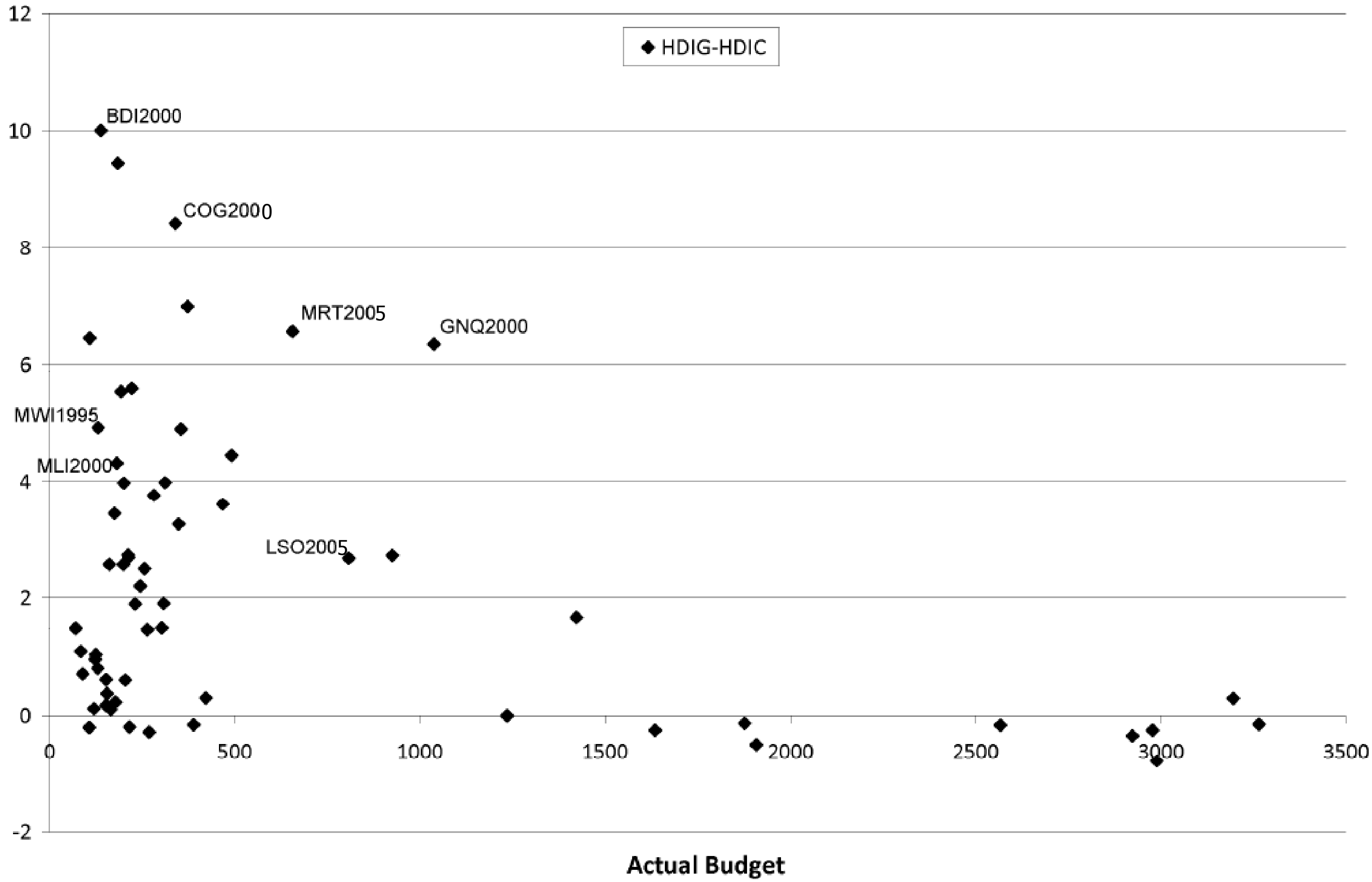
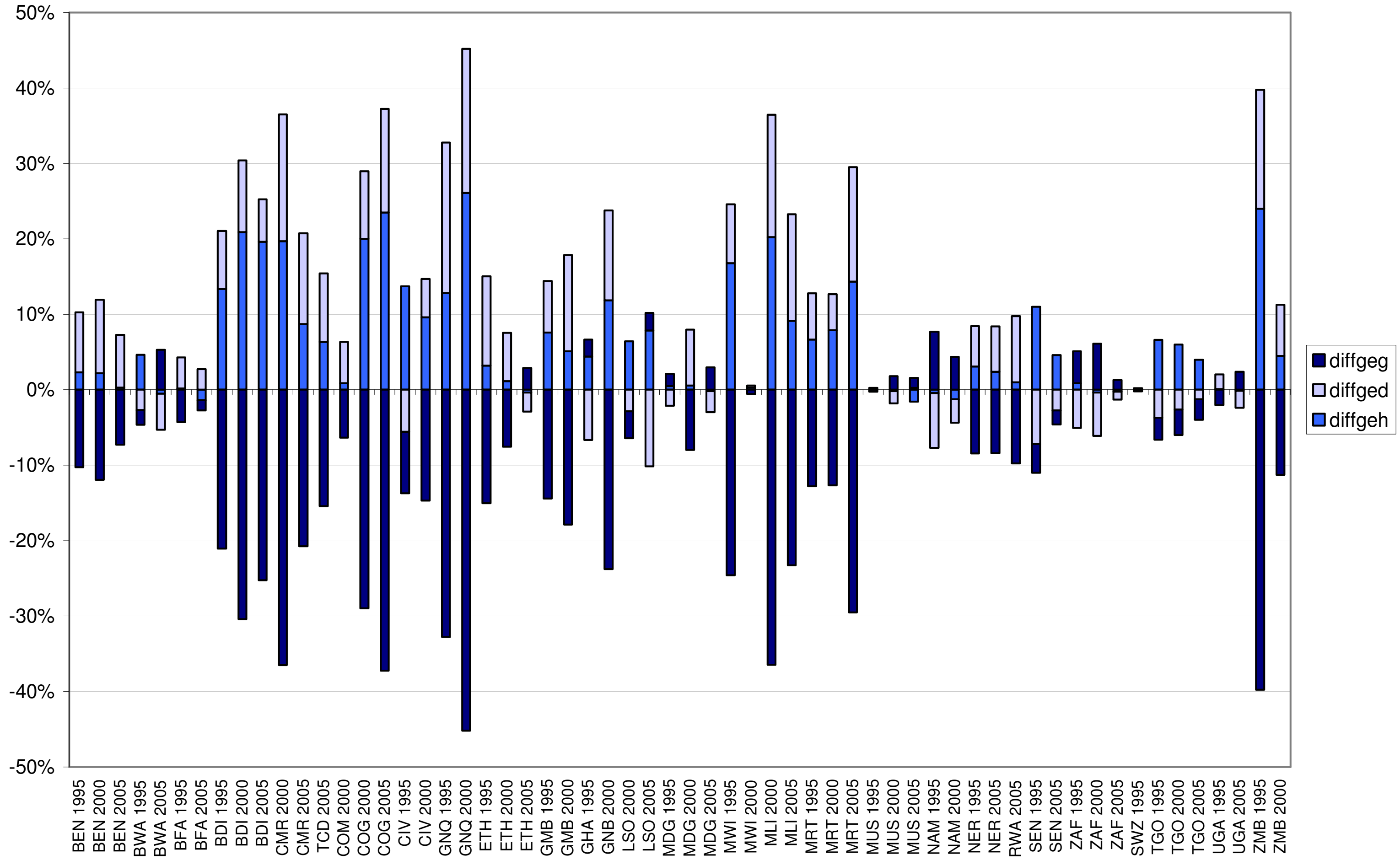

BEN2000 , BUDG = 50 − 3200
V
H
200
400
600
800
1000
1200
1400
500
600
700
BWA1995 , BUDG = 50 − 3200
V
H
500
600
700
800
900
400
450
500
550
600
650
700
UGA1995 , BUDG = 50 − 3200
V
H
500
1000
1500
2000
400
500
600
700
Actual HDI
Expected HDI
EPF of actual budget
EPFs for increasing budgets

Potential improvements



Budget redistribution



Main results

- HDI efficiency surplus/deficit
  1. Good/bad luck
  2. Inefficient spending
- Reasons
  1. Needs further investigation
  2. High correlation with governance indicators
- Necessary policy measures
  1. Depending on reasons
  2. Reallocation of up to 20% of total government expenditures
- Additional policy measures

  Increase total government spending, esp. at low levels

Future research

- Factors influencing good/bad luck
- “u-shape” vs “increasing” move of EPFs for increasing budgets
- Intertemporal problem
- “Green” extension of HDI

Thank you for your attention!

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Minimum possible improvement

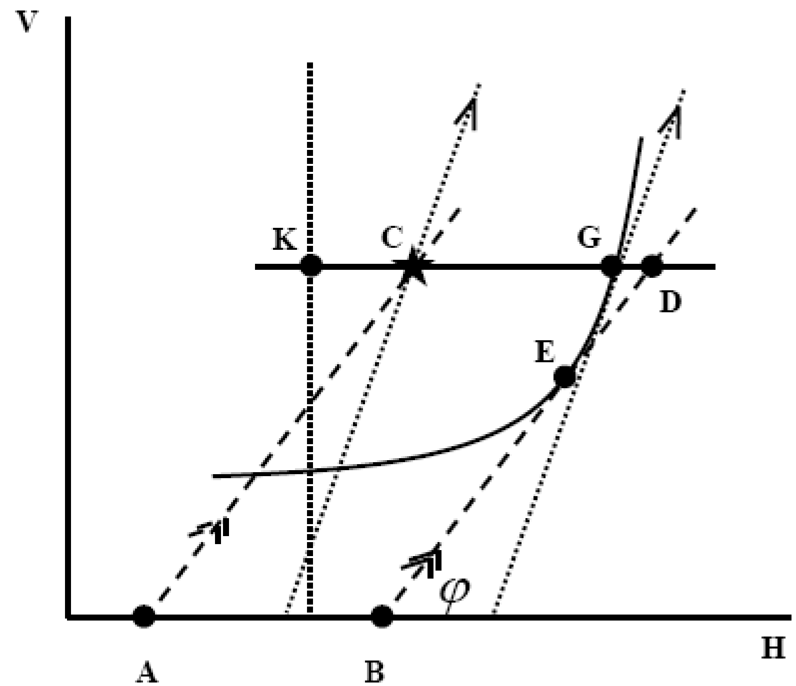
$$\Delta\Theta = \Theta^E - \Theta^C = H^E - H^C - \alpha^E \cdot (V^E - V^C)$$

$$\partial\Delta\Theta / \partial\alpha^E = \partial H^E / \partial\alpha^E - (V^E - V^C) - \alpha^E \cdot \partial V^E / \partial H^E \cdot \partial H^E / \partial\alpha^E = 0$$

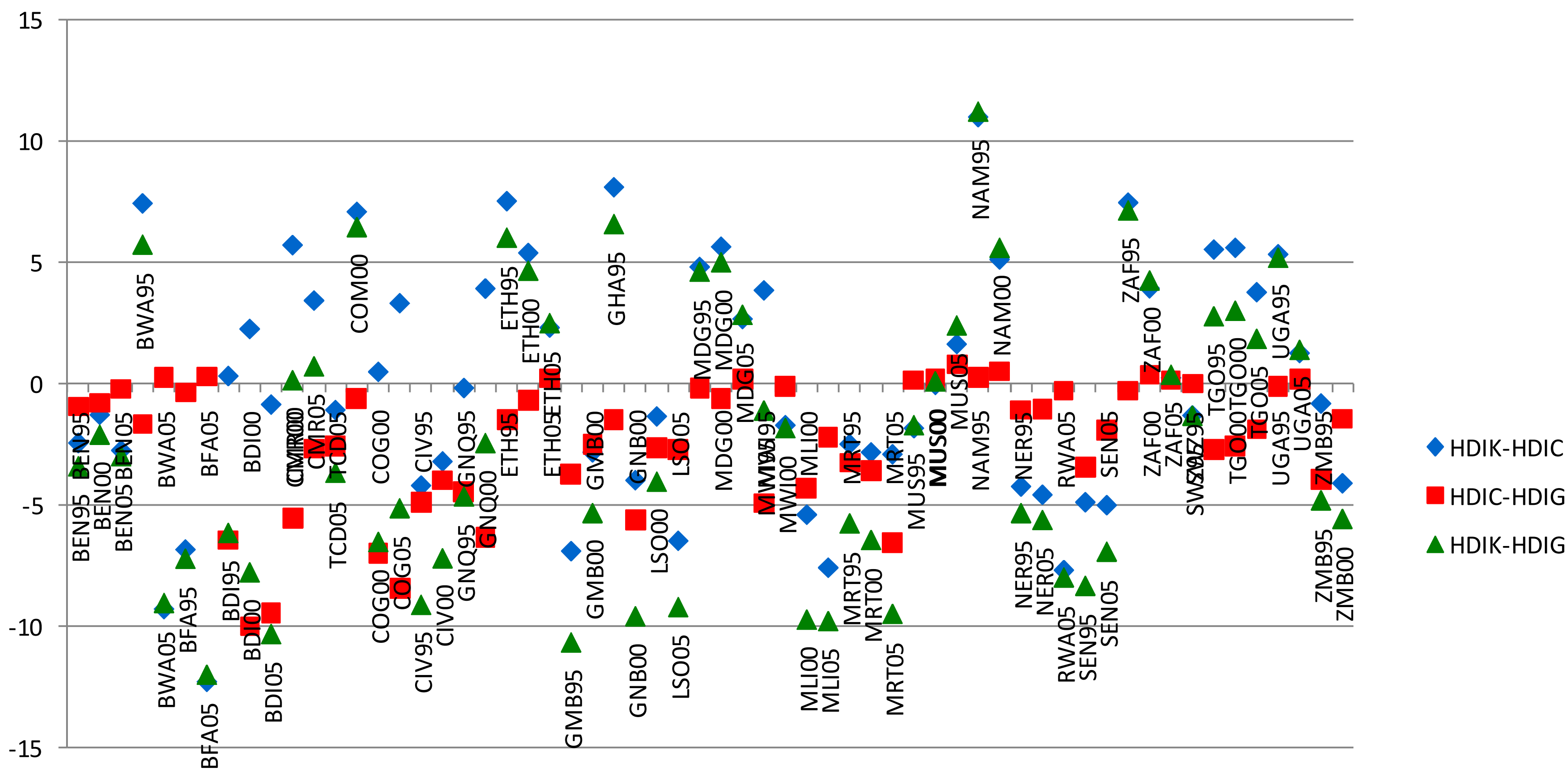
$$\partial V^E / \partial H^E = 1 / \alpha^E$$

$$\Rightarrow \quad V^E = V^C$$

$$\Theta^K - \Theta^G = \{\Theta^K - \Theta^C\} + \{\Theta^C - \Theta^G\}$$



HDI surpluses and deficits (in % points)



HDIK-HDIC= Stochastic component HDI surplus/deficit, releative to expected HDI
HDIC-HDIG = Inefficiency component HDIsurplus/deficit
HDIK-HDIG = Total HDI surplus/deficit measured relative to efficient HDI
NB HDIX is HDI in point X in Figure 4

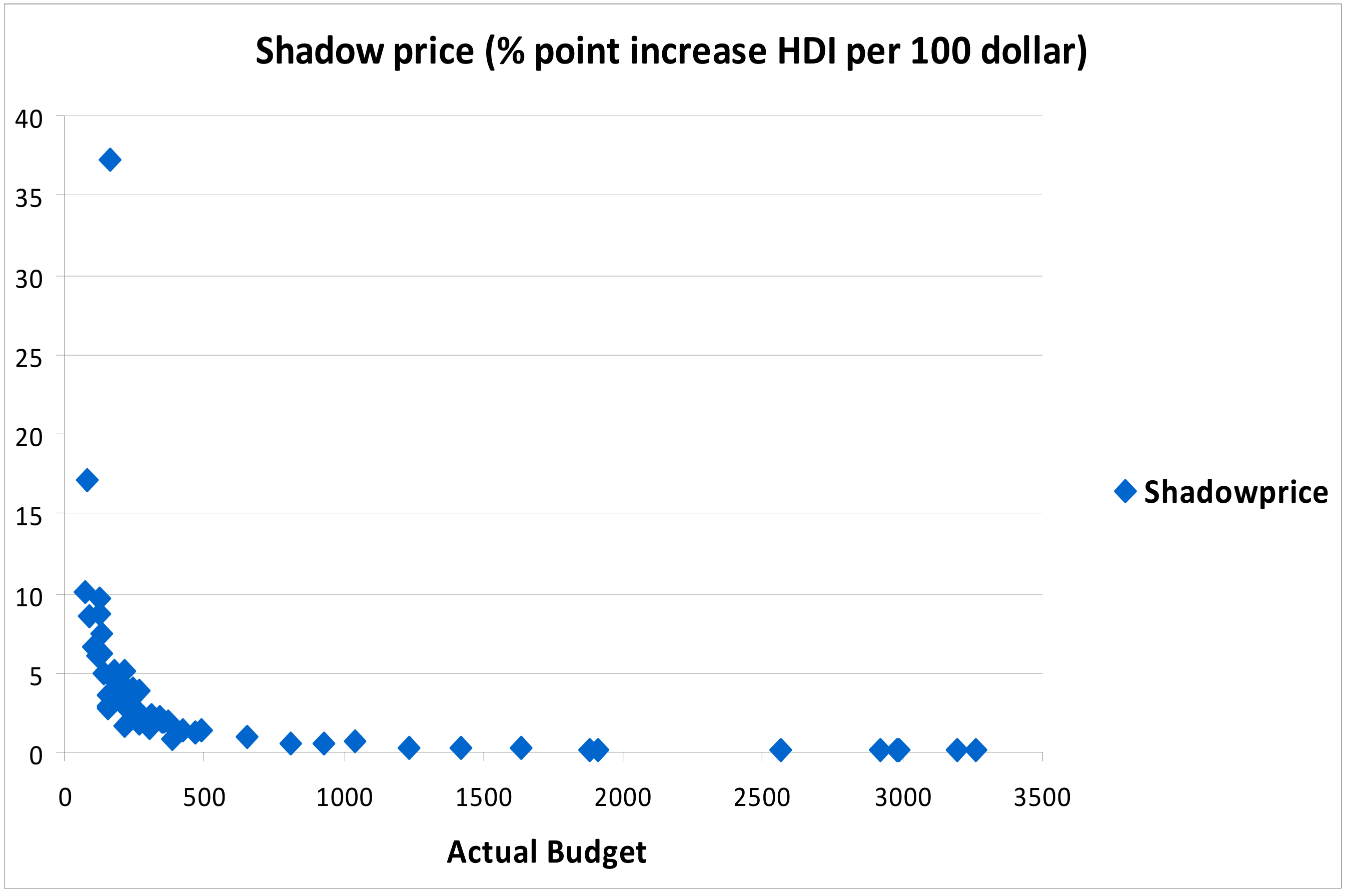
HDI surplus and governance

Correlations

	K-tau				Spearman		
	FHPR	FHCL	FREE		FHPR	FHCL	FREE
OBJ(K)-OBJ(G) = total welfare surplus (+/-), measured relative to efficient welfare (point G)	0.074	0.1226	-0.1169		0.1361	0.2037	-0.1823
OBJ(C)-OBJ(G) = welfare surplus (+/-) due to efficient/inefficient budget allocation	-0.3169***	-0.3712***	0.3056***		-0.4816***	-0.5547***	0.4830***
OBJ(K)-OBJ(C) = welfare surplus (+/-) due to good/bad luck, measured relative to expected welfare	-0.0718	-0.0503	0.0243		-0.1091	-0.0794	0.0536

* significant at 1%, **significant at 5%, *** significant at 10%

Potential improvements



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Variance of HDI

$$\varepsilon^H = i' \cdot \varepsilon^t / T$$

$$\varepsilon^t = \varepsilon^J \cdot y + \varepsilon^K \cdot x$$

$$V = E(\varepsilon^H \cdot \varepsilon^{H'}) = E(i' \cdot \varepsilon^t \cdot \varepsilon^{t'} \cdot i / T^2) = i' \cdot E(\varepsilon^t \cdot \varepsilon^{t'}) \cdot i / T^2 = \sum_{i=1}^{T} \sum_{j=1}^{T} E(\varepsilon_i^t \cdot \varepsilon_j^t) / T^2$$

$$\varepsilon^t \cdot \varepsilon^{t'} = \begin{pmatrix} \varepsilon_1^t \cdot \varepsilon_1^t & \varepsilon_1^t \cdot \varepsilon_2^t & \varepsilon_1^t \cdot \varepsilon_3^t \\ \varepsilon_2^t \cdot \varepsilon_1^t & \varepsilon_2^t \cdot \varepsilon_2^t & \varepsilon_2^t \cdot \varepsilon_3^t \\ \varepsilon_3^t \cdot \varepsilon_1^t & \varepsilon_3^t \cdot \varepsilon_2^t & \varepsilon_3^t \cdot \varepsilon_3^t \end{pmatrix}$$

$$\varepsilon_i^t = \sum_{k=1}^{T} \varepsilon_{i,k}^J \cdot y_k + \sum_{l=1}^{X} \varepsilon_{i,l}^K \cdot x_l$$

$$E(\varepsilon_i^t \cdot \varepsilon_j^t) = \sum_{k=1}^{Y} y_k \cdot \sum_{m=1}^{Y} E(\varepsilon_{i,k}^J \cdot \varepsilon_{j,m}^J) \cdot y_m + \sum_{k=1}^{Y} y_k \cdot \sum_{m=1}^{X} E(\varepsilon_{i,k}^J \cdot \varepsilon_{j,m}^K) \cdot x_m + \sum_{k=1}^{X} x_k \cdot \sum_{m=1}^{X} E(\varepsilon_{i,k}^K \cdot \varepsilon_{j,m}^J) \cdot y_m + \sum_{k=1}^{X} x_k \cdot \sum_{m=1}^{X} E(\varepsilon_{i,k}^K \cdot \varepsilon_{j,m}^K) \cdot x_m$$

		Health H		Education E		Standard of living G	
		Y	X	Y	X	Y	X
Health H	X	$\Omega^{YY}_{H,H}$	$\Omega^{YX}_{H,H}$	$\Omega^{YY}_{H,E}$	$\Omega^{YX}_{H,E}$	$\Omega^{YY}_{H,G}$	$\Omega^{YX}_{H,G}$
	Y	$\Omega^{XY}_{H,H}$	$\Omega^{XX}_{H,H}$	$\Omega^{XY}_{H,E}$	$\Omega^{XX}_{H,E}$	$\Omega^{XY}_{H,G}$	$\Omega^{XX}_{H,G}$
Education E	X	$\Omega^{YY}_{E,H}$	$\Omega^{YX}_{E,H}$	$\Omega^{YY}_{E,E}$	$\Omega^{YX}_{E,E}$	$\Omega^{YY}_{E,G}$	$\Omega^{YX}_{E,G}$
	Y	$\Omega^{XY}_{E,H}$	$\Omega^{XX}_{E,H}$	$\Omega^{XY}_{E,E}$	$\Omega^{XX}_{E,E}$	$\Omega^{XY}_{E,G}$	$\Omega^{XX}_{E,G}$
Standard of living G	X	$\Omega^{YY}_{G,H}$	$\Omega^{YX}_{G,H}$	$\Omega^{YY}_{G,E}$	$\Omega^{YX}_{G,E}$	$\Omega^{YY}_{G,G}$	$\Omega^{YX}_{G,G}$
	Y	$\Omega^{XY}_{G,H}$	$\Omega^{XX}_{G,H}$	$\Omega^{XY}_{G,E}$	$\Omega^{XX}_{G,E}$	$\Omega^{XY}_{G,G}$	$\Omega^{XX}_{G,G}$

$$V = 1/T^2 \cdot \sum_{i=1}^{T}\sum_{j=1}^{T}\left(y'\cdot\Omega_{i,j}^{YY}\cdot y + y'\cdot\Omega_{i,j}^{YX}\cdot x + x'\cdot\Omega_{i,j}^{XY}\cdot y + x'\cdot\Omega_{i,j}^{XX}\cdot x\right)$$

$$= y'\cdot\overline{\Omega}^{YY}\cdot y + y'\cdot\overline{\Omega}^{YX}\cdot x + x'\cdot\overline{\Omega}^{XY}\cdot y + x'\cdot\overline{\Omega}^{XX}\cdot x$$

$$\Phi = H - \alpha\cdot V + \lambda\cdot(B - i'\cdot Exp(y))$$

$$= i'\cdot(J.y + K.x)/T - \alpha\cdot V + \lambda\cdot(B - i'\cdot Exp(y))$$

$$\frac{\partial\Phi}{\partial y} = \frac{J'\cdot i}{T} - \alpha\cdot\frac{\partial V}{\partial y} - \lambda\cdot Exp(y) =$$

$$= \frac{J'\cdot i}{T} - \alpha\cdot\left((\overline{\Omega}^{YY} + \overline{\Omega}^{YY'})\cdot y + (\overline{\Omega}^{YX} + \overline{\Omega}^{XY'})\cdot x\right) - \lambda\cdot Exp(y) = 0$$

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Country coverage

1	AGO	Angola	17	GAB	Gabon	33	NGA	Nigeria
2	BEN	Benin	18	GMB	Gambia, The	34	RWA	Rwanda
3	BWA	Botswana	19	GHA	Ghana	35	STP	Sao Tome and Principe
4	BFA	Burkina Faso	20	GIN	Guinea	36	SEN	Senegal
5	BDI	Burundi	21	GNB	Guinea-Bissau	37	SYC	Seychelles
6	CMR	Cameroon	22	KEN	Kenya	38	SLE	Sierra Leone
7	CPV	Cape Verde	23	LSO	Lesotho	39	SOM	Somalia
8	CAF	Central African Republi	24	LBR	Liberia	40	ZAF	South Africa
9	TCD	Chad	25	MDG	Madagascar	41	SDN	Sudan
10	COM	Comoros	26	MWI	Malawi	42	SWZ	Swaziland
11	ZAR	Congo, Dem. Rep.	27	MLI	Mali	43	TZA	Tanzania
12	COG	Congo, Rep.	28	MRT	Mauritania	44	TGO	Togo
13	CIV	Cote d'Ivoire	29	MUS	Mauritius	45	UGA	Uganda
14	GNQ	Equatorial Guinea	30	MOZ	Mozambique	46	ZMB	Zambia
15	ERI	Eritrea	31	NAM	Namibia	47	ZWE	Zimbabwe
16	ETH	Ethiopia	32	NER	Niger			