HOW TO SPEND A WINDFALL
Dealing with volatility and capital scarcity

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OUTLINE

- Hedging and other financial instruments
- Two-period model of precautionary buffers with oil price uncertainty and asset returns uncertainty
- Intergenerational versus liquidity funds
- Infinite-horizon applications to windfalls of Norway, Ghana and Iraq
- Capital scarcity & investing to invest: volatility curse
- Application to Ghana

Hedging against oil price volatility: Mexico

- Hedge after oil price reached 140$/b with strike price of 70$/b.
- Profits: 8 bln $. Cost of option: 1.5 bln$.

Problems with hedging

- Ecuador, Columbia, Algeria, Texas, Louisiana also
- But expensive and risky
- Maturities are too short (also for oil)
- Markets are too thin and lack sufficient depth to provide adequate protection
- Futures and other derivatives markets not
- Can use structured reverse reversal (e.g., zero premium collar) options or barrier options instead of plain vanilla options
- Politically risks
- Big commodity exporters with private information can influence market price and be accused of speculation instead of insurance

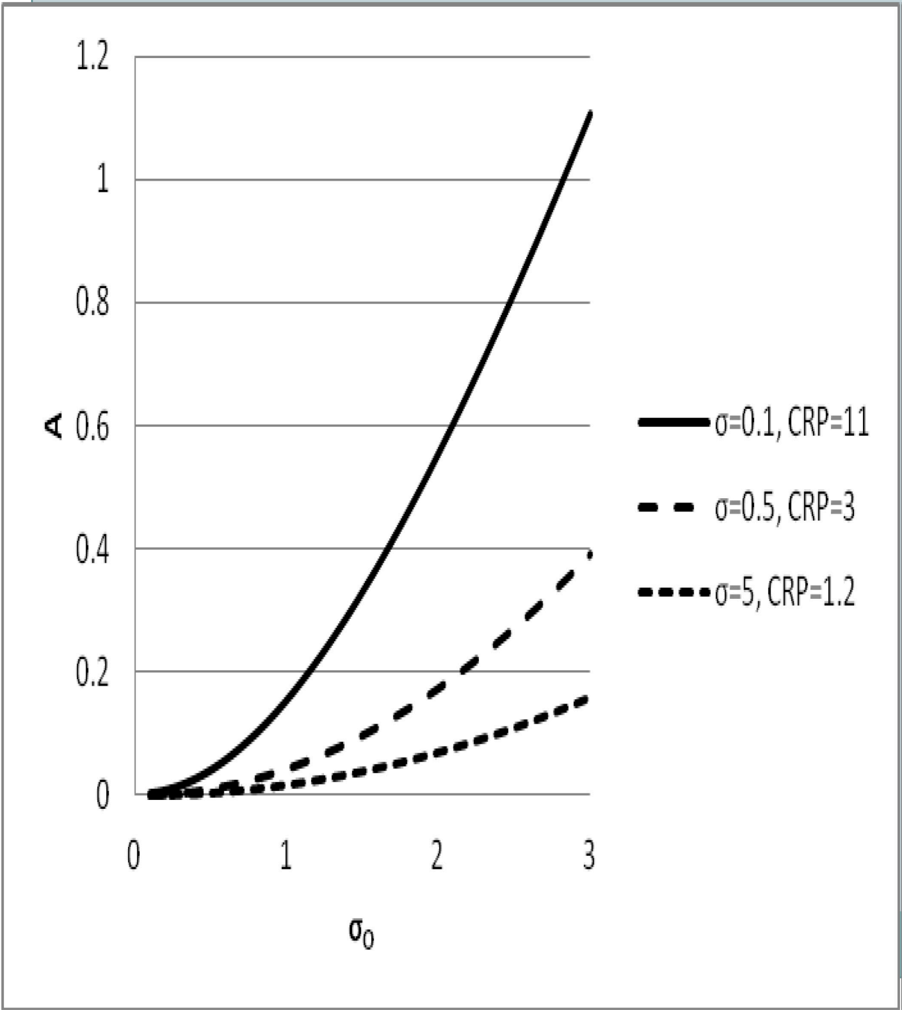
Benchmark two-period model

- Private sector has no good access to international capital markets, hedging, etc., but government does
- Exogenous non-windfall income
- Set $r = \rho = 0$, so complete smoothing of consumption in absence of uncertainty: $C_1 = C_2 = Y + O$, $O = O_P$
- CES utility: EIS = σ, CRRA = $1/\sigma$ and CRP = $1 + 1/\sigma$
- Oil income uncertainty and asset returns uncertainty
- Stochastic Euler equation:

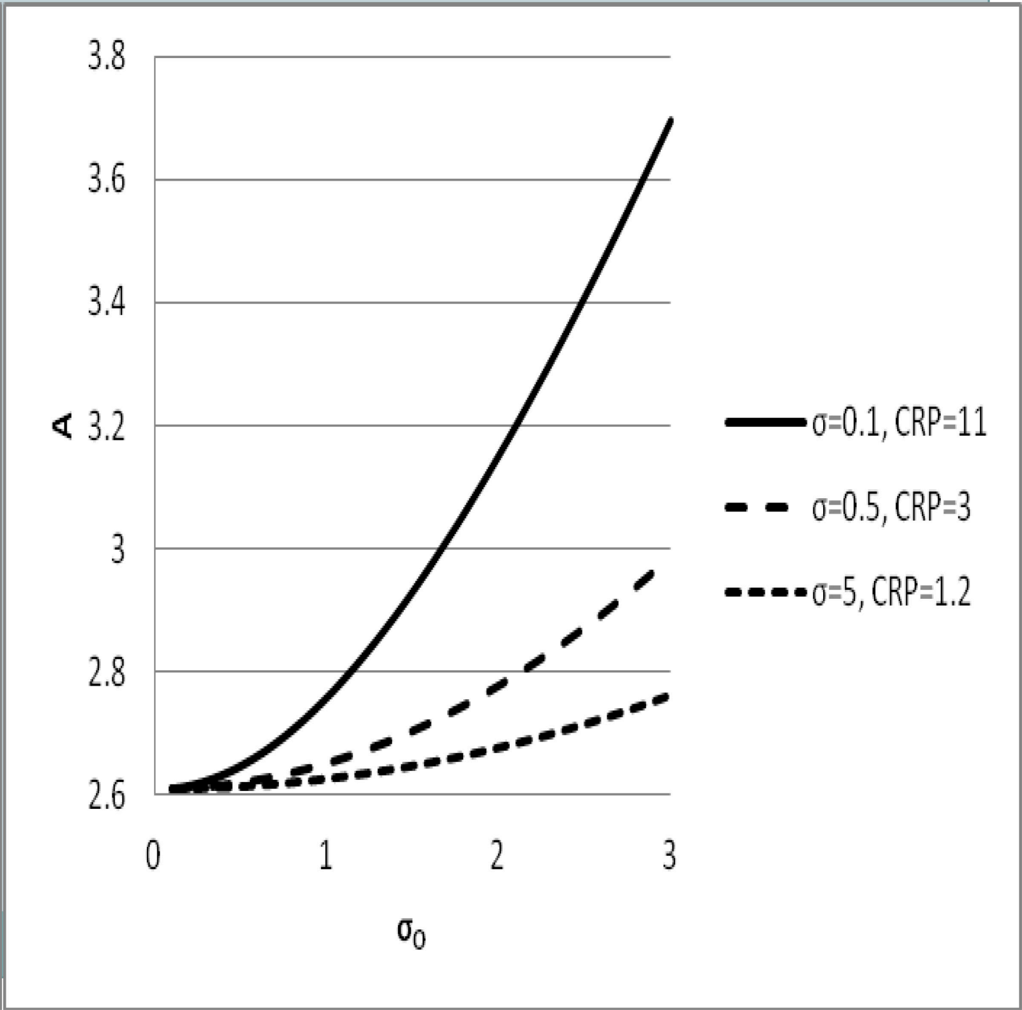
$$U'(C_1) = \frac{1}{1+\rho} \mathrm{E}\left[(1 + r + \varepsilon_r) U'\left((1 + r + \varepsilon_r) A + Y + O_2 + \varepsilon_O \right) \right].$$

Oil income volatility
(temporary: need also intergenerational fund)

- Permanent windfall



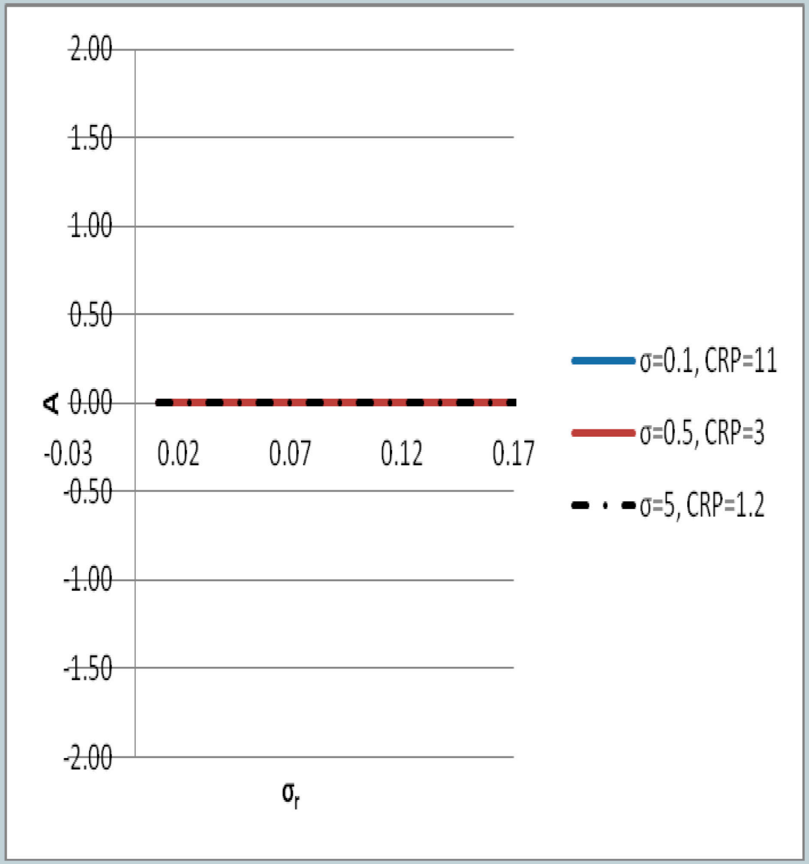
Temporary windfall

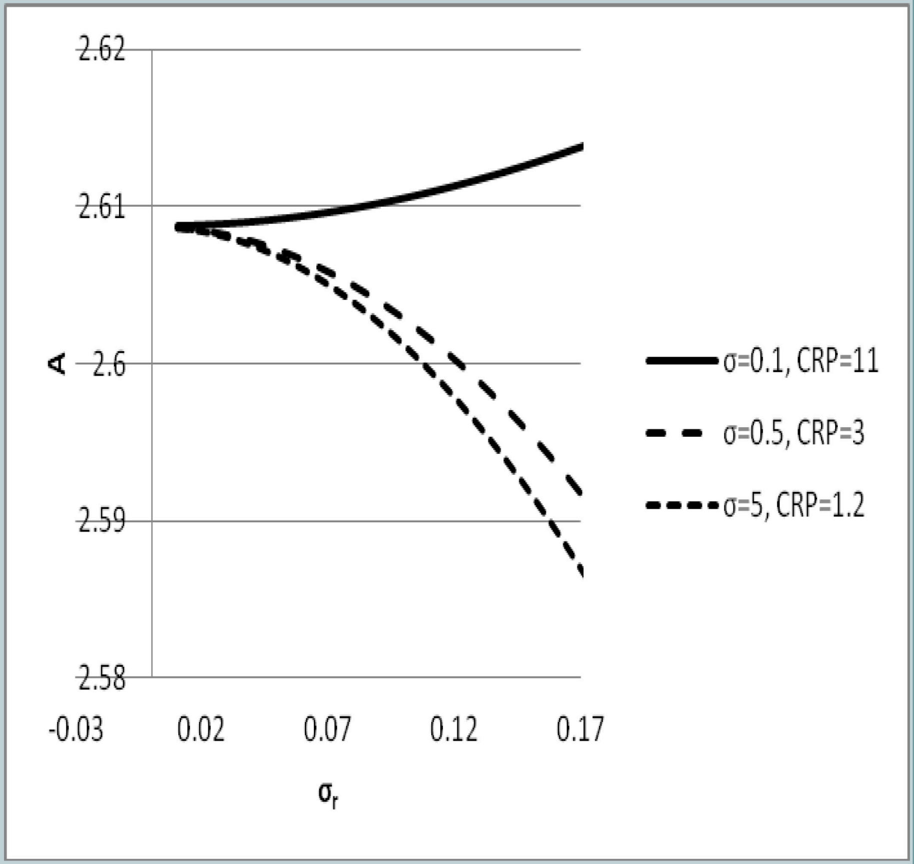


Asset returns uncertainty

- Permanent windfall

Temporary windfall





Sandmo (1970, RES): uncertainty and saving

- Boulding: uncertainty leads to precautionary saving (if third derivative is positive), especially if $1+1/\sigma$ big
- Marshall: 'those who save a lot have a lot to lose' (i.e., the ones with temporary windfalls), especially if CRRA = $1/\sigma$ big
- For small values of σ, say 0.1, the positive prudence effect dominates negative risk aversion effect, so net effect of asset return uncertainty on saving is positive
- For large value of σ, say > 0.5, less saving than is necessary to smooth expected fall in future oil income (Marshall effect dominates)

Interpretation of prudence effect

- Second-order approximation of stochastic Euler equation yields:

$$\frac{U'(C_1) - U'(\mathrm{E}[C_2])}{U'(\mathrm{E}[C_2])} = \frac{CRP \times CRRA}{2\mathrm{E}[C_2]^2}\left(A^2\sigma_r^2 + \sigma_O^2 + 2A\,\mathrm{cov}(\varepsilon_r, \varepsilon_O)\right)$$

$$- \frac{CRRA}{(1+\rho)\mathrm{E}[C_2]}\left(A\sigma_r^2 + \mathrm{cov}(\varepsilon_r, \varepsilon_O)\right).$$

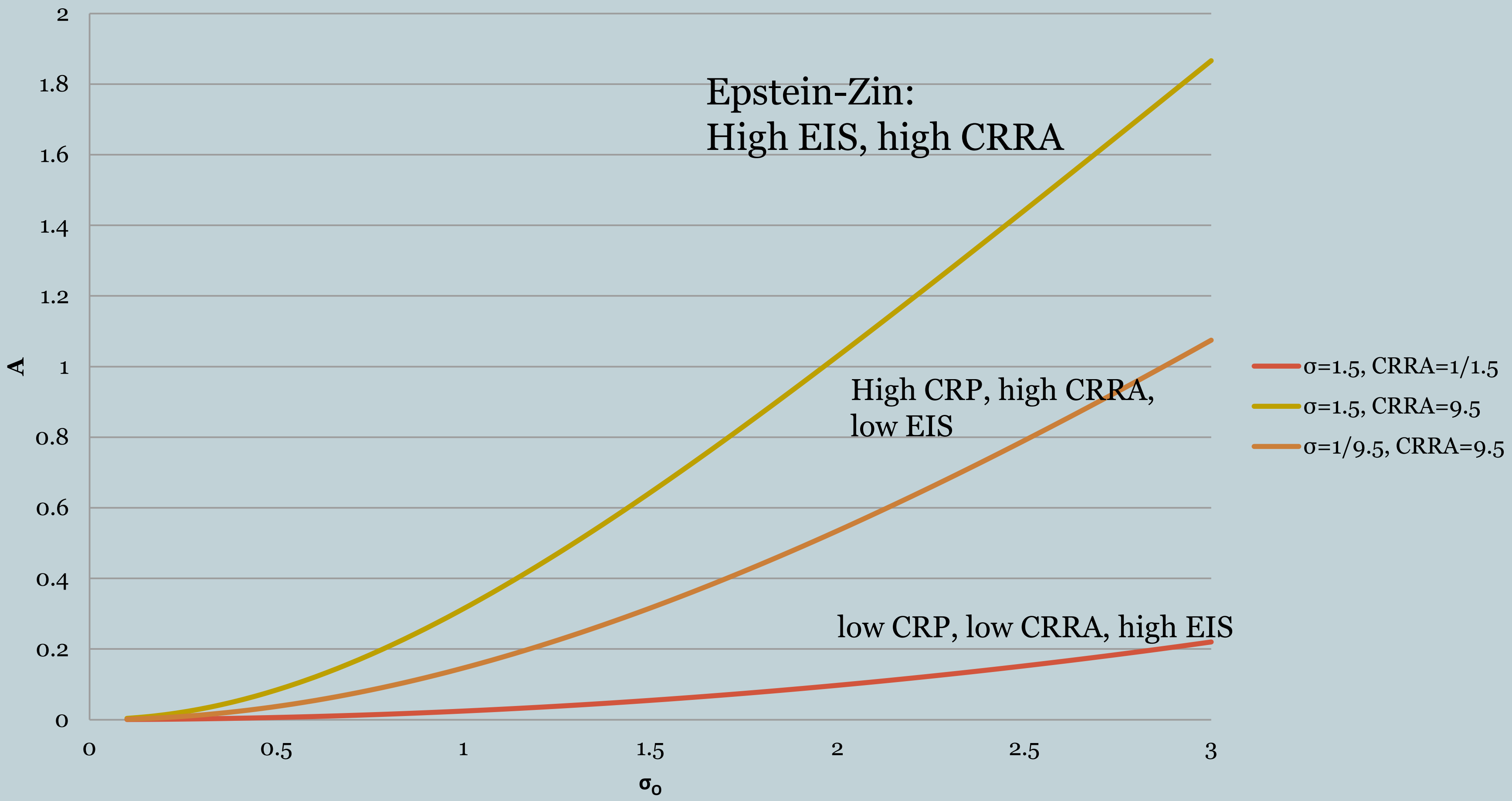
- Precautionary saving high if CRP and $\sigma_O/\mathrm{E}[C_2]$ big irrespective of size of intergenerational fund
- With asset returns uncertainty only +ve buffer if:

$$0.5CRP > \frac{(1+r)A + Y + O_2}{(1+r)A}.$$

What assets should fund invest in?

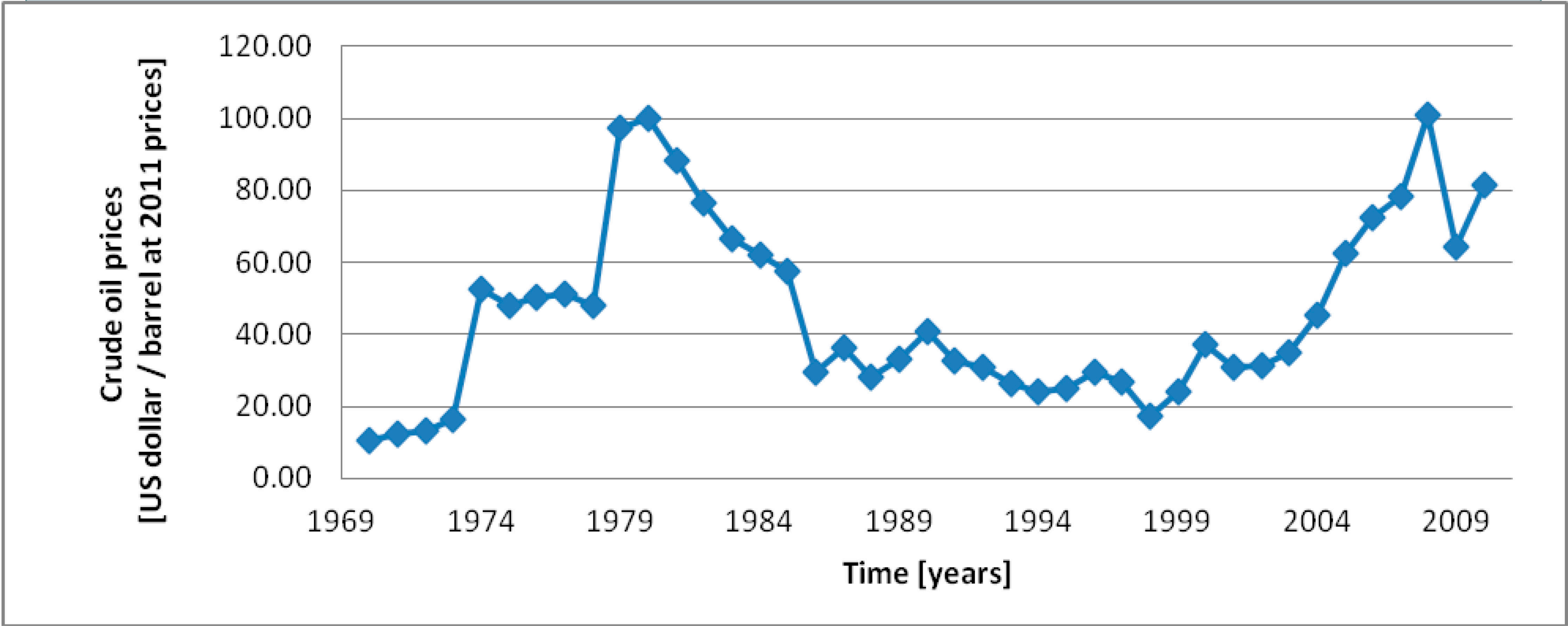
- Countries with net foreign assets should invest in stocks whose fortunes are inversely related to those of the oil market: cov(ε_r, ε_O) <0
- Invest in energy-intensive companies (aluminium smelters, steel producers, etc.) and producers of renewables, energy-efficient cars, etc.
- Then one needs to hold less precautionary buffers
- If $A\ \varepsilon_r + \varepsilon_O = 0$, the prudence terms drops out completely
- Net debtor countries should do the opposite: avoid energy-intensive companies, etc.

Epstein-Zin preferences (Vissing-Jorgenson and Attanasio, 2003)



World crude oil prices 1970-2010

- ML estimate of geometric Brownian motion gives drift parameter of 0.009 (insignificantly different from zero) and s.d. of 0.28 (cf. Bems and de Carvalho Filho, 2011)



Prudent saving with infinite horizons

- Geometric Brownian motion: $dP(t) = \upsilon_P P(t) + \sigma_P P(t) dW(t)$,
- Expected social welfare: $$\mathrm{E}_0\left[\int_0^{\infty} U\left(C(t)\right) e^{-\rho t} dt\right]$$
- Stochastic Euler equation:

$$\frac{1}{dt}\mathrm{E}_t\left[dC\right] = \sigma\left[r-\rho\right]C + \frac{1}{2}CRP\left[O-\frac{\partial S}{\partial P}\right]^2\left(\frac{\sigma_P P}{C}\right)^2 C$$

- Note: MPC out of wealth created by an oil price shock $= O - \partial S/\partial P = \partial C/\partial P$

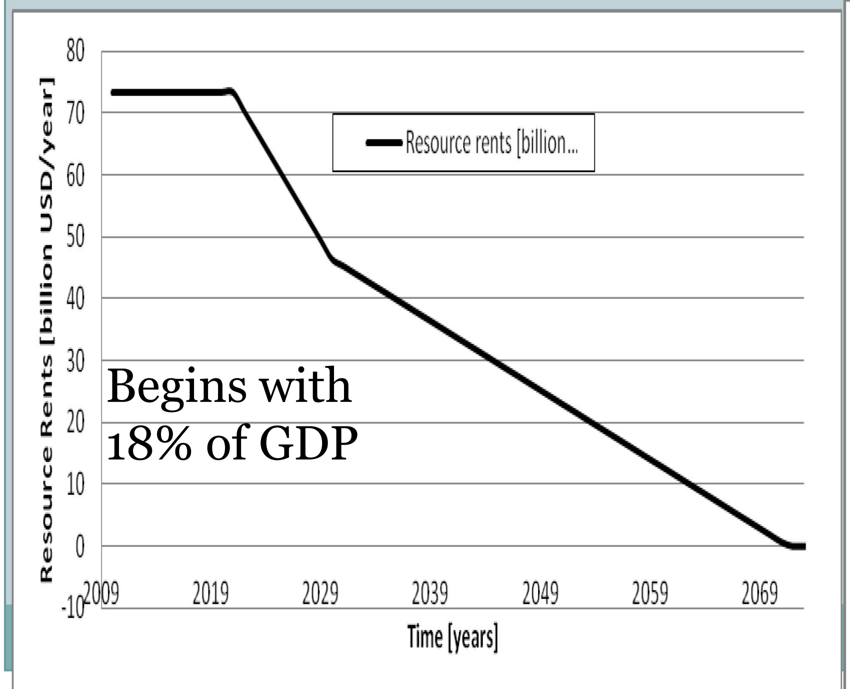
So relative size of liquidity fund is big if:

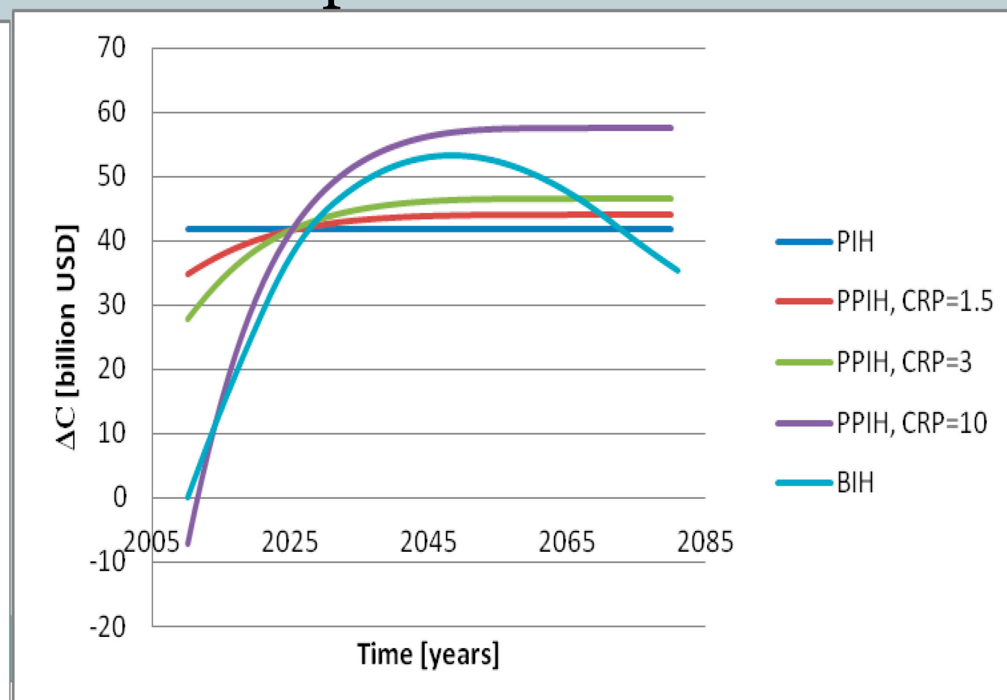
- Variance of oil income uncertainty *relative* to size of economy is large (Iraq > Norway > Ghana)
- Government is more prudent
- Windfall is more permanent and less temporary (Iraq > Norway > Ghana)
- So expect biggest liquidity fund for Iraq, then for Norway (lasts much longer until 2050-60 than Ghana) and smallest for Ghana (lasts very short, small relative to size of economy)

NORWAY: declining oil windfall (reserves = 46 trillion barrels of oil equiv.)

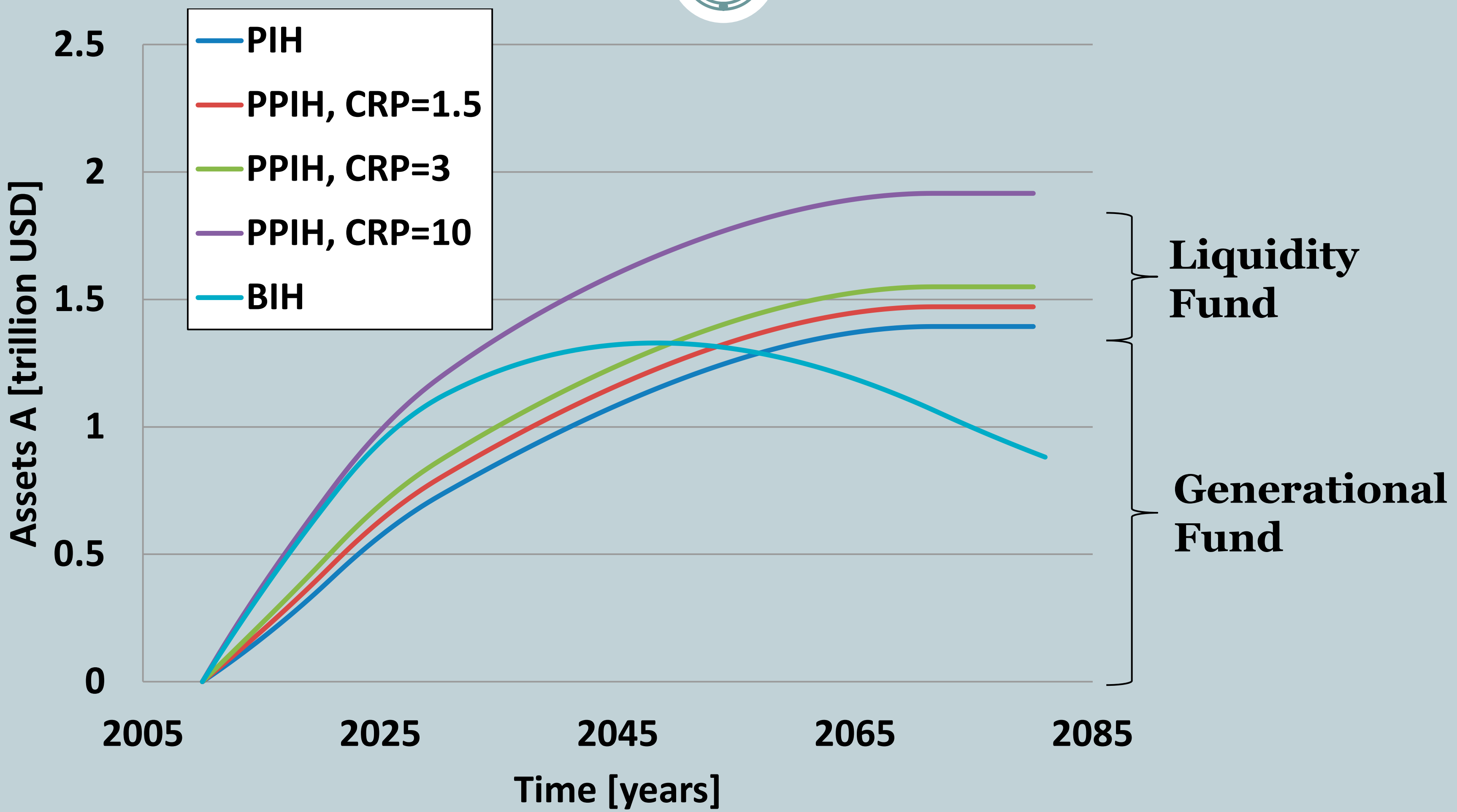
- With CRP=3, need fund of 1.55 not 1.39 trillion US$
- 10% of intergen. fund; 37% if CRP=10 (1.92 trillion US$)
- Not Δ*C*=41.8 billion US$ (10% of GDP or 8387$/capita), but first less (21.7) then more (46.6 billion US$)
- Oil rents

Consumption increments





NORWAY: size of funds

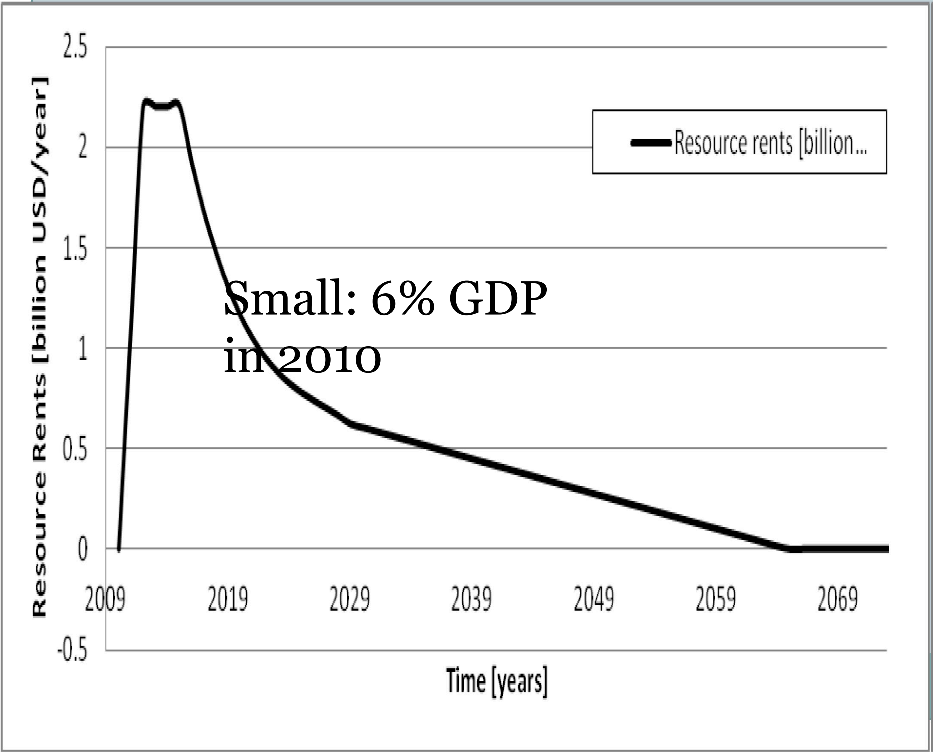


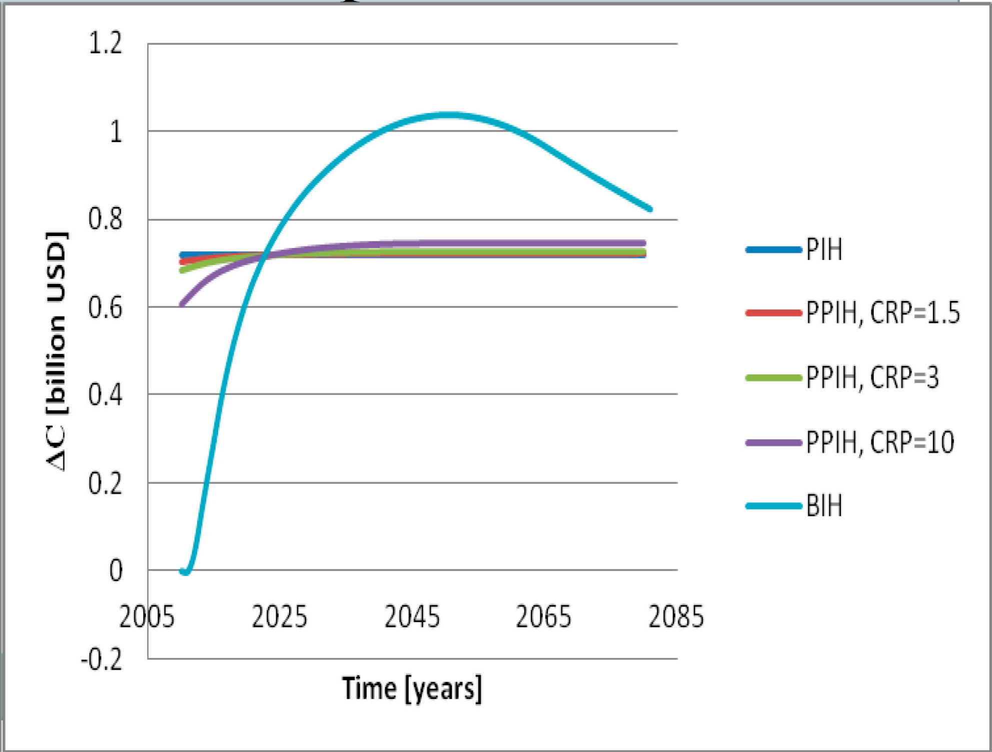
Comments on Norway

- For high CRP the optimal prudent response is close to the bird in hand rule for the next 20 years or so.
- Temporary windfall implies that MPC falls monotonically from 0.84 billion $ for every $ increase in price of barrel of oil in 2005 to zero in 2065. Hence, prudence effects falls with time and thus the upward tilt of the consumption paths flattens out.
- Need to take account of emerging pension burden. So do not focus on oil only.

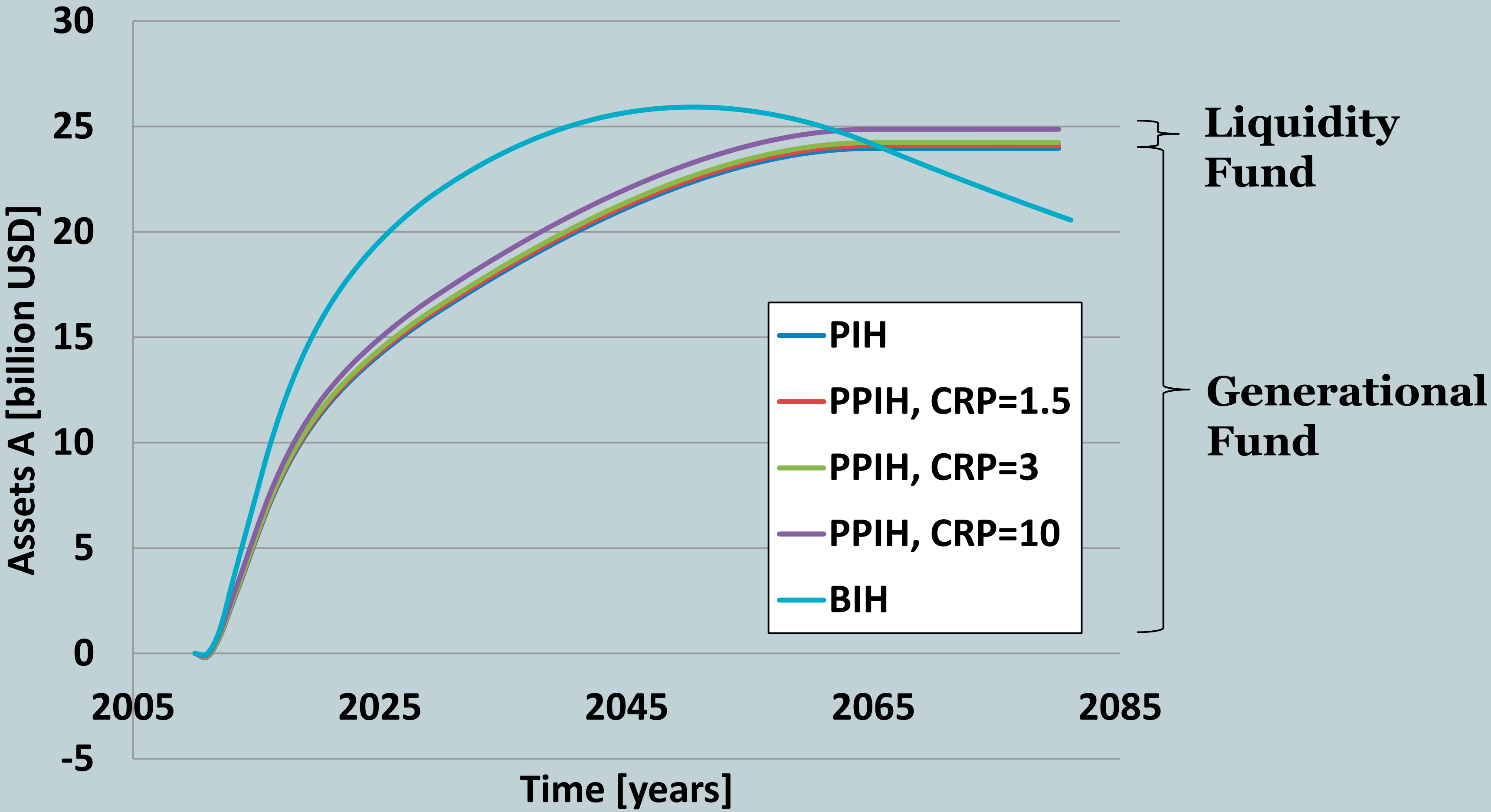
GHANA: temporary, small windfall (reserves = 700 million barrels of oil)

- Intergenerational fund=24 b$, Δ*C*=719 m$=29.5$/yr per citizen. Optimal size of liquidity buffer is tiny (not more than 1 billion $). A SWF of 1000$/capita
- Oil rents Consumption increments



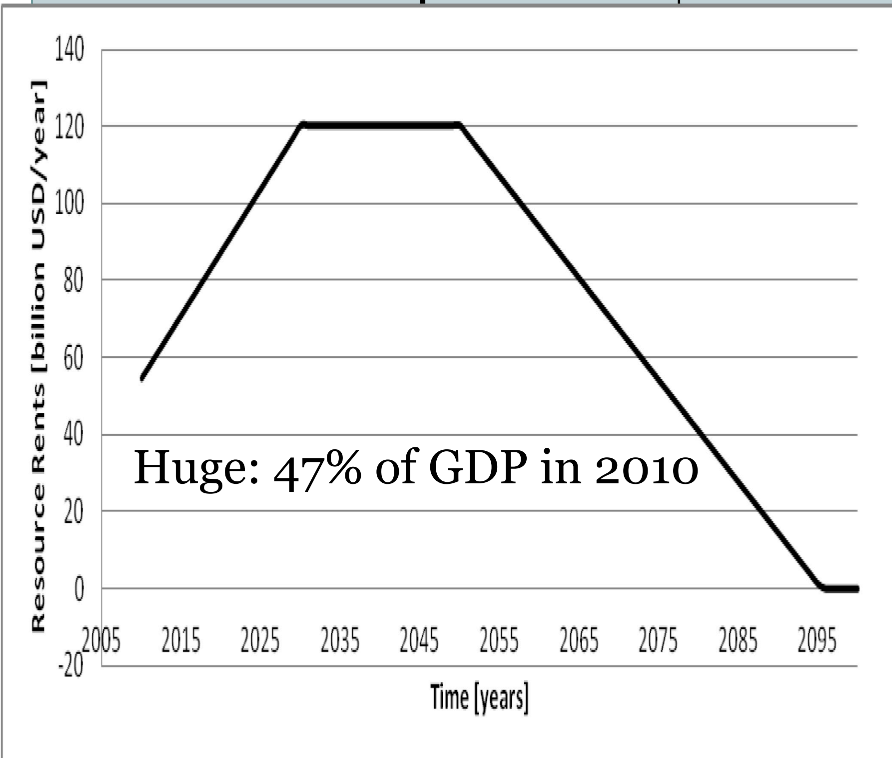


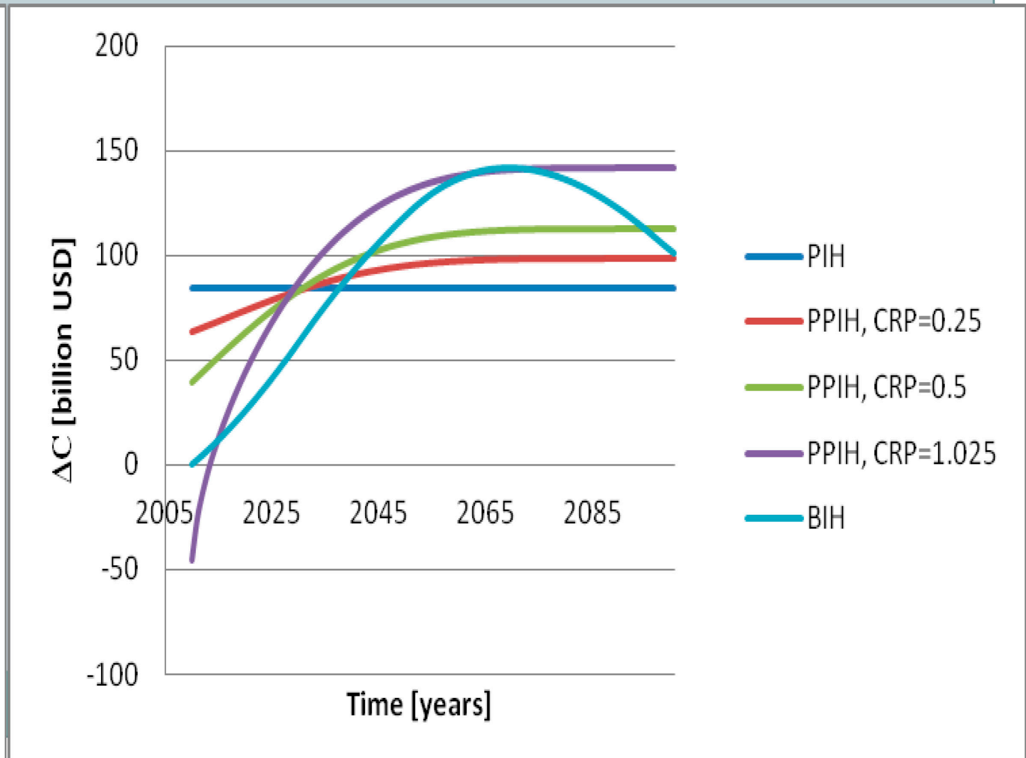
GHANA: size of funds



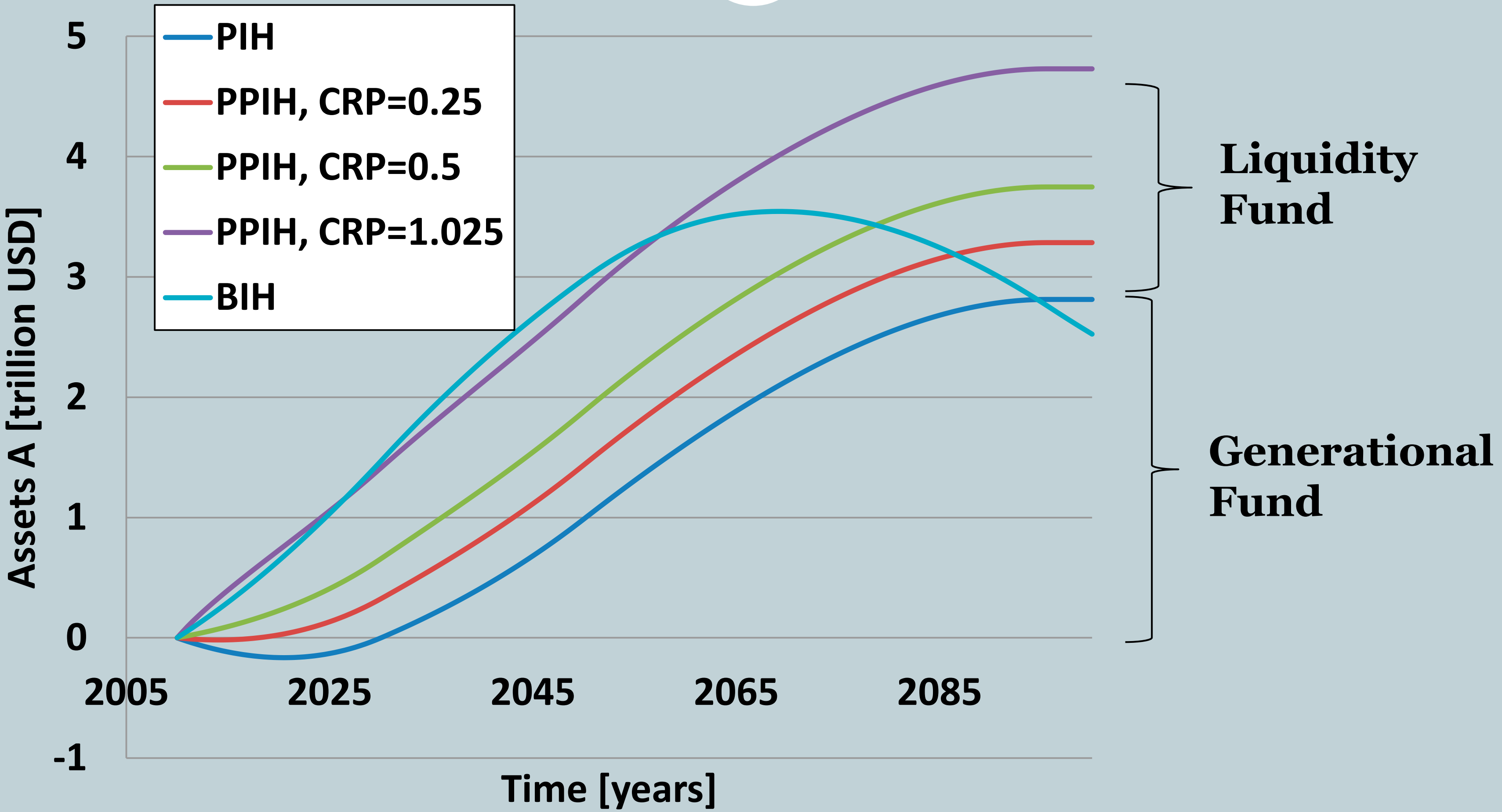
IRAQ: huge and rising oil windfall (reserves = 115 trillion barrels of oil)

- Need intergenerational SWF of 2.81 trillion$ or 92500 \$/capita. We then have ΔC = 84.4 billion \$ or annuity of 2775\$/capita. Even if CRP=1.025, liquidity fund is 1.92 trillion \$ (68% of i.g. Fund). Very similar to BIH path: ΔC=-45.2 billion \$ in begin and then to +142 billion \$ in the end.





IRAQ: size of funds



Capital scarcity, investing to invest and volatility

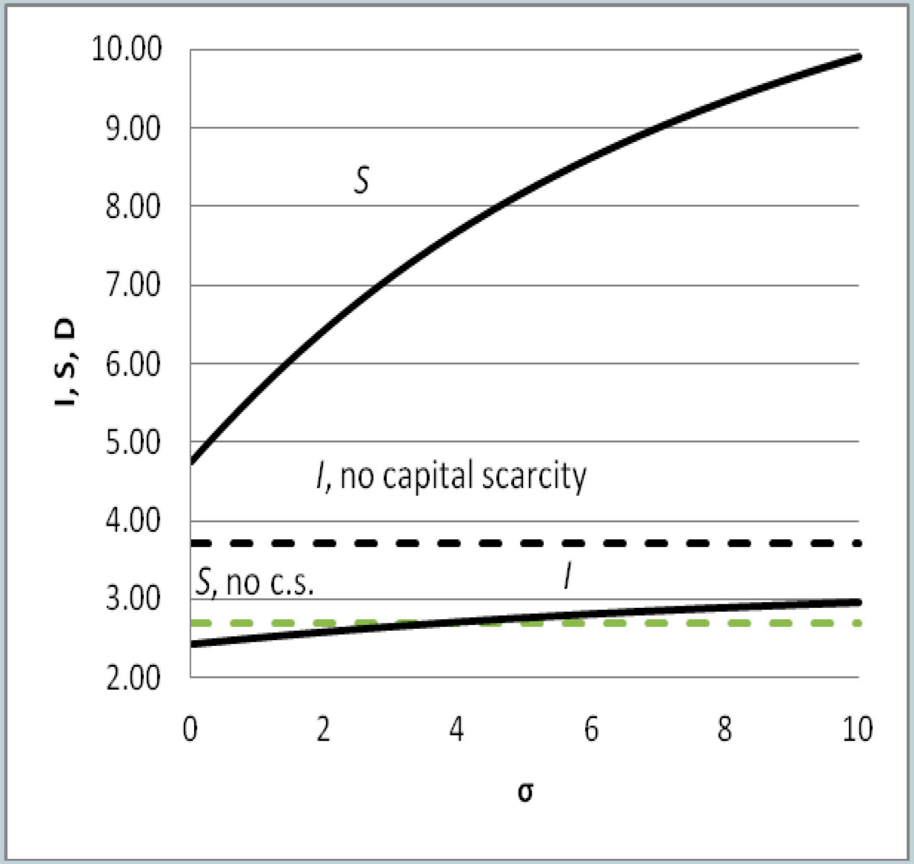
- Risk premium on international debt: $r = \rho + \pi(D)$ with $\pi' > 0$ and $D = -A$
- Replace Y by $Y + (1 + \varepsilon_I)\, F'(I)$, $F' > 0$, $F'' < 0$
- Separation theorem no longer holds: part of windfall must be spent on domestic investment

$$U'(C_1) = \mathrm{E}\left[\left(\frac{1+\rho+\pi(D)+D\pi'(D)+\varepsilon_r}{1+\rho}\right)U'(C_2)\right],$$

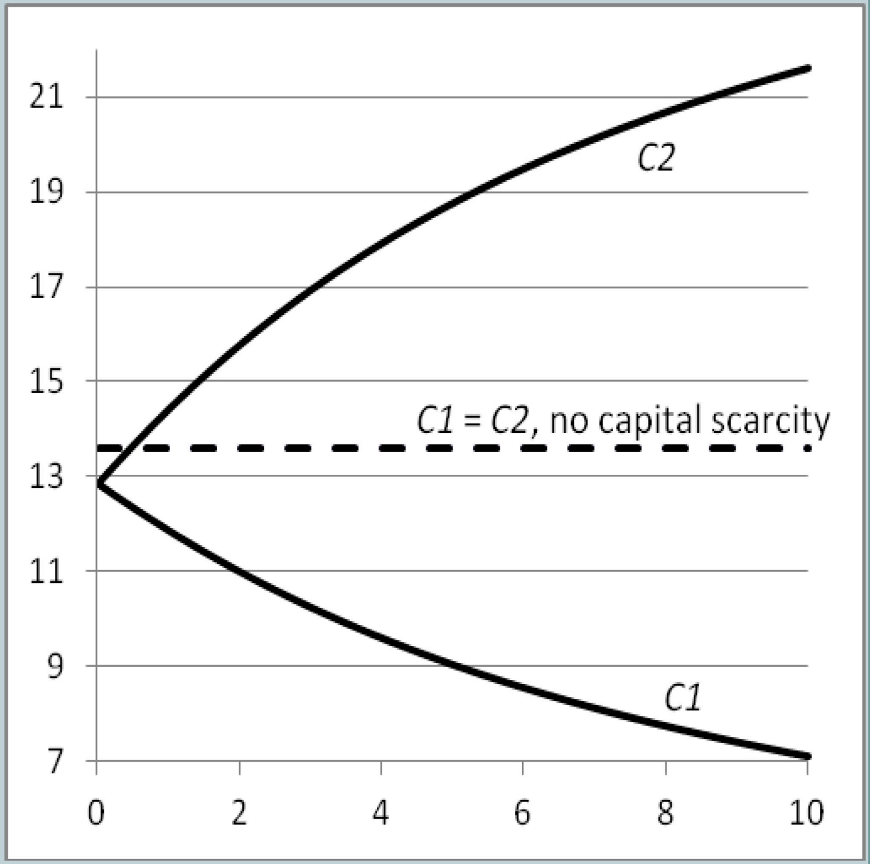
$$U'(C_1) = \mathrm{E}\left[\left(\frac{(1+\varepsilon_I)F'(I)}{1+\rho}\right)U'(C_2)\right],$$

Investment and capital scarcity: no uncertainty (solid lines: cap. scarcity; dashed lines: no scarcity)

- Investment, saving, debt

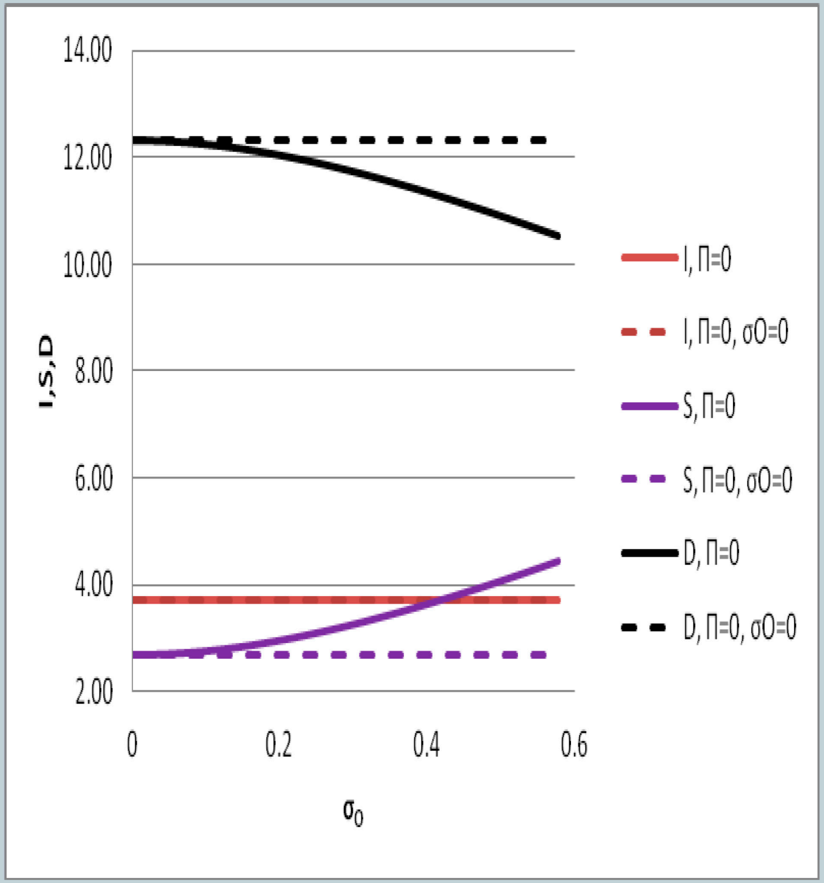


Present and future cons.

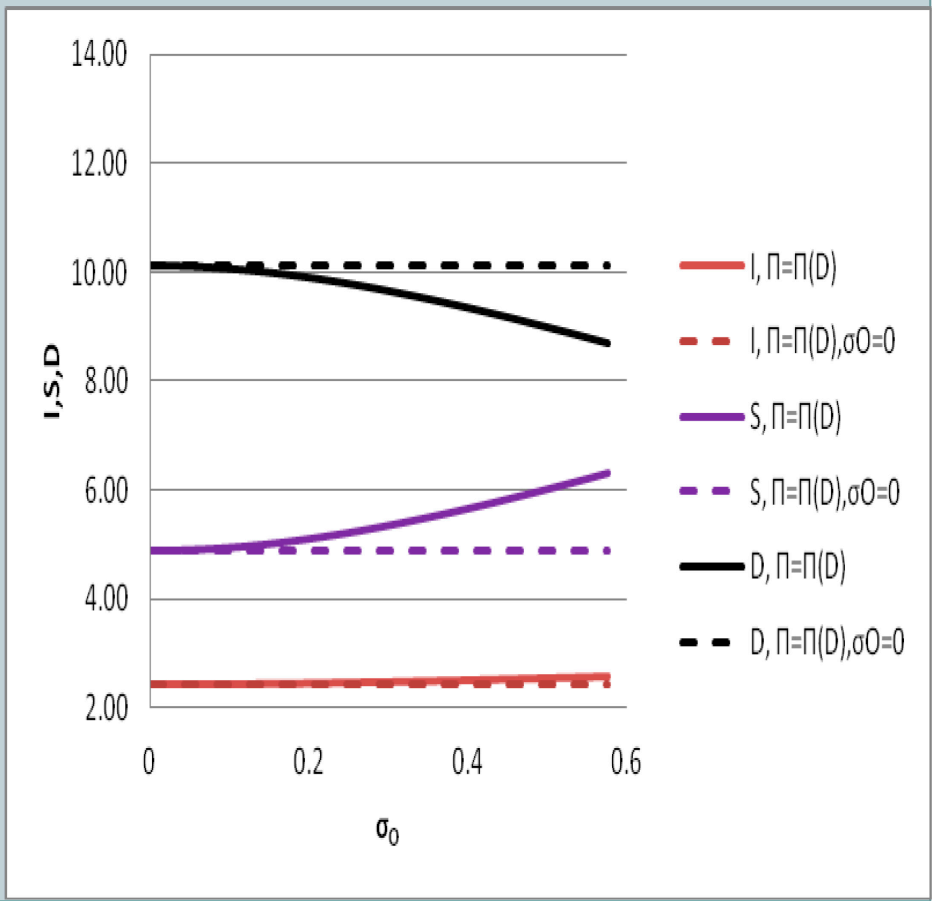


Windfall uncertainty and capital scarcity: allocate some of windfall to investment

- No capital scarcity

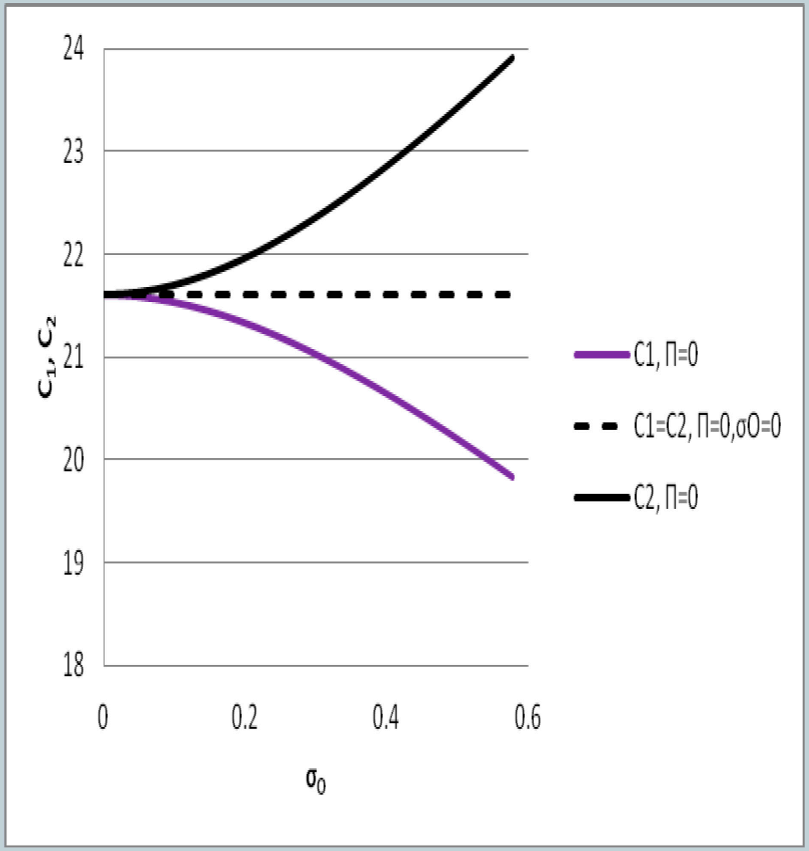


Capital scarcity

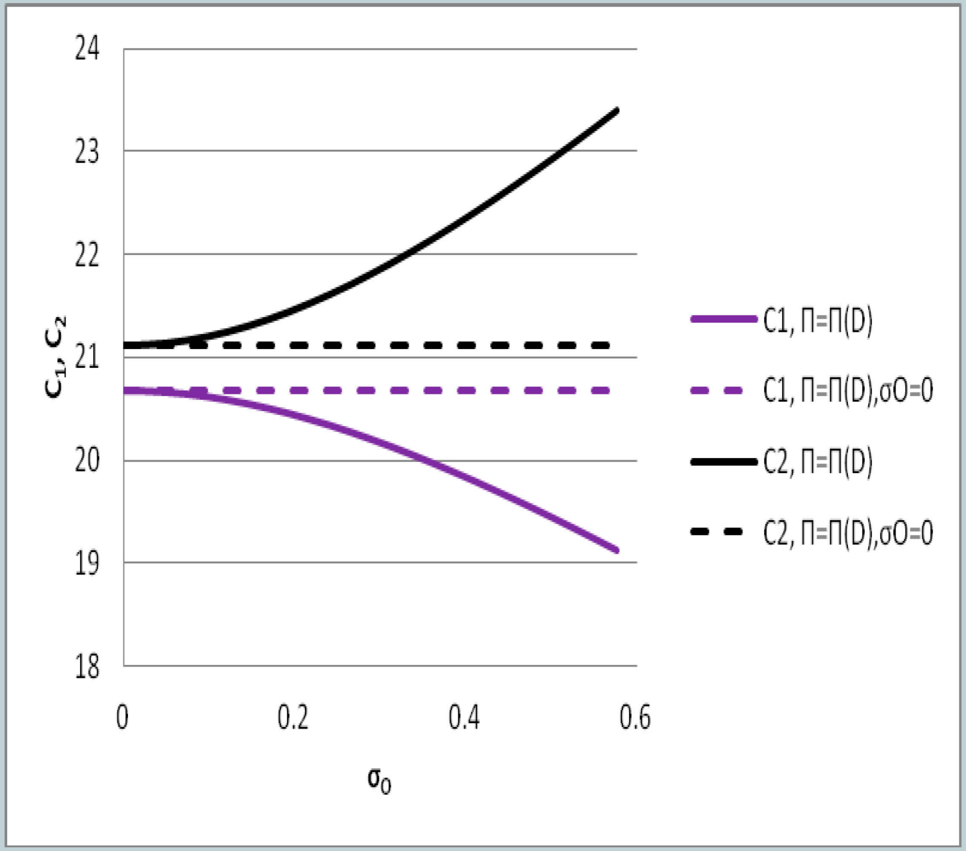


Windfall uncertainty and capital scarcity

- No capital scarcity

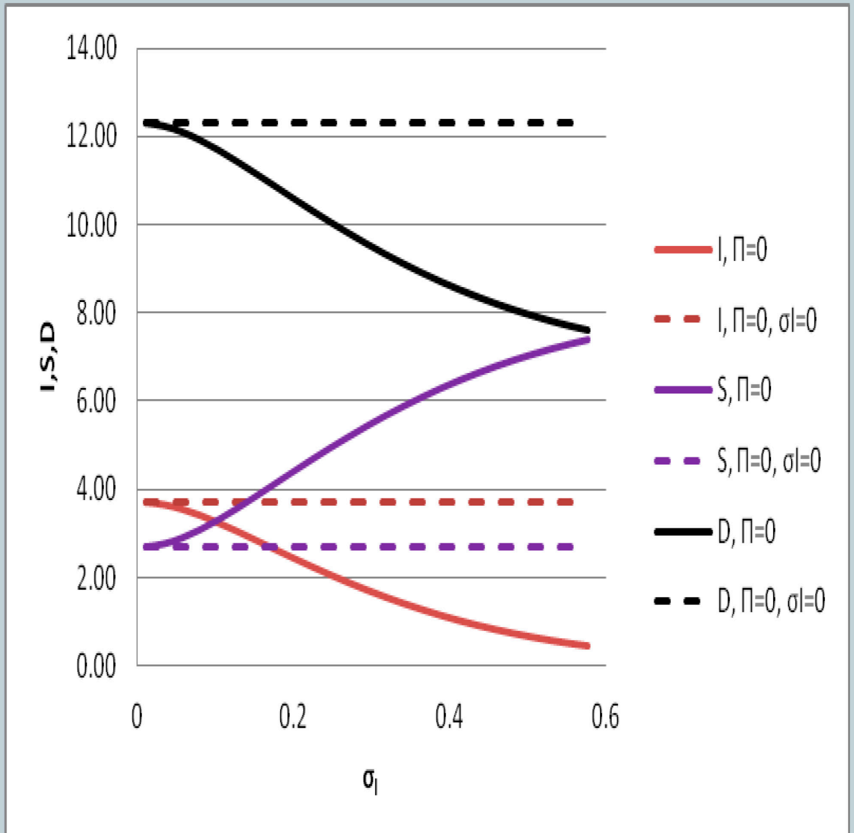


Capital scarcity

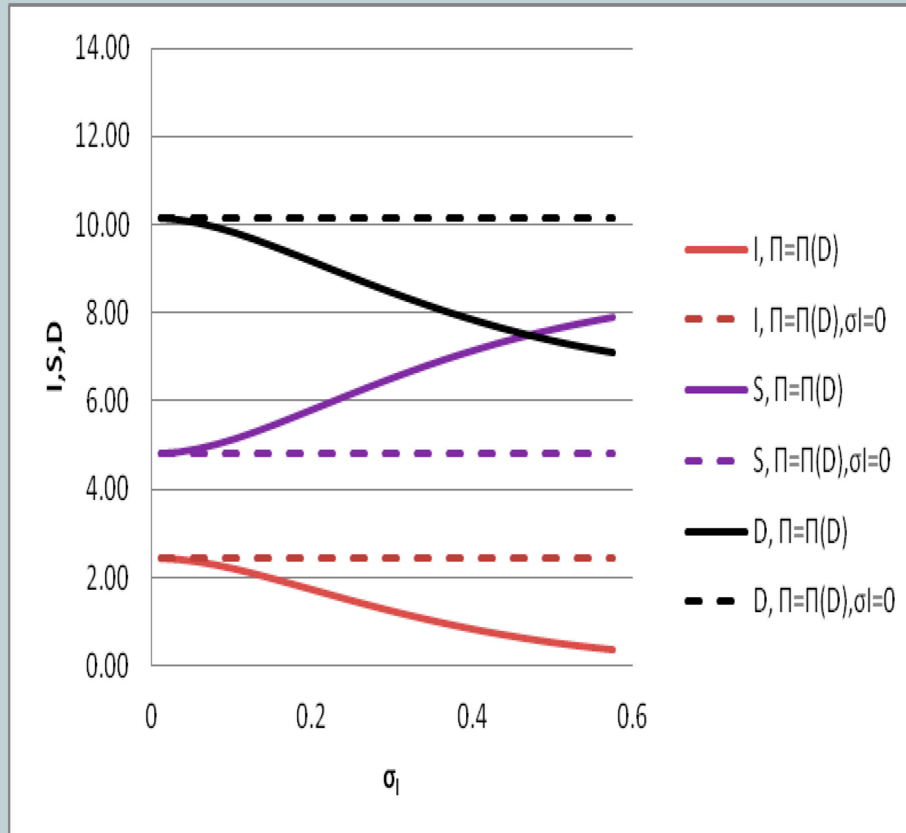


Uncertainty about public investment returns: a story of ‘big savers and small investors’

- Cf. Cherif and Hasanov (2011)
- No capital scarcity



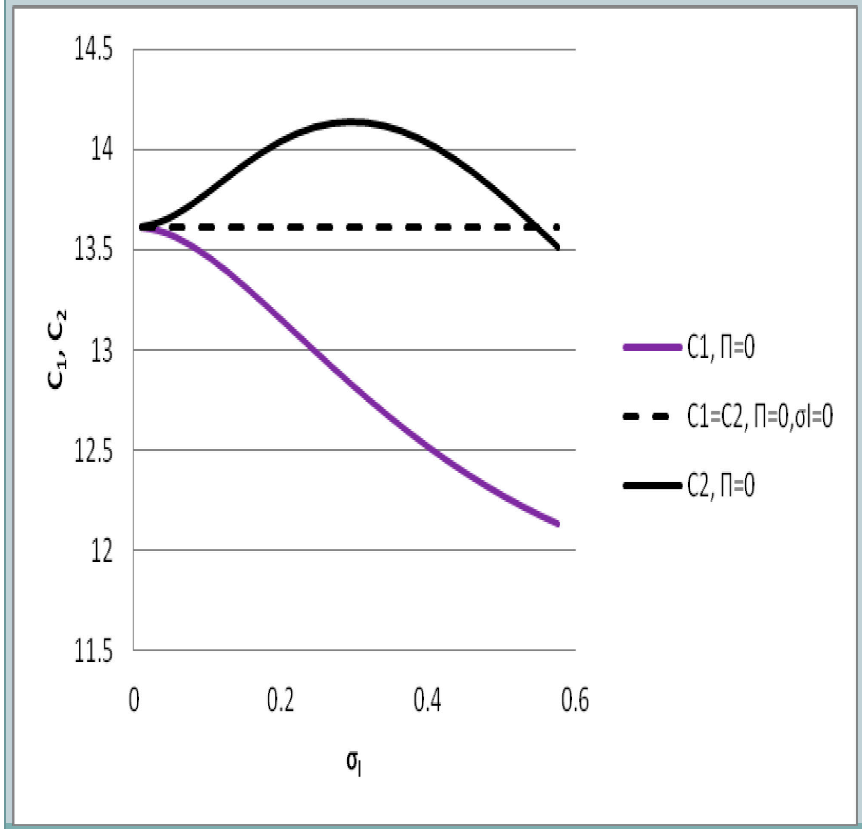
Capital scarcity

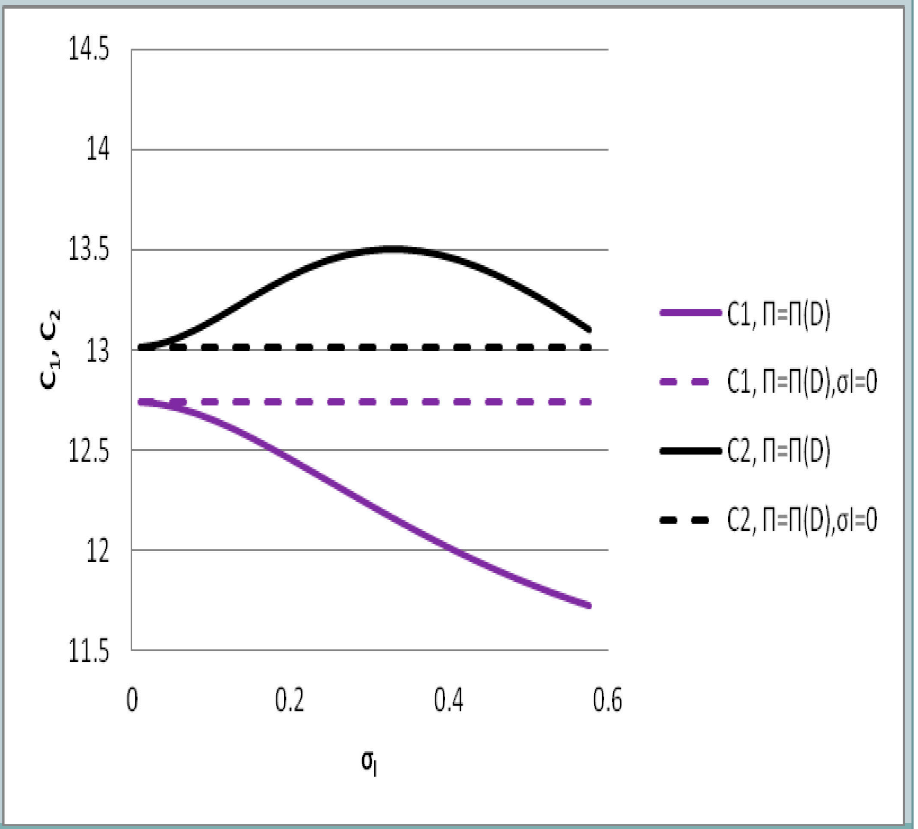


Uncertainty about public investment returns

- No capital scarcity

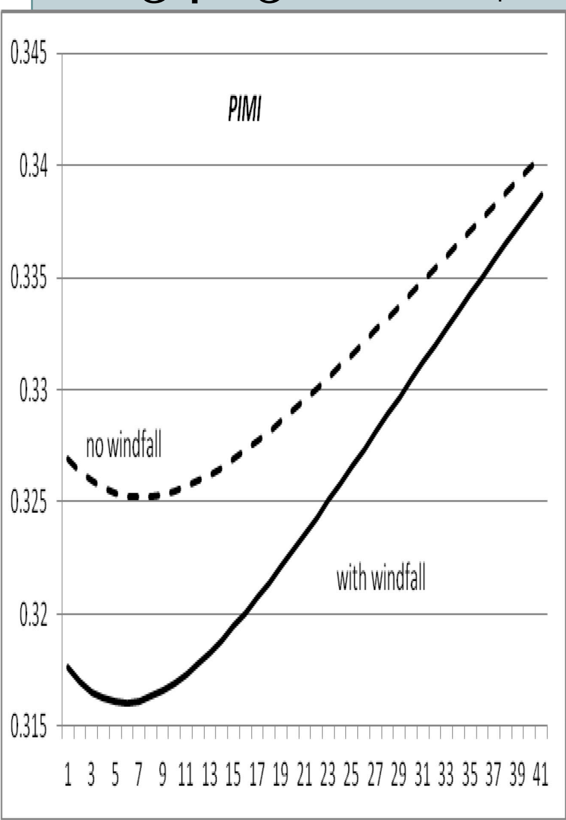
Capital scarcity

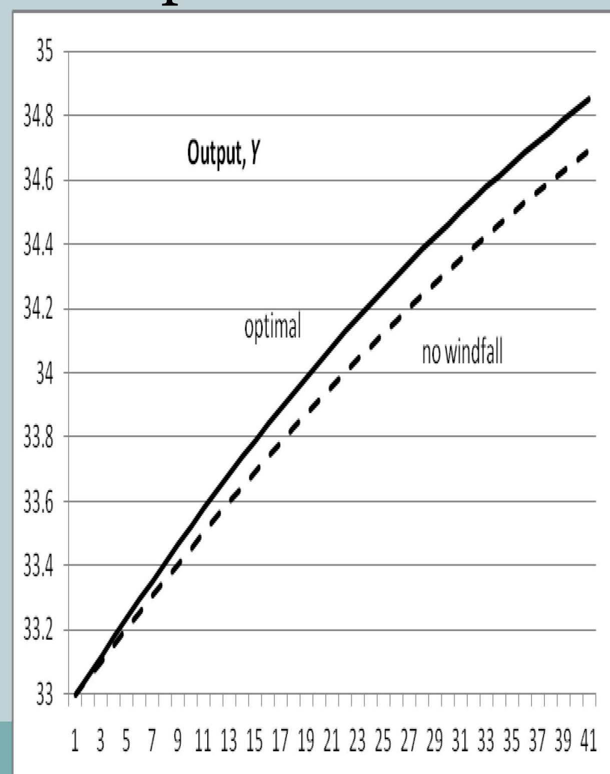


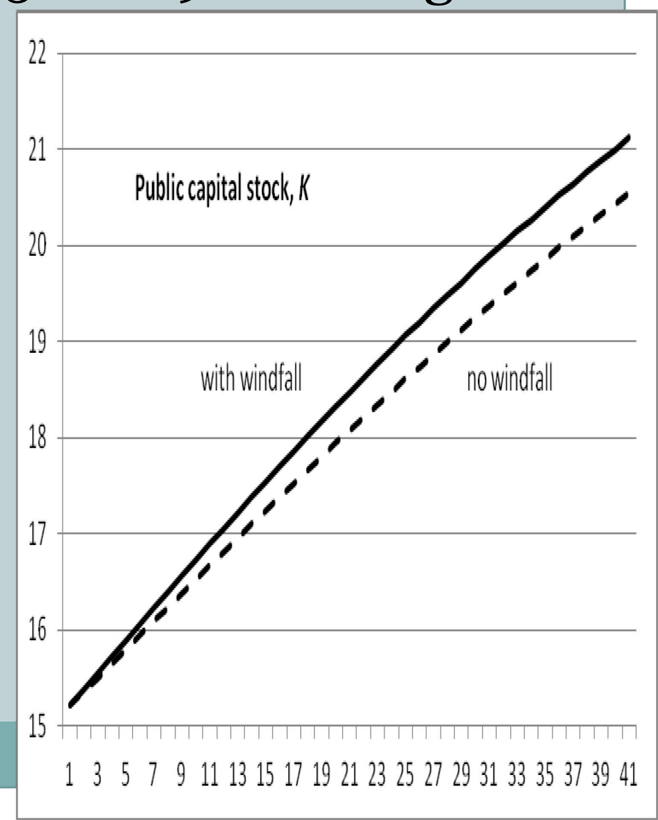


Investing to invest in Ghana

- PIMI and internal adjustment costs for investment
- Calibrated to Ghana (year 1 = 2010) using vdP and Venables (2011) estimate of interest spread. GDP increases from 34.69 to 34.85 billion \$. Consumption rises from 27.51 to 29.01 in begin.

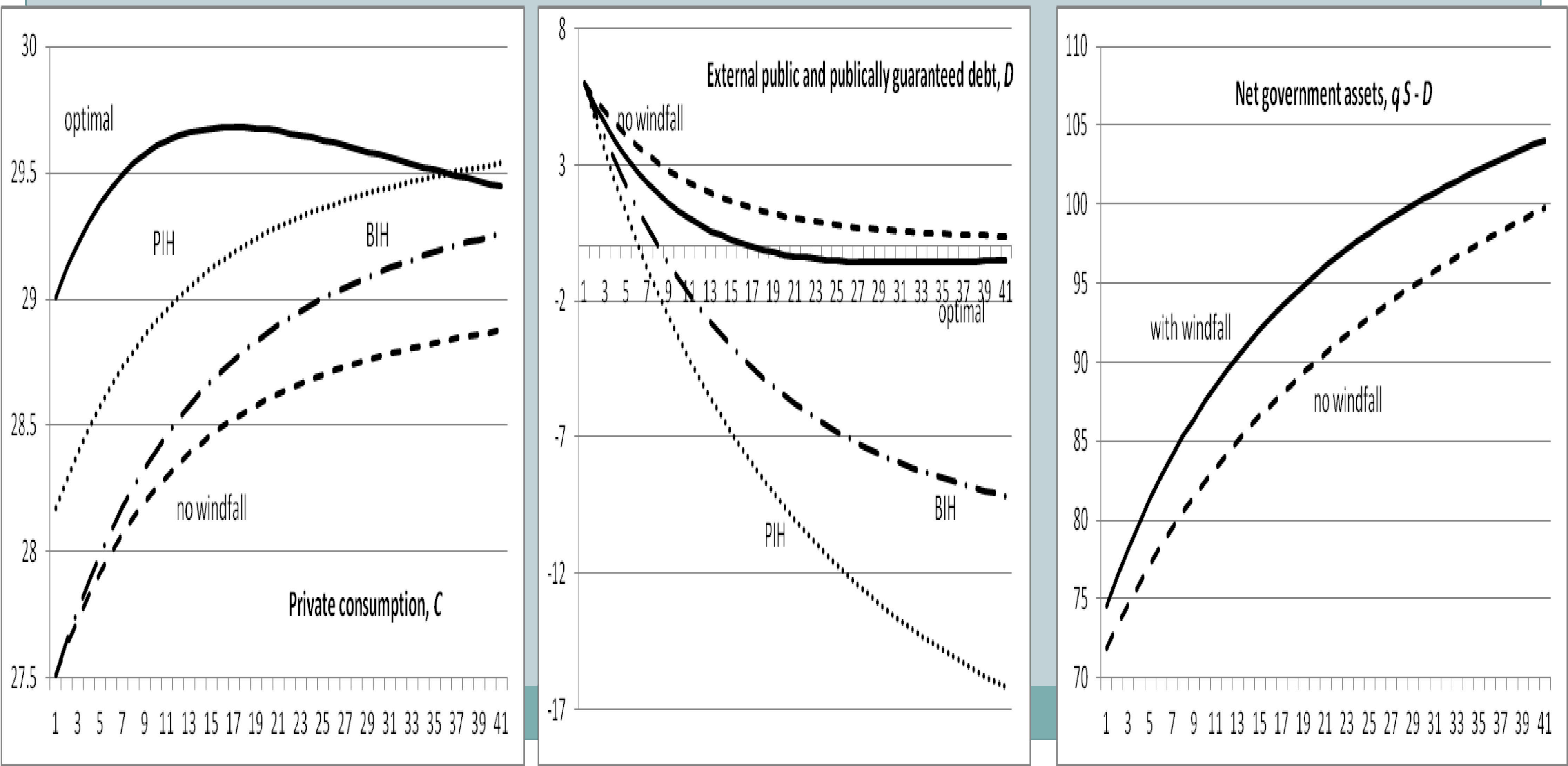






Investing to invest in Ghana

- Output elasticity of public capital = 0.17
- Most of consumption is upfront. *q*, *A* and *I* jump up on impact



CONCLUSION

- Developed oil-rich countries should build an intergenerational and a liquidity fund to sustain a permanent increase in consumption and to hedge against volatility. The windfall should not be spent on investment
- This fund should be diversified and be orthogonal to oil risk
- Poorer, capital-scarce oil-rich countries should spend part of their windfall on investment. Due to absorption problems, they should also have a parking fund.