Macro Policy Responses to Natural Resource Windfalls and the Crash in Commodity Prices

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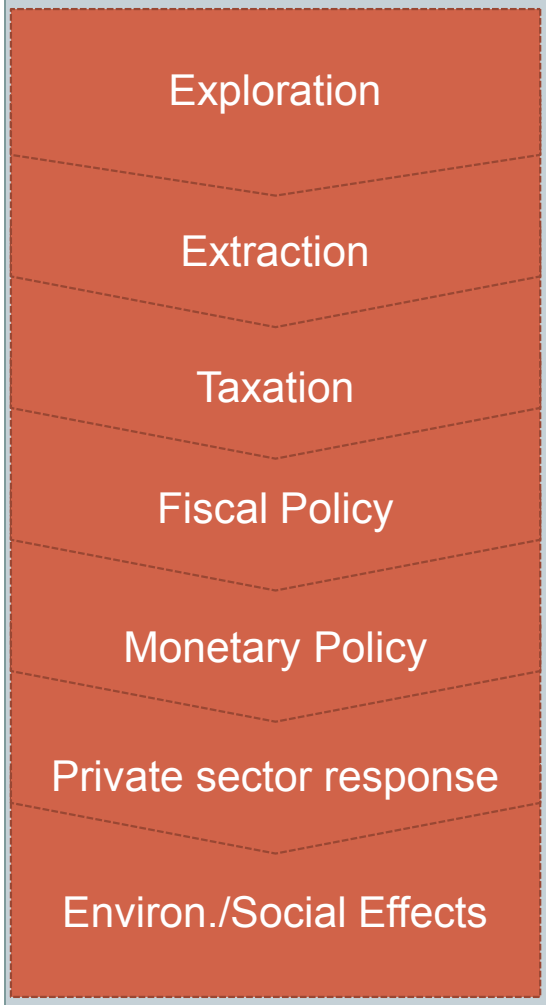
WINDFALL REVENUE

- Discoveries of new fields of oil or gas
- But also mining of diamonds, copper, bauxite, …
- Sustained higher prices of existing reserves will create windfall as well. But an oil price crash …
- Windfalls: large, temporary, anticipated & volatile.
- Also, foreign aid is windfall of foreign exchange.
- Consensus: save the windfall by putting it aside in a sovereign wealth fund, so the interest on the fund can help to finance a permanent increase in the budget deficit (permanent rise in spending/transfers and/or permanent cut in taxes) and consumption.

Managing natural resource should take into account everything from exploration, through fiscal policy to the final environmental and social impacts of mining



- Cairns (1990), Jakobsson et al. (EE, 2012), Real Options (Dixit + Pindyck, 1994 Book)
- Hotelling Rule (1931). Anderson et al. on Hotelling under pressure (2014, NBER 20280). Nakov + Nuno (EJ, 2013)
- Royalties - distortionary but easily monitored. Rent/Profit tax – efficient but avoidable with transfer pricing. Daniel et al. (Book, 2010)
- PPI vs CPI vs PEP (Frankel, 2011; Catao + Chang, IMFER 2013). Source of shock matters (Bodenstein et al., IMFER 2012). Announcement effects (Arezki et al., 2016, Wills, 2014)
- Spill-overs vs Dutch disease. Absorption constraints. Saving.
- Rehabilitation
- Local input requirements

Focus on what governments should do once they have collected resource wealth.

Spend

More public services?
Tax cuts?

Invest

Public capital?
Private capital? How?

Save

Sovereign wealth fund?
Domestic/Foreign?
What types of assets?

Benchmark Result 1: permanent-income rule

- In small open economy with perfect access to international capital markets smooth the time path of consumption/capita: 'if in doubt, smooth it out'.
- By borrowing ahead of windfall, saving during the windfall in an *intergenerational* SWF, and living of the interest of the SWF after the windfall has ceased.
- So cut spending/raise taxes if crash is permanent, but borrow or dip in the SWF if crash is temporary.
- Hartwick rule: running down oil wealth must be compensated for by equal increase in SWF wealth.
- Do not invest any of the windfall abroad (cf Norway).

Benchmark Result 2: managing Dutch disease

- Windfall induces contraction of traded and expansion of non-traded sector (Dutch disease).
- The PI rule induces a small and immediate permanent appreciation of the real exchange rate, and thus avoids the sharp appreciations and sectoral reallocations of the spend-all rule.
- The commodity price crash requires an immediate and modest depreciation of the real exchange rate, so the non-oil sectors can expand. Tightening the belt too much relative to the PI rule induces to sharp depreciations of the real exchange rate.

TWO-SECTOR SCANDINAVIAN MODEL OF DUTCH DISEASE

THE PRESENT: small letters

$\mathrm{e}'(p)c = \mathrm{y}_p(p)$ non-traded goods market equilibrium

$\mathrm{e}(p)c + f = \mathrm{y}(p) + n$ current account (traded goods)

$$\Rightarrow \quad c = \mathrm{d}(n - f) \quad \text{with} \quad \mathrm{d}_{n-F} = 1/\mathrm{e}(p) > 0$$

$$p = \mathrm{p}(n - f) \quad \text{with} \quad \mathrm{p}_{n-F} = \frac{p}{\mathrm{e}(p)c}\frac{1}{\varepsilon^d + \varepsilon^s} > 0$$

THE FUTURE: capital letters

$\mathrm{E}'(P)C = \mathrm{Y}_P(P)$ non-traded goods market equilibrium

$\mathrm{Y}(P) + N + (1+r)f = \mathrm{E}(P)C$ current account

$$\Rightarrow C = \mathrm{D}\big(N + (1+r)f\big), \quad \mathrm{D}_P = 1/\mathrm{E}(P) > 0$$

$$P = \mathrm{P}\big(N + (1+r)f\big), \quad \mathrm{P}_{N+(1+r)f} = \frac{P}{\mathrm{E}(P)C}\frac{1}{\varepsilon^D + \varepsilon^S} > 0$$

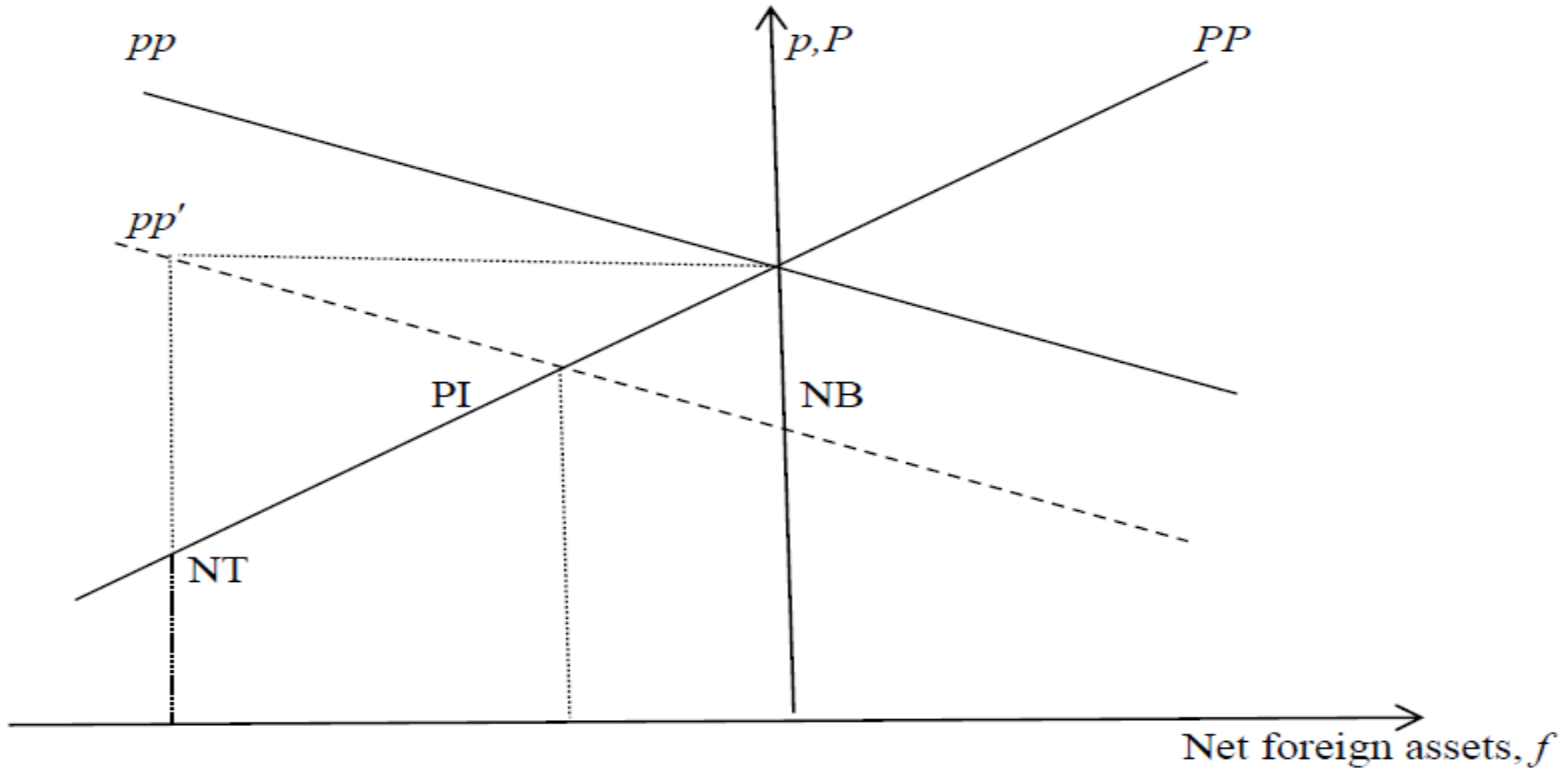
LINKING PRESENT AND FUTURE: EULER EQUATION

$$\frac{C}{c} = \left(\frac{\mathrm{e}(p)}{\mathrm{E}(P)}\right)^{\frac{1}{\eta}} = \frac{\Phi(P)}{\phi(p)} \quad \text{or} \quad P = p \quad \text{from solving present and future NT-GME}$$

$$p = \mathrm{p}(n - f, l) \quad \text{with} \quad \mathrm{p}_{n-F} = \frac{p}{\mathrm{e}(p)c} \frac{1}{\varepsilon^d + \varepsilon^s} > 0, \text{ current price of non-trdables,}$$

$$P = \mathrm{P}\big(N + (1+r)f, L\big), \quad \mathrm{P}_{N+(1+r)f} = \frac{P}{\mathrm{E}(P)C} \frac{1}{\varepsilon^D + \varepsilon^S} > 0, \text{ future price, and Euler eq'n } \quad P = p.$$

Figure 2: Real exchange rate, foreign assets and a temporary commodity price crash



Key: The solid lines correspond to initial outcome and dashed lines to after a temporary crash in commodity prices. The equilibrium shifts from E to PI under the permanent-income rule, from E to NB under full tightening of spending if international borrowing is ruled out, and from E to NT if spending is not tightened at all and the country borrows from abroad instead.

Modification 1: stochastic volatility

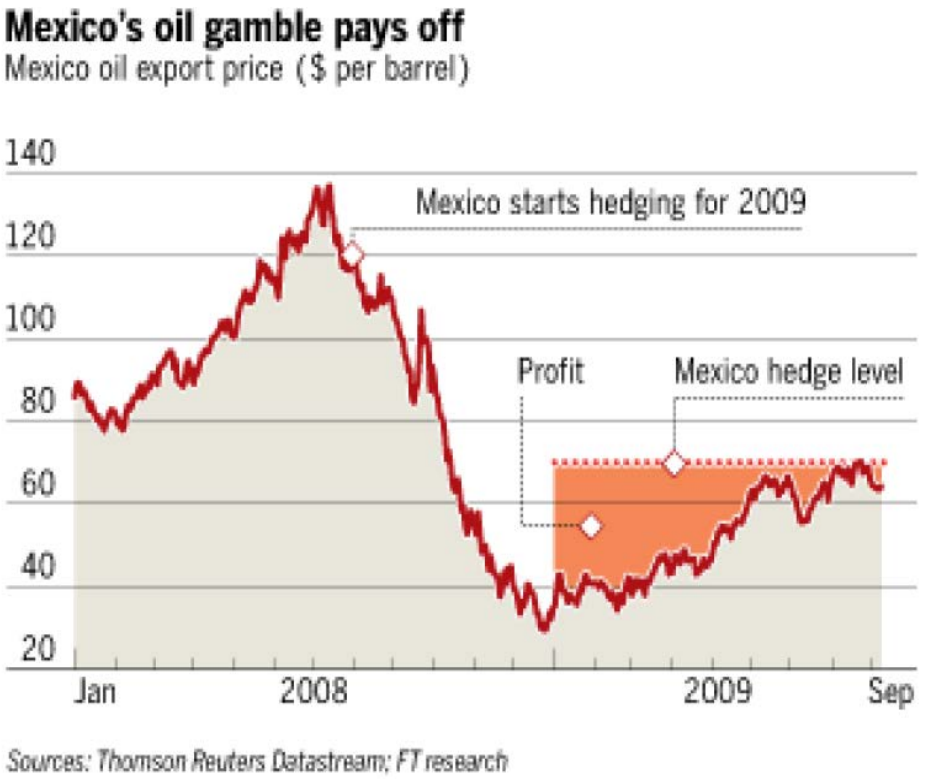
- Stochastic volatility of commodity prices requires an additional *stabilisation* or *liquidity fund* to collect precautionary saving buffers. These buffers are large if relative risk aversion, relative prudence are large, the standard deviation of windfall uncertainty relative to consumption is large, and shocks are more persistent.
- Prudence implies low initial consumption, so no full intertemporal smoothing. With a windfall the real exchange rate initially appreciates by less than in long run.
- Commodity price crash leads to less precautionary saving as amount at risk has fallen.
- Long-lasting windfalls imply small intergenerational SWF but large stabilisation SWF. Vice versa for short windfalls.

How to handle extreme volatility?

- Problems with hedging, so stabilisation fund may be better.

Hedging

- Mexico: spent $1.5bn on option, earned $8bn
- Ecuador, Colombia, Algeria, Texas, Louisiana;
- Unlikely to become widespread?
  - Political risks when lose
  - Market impact of hedging:
    - Information
    - Market power

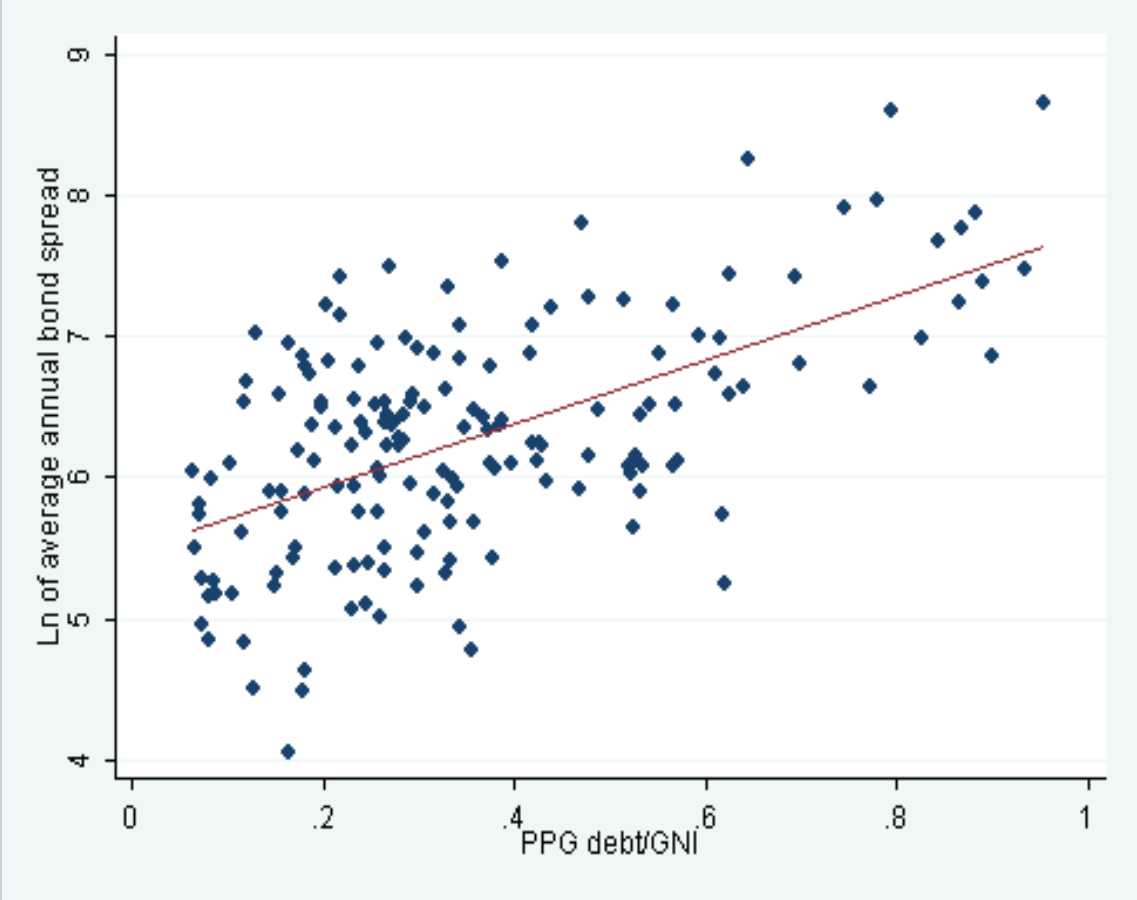


Modification 2: capital scarcity

- Many developing countries have no good access to international capital markets and thus find it hard to invest in domestic investment projects for which the cost of borrowing is high.
- In that case, the PI rule is sub-optimal. It is better to bring consumption forward as current generations are relatively poor by bringing down cost of borrowing domestically, alleviating capital scarcity, and using part of the windfall for domestic investment (with Venables).
- Don't build SWF, but give development process a leg-up.
- A commodity price crash induces more indebtedness and a fall in domestic investment.

Developing countries: capital scarcity

- Capital scarcity and low income
- ⇒ High return to immediate consumption & to domestic investment.
- Empirical evidence: interest premium if foreign debt is high and foreign reserves low

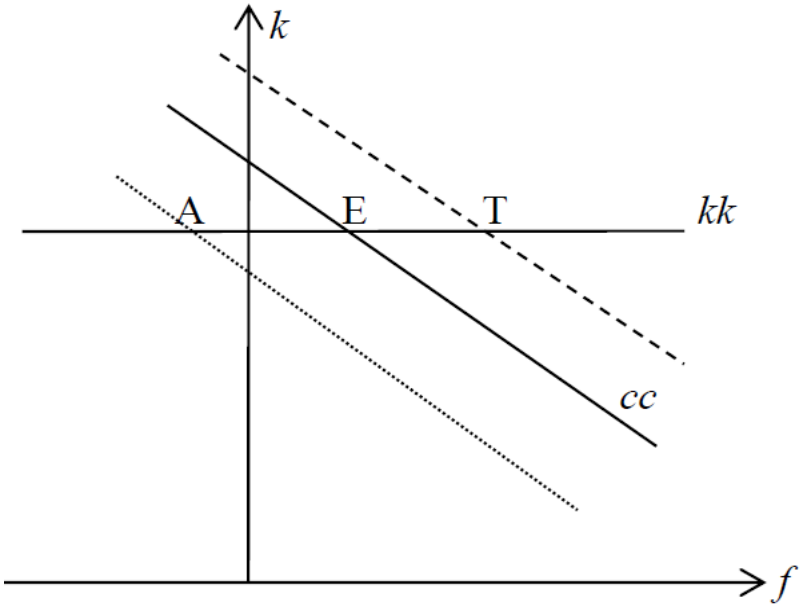


$$\Upsilon'(k) = \bar{r} + \pi(f) + \pi'(f)f + \delta \quad kk\text{-locus}$$

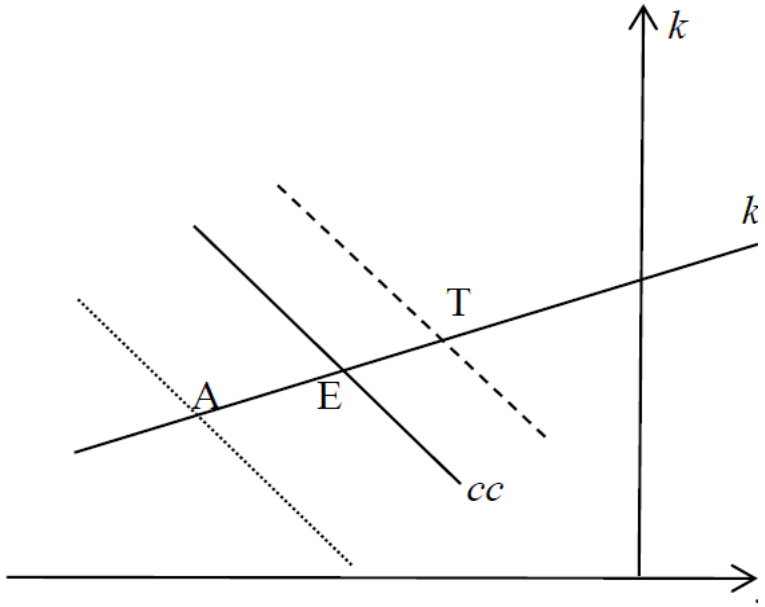
$$\frac{C}{c} = \left(\frac{1 + \bar{r} + \pi(f) + \pi'(f)f}{1 + \bar{r}} \right)^{\frac{1}{\eta}} = \frac{\Upsilon(k) + (1-\delta)k + N + \left[1 + \bar{r} + \pi(f)\right]f}{y + n - k - f} > 1, \quad cc\text{-locus.}$$

Figure 1: SWF management and domestic investment in response to a windfall

(a) ***Perfect access to capital markets***



(b) ***Capital scarcity***



Key: The solid lines indicate outcomes for when there is no windfall; the dashed lines for a temporary windfall; and the dotted lines for an anticipated windfall. A temporary windfall shifts the equilibrium from E to T; an anticipated windfall shifts the equilibrium from E to A.

Modification 3: RWR and unemployment

- Real consumption wage is rigid, so a depreciation caused by commodity price crash boosts producer wage and cuts employment in traded sector and vice versa in the non-traded sector. If traded sector is labour intensive, aggregate employment falls.
- It is not optimal to smooth consumption by cutting it permanently after a commodity price crash, but to not cut it too much initially whilst RWR holds to limit real depreciation and mitigate fall in unemployment.
- More interesting is to have RWR with structures.

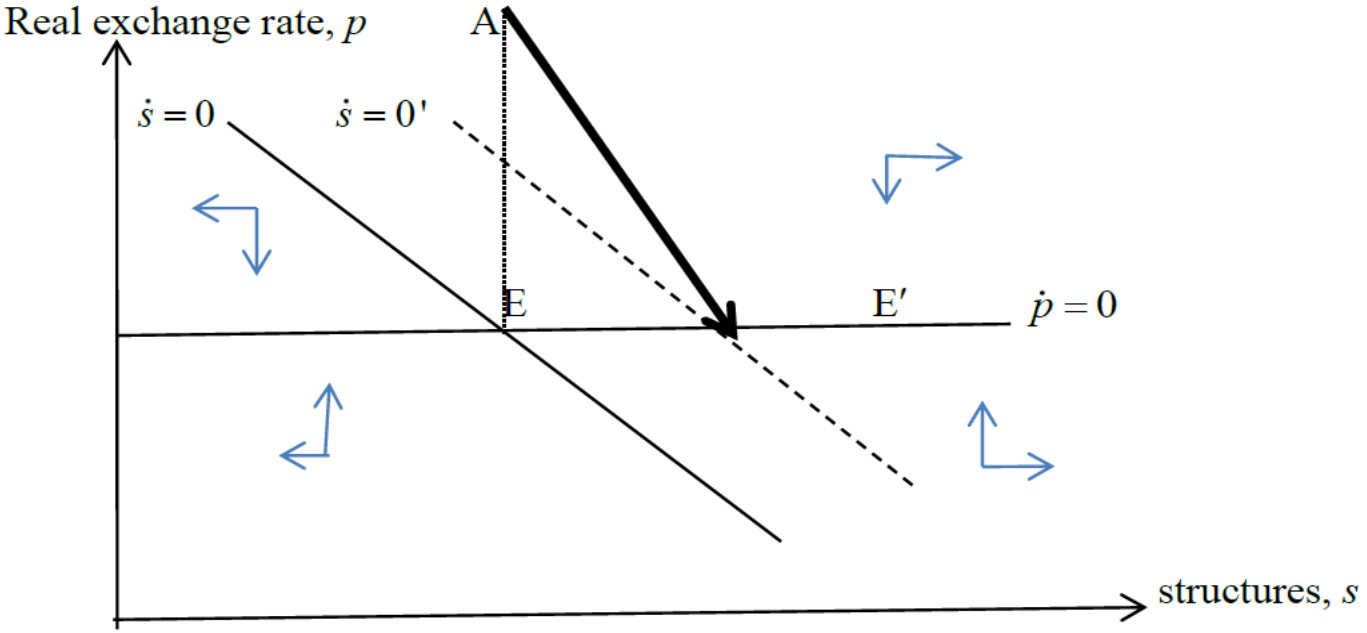
Modification 4: absorption constraints

- Most investment must be home grown. It takes time to build structures. Furthermore, structures cannot be imported from abroad and must be produced mostly in the non-traded sector (with Venables).
- This leads to absorption constraints.
- To overcome these, there must be temporary appreciation of real exchange rate to signal profitability of investing in structures so that windfall-induced demand can eventually be met more efficiently.
- Over time this allows more labour and other factors to be shifted from the traded to the non-traded sectors.

$$\dot{s} = \mathrm{y}_p - \mathrm{e}'(p)c - \delta s = \mathrm{y}_p(s,p,l) - \mathrm{e}'(p)\left[e(p)\lambda\right]^{-1/\eta} - \delta s, \quad s(0) = s_0,$$

$$\dot{p} / p = r + \delta - \mathrm{y}_s(s,p,l), \quad p(0) \text{ free},$$

Figure 3: Absorption constraints and Dutch disease



Key: A permanent-income rule for managing a temporary windfall boosts consumer spending. This shifts the $\dot{s} = 0$ locus to the right. The equilibrium shift up on impact from E to A, and afterwards the equilibrium moves along the saddle-path (the bold solid arrow) to E′.

Effects depend on factor intensity

- So if non-traded sector is more capital intensive than traded sector, temporary bottlenecks and appreciation of real exchange rate until the required amount of home-grown capital is accumulated. Less sovereign wealth in long run than under the PI rule.
- But if traded sector is more capital intensive, real exchange rate does not adjust. Traded sector gradually gets rid of capital via wear and tear, and relies more on imports to make room for non-traded sector to gradually expand and make room for higher consumption of non-traded goods. More sovereign wealth in long run than under the PI rule.

Modification 5: OLG and finite lives

- *Timing* of handing out oil dividends does not matter with Ricardian debt neutrality.
- So use Yaari-Blanchard-Weil OLG with efficient annuity markets where assets go to the insurance companies upon death in return for an annuity. Premium equals probability of death: $\overline{\gamma}$.
- Handing out temporary windfall immediately gives bigger consumption boost on impact than PI rule. If $\rho = r$, under PI rule households consumption jumps up immediately. Under spend-all rule households save during windfall and decumulate assets after windfall.

Impatient households

- If rate of time preference ρ exceeds return on assets r, the economy has an inclination to borrow.
- Steady c locus is no longer vertical, but slopes down.
- Under spend-all rule consumption still jump up more on impact than under PI rule.
- As before, households must save themselves under spend-all rule to compensate for government not doing it on their behalf. But they do not manage to smooth consumption (and real exchange rate fully).
- Households decumulate/borrow under PI rule. Consumption overshoots permanent boost on impact.

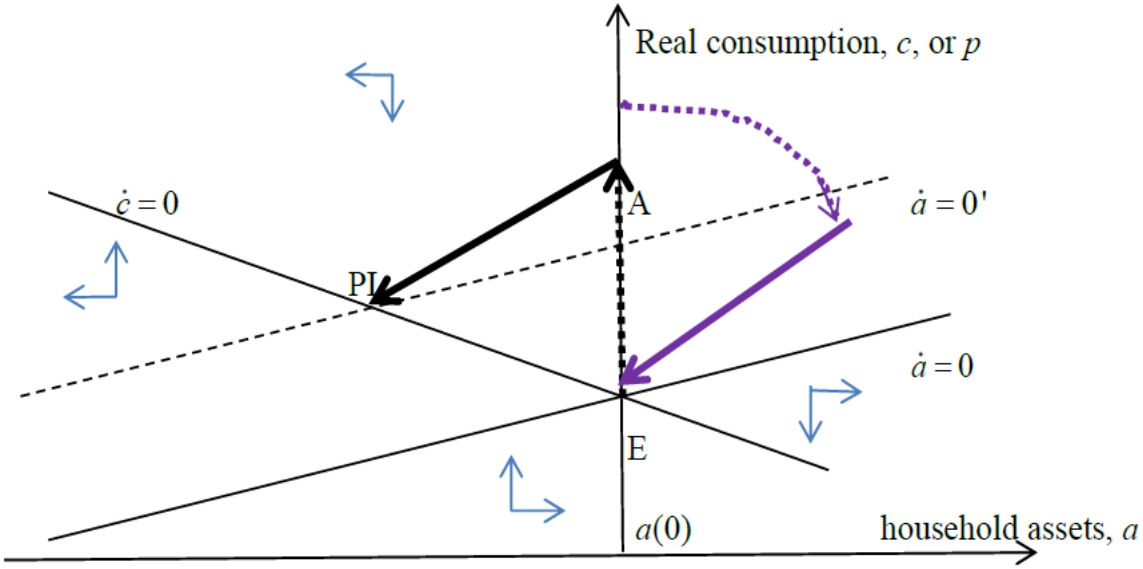
$$\dot{a} = ra + \tau - \Omega(c),\ a(0) = a_0, \quad \text{with } \Omega(c) \equiv \mathrm{e}(p)c - \mathrm{y}(p,l) \text{ and } \Omega'(c) = \mathrm{e}(p) > 0,$$

$$\dot{c} = \left(r - \rho - \frac{\dot{\mathrm{e}}(\mathrm{p}(c))}{\mathrm{e}(\mathrm{p}(c))} \right) c - \gamma \frac{a}{\mathrm{e}(\mathrm{p}(c))} = \left(\frac{\varepsilon^d + \varepsilon^s}{\varepsilon^d + \varepsilon^s + \theta} \right) (r - \rho)c - \gamma \frac{a}{\mathrm{e}(\mathrm{p}(c))}, \quad c(0) \text{ free},$$

$$\gamma \equiv \bar{\gamma}(\rho + \bar{\gamma})$$

$$\rho > r.$$

Figure 4: Permanent-income rule and Dutch disease with finite lives



Key: Under the permanent-income rule, the $\dot{c} = 0$ locus moves up. Under the permanent-income rule the equilibrium shifts on impact from E to A, and then moves along the saddle-path (fat solid black arrow) to PI. The effects of the spend-all rule of a temporary windfall are given by the dotted purple line during the windfall and by the solid purple arrow after the windfall. The permanent-income rule leads households to permanently decumulate assets, whilst the spend-all rule leads them to temporarily accumulate assets.

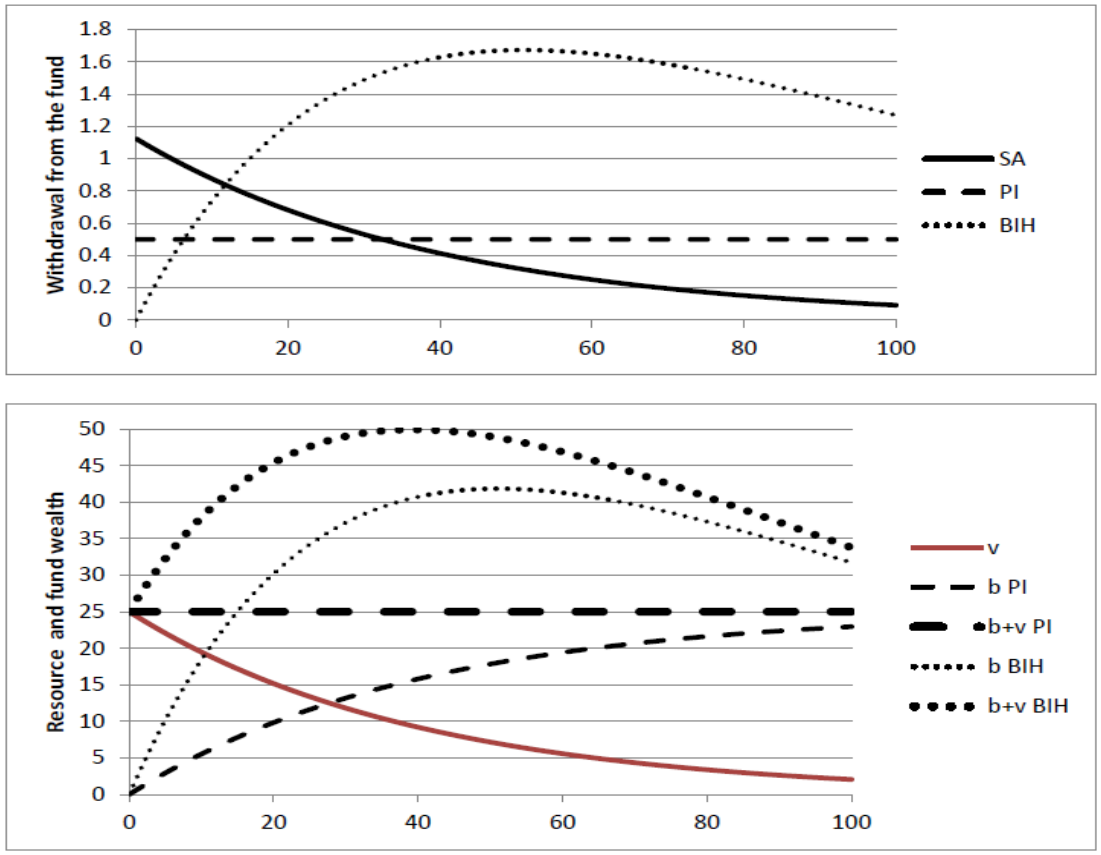
Bringing it together

- Combine elements of Dutch disease, absorption constraints and OLG with finite lives to discuss various rules for managing resource wealth:
  - Permanent-income rule: dashed lines
  - Spend-all rule: solid lines
  - Bird-in-hand rule: dotted lines
- v = below-ground oil wealth, b = fund wealth, and $b+v$.
- Specification:
  - Initial windfall is half of no-windfall GNP, then declines exponentially.
  - Traded sector uses only labour, non-traded sector uses labour and structures,
  - Logarithmic utility.

$$\tau(t) = \begin{cases} \overline{n}e^{-\mu t} & \text{under spend-all policy} \\ \left(\dfrac{0.04}{0.04 - r - \mu}\right)\overline{n}\left(e^{-\mu t} - e^{-(0.04-r)t}\right) & \text{under bird-in-hand policy} \\ r\overline{n}/(r+\mu) & \text{under permanent-income policy,} \end{cases}$$

$$\overline{n} = 1.125, \quad \mu = 0.025, \quad r = 0.02.$$

Figure 5: Three different policy rules for managing natural resource windfalls



Key: Outcomes under the spend-all (SA), permanent-income (PI) rule and bird-in-hand (BIH) are denoted by black solid, dashed and dotted lines, respectively.

Saddle-path model: p & c non-predetermined

$$\dot{s} = \mathrm{y}_p(s,p,l) - \mathrm{e}'(p)(c+g) - \delta s, \quad s(0) = s_0, \quad \text{structures}$$

$$\dot{a} = ra + \mathrm{y}(s,p,l) + h - \mathrm{e}(p)c, \quad a(0) = a_0, \quad \text{household assets}$$

$$\dot{p}/p = r + \delta - \mathrm{y}_s(s,p,l), \quad \text{price of non-tradables}$$

$$\dot{c} = \left(r - \rho - \theta\left[r + \delta - \mathrm{y}_s(s,p,l)\right]\right)c - \gamma\frac{a}{\mathrm{e}(p)}, \quad c(0) \text{ free},$$

with $\gamma \equiv \overline{\gamma}(\rho + \overline{\gamma}) = 0.001$, real consumption

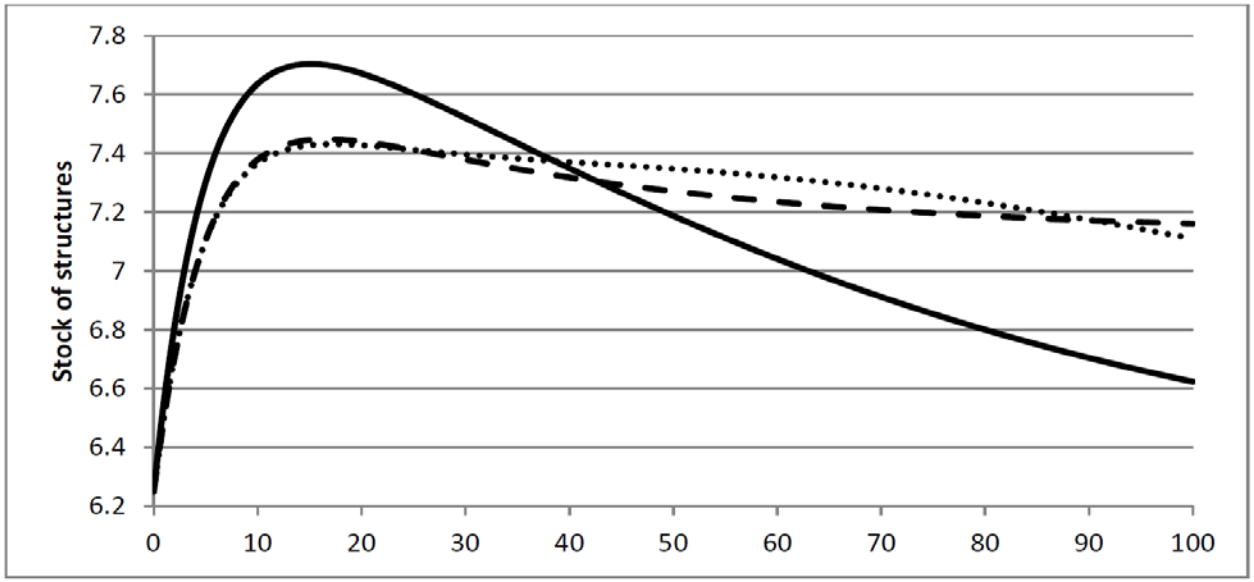
$$h = \frac{1}{1+\psi}\tau \quad \text{and} \quad \mathrm{e}(p)g = \frac{\psi}{1+\psi}\tau \quad \text{with } \tau \text{ transfer from fund}$$

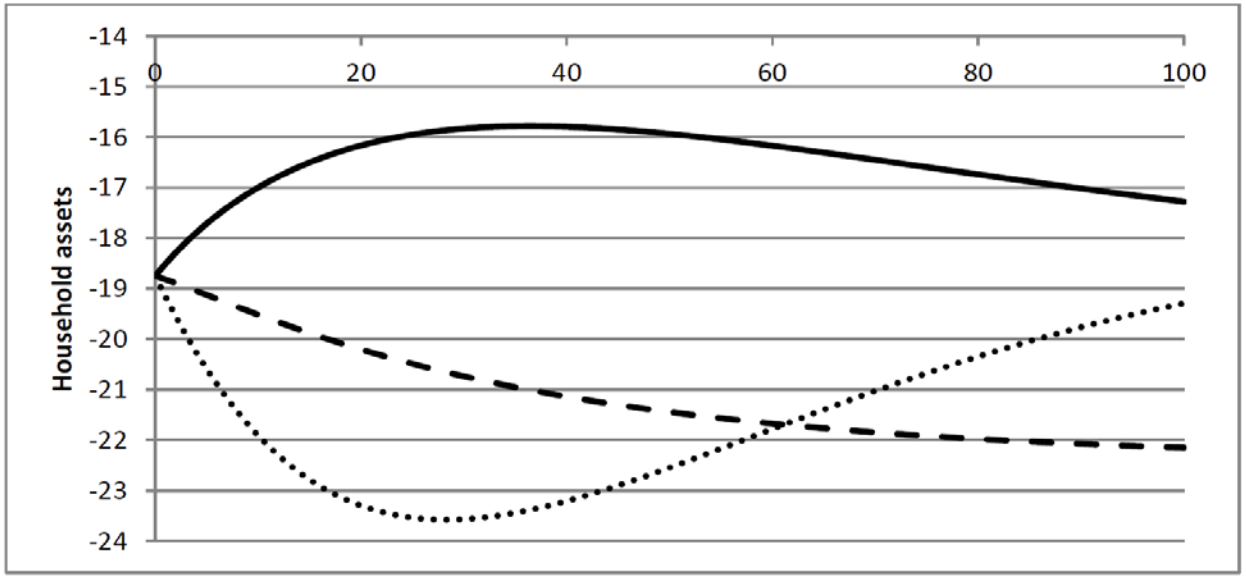
with ψ=0.25 and $f = a + b - d(0)$, foreign assets.

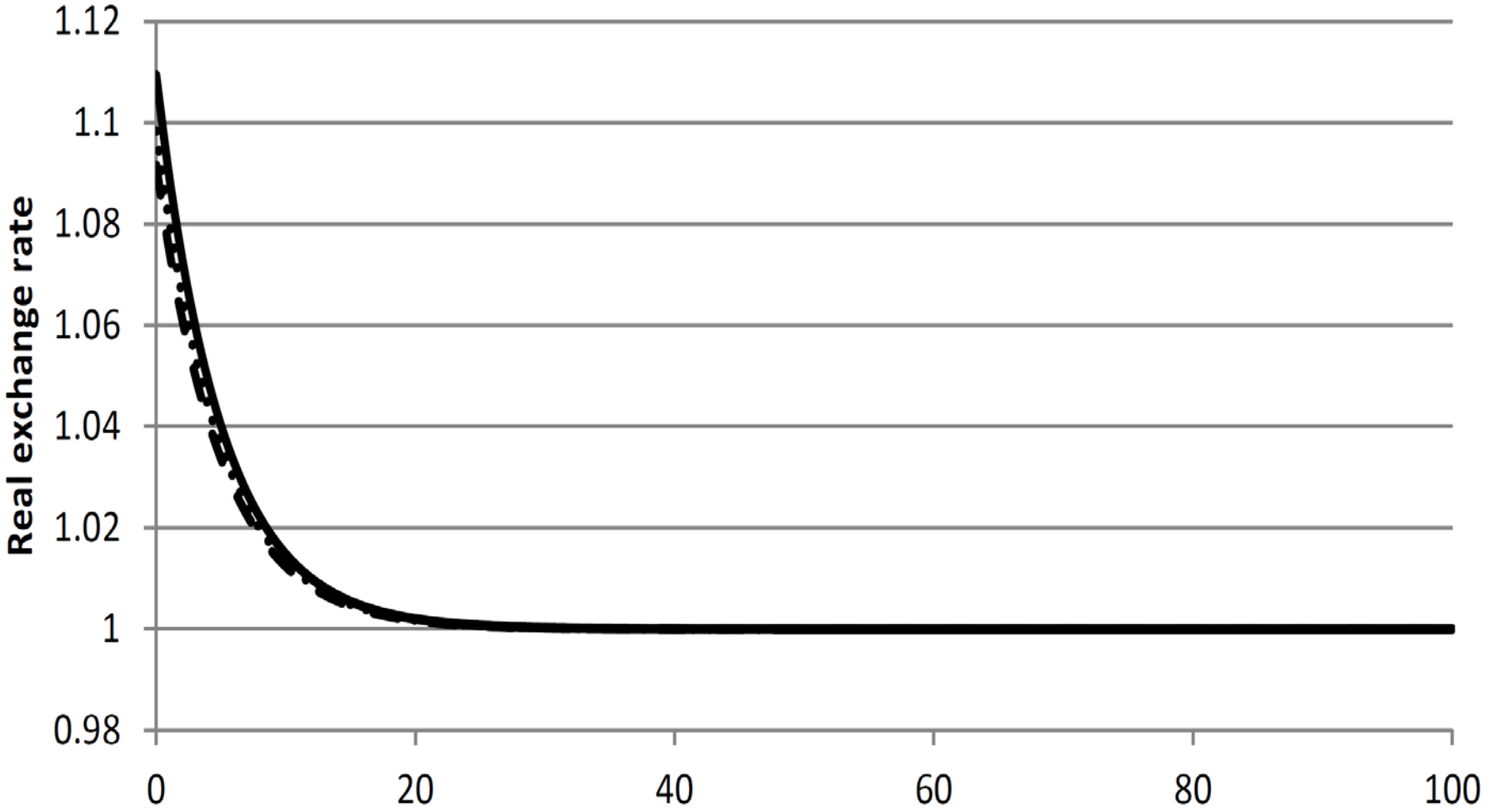
Use $\mathrm{y}(s,p,l) = A^T l + \alpha p A^N \left[(1-\alpha)pA^N / A^T\right]^{(1-\alpha)/\alpha} s$, α=0.2,δ=0.02,

and $\mathrm{e}(p) = p^\theta$ with θ=0.6,$A^T = 2, A^N = 1.51, \rho = 0.03 > r = 0.02$.

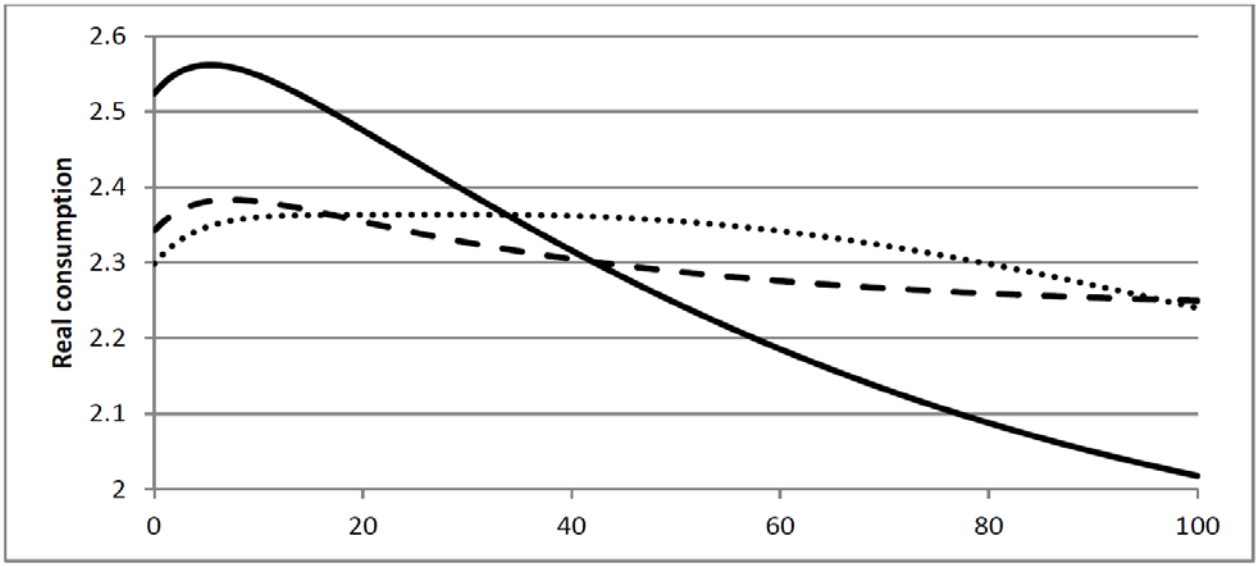
Figure 6: Dynamic policy simulations of the three different rules for managing the fund

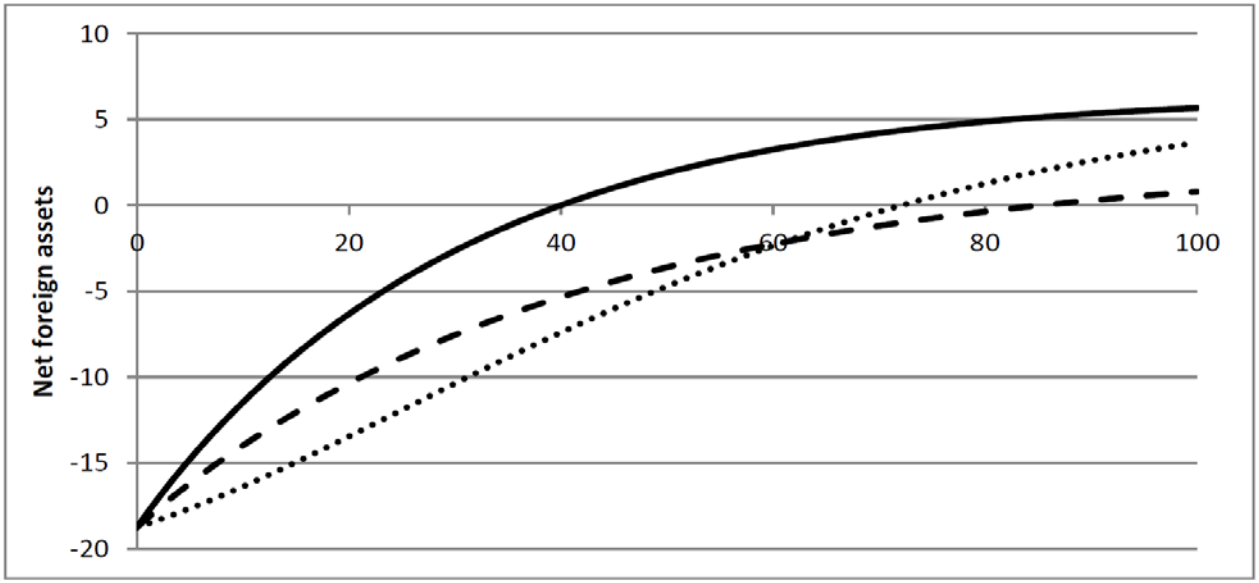






Key: Solid lines – spend-all rule; dashed lines = PI rule; and dotted lines = BIH rule





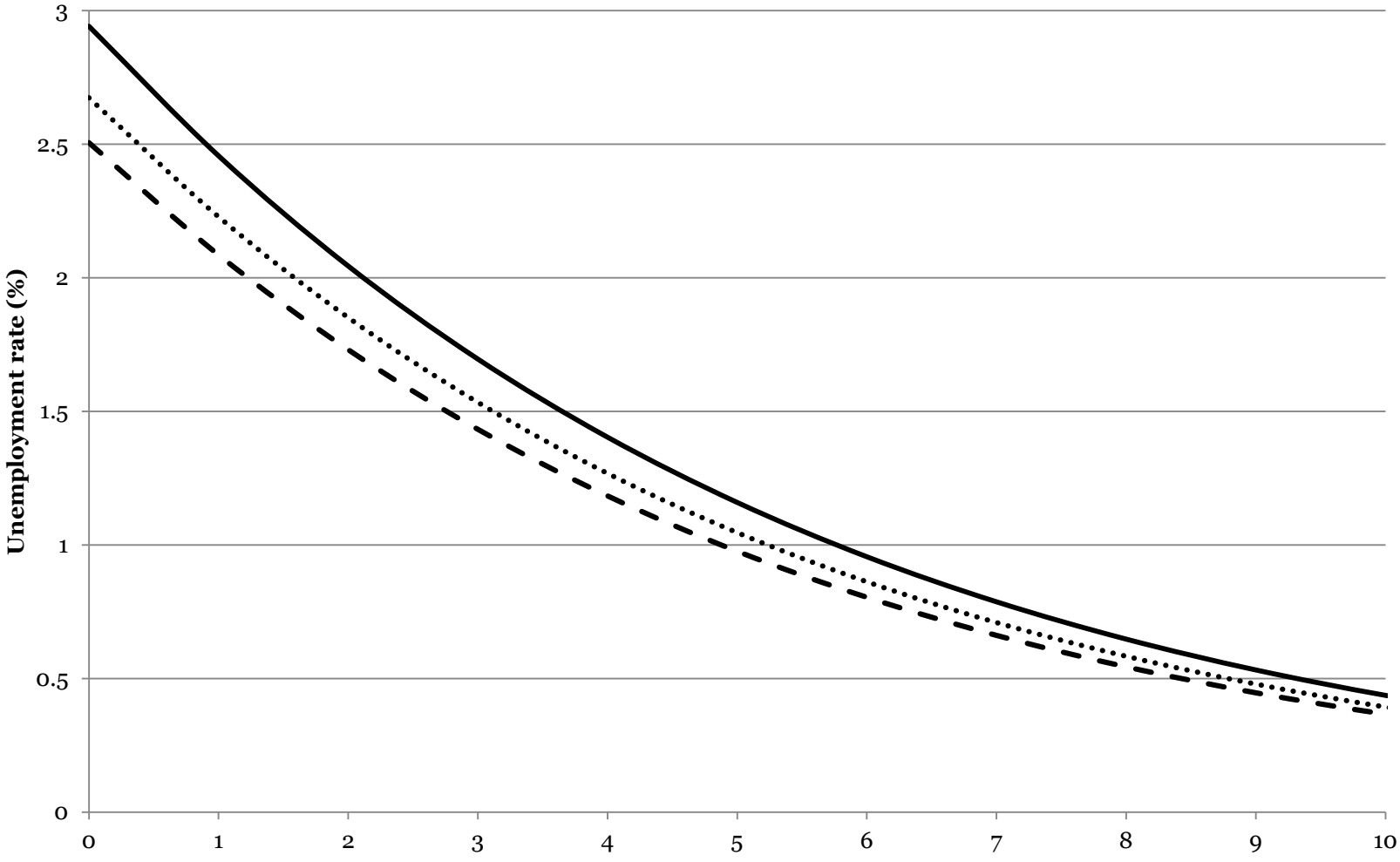
Key: Solid lines – spend-all rule; dashed lines = PI rule; and dotted lines = BIH rule

Oil price crash with RWR and unemployment

- Persistent bouts of unemployment caused by sluggishness of real consumption wage (ζ=0.2).
- Growth of real consumption wage is proportional to negative of rate of change of price of non-tradables.
- Hence, employment increases in marginal product of structures, and given that non-traded sector is intensive in structures, employment increases in price of non-tradables.
- Commodity price crash induces temporary real depreciation and thus transient unemployment: more so for tighten-your-belt rule (solid lines) than for PI rule (dashed lines) or BIH rule (dotted lines).

$$\dot{z}/z = \zeta(l - \bar{l}) \quad \text{with} \quad RCW = z \equiv y_l(s,p,l)/\mathrm{e}(p) \quad \text{and} \quad \mathrm{y}_{ss} = \mathrm{y}_{sl} = 0, \;\; \mathrm{y}_{sp} > 0,$$

$$l = \bar{l} - (\theta/\zeta)\dot{p}/p = \bar{l} - (\theta/\zeta)\left[r + \delta - \mathrm{y}_s(s,p,l)\right] \Rightarrow l = l(p), \quad l'(p) = (\theta/\zeta)\mathrm{y}_{sp} > 0.$$



Nominal wage rigidity: role monetary policy

- Rather than using Calvo-style overlapping price or Taylor-style overlapping wage contracts, use old-style adaptive expectations.
- Fisherian hypothesis gives the nominal interest rate.
- Taylor rule targets inflation and unemployment. Contrasts it with a general rule with strong real exchange rate targeting (suggested by Frankel) and with nominal exchange rate peg.
- Monetary policy is loosened if inflation is below target and unemployment is high, but in general monetary policy is tightened if the real exchange rate is below target.
- Unemployment is high if marginal productivity of structures is low, expected inflation is above target, and the real exchange rate is below target (higher nominal interest rate $\Rightarrow$ higher price of non-tradables, higher CPI & lower RWR).

$$\dot{z}/z = -\theta \dot{p}/p = \zeta(l - \bar{l}) + \pi^e - \pi, \quad \text{augmented Phillips curve}$$

$$\bar{l} - l = (\theta/\zeta)\left[r + \delta - \mathrm{y}_s(s,p,l)\right] - (1/\zeta)(\pi - \pi^e),$$

$$\dot{\pi}^e = \varpi(\pi - \pi^e), \quad \pi^e(0) = \pi_o^e, \quad \text{adaptive expectations}$$

$$i = r + \pi^e = r + \bar{\pi} + \varphi_1(\pi - \bar{\pi}) - \varphi_2(\bar{l} - l) - \varphi_3(p - \bar{p})$$

with $\varphi_1 > 1, \varphi_2 > 1, \varphi_3 > 0$, Taylor rule

or $\pi = \bar{\pi} + (1/\varphi_1)\left[\pi^e - \bar{\pi} + \varphi_2(\bar{l} - l) + \varphi_3(p - \bar{p})\right],$

Hence, the reduced-form unemployment rate is

$$\bar{l} - l = \frac{\theta\varphi_1\left[r + \delta - \mathrm{y}_s(s,p,l)\right] + (\varphi_1 - 1)(\pi^e - \bar{\pi}) - \varphi_3(p - \bar{p})}{\varphi_1\zeta + \varphi_2},$$

and dynamics of household asset accumulation is

$$\dot{a} = ra + \mathrm{y}(s,p,l) + h - \mathrm{e}(p)c - im = ra + \mathrm{y}(s,p,l) + h - \left[\mathrm{e}(p) + i\Xi(i)\right]c, \quad a(0) = a_0.$$

Alternative to Taylor rule

- Nominal exchange rate peg corresponds to $\varphi_1 \to \infty$. So $\pi = \bar{\pi}, \quad \bar{l} - l = (\theta / \zeta)(r + \delta + \mathrm{y}_s)$ if $\pi^e(0) = \bar{\pi}$.

- Real exchange targeting so adverse effect of depreciation of real exchange rate on unemployment is completely eliminated: $\varphi_3 = \theta \varphi_1 \mathrm{y}_s / p > 0$.
- Central bank contracts monetary policy if real exchange rate weakens after commodity price crash.
- Unemployment is thus high if expected inflation is above target: $\bar{l} - l = \dfrac{\theta\varphi_1(r+\delta) + (\varphi_1 - 1)(\pi^e - \bar{\pi}) + \varphi_3 \bar{p}}{\varphi_1 \zeta + \varphi_2}$.

CONCLUSION

- Developed oil-rich countries should build an *intergenerational fund* and a *stabilisation* or *liquidity fund* to sustain a permanent increase in consumption and hedge against volatility. The windfall should be invested abroad and not spent on domestic investment
- This fund must be diversified and borthogonal to oil risk. And take account of the 'elephant in the room': go short when lots of subsoil oil and deleverage with depletion.
- 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*.

Political considerations

- With partisan preferences about public investment projects, incumbent will over-borrow and over-invest in its pet projects, especially if these are more illiquid than the SWF portfolio and chance of being kicked out of office is large.
- Sovereign wealth funds are more likely to be raided than old investment projects being dismantled.
- Budget inertia and lobbying favouring projects that confer large benefits on small groups.
- Common-pool problems: voracious rent seeking.
- In failed states better to leave oil under ground, but ….

Political commitment and signalling

- Need a commitment technology which binds all future governments: Nigeria's Fiscal Responsibility Bill to ensure that countries save and invest enough. Compare with independent central bank.
- Borrowing ahead of the windfall creates a signalling problem, so bad politicians may get elected who later squander the windfall. Hence, politicians can signal their goodness with bird-in-hand rule or with high-quality, accountable spending projects and open competitive tender procedures as these are costly to imitate for bad politicians (cf. Besley).

Other fiscal policy motives

- Habit persistence: get addicted to high levels of public spending & optimal non-oil budget balance depends on previous period's balance.
- Anticipated public spending hikes (greying).
- Hand oil revenue out as citizen dividends (Alaska, Alberta), since government cannot be trusted. But citizens may not be as far-sighted or have less access to capital markets. Costly for government to tax citizens again. No smoothing is very sub-optimal.

Finally, risk of stranded assets

- To keep global warming below 2 degrees Celsius the world can only burn a couple of hundred GtC.
- Reserves of the big oil and gas companies are much bigger and that is not counting reserves of the state companies. Furthermore, there is a lot of new investment in fossil fuel including shale gas.
- If climate policy is going to be credible, there is a serious risk of stranded fossil fuel assets and one may as well short the oil and gas majors.
- What should for gas-exporting countries like Algeria do? Race to burn the last ton of carbon?

2 degrees Celsius and stranded fossil fuel assets

Globally keep 1/3 of oil (Canada, Arctic), ½ of gas and 4/5 of coal (mainly China, Russia, US) reserves unburnt. Reserves are 3x and resources 10-11x the carbon budget. In Middle East 260 billion barrels of oil cannot be burnt. McGlade and Ekins (2015, Nature)