When Does a Central Bank's Balance Sheet Require Fiscal Support?

Marco Del Negro
Federal Reserve Bank of New York
Christopher A. Sims
Princeton University

ECB Public Finance Conference, December 2014

Disclaimer: **The views expressed are ours and do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System**

Yet another balance sheet simulation?

- Hall and Reis (2013), Carpenter et al. (2013), Greenlaw et al. (2013), Christensen et al. (2013) examine likely scenarios, based on historically normal behavior of interest rates and demand for central bank liabilities
- None of these papers uses a model where **inflation** and **interest rates** are **endogenously** determined
- We use a complete, though simplified, economic model to study why a central bank's balance sheet matters at all and the consequences of a lack of fiscal backing for the central bank

Yet another balance sheet simulation?

- Hall and Reis (2013), Carpenter et al. (2013), Greenlaw et al. (2013), Christensen et al. (2013) examine likely scenarios, based on historically normal behavior of interest rates and demand for central bank liabilities
- None of these papers uses a model where **inflation** and **interest rates** are **endogenously** determined
- We use a complete, though simplified, economic model to study why a central bank's balance sheet matters at all and the consequences of a lack of fiscal backing for the central bank
- **We show that a large, long-duration central bank balance sheet, together with lack of fiscal support, can impair the central bank's ability to control inflation**

Contribution

In our model, interest rates, inflation, and seigniorage are endogenous, hence we can answer questions such as:

1. Under what conditions does the central bank need fiscal support?
   - The central bank has one quasi-fiscal resource: **seigniorage**. Seigniorage is quantitatively important (its PDV is very **large** in our baseline calibration)... but is endogenous
   - CB's ability to maintain policy commitments without support from the fiscal authority depends on whether seigniorage increases (**hedge**) or decreases in scenarios where the value of CB's assets drops.

Contribution

2. Can **self-fulfilling solvency crises** arise when the CB holds (a lot of) long-duration assets?

- If the CB cannot rely on fiscal backing $\rightarrow$ has to rely on seigniorage ($\rightarrow$ higher inflation) if the value of its assets were to fall below the value of reserves

- ... an equilibrium may arise where the public's high interest rates/inflation expectations become self-fulfilling:

  - $\uparrow$ future interest rates $\rightarrow$ $\downarrow$ value of long-duration assets $\rightarrow$ balance sheet gap that needs to filled with future seigniorage

- Multiplicity arises depending on 1) size/duration of balance sheet, 2) properties of currency demand function.

How could a central bank be "insolvent"?

- Can't it always "print money"?
  - CB has of course no problem paying nominal liabilities – but can't do that <u>and</u> control inflation (follow the Taylor rule)

- Can't CB run a Ponzi scheme? That is, continue following Taylor rule and issue an ever-increasing amount of reserves?
  - No. Private sector transversality condition is violated

The model

- Simple, perfect-foresight, non-linear, continuous-time model
  - Exogenous real interest rate ρ and income Y
  - Flexible prices
- All uncertainty is revealed at time 0

Households

- Households/**private sector** maximize

$$\int_0^\infty e^\beta \log C \, dt$$

subject to

$$C(1+\psi(v)) + \dot{F} + \frac{\dot{V} + \dot{M} + q\dot{B}^P}{P} =$$
$$Y - \tau + \rho F + r\frac{V}{P} + (\chi + \delta - q\delta)\frac{B^P}{P}$$

- F: storage/foreign assets paying an exogenous real rate ρ
- V: overnight reserves paying nominal rate r. M: currency
- B^P: Woodford (2001)-style bond (depreciates at rates δ, coupon $\delta + \chi$, duration δ^{-1})
- All assets pay <u>same</u> real return

Households

- Households/**private sector** maximize

$$\int_0^\infty e^\beta \log C \, dt$$

subject to

$$C(1+\psi(v)) + \dot{F} + \frac{\dot{V} + \dot{M} + q\dot{B}^P}{P} =$$
$$Y - \tau + \rho F + r\frac{V}{P} + (\chi + \delta - q\delta)\frac{B^P}{P}$$

- F: storage/foreign assets paying an exogenous real rate ρ
- V: overnight reserves paying nominal rate r. M: currency
- B^P: Woodford (2001)-style bond (depreciates at rates δ, coupon $\delta + \chi$, duration δ^{-1})
- All assets pay <u>same</u> real return
- Population growth n and productivity growth γ (omitted)

Transactions technology

$$v = \frac{PC}{M}; \quad \psi(v) = \psi_0 e^{-\psi_1 / v}$$

- Elasticity of money demand goes to zero as $r \to 0$ (Mulligan & Sala-i-Martin 2000, Alvarez and Lippi 2009).
- Real balances go to zero for $r > \psi_0 \psi_1$

Fiscal policy

- Fiscal Authority budget constraint:

$$g + (\chi + \delta - \delta q)\frac{B}{P} = \tau + \tau^C + q\frac{\dot{B}}{P}$$

- $B = B^P + B^C$ (bonds are held either by the public or the CB)
- τ^C remittances from CB
- Passive fiscal policy (except for discussion of "fiscal backing"):

$$\tau = \xi_0 + \xi_1 q \frac{B}{P}, \quad \xi_1 > \rho$$

Conventional and unconventional monetary policy

- Reaction function for interest on reserves r:

$$\dot{r} = \theta_r \cdot \left(\bar{r} + \theta_\pi \left(\frac{\dot{P}}{P} - \bar{\pi} \right) - r \right), \quad \boxed{r \geq \underline{r}}$$

- Unconventional monetary policy: path for B^C (Treasuries held by CB)

- The central bank budget constraint is:

$$q \frac{\dot{B}^C}{P} - \frac{\dot{V} + \dot{M}}{P} = (\chi + \delta - \delta q) \frac{B^C}{P} - r \frac{V}{P} - \tau^C$$

Equilibrium

- Fisher eq. + Taylor rule yield a solution for interest rates:

$$r_t = \int_0^\infty e^{-(\theta_\pi - 1)\theta_r s}\theta_r \left(\theta_\pi \rho_{t+s} - (\bar{r} - \theta_\pi \bar{\pi})\right) ds + \kappa e^{(\theta_\pi - 1)\theta_r t}$$

  - κ: This source of multiplicity (Cochrane 2011) is not the only one in this model

Equilibrium

- Fisher eq. + Taylor rule yield a solution for interest rates:

$$r_t = \int_0^\infty e^{-(\theta_\pi - 1)\theta_r s} \theta_r \left(\theta_\pi \rho_{t+s} - (\bar{r} - \theta_\pi \bar{\pi}) \right) ds + \kappa e^{(\theta_\pi - 1)\theta_r t}$$

  - κ: This source of multiplicity (Cochrane 2011) is not the only one in this model

- $v_t^2 \psi'(v_t) = r_t, \quad v_t = \dfrac{P_t C_t}{M_t}$, defines money demand $\Rightarrow$ seigniorage

  - CB determines the size of the balance sheet (B^C) and r, but its composition between interest-bearing liabilities (V) and currency (M) is determined by the private sector

A present value take on CB solvency and remittances

$$\underbrace{q\frac{B_0^C}{P_0} - \frac{V_0}{P_0}}_{\text{Mkt value of assts - reserves}} + \underbrace{\int_0^\infty \frac{\dot{M}_t}{P_t} e^{-\int_0^t \rho_s ds} dt}_{\text{PDV seigniorage}} = \underbrace{\int_0^\infty \tau_t^C e^{-\int_0^t \rho_s ds} dt}_{\text{PDV remittances}}$$

- if LHS > 0 CB is "**solvent**": it can **continue to follow the Taylor rule without requiring fiscal support** $\rightarrow$ CB budget constraint irrelevant for equilibrium (like gvmt's with passive fiscal policy)
  - See also Hall and Reis (2013), Bassetto and Messer (2013)...
- As long at $\tau^C \geq 0$, rule for remittances does not matter for equilibrium

Three levels of CB balance sheet problems

Level 1: Accounting capital (book value of $B^C - V - M$) < 0

- Common for several CBs (see Stella). For Fed, rule for remittances implies $\tau^C = 0$ for some periods. No fiscal support ($\tau^C < 0$) required

Level 2: $qB^C - V < 0$: Market value of assets $<$ interest-bearing liabilities

No fiscal support required as long as $\int_0^\infty \frac{\dot{M}_t}{P_t} e^{-\int_0^t \rho_s ds} dt > V - qB^C$

- PDV of seigniorage provides a *hedge* against drops in q

Level 3: $\frac{qB^C - V}{P_0} + \int_0^\infty \frac{\dot{M}_t}{P_t} e^{-\int_0^t \rho_s ds} dt < 0$

- $\int_0^\infty \tau_t^C e^{-\int_0^t \rho_s ds} dt < 0 \rightarrow \tau_t^C < 0$ for some $t \rightarrow$ fiscal support required to continue following Taylor rule

“Backing” vs. “support”

- What we’ve discussed so far is “support” — transfers of resources from the fiscal authority to the central bank.
- The fiscal theory of the price level (FTPL) implies that fiscal “backing”, which is something different (active fiscal policy), can produce a uniquely determined price level

Does seigniorage provide fiscal backing?

- FTPL off the CB budget constraint?
- No. PDV of seigniorage in real terms is endogenous
- Seigniorage depends on inflation policy $\Rightarrow$ A central bank that is seen as ready to change policy so as to increase seigniorage if necessary to avoid asking for fiscal backing can create indeterminacy

Simulations

- Baseline: real rate path (ρ) chosen so that r path roughly matches Carpenter et al./current FFR expectations

- Scenarios (time 0 "surprise", perfect foresight afterwards)

  1. *Exogenous "shocks"*
     – Question: **Can the CB stick to the Taylor rule** (control inflation) **without violating solvency**?

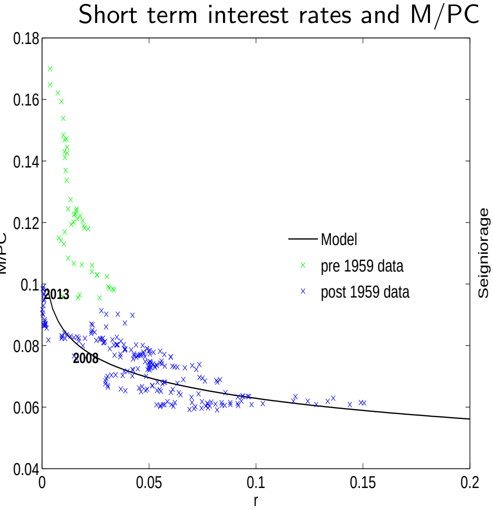
     - "Higher rates" Carpenter et al. scenario
     - (Exogenous) "inflation scare"
     - Explosive paths (hyperinflations)

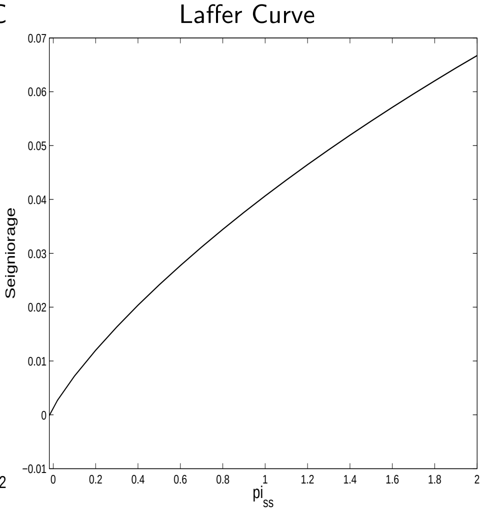
  2. *Self-fulfilling crises*

Parameters

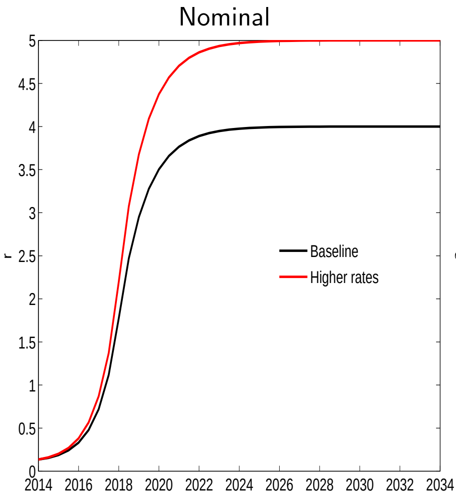
normalization, foreign assets					
$Y - G$	$=$	1	F_0	$=$	0
discount rate, reversion to st.st., population and productivity growth					
β	$=$	0.01	γ	$=$	0.01
n	$=$	0.0075			
monetary policy					
θ_π	$=$	2	θ_r	$=$	1
$\bar{\pi}$	$=$	0.02			
Assets (par value), reserves, and currency as of Jan 2 2014					
$\frac{B^C}{P}$	$=$	.327	$\frac{V}{P}$	$=$	.207
$\frac{M}{P}$	$=$	.104			
bonds: duration and coupon					
δ^{-1}	$=$	6.8	χ	$=$	0.034
money demand					
ψ_0	$=$	.63	ψ_1	$=$	103.14

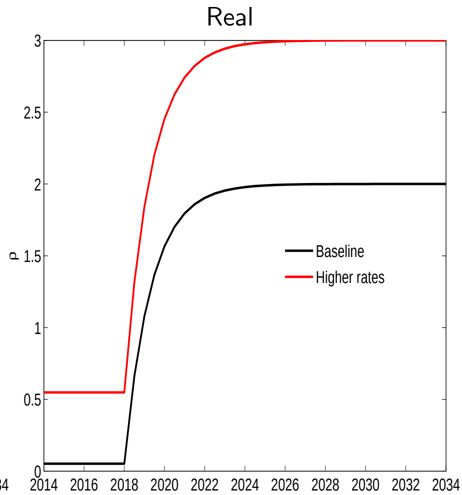
Money demand and the Laffer curve





Baseline and "Higher Rates" scenario





Balance sheet implications

	qB/P $-V/P$	PDV seigniorage	(1)+(2)	q	$\bar{B}/B$
Baseline scenario	0.146	1.139	1.285	1.08	

At steady state PDV of seigniorage $\int_0^\infty (\frac{\dot{M}_t}{M_t} + n)\frac{M_t}{P_t} e^{-\int_0^t (\rho_s - n)ds} dt$ is given by $\frac{(\bar{\pi} + \gamma + n)\,\bar{m}}{(\beta - n)}$. Numerator in our calibration (.0027) is lower than historical average (.0047) , but denominator $\beta - n$ is very small!

Balance sheet implications

	qB/P $-V/P$	PDV seigniorage	(1)+(2)	q	$\bar{B}/B$
Baseline scenario	0.146	1.139	1.285	1.08	
Higher rates (β)	0.130	0.181	0.311	1.06	12.62
Higher rates (γ)	0.141	1.443	1.584	1.06	60.23

Self-fulfilling CB solvency crises

- Can multiple equilibria arise in absence of fiscal support? If $\tau_t^C \geq 0$ for all t, then the CB *must rely on seigniorage if* $qB - V < 0$

- Allow for a time-varying inflation target $\bar{\pi}_t$, and assume that the central bank chooses at time 0 the future time path for $\bar{\pi}_t$ (and it can commit to this target from time 0 onward).

- The central bank's objective function consists in minimizing deviations of inflation from 2%:

$$\min_{\bar{\pi}_t} \int_0^\infty e^{-\beta t} \left(\pi_t - 0.02\right)^2 dt$$

subject to the private sector equilibrium conditions, and the constraint $\tau_t^C \geq 0$ all t.

Self-fulfilling CB solvency crises

- Can multiple equilibria arise in absence of fiscal support? If $\tau_t^C \geq 0$ for all t, then the CB *must rely on seigniorage if* $qB - V < 0$

- Allow for a time-varying inflation target $\bar{\pi}_t$, and assume that the central bank chooses at time 0 the future time path for $\bar{\pi}_t$ (and it can commit to this target from time 0 onward).

- The central bank's objective function consists in minimizing deviations of inflation from 2%:

$$\min_{\bar{\pi}_t} \int_0^\infty e^{-\beta t} \left(\pi_t - 0.02\right)^2 dt$$

  subject to the private sector equilibrium conditions, and the constraint $\tau_t^C \geq 0$ all t.

- $\bar{\pi}_t = 0.02$, all t, is one equilibrium (in which the $\tau_t^C \geq 0$ constraint is not binding)

Self-fulfilling CB solvency crises

- Find solutions of

$$\frac{q_0(\bar{\pi}_t)B^C_{0^-} - V_0}{P_0(\bar{\pi}_t)} + PDVS_0(\bar{\pi}_t) = 0$$

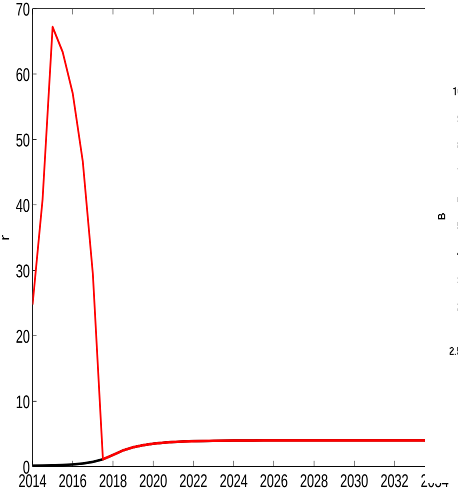
  CB cannot deviate as long as $\bar{\pi}^*_t < \bar{\pi}_t$ implies a violation of solovency constraint

- Specifically, we consider equilibria where the central bank will change its inflation target to $\tilde{\pi} > 2\%$ for a period $\tilde{\Delta}$

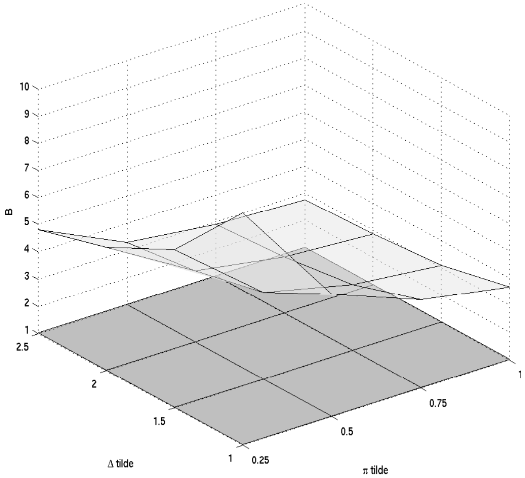
- Multiplicity here is related to, but very *different* from, that arising with nominal government debt (Calvo 1988, .., Corsetti and Dedola 2013, Aguiar et al. 2013)

For what level of B^C are self-fulfilling crises possible?

Interest Rate Path



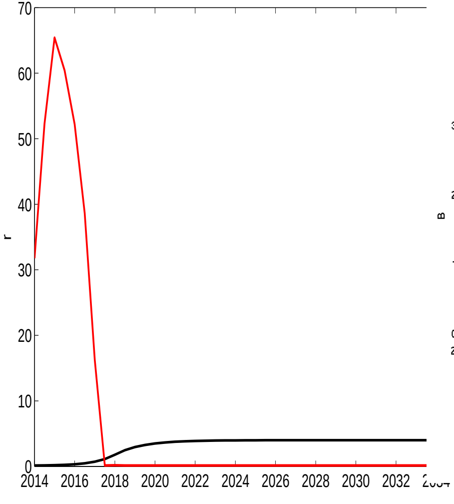
Threshold Balance Sheet Limit
fraction of current B



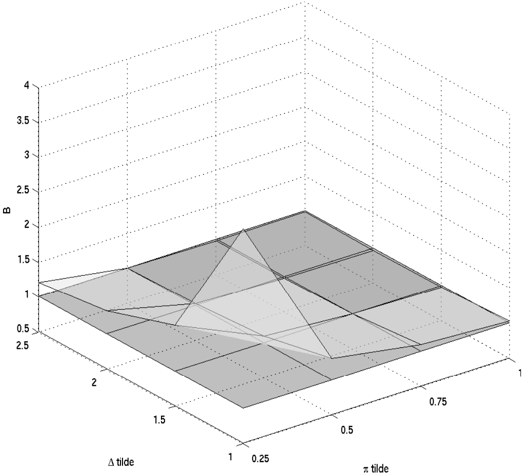
For what level of B^C are self-fulfilling crises possible?

- $\kappa < 0$ in $r_t =$ stable solution $+ \kappa e^{\theta_r(\theta_\pi - 1)t}$

Interest Rate Path



Threshold Balance Sheet Limit
fraction of current B

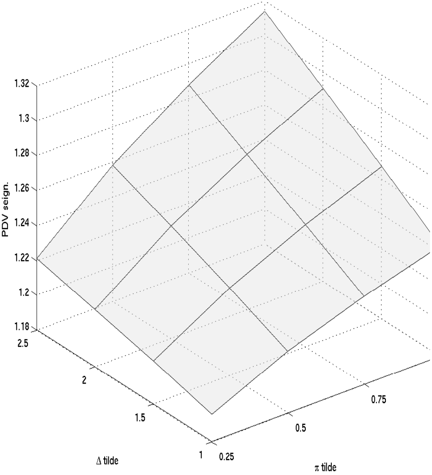


Conclusions

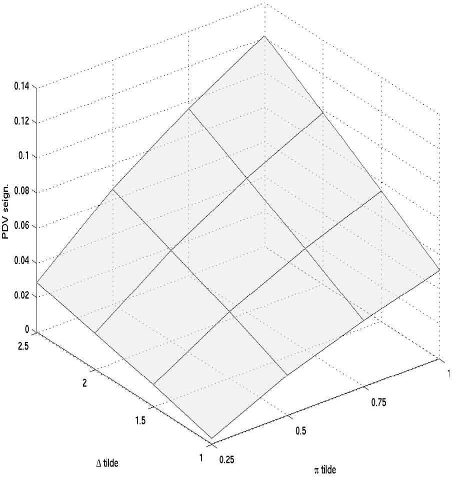
- CB solvency would become an issue only under rather extreme scenarios, for current balance sheet size
- These conclusions hinge on the properties of **currency demand** and **seigniorage**
  - ... on which there is considerable uncertainty
- Implications: Fiscal support for the CB allows it to pursue its mandate without being concerned about its balance sheet
  - ... and such support seems unlikely to be needed in equilibrium on the basis of our model

PDV seigniorage – self-fulfilling equilibria

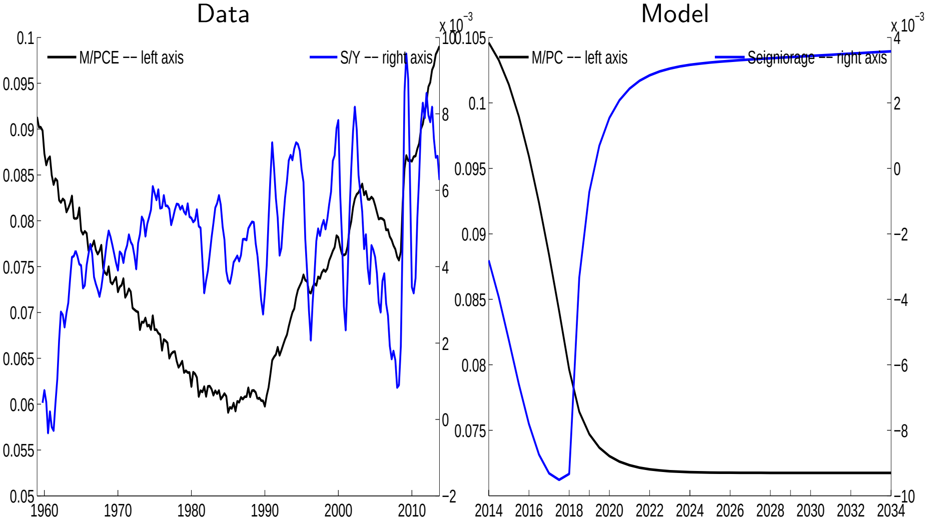
$\kappa = 0$



$\kappa < 0$



Seigniorage and M/PC



Rule for remittances

- As long at $\tau^C \geq 0$, rule for remittances does not matter for equilibrium
- Two principles: i) remittances cannot be negative, ii) whenever positive, remittances are such that the central bank capital measured at historical costs remains constant over time:

$$\tilde{K} = \left(\tilde{q}B^C - V - M\right) e^{nt} = \text{constant}.$$

where $\tilde{q}$ evolves according to

$$\dot{\tilde{q}} = (q - \tilde{q}) \max\left\{0, \frac{\dot{B}^C}{B^C} + \delta\right\}$$

yielding

$$\tau^C = \max\left\{0, (\chi - \delta(\tilde{q} - 1)) \frac{B^C}{P} + \left(\dot{\tilde{q}} - (q - \tilde{q})\left(\frac{\dot{B}^C}{B^C} + (\delta + n)\right)\frac{B^C}{P}\right) - r\frac{V}{P}\right\} \underbrace{\mathcal{I}_{\{\tilde{K} \geq \tilde{K}_0\}}}_{\text{Deferred Asset}}$$

Paths for remittances