Investing in Public Infrastructure: Roads or Schools?

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2. **The Model**
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   - Households
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   - Big push or not? Implications for growth and debt sustainability
   - Key determinants of optimal composition
4. **Concluding Remarks**

In what should governments in low-income countries invest?

- Roads?

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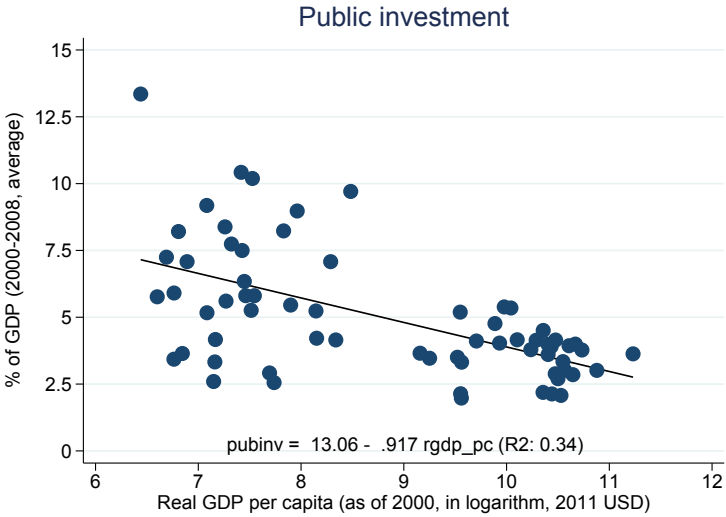
- Schools? Both?

Why do developing economies tend to invest more in roads and not enough in schools relative to richer countries?



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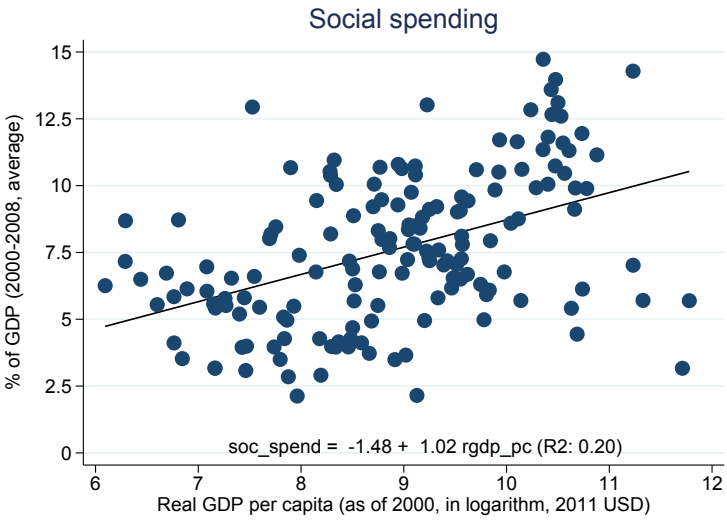


Why model schools separately?

- Why is spending on schools not higher in developing economies? What are the macroeconomic implications of investing in roads vs. schools? What is the optimal composition? What are the key determinants of the optimal allocation of public infrastructure investment?

Why model schools separately?

- Why is spending on schools not higher in developing economies? What are the macroeconomic implications of investing in roads vs. schools? What is the optimal composition? What are the key determinants of the optimal allocation of public infrastructure investment?
- We use a dynamic small open economy model to answer these questions, highlighting the delayed and persistent effects of investment in schools on output.
  - Nature of schooling system implies accumulated education does not immediately transform into more efficient labor.
- There are other important differences between roads and schools:
  - The return on schools is believed to be (much) higher than the return on roads.
  - O&M expenditures are higher for schools than for roads.

A look at the literature

- Public investment in endogenous growth models: Barro (1990), Barro and Sala-i-Martin (1992), Futagami et al. (1993), Glomm and Ravikumar (1994).
- Introducing features of developing economies: Chatterjee and Turnovsky (2007), Agenor (2010), Buffie et al. (2012).
- Public infrastructure and public debt sustainability: Buffie et al. (2012), Abiad et al. (2015), Melina et al. (2016).
- Aid-financed public investment: Adam and Bevan (2006), Cerra et al. (2008), Berg et al. (2010).
- Composition of public spending with a fixed total spending: Devarajan et al. (1996).
- **Roads vs. hospitals** with budget-neutral policy: Agenor et al. (2010).

Key results

1. Long-run scaling up in schools results in:
   - Higher output, but with *very long* delays (more than 20 years).
   - More taxes and debt in the short and medium term.
2. A (temporary) big push exacerbates fiscal/debt concerns.
   - Despite the spike in debt, it reduces the relative disadvantage of schools in terms of output (reduced delay of benefits).
   - BUT, there are much higher short-run costs in terms of private consumption and investment.
3. Even with a high return differential in favor of schools, the government finds it optimal to invest in both
   - 76.5% for long-run scaling up.
   - 51.3% with a big push added.
4. Governments may underinvest in schools due to
   - Return differential may be lower than previously thought.
   - Debt intolerance.
   - Myopia of policymakers.

The Model

Firms

- There is a continuum of perfectly competitive, profit-maximizing firms, producing good y_t.
- They have a Cobb-Douglas production technology, combining private capital k_{t-1}, government-supplied infrastructure (roads) z_{t-1}^{j}, and effective labor $e_t^{\chi} l_t$.
  - Public investment in roads increases the productivity of firms.
  - Public investment in schools makes labor more effective.

Households

- The economy is populated by a continuum of infinitely-lived households, maximizing their expected lifetime utility over consumption c_t and leisure n_t.
  - They devote time l_t for producing goods and time u_t to enhance their human capital (by going to school).
- Households have access to domestic borrowing and can save by accumulating private capital, which they rent to firms.
- They receive wages from supplying labor and transfers from the government, and they also pay consumption taxes (VAT-like).
- The process of schooling combines government-provided schools z_{t-1}^{e} and effective time spent studying $e_t^{\chi} u_t$.
  - However, there is some inertia in how productive households become: Only a fraction ω gets out of schools and moves to the labor force.

Government

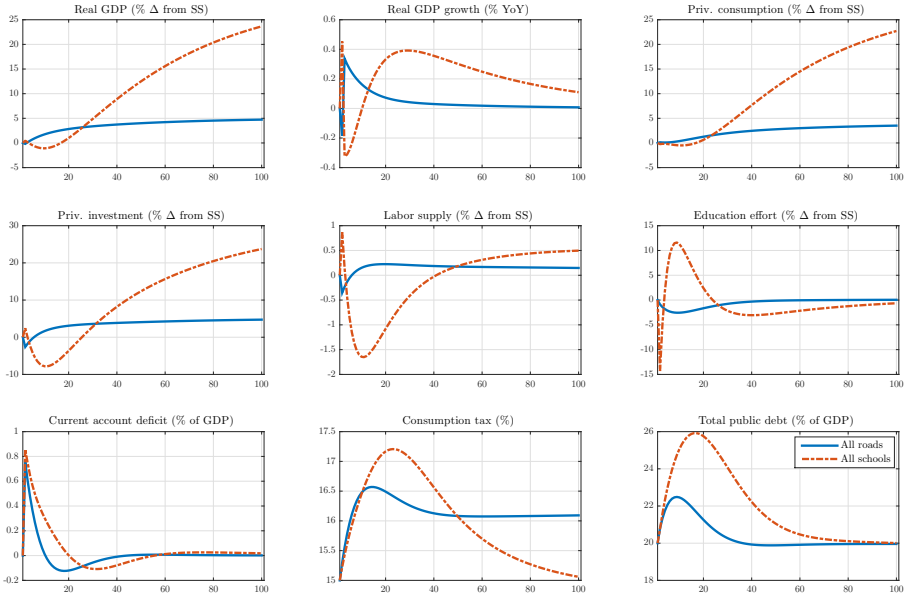
- The government decides how much it wants to allocate the infrastructure scaling up to roads and/or schools.
  - O&M expenditures are proportional to their stocks.
- *Government expenditures:* Transfers, debt service, and infrastructure investment and recurrent expenditures (on schools and roads).
- *Government revenues:* VAT on households' consumption and other revenues and grants.
- The government is allowed to have a fiscal deficit that can be financed through a combination of debt instruments (domestic or external) and fiscal adjustment (through taxes or transfers).
  - Fiscal rules ensure taxes and transfers adjust to cover the fiscal gap in the long run.

Experiments

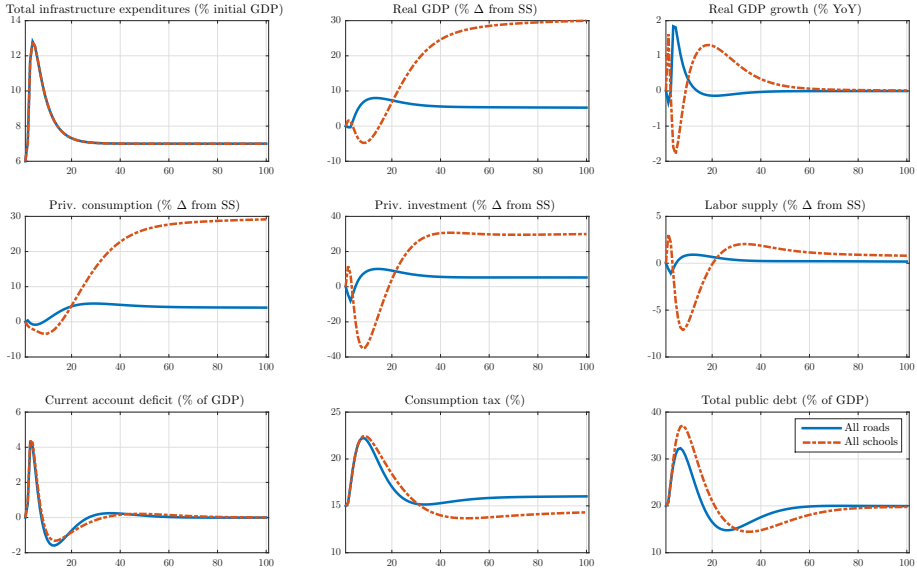
Calibration to an "average" LIC

Definition	Param.	Value
Economic Infrastructure		
Return on public economic infrastructure	$R^i_{z,o}$	25.0%
Capital exp. in roads to GDP ratio	g^i_o/y_o	2.0%
Current exp. in roads to GDP ratio	m^i_o/y_o	2.0%
Social Infrastructure		
Return on public social infrastructure	$R^e_{z,o}$	40.0%
Capital exp. in schools to GDP ratio	g^e_o/y_o	0.6%
Current exp. in schools to GDP ratio	m^e_o/y_o	1.4%
Speed of transition from schools to the labor force	ω	0.08

Investing in schools: More time, more taxes, more debt

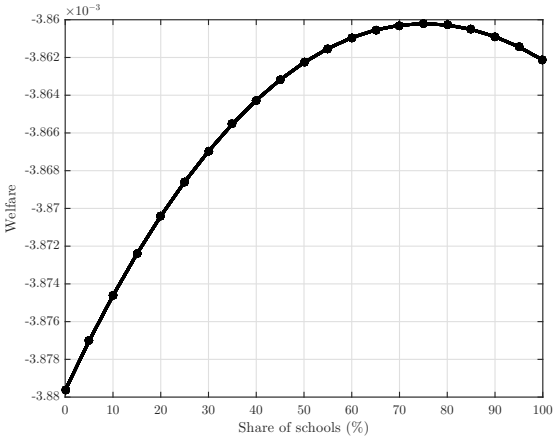


A big push: Growth benefits kick in earlier



Optimal composition of scaling up

Without big push: **76.5%**.



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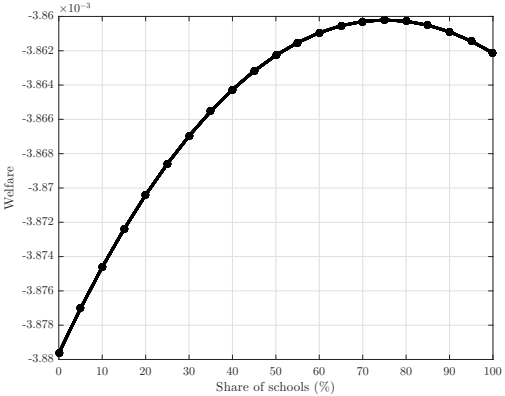
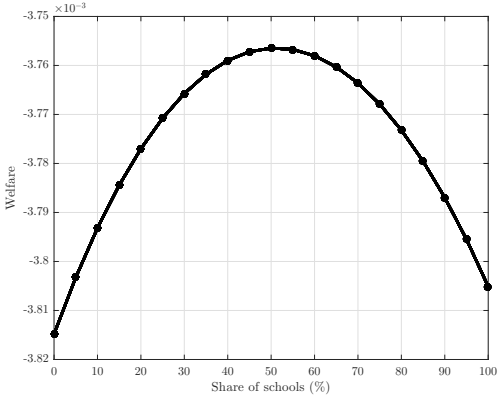
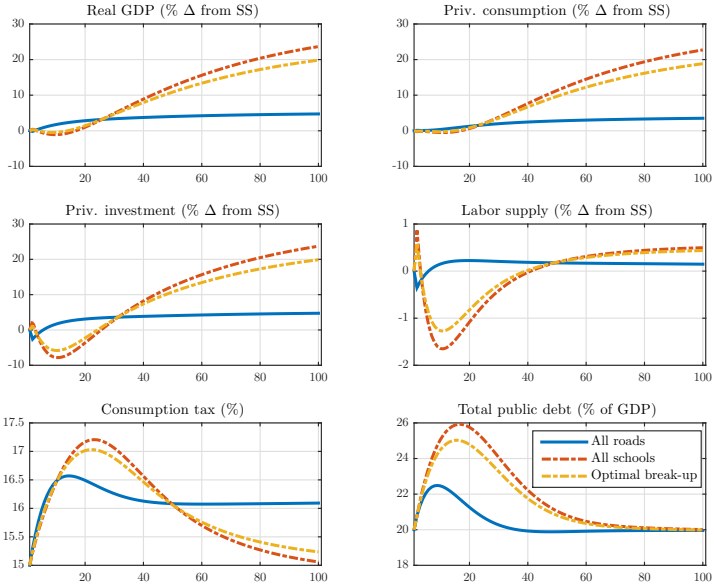


With big push: **51.3%**.



Sandwiched between the extremes



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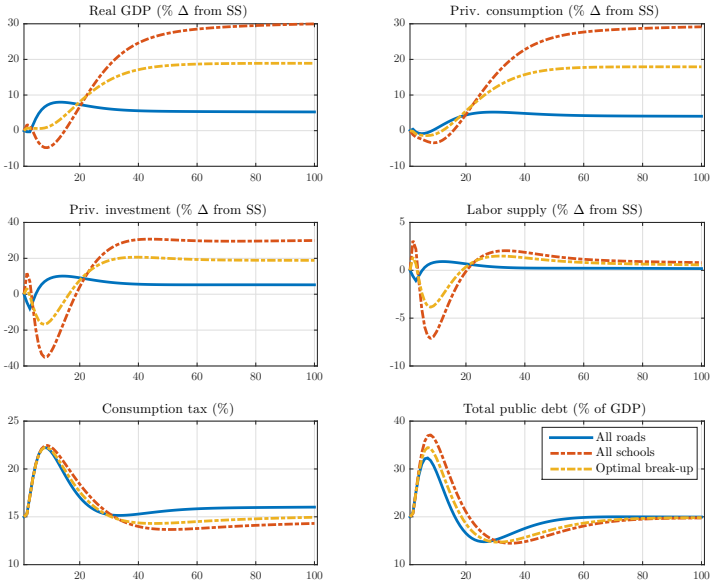
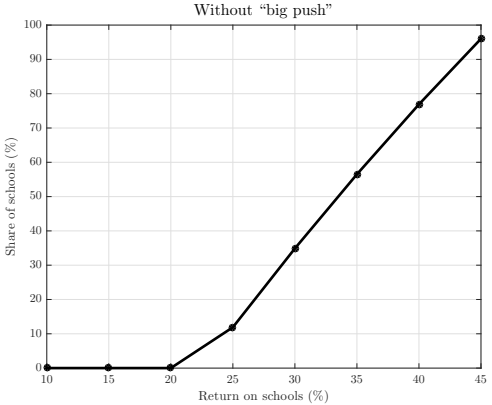


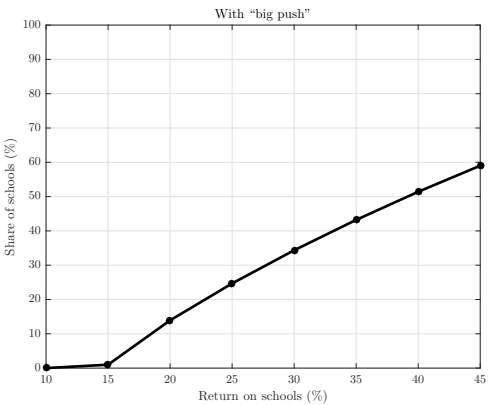
Key determinants of the optimal composition

- It may well be that governments have failed to spend more on schools for valid reasons:
  - Roads and schools may be equally scarce and thus the return differential between roads and schools may be smaller.
  - Government's debt aversion, negotiating with foreign creditors may be too cumbersome or there are some challenges in accessing international financial markets.
  - Political myopia or short-sightedness of the policymaker.

Return differential

- So far, we have assumed that human capital is scarcer than physical infrastructure.
- In a world in which roads and schools are equally scarce, the government would allocate a far greater fraction of the investment to roads (between 12% and 25% in schools).

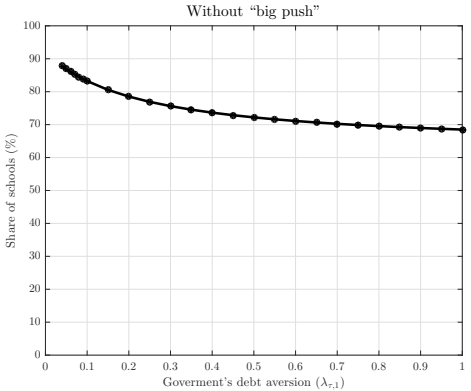


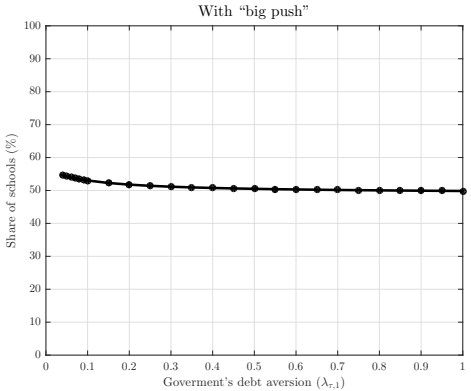


- The larger the return differential, the larger is the fraction of the scaling up towards schools.

Debt aversion

- The need for higher (distortionary) taxation makes it optimal for the government to devote smaller fraction of the scaling up to schools.
- With more debt tolerance, the government would invest further in schools (close to 90% without the big push and about 55% with a big push).

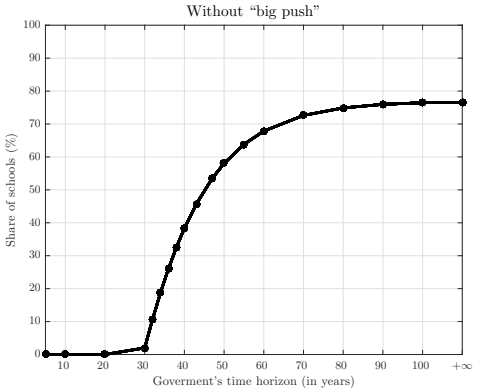


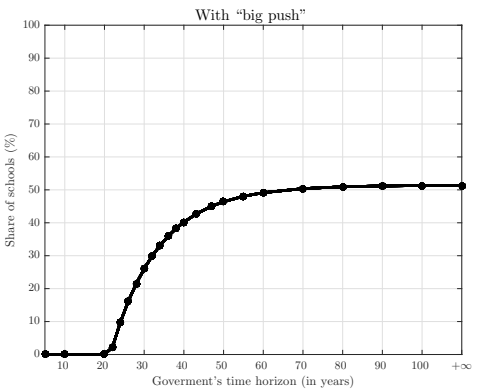


- The greater the level of debt aversion, the higher is the government's willingness to balance its budget (more fiscal adjustment) and the lesser is the fraction of the scaling up towards schools.

Political myopia

- We have implicitly assumed that our policymaker is a benevolent planner, but its selfish desire for getting reelected may translate into more investment in roads instead of schools.
- A planner with a horizon of less than 30 years would not invest in schools at all. It would only do so almost as an altruistic social planner if its planning horizon is beyond 70 years.





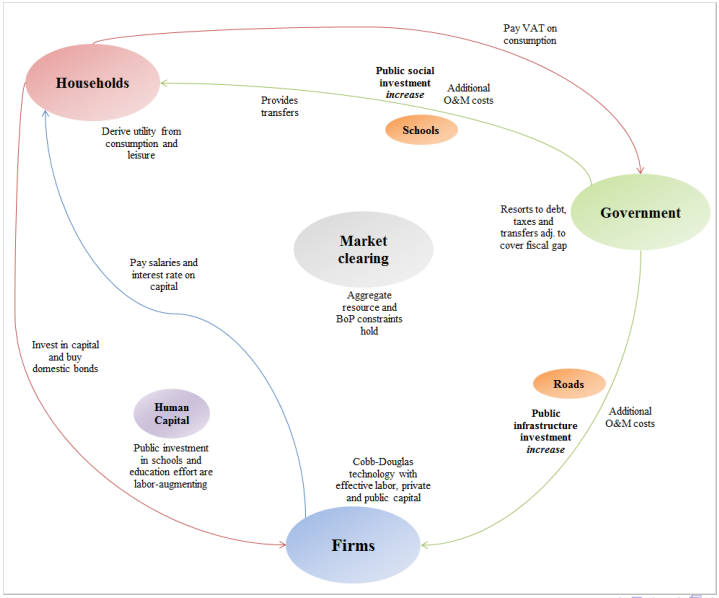
- The greater the level of political myopia, the less the government cares about future generations and the lesser is the fraction of the scaling up towards schools.

Concluding remarks

- We use a dynamic small open economy model to explore the macroeconomic trade-offs between scaling up public infrastructure investment in roads vs. schools.
  - Long-run scaling up in schools: higher output but *very long* delays, more taxes and more debt.
  - A (temporary) big push reduces the relative disadvantage of investing in schools: but with much higher short-run costs in terms of private consumption and investment.
- The optimal composition would be to invest about 76% of the scaling up in schools (or 51% with a big push).
- The failure to invest more in schools can be justified in the model by return differentials, debt aversion, and political myopia.
- Tied concessional financing and grants can potentially mitigate the adverse effects of both debt aversion and political myopia.

Thank you!

The economy in a snapshot



- Firms
- Households
- Social Capital
- Government
- Calibration
- Experiments

The model

- A real, micro-founded dynamic small open economy model with one produced good.
- Households enjoy consumption and leisure.
- Exogenous growth, g: Variables detrended by $(1+g)^t$.

- Government can incur debt: Debt accumulation triggers fiscal adjustment over time.
- Public investment in roads or economic infrastructure increases the productivity of firms.
- Human capital is produced using:
  - Public investment in schools or social infrastructure, and
  - Households' time spent in schools.
- Human capital-adjusted effective labor as input for productive activities.
- Human capital flows from schools to labor pool slowly, with a delay.

Back to Snapshot

Firms' technology

- There is a continuum of perfectly competitive, profit-maximizing firms producing good y_t.
- The social capital accumulated via schooling increases the effectiveness of time/labor.
- Firms combine
  - private capital, k_{t-1},
  - effective labor, $e_t^{\chi} l_t$, and
  - government-supplied infrastructure, z_{t-1}^i,

  according to a Cobb-Douglas production technology:

$$y_t = A^y \left(z_{t-1}^i\right)^{\psi} \left(k_{t-1}\right)^{\alpha} \left(e_t^{\chi} l_t\right)^{1-\alpha}, \tag{1}$$

  where
  - $A^y > 0$ is total factor productivity,
  - $\psi > 0$ is the elasticity of output wrt public infrastructure capital,
  - $\alpha \in (0,1)$ is the (private) capital share of output, and
  - $\chi > 0$ determines how human capital transforms raw labor into effective units of labor.

Back to Snapshot

Firms' factor demands

- Firms' factor demands based on profit maximization:

$$\alpha \frac{y_t}{k_{t-1}} = r_t^k, \tag{2}$$

and

$$(1-\alpha)\frac{y_t}{l_t} = w_t e_t^{\chi}, \tag{3}$$

where

  - r_t^k is the rental rate for capital,
  - w_t is the wage rate per unit of *effective* labor.

- w_t, unlike all other non-stationary variables, has been normalized/made stationary by dividing by $(1+g)^{(1-\chi)t}$.
- However, the wage rate per unit of *raw* labor, $w_t e_t^{\chi}$, does grow at rate g, like all other non-stationary variables.

Back to Snapshot

Households' preferences

- The economy is populated by a continuum of infinitely-lived households.
- They maximize their expected lifetime utility over consumption and leisure.

$$\max \sum_{t=0}^{\infty} \beta^t \left(\frac{\left[c_t \left(1 - n_t\right)^{\zeta} \right]^{1-\frac{1}{\kappa}} - 1}{1 - \frac{1}{\kappa}} \right), \tag{4}$$

where

- $\beta \equiv (1+\rho)^{-1}(1+g)^{1-1/\kappa} \in (0,1)$ is the household's discount factor,
  - ρ is the pure rate of time preference,
- $\kappa > 0$ is the elasticity of intertemporal substitution, and
- $\zeta > 0$ controls the degree of substitution between leisure and consumption (the Frisch elasticity of labor supply).

- They devote time l_t for producing goods and time u_t to accumulate social capital (by going to school). Thus, we have

$$n_t = l_t + u_t. \tag{5}$$

Back to Snapshot

Households' budget constraint

- Households' income (sources of funds) consist of:
  - wages from supplying labor, $w_t e_t^{\chi} l_t$,
  - income from renting out capital, $r_t^k k_{t-1}$,
  - firms' profits, Φ_t, and
  - transfers, $\mathscr{T}_t$, from the government.
- Their expenditures (uses of funds) consist of:
  - consumption, c_t, subject to VAT-tax at rate, τ_t, and
  - investment in private capital, I_t, subject to depreciation at rate δ.
- It can also buy domestic bonds, b_{t+1}^d, which pay interest at rate r_t^d,
- Thus, their budget constraint is:

$$(1+\tau_t)\, c_t + I_t + b_t^d \quad \leq \quad w_t e_t^{\chi} l_t + r_t^k k_{t-1} + \left(1 + r_{t-1}^d\right) \frac{b_{t-1}^d}{1+g} + \mathscr{T}_t + \Phi_t. \tag{6}$$

Back to Snapshot

Accumulation of human capital

- The process of education/schooling combines
  - government-provided schools, z^e_{t-1}, and
  - effective time spent studying, $e^{\chi}_t u_t$,

  to produce human capital:

$$A^e \left(z^e_{t-1}\right)^{\phi} \left(e^{\chi}_t u_t\right)^{\nu}, \tag{7}$$

  where

  - $A^e > 0$ is the productivity parameter,
  - $\phi > 0$ is the elasticity of human capital output wrt government-provided education infrastructure, and
  - $\nu > 0$ is the elasticity wrt effective schooling time.

Back to Snapshot

Accumulation of human capital: Continued

- We abstract from time-to-build considerations.
- Instead, we highlight inertia in human capital accumulation:
  - Once a road is completed, it can be immediately used in a productive manner.
  - Building a school, however, does not immediately translate into higher human capital in the labor force;
  - It takes several more years to train students who become productive workers.
- For this, we define an intermediary stock of human capital ξ_t currently trapped in schools.
- Every period, a fraction ω of this stock moves from schools to the labor force. On average, newly accumulated human capital becomes productive with a delay of $1/\omega$ periods.
- Thus, stock of ξ_t evolves as:

$$(1+g)\,\xi_t = (1-\omega)\,\xi_{t-1} + A^e \left(z^e_{t-1}\right)^{\phi} \left(e^{\chi}_t u_t\right)^{\nu}. \tag{8}$$

- And, the human capital in the labor force (with depreciation rate, δ_e) evolves as:

$$e_t = (1-\delta_e)\,\frac{e_{t-1}}{1+g} + \omega \xi_{t-1}. \tag{9}$$

Back to Snapshot

Government

- The government's expenditures include:
  - Investment in
    - schools, g_t^e, and
    - roads, g_t^i,
  - Recurrent expenditures, m_t, on operating and maintaining roads and schools
    - proportional to their stocks. That is,

$$m_t^j = \gamma_z^j z_{t-1}^j \qquad \text{for} \quad j = e, i, \tag{10}$$

      where $\gamma_z^j > 0$ are parameters,
  - Transfers to households $\mathscr{T}_t$.
- Its revenues/ source of funds include:
  - VAT on households' consumption.
  - Other revenues and grants.
- It can also borrow:
  - b_{t+1}^d from their domestic financial market at interest rate r_t^d, and
  - $b_{t=1}^x$ from external financial markets at interest rate r_t^x.

Back to Snapshot

Government: Fiscal adjustment

- Given public investment, the fiscal gap (i.e. $\mathfrak{Gap}_t = \mathfrak{Exp}_t - \mathfrak{Rev}_t$) *before* policy adjustment

$$\mathfrak{Gap}_t = g_t^z + m_t^z + \left(r_{t-1}^d - g\right)\frac{b_{t-1}^d}{1+g} + \left(r_{t-1}^x - g\right)\frac{b_{t-1}^x}{1+g} + \overline{\mathscr{T}}_t - \overline{\tau}_t c_t - \mathscr{G}_t. \tag{11}$$

- This fiscal gap (in our case due to the scaling-up of public investment) can be financed through a combination of
  - borrowing: domestic and/or external; and/or
  - fiscal adjustment: taxes or transfers.

  These can also be seen from the government's modified budget constraint as

$$\mathfrak{Gap}_t = \Delta b_t^x + \Delta b_t^d + \left(\tau_t - \overline{\tau}_t\right) c_t - \left(\mathscr{T}_t - \overline{\mathscr{T}}_t\right). \tag{12}$$

- Debt sustainability requires taxes/transfers eventually adjust to cover the fiscal gap in the long run (i.e., $\Delta b_t^x + \Delta b_t^d = 0$).
  - Government's fiscal rules ensure this by making taxes and transfers respond to the level of public debt.

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