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Transport Infrastructure Provision, Congestion and Endogenous Growth

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Structure of the Presentation

1. Purpose of this paper
2. Transport infrastructure in endogenous growth models
3. Transport infrastructure as an unpaid factor
4. Optimal fiscal policy in a decentralised economy (work in progress)
5. Preliminary conclusions

1. Purpose of the paper

- Endogenous growth: generated by including some kind of publicly provided input in the production function
  - Usually non-rivalry, congestion and therefore, market failure involved (Gómez, 2008; Eicher/ Turnovsky, 2000; Bretschger, 1996)
  - Theoretical results are confirmed for transport infrastructure by empirical evidence (Colombier, 2009; Nijkamp and Poot, 2004; Aschauer, 1989)

- However: important shortcoming: congestion of transport infrastructure is exogenously givern in endogenous growth models (e.g. Gómez, 2016, Ott and Turnovsky 2006)
  - ⇒ Degree of congestion is independent from capacity utilsation of transport infrastructure and stays constant
  - ⇒ (Note that we consider only that type of congestion what the literature dubbs ‚relative congestion‘)

1. Purpose of this paper

- Literature recommends modelling congestion endogenously (Ott/ Turnovsky, 2006; Eicher/ Turnovsky, 2000)
- Our contribution to the literature
  - Degree of congestion is endogenously determined
    - Based on a proposal by Barro/ Sala-i-Martin (1992)
    - Insights from transport science (Walker, 1995)
  - Modelling transport infrastructure as a rival but non-excludable good
    - Based on a proposal by Barro/ Sala-i-Martin (1992) and Pickhardt (2003)
- Examination whether closer approximation of transport infrastructure changes policy conclusion (work in progress)

2. Transport infrastructure in endogenous growth models

$$Y = K * F\left(\frac{G}{K}\frac{1}{n^{\varepsilon-1}}\right) \text{ with } \varepsilon := \text{degree of congestion} \qquad (1)$$

$$\varepsilon = 1 => G \text{ is rival}; \varepsilon = 0 => G \text{ is non-rival}$$

- Fairly standard to model transport infrastructure as a non-rival and congestible input provided by the government (e.g. Gômez, 2016, Ott / Turnovsky, 2006; Fisher/ Turnovsky, 1998)
- Degree of congestion is exogenous and expressed by the degree of rivalry of G (ε=1: complete congestion; ε=0: no congestion)
- Production function exhibits constant returns to scale in private capital (K) and in the publicly provided input (G),
- n household producers

3. Transport Infrastructure as an Unpaid Factor

$$Y = \gamma(k)K^{1-\alpha}G^{\alpha} \qquad (2)$$

With $k=K/G$; γ:= congestion factor; $\gamma \geq 0$; $\gamma_k < 0$; $\gamma_{kk} < 0$; $\gamma_g > 0$; $\gamma_{gg} < 0$; $\gamma_{gk} > 0$;

- Degree of congestion is dependent on the relationship between the total amount of private capital (K) and the total amount of the publicly provided input (G), and is therefore *endogenous* (Walker, 1995; Barro/ Sala-i-Martin, 1992)
- Transport infrastructure can be classified as a production externality that Meade (1952) called *unpaid factor* (Colombier and Pickhardt, 2005)
- Rivalry of transport infrastructure does not depend on the degree of congestion and is given by the way firms use the transport infrastructure (Pickhardt, 2003)

3. Transport infrastructure as an unpaid factor

- **Case I**: non-excludable unpaid factor
- Case II: excludable unpaid factor => imposing a user fee is feasible

- Assumptions of the model
  - Production technology as described above
  - Standard CES utility function
  - Each household supplies one unit of labour inelastically
  - No population growth => n is constant

$$\max_{C,G} U_0 = \int_0^{\infty} e^{-ßt} \frac{C(t)^{1-\sigma}}{1-\sigma} dt, \text{ w.r.t.}$$

$$\dot{K}(t) = Y(t) - C(t) - G(t)$$

$$\text{with} : \beta > 0; 0 < \sigma < 1 \qquad (3)$$

3. Transport infrastructure as an unpaid factor

Social optimum

congestion effect<0
no congestion=0

$$\psi = \frac{\dot{C}}{C} = \frac{\dot{c}}{c} = \frac{1}{\sigma}\left((1-\alpha) + \eta_{\gamma,k}\right)\frac{\gamma}{k^{\alpha}} - \beta \qquad (4)$$

Social marginal productivity of capital

with $\eta_{\gamma,k} = \frac{\partial\gamma}{\partial k}\frac{k}{\gamma} \wedge \frac{d\psi}{dk} < 0$

3. Transport infrastructure as an unpaid factor

- Prerequisite for endogenous growth: Social marginal productivity of capital has to be constant and above the rate of time preference β.

$$\hat{Y}_K = (\hat{K} - \hat{G})\left(1 - \frac{G}{Y}\right) = 0 \Leftrightarrow \hat{K} = \hat{G} \qquad (5)$$

- Endogenous growth can be generated with congestible transport infrastructure if the unpaid factor grows at the same rate as private capital
- In contrast to the literature (e.g. Eicher and Turnovsky, 2000) :
  - Steady-state growth rate is determined by capacity utilisation
  - Degree of congestion is endogenously determined and has no impact on returns to scale (no scale effects)

$$\hat{Y} = ((1-\alpha) + \eta_{\gamma,k})\hat{K} + (\alpha + \eta_{\gamma,G})\hat{G} \text{ with } \eta_{\gamma,G} = -\eta_{\gamma,k} \qquad (6)$$

4. Optimal fiscal policy in a decentralised economy (work in progress)

- Assumptions:
  - Total amount of unpaid factor is exogenous to the representative household (Barro/ Sala-i-Martin, 1992)
  - Congestion effect is ignored by representative household
  - The government balances the budget
  - The government has an Income tax and excise duty (e.g. fuel tax) at their disposal
- Optimal fiscal policy (preliminary results)
  - Growth rate of social optimum can be attained
  - Income tax rate internalizes congestion
  - Excise duty simulates marginal cost pricing
  - Income tax rate and excise duty equate marginal social costs of using transport infrastructure

5. Preliminary conclusions

- Our paper shows that a steady-state growth rate can be achieved with congestible publicly provided unpaid factor, i.e. transport infrastructure

- The optimal degree of congestion is determined endogenously
  - The government has to keep the proportion between the unpaid factor and private capital constant
  - Optimal degree of capacity utilisation (K/G)

- Given the plethora of fiscal rules in the EU governments are well-advised to maintain and increase the provision of transport infrastructure in line with private capital accumulation to achieve stable long-run growth path

5. Preliminary conclusions

- Preliminary results with respect to optimal tax policy suggest that income tax rate are advisable to internalise congestion effect efficiently (work in progress)
  - In line with the results of endogenous-growth models with exogenous congestion (e.g. Gómez, 2012; Ott and Turnovsky, 2006)

- Further proceeding:
  - Analyse policy implications of an excludable unpaid factor
  - Include the unpaid factor as a stock, possible network effects and negative externality on the environment
  - Make a distinction between users and non-users of the transport infrastructure