Commuting, congestion and the taxation of work trips

Bruno De Borger
University of Antwerp
Background literature

- Bargaining and (environmental) externality taxation (Bayundir-Uppman and Raith (EER 2003), Schöb (2005))
- Congestion taxes and competitive labour markets: Mayeres-Proost (JPubEcs 1997), Parry-Bento (ScanJEcs 2001), Van Dender (ScanJEcs 2003)
- Bargaining models and congestion: De Borger (2009), De Borger and Wuyts (2009)
Motivation

- Commuting is a large fraction of peak-period transport demand
- Congestion and congestion tolls are likely to affect labour market outcomes
- How should work and non-work trips be taxed?
- Does the structure of the labour market affect labour market responses to congestion and congestion tolls?
- Does the structure of the labour market affect optimal congestion policies?
Overview of the rest of the lecture

- Competitive labour markets
  - Taxing labour and transport trips
- Bargaining models
  - Transport taxes, congestion and union preferences
  - Subsidize commuting?
  - Extensions: telecommuting
- Some illustrative numerical results
- Conclusions
Part I: Competitive labour markets

- Assumptions simplest version of the model (Parry-Bento (SJE (2001))
  - Wage is determined on competitive labour market; exogenous to the individual
  - All trips are commuting trips: peak period transport conditions
  - Perfect complimentarity commuting and labour supply
  - Two transport modes: congested road and uncongested public transport (e.g., metro)
  - No formal spatial dimension (e.g., Borck-Wrede (JUE (2005)))
  - No distributive concerns
Structure of the model I

- Utility defined on consumption good (C), leisure (N), and road (R) and public transport (P) use
  \[ U = u(C, N) + T(R, P), \]

- Days of (fixed hours) labour supply (L) equals commuting round trips
  \[ L = R + P. \]

- Time constraint
  \[ \bar{L} = N + L + \pi R + \phi P, \]

- Public transport is uncongested; time per trip \( \phi \) fixed

- Road congestion function
  \[ \pi = \pi(R), \]
Structure of the model II

- Government levies taxes on labour and commuting by road, adn it provides lump sum transfer
- Commuting by public transport remains untaxed
- Budget constraint individual
  \[ C + \tau R = (1 - \tau)L + G \]
- Government budget constraint
  \[ tL + \tau R = G \]
Behavior consumers

- Treat congestion as exogenous
- Maximizing behavior implies generalized costs of road and public transport are equal

\[ \frac{\pi u_N}{u_C} - \frac{T_R}{u_C} + \tau = \phi \frac{u_N}{u_C} - \frac{T_P}{u_C} \]

- Demand and labour supply functions

\[ R = R(\tau, t, G, \pi) \quad P = P(\tau, t, G, \pi) \quad L = L(\tau, t, G, \pi) \]
Welfare effect of increase in congestion toll financed by labour tax I

- **Indirect utility**

\[
V(\tau, t, G, \pi) = \max_{\{C, N, R, P\}} \ u(C, N) + T(R, P) + \lambda \{ G + (1 - t)L - C - \tau R \} \\
+ \quad \gamma \{ \bar{L} - (1 + \pi)R - (1 + \phi)P - N \},
\]

- **Utility change of congestion toll recycled via labour tax**

\[
\frac{dV}{d\tau} = \frac{\partial V}{\partial \tau} + \frac{\partial V}{\partial t} \frac{dt}{d\tau} + \frac{\partial V}{\partial \pi} \frac{d\pi}{d\tau} \frac{dR}{d\tau}
\]

- **Differentiate government budget restriction**

\[
\frac{dt}{d\tau} = - \frac{R + \tau \frac{dR}{d\tau} + t \frac{dL}{d\tau}}{L} < 0
\]
Welfare effect of tax reform

- Welfare effect can be written as (using envelope and government budget constraint)

\[ \left\{ \pi R \frac{u_N}{u_C} - \tau \right\} \left\{ -\frac{dR}{d\tau} \right\} + t \frac{dL}{d\tau} \]

- Trades off distortions on road transport (deviation toll and marginal external cost) and labour markets (labour tax)
Employment effects of congestion toll I

- Change in labour supply
  \[
  \frac{dL}{d\tau} = \frac{\partial L}{\partial \tau} + \left\{ \frac{\partial L}{\partial t} \frac{dt}{d\tau} \right\} + \left\{ \frac{\partial L}{\partial \pi'} \frac{d\pi'}{d\tau} \right\}
  \]

- Direct effect reduces return to working relative to leisure
- Tax recycling effect raises employment
- Lower congestion reduces time cost of going to work and raises labour supply
Employment effects of congestion toll II

- Using government budget restriction and substituting we find:

\[
\frac{dL}{d\tau} = \left\{ \frac{\partial L}{\partial t} \frac{dR}{dt} \frac{\tau}{L} \right\} + \left\{ \frac{\partial L}{\partial \pi} \frac{dR}{d\tau} \right\} \frac{L}{1 + \frac{t}{L} \frac{\partial L}{\partial t}}
\]

- In absence of congestion, employment effect plausibly negative
- Congestion has opposite effect, implying more favorable employment effects
- Numerical analysis suggests effects may be positive
Employment effects of different recycling instruments

- **Lump sum transfer**
  \[
  \frac{dL}{dt} = \frac{\partial L}{\partial \tau} + \left\{ \frac{\partial L}{\partial G} \frac{dG}{dt} \right\} + \left\{ \frac{\partial L}{\partial \pi} \frac{d\pi}{dt} \right\}
  \]

- **Less favorable employment effects: recycling effect plausibly negative**

- **Public transport subsidies**
  \[
  \frac{dL}{dt} = \frac{\partial L}{\partial \tau} + \left\{ \frac{\partial L}{\partial s} \frac{ds}{dt} \right\} + \left\{ \frac{\partial L}{\partial \pi} \frac{d\pi}{dt} \right\}
  \]

- **Recycling effect positive but (assuming equal congestion effects) smaller than for labour tax recycling**
Optimal taxation

- Optimal congestion toll equals marginal external cost
  \[ \tau^* = \pi R u_N / u_C \]

- Based on particular assumptions
  - Zero tax on public transport
  - Specific separability
  - Implied assumption of wage elasticities of road and public transport
Optimal taxation in a model with multiple trip purposes

- Consumer cares about consumption (0), leisure (N), leisure and commuting trips by road (1,3), leisure and commuting trips by public transport (2,4)

\[ u = U(q_0, q_1, q_2, N) + T(q_3, q_4), \]

- Constraints

\[ (1 - t_L)L + S = q_0 + \sum_{i=1}^{4} p_i q_i \quad [\lambda] \]

\[ L = N + L + \sum_{i=1}^{4} a q_i \quad [\gamma] \]

- Perfect complimentarity

\[ L = q_3 + q_4 \]
Prices and congestion

- **Transport prices**

  \[ p_i = c_{\text{car}} + t_i \quad (i = 1, 3) \]

  \[ p_i = t_i \quad (i = 2, 4) \]

  - Car use: resource cost plus tax
  - Public transport use: fare

- **Congestion**

  \[ a = a(F) \]

  \[ F = \sum_{i=1}^{4} \alpha_i q_i \quad \alpha_1 = \alpha_3 = 1 \quad \text{and} \quad (\alpha_2 = \alpha_4) < 1 \]
The optimal tax problem

- Max indirect utility of typical individual s.t. government budget restriction

\[ \mathcal{V} = V(t_L; t_i, i = 1, \ldots, 4; \alpha; S) + \mu \left( \sum_{i=1}^{4} t_i q_i + t_L L - \sum_{i=2,4} c_{bus} q_i - S \right). \]
Optimal (differentiated) tax rules

- Optimal transport taxes satisfy:

\[
\frac{t_i + \delta_{Li} t_L}{p_i} = \theta \frac{1}{\varepsilon_{ii}} - \frac{1}{p_i} \sum_{j=1, j \neq i}^{4} \frac{\varepsilon_{ji} q_j}{\varepsilon_{ii} q_i} \left( t_j + \delta_{Lj} t_L - \delta_{pj} c_{bus} - \frac{\gamma}{\mu} \alpha_j d' F \right)
\]

Ramsey

\[
+ \frac{\gamma d' F}{\mu p_i}, \quad i = 1, \ldots, 4,
\]

Pigou

\[
\delta_{Li} = 1 \text{ for } i = 3, 4
\]

\[
\delta_{bus. i} = 1 \text{ for } i = 2, 4
\]

\[
\theta = \frac{1 - \mu / \lambda}{\mu / \lambda}
\]
Interpretation

- Tax indeterminacy for commuting (3,4)
- External cost, Ramsey, trip interaction terms
- Trip interaction reflect deviations of taxes from external cost in other transport services
Zero cross elasticities between leisure and commuting

- **Tax rule car commuting** (idem for bus)

\[
\frac{t_3 + t_L}{p_3} = \left[ \frac{\varepsilon_{44}}{\varepsilon_{33}\varepsilon_{44} - \varepsilon_{43}\varepsilon_{34}} \right. - \frac{p_4 q_4}{p_3 q_3} \left. \frac{\varepsilon_{43}}{\varepsilon_{33}\varepsilon_{44} - \varepsilon_{43}\varepsilon_{34}} \right] \theta + \frac{\gamma d'F}{\mu p_3} \]

- **Ramsey weights related to elasticity labour supply** (w is weight)

\[
\frac{1}{\varepsilon_{LL}} = wR_3 + (1 - w)R_4
\]

- Ramsey weights more important when low elasticity of labour supply
- Tax commuting less when taxing it would strongly affect labour supply
Zero cross elasticities between transport modes

- Tax rule car commuting (idem bus):

\[
\frac{t_3 + t_L}{p_3} = \left[ \frac{1}{\varepsilon_{33}} \right] \theta + \frac{\gamma d F}{\mu p_3}
\]

- Standard Ramsey rule corrected for commuting labour supply complimentarity
Optimal (uniform) tax rules

- No tax differentiation between commuting and leisure travel
- Optimal taxes satisfy (zero cross elasticities transport):

\[
\begin{align*}
  i_L &= \frac{p_L}{\epsilon_{LL}} - \frac{\partial q_3}{\partial t_L} \left( t_{\text{car}} - \frac{\gamma}{\mu} d'F \right) - \frac{\partial q_4}{\partial t_L} \left( t_{\text{bus}} - c_{\text{bus}} - \frac{\gamma}{\mu} \alpha_{\text{bus}} d'F \right) \\
  t_{\text{car}} &= \frac{1}{\frac{\partial q_1}{\partial t_{\text{car}}} + \frac{\partial q_3}{\partial t_{\text{car}}}} \left( q_1 + q_3 - t_L \frac{\partial q_3}{\partial t_L} \right) + \frac{\gamma}{\mu} d'F \\
  t_{\text{bus}} &= \frac{1}{\frac{\partial q_2}{\partial t_{\text{bus}}} + \frac{\partial q_4}{\partial t_{\text{bus}}}} \left( q_2 + q_4 - t_L \frac{\partial q_4}{\partial t_L} \right) + \frac{\gamma}{\mu} \alpha_{\text{bus}} d'F + c_{\text{bus}}.
\end{align*}
\]

- Note that marginal external cost pricing does not solve the system
Interpretation

- Trade off between trying to reduce commuting toll (in order not to reduce labour supply too much) and trying to shift the tax burden to leisure traffic
- Tax indeterminacy obviously resolved
Numerical model

- Apply for standard 20km commuting trip
- Linear congestion function
- Value of time in reference 7.65 euro/hour
## Results

<table>
<thead>
<tr>
<th></th>
<th>(1) Initial situation</th>
<th>(2) Optimal uniform taxes at reference labour tax ($t_L = 40%$)</th>
<th>(3) Optimal differentiation at reference labour tax ($t_L = 40%$)</th>
<th>(4) Optimal differentiation and optimal labour tax ($t_L = 32.5%$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Welfare index</strong></td>
<td>1</td>
<td>1.000189</td>
<td>1.001299</td>
<td>1.004208</td>
</tr>
<tr>
<td><strong>Transport tax (Euro/trip)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Leisure bus trips</td>
<td>0.527</td>
<td>0</td>
<td>1.034</td>
<td>8.823</td>
</tr>
<tr>
<td>(3) Commuting car trips</td>
<td>4.240</td>
<td>4.840</td>
<td>0</td>
<td>5.457</td>
</tr>
<tr>
<td>(4) Commuting bus trips</td>
<td>0.527</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Trip demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total trip demand index</td>
<td>1</td>
<td>1.000</td>
<td>0.965</td>
<td>0.900</td>
</tr>
<tr>
<td>% commuting trips</td>
<td>53.0%</td>
<td>52.8%</td>
<td>56.3%</td>
<td>62.9%</td>
</tr>
<tr>
<td><strong>Modal split (share of car trips)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leisure</td>
<td>75.0%</td>
<td>74.0%</td>
<td>73.5%</td>
<td>74.5%</td>
</tr>
<tr>
<td>Commuting</td>
<td>67.0%</td>
<td>58.8%</td>
<td>80.1%</td>
<td>63.3%</td>
</tr>
<tr>
<td>All trips</td>
<td>70.6%</td>
<td>66.0%</td>
<td>77.2%</td>
<td>67.5%</td>
</tr>
<tr>
<td><strong>Taxes/marginal external congestion costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) Leisure car trips</td>
<td>0.617</td>
<td>0.700</td>
<td>1.078</td>
<td>2.302</td>
</tr>
<tr>
<td>(2) Leisure bus trips</td>
<td>1.533</td>
<td>0</td>
<td>2.983</td>
<td>24.950</td>
</tr>
<tr>
<td>(3) Commuting car trips</td>
<td>0.617</td>
<td>0.700</td>
<td>0</td>
<td>0.772</td>
</tr>
<tr>
<td>(4) Commuting bus trips</td>
<td>1.533</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Interpretation I

- Optimal uniform taxes at reference labour tax
  - High reference labour tax: transport taxes below MEC
  - Small welfare effects
- Optimal differentiated transport taxes at reference labour tax
  - Leisure trips taxed at more than MEC, commuting untaxed
Interpretation II

- Tax indeterminacy implies optimal labour tax-commuting taxes cannot be determined
- Look at tax structure where bus commuting remains untaxed (labour tax is 32.5%)
- Commuting car trips now taxed
Implications

- Countries with high labour taxes should tax peak period passenger transport below marginal external cost
- Countries with high labour taxes should ‘subsidize’ commuting: lower tolls on commuters versus non-commuting
- Large welfare effects of non-differentiation
- Do not subsidize commuting at current low tolls
Part II: Optimal taxation of work trips in a wage bargaining model

- Assumptions
- Theoretical model
- Congestion, road tolls and wage bargaining outcomes
- Optimal taxation
- The role of union ‘preferences’
Assumptions of the basic model I

- Two types of households: “employed” and “not employed”
- All workers are union members, represented by a single union
- The employed work for firm producing output at exogenous world price
- Labour market outcomes are the result of (right-to-manage) bargaining between firm and union.
Assumptions of the basic model II

- Perfect complementarity between employment and commuting
  - Working times fixed
  - Each working day requires roundtrip commute

- Following Parry-Bento-Van Dender, the model reflects average peak period transport conditions over an extended period of time
  - The employed demand both commuting and non-commuting transport
  - People not employed only demand non-commuting transport
Assumptions of the basic model III

- Preferences quasi-linear
- All transport takes place on a single link
- Government faces an exogenous budget constraint
- Main tax instruments
  - Labour tax
  - Uniform transport tax on all trip purposes
Labour market participation and union membership

- Population normalized at 1
- A fraction $m$ participates on the labour market, $(1-m)$ does not participate at all (discourage workers, retired, etc.)
- Employment is given by $L$ ($0 < L < m$), unemployment is $(m-L)$
- All labour market participants are unionized; union membership is then $m$
Behavior of households I

- The employed care about a general numeraire consumption good (C), commuting (c) and non-commuting (n) transport, and leisure (l)
- Each day of work requires one round trip commuting
- Problem is

\[
\begin{align*}
\text{Max} & \quad C^e + u^e(T^e_n, \bar{T}^e_n, l^e) \\
C^e, T^e_n, & \quad l^e \\
C^e + (1+\tau_T)T^e_n = & \left[ w - \tau \right] \left[ -(1+\tau_T)\bar{T}^e_c + G \right] \\
l^e + aT^e_n + (1+a)\bar{T}^e_c = & \quad R
\end{align*}
\]

- All trips expressed in terms of a commuting trip
Behavior of employed households II

- Indirect utility employed
  \[ V^e(w - \tau_L, \tau_T, a, G) \]

- Note
  \[ \frac{\partial V^e}{\partial \tau_L} = -1 < 0, \quad \frac{\partial V^e}{\partial \tau_T} = -(\bar{T}_c^e + \bar{T}_n^e) < 0, \quad \frac{\partial V^e}{\partial a} = -\theta^e (\bar{T}_c^e + \bar{T}_n^e) < 0 \]

- Value of time denoted \( \theta^e \)
- People not working care about the consumption good, leisure and non-commuting transport
- Yields indirect utility:
  \[ V^u(\tau_T, a, G) \]
  \[ \frac{\partial V^u}{\partial \tau_T} = -T^u < 0, \quad \frac{\partial V^u}{\partial a} = -\theta^u T^u < 0 \]
Congestion

- Congestion function $a(T)$
  
  $$a' > 0, \quad a'' > 0$$

- Depends on total transport demand
  
  $$T = L(\bar{T}^c + T^e) + (1 - L)T^u$$
Union preferences

- Conditional on taxes, congestion etc., union preferences depend on wages and employment
- Union utility
  \[ \Omega(w, L, \tau, \tau, a) \]
- Scarce empirical evidence suggests unions care about congestion and congestion taxes
  - Discussion of London charging scheme by union leaders
  - Debate on New York City congestion pricing by unions (NY Times, March 2007)
  - Union Conference on congestion and road pricing (Brussels, May 2007; Rome, March 2008)
The firm

- Labour is the only input
- Profit
  \[ \pi(w,L) = f(L) - wL; \quad f' > 0, f'' < 0 \]
- Profit maximizing behavior at exogenous world output price normalized at 1
Bargaining

- Right to manage bargaining between union and firm
  - Bargaining over wage
  - Conditional on negotiated wage, the firm autonomously sets employment

- Bargaining outcomes obtained as solution to

\[
\begin{align*}
\max_w & \quad \mu \ln(\Omega(w, L; \tau_L, \tau_T, a)) + (1 - \mu) \ln(\pi(w, L)); \\
L & = L^d(w)
\end{align*}
\]

- Union power \( \mu \)
- Labour demand is the solution of \( w = f'(L) \)
Bargaining outcomes I

- Negotiated wages and resulting employment depend on transport parameters
  \[ w(\tau_L, \tau_T, a), \quad L(\tau_L, \tau_T, a) \]
- For a variety of ‘plausible’ union utility functions, the labour tax, the transport tax and congestion all raise wages and reduce employment
- Example
  \[ \Omega = \left[ LV^o(.) \right]^{\beta} \left[ (m - L) V^u(.) \right]^{1-\beta} \]
Bargaining outcomes II

- Will a more powerfull union be able to transmit a given tax or congestion increase into higher wages?
- Answer is ambiguous and depends on characteristics of the production function
  - Isoelastic (Cobb-Douglas): more powerful union satisfied with lower wage increase
  - Other cases: use higher power to get larger wage increase
The optimal tax problem

- Welfare function captures expected well-being of employed and those not employed, and firm profits
- Government is budget constrained: tax revenues pay for fixed lump sum transfer
- Problem

\[
\begin{align*}
\max_{\tau_L, \tau_T} & \quad L V^e (w - \tau_L, \tau_T, a, \alpha, G) + (1 - L) V^u (\tau_T, a, G) + \left[ f (L) - w L \right] \\
\text{s.t.} & \quad \tau_T T + \tau_L L = G \quad (\gamma)
\end{align*}
\]
Derivation optimal taxes

- First order conditions

\[
\frac{dL}{d\tau_L} \{V^e - V^u + \gamma \tau_L\} + \frac{dT}{d\tau_L} \{\gamma \tau_T - MEC\} + L(\gamma - 1) = 0
\]

\[
\frac{dL}{d\tau_T} \{V^e - V^u + \gamma \tau_L\} + \frac{dT}{d\tau_T} \{\gamma \tau_T - MEC\} + T(\gamma - 1) = 0
\]

- Where

\[
MEC = -a' \left[ L \frac{\partial V^e}{\partial a} + (1-L) \frac{\partial V^e}{\partial a} \right] = a' \left[ L \left( \theta^e (\bar{T}^e + T^e) \right) + (1-L) \theta^u T^u \right]
\]

- This is marginal external congestion cost; weighted average of welfare loss of employed and people not employed
Taxes and long run total transport demand

- Impact of labour and transport tax

\[
\frac{dT}{d\tau_L} = \frac{1}{1-\rho} \left[ (T^e - T^u) \frac{\partial L}{\partial \tau_L} \right]
\]

\[
\frac{dT}{d\tau_T} = \frac{1}{1-\rho} \left[ (S) + (T^e - T^u) \frac{\partial L}{\partial \tau_T} \right]
\]

where

\[ T^o = \bar{T}_c^o + T_n^o \]

\[ S = L \frac{\partial T_n^o}{\partial \tau_T} + (1 - L) \frac{\partial T^u}{\partial \tau_T} < 0 \]

\[ \rho = L \frac{\partial T_n^o}{\partial a} a' + (1 - L) \frac{\partial T^u}{\partial a} a' + (T^e - T^u) \frac{\partial L}{\partial a} a' \]
Taxes and long run employment

- Impact of labour and transport tax

\[
\frac{dL}{d\tau_L} = \frac{1 - \rho_i}{1 - \rho} \left\{ \frac{\partial L}{\partial \tau_L} \right\}
\]

\[
\rho_i = L \frac{\partial T_n^o}{\partial a} + (1 - L) \frac{\partial T_n^u}{\partial a}
\]

\[
\frac{dL}{d\tau_T} = \frac{1}{1 - \rho} \left\{ [1 - \rho_i] \frac{\partial L}{\partial \tau_T} + [S] \frac{\partial L}{\partial a} a' \right\}
\]

- Long-run employment effects differ from direct impact due to congestion effects
Optimal transport tax I

\[ \tau = \frac{MEC}{T} \gamma + \frac{(1-\gamma)(1-\rho_t)}{\gamma [S]} \] \[ \times \left[ \left( \frac{(1-\gamma)(1-\rho_t)}{\gamma [S]} \right) \right] \frac{L \partial L}{\partial \tau} T \left[ \frac{1-\gamma}{\gamma} \right] \frac{\partial L}{\partial \tau} \left[ \frac{\partial L}{L} \right] \frac{L}{a L} \right] \] 

- Four clearly identifiable terms: Pigou, Ramsey, (relative) employment effect transport tax and congestion
- Larger wage effects of transport taxes reduce optimal tax
- Opposite holds for congestion itself
Optimal transport tax II

- Tax can vary dramatically depending on union preferences with respect to employment and congestion.
- If congestion does not matter to the union but transport prices do then the tax is structurally below Ramsey.
- If the opposite holds then the tax structurally above Ramsey.
Optimal labour tax

\[ \tau_L = -\left( \frac{V^o - V^u}{\gamma} \right) - \left( \frac{\gamma - 1}{\gamma} \right) \left\{ \frac{L}{\partial \tau_L} + \frac{(T^o - T^u)(L \frac{\partial L}{\partial \tau_T} - T \frac{\partial L}{\partial \tau_L})}{\partial \tau_L[S]} \right\} \]

- Corrects for the distortion due to wage bargaining: tax negative with lump sum tax available
- Corrects for relative effects transport and labour taxes on employment
General results are not surprising: labour market effects matter in expected sense

Bargaining framework implies that tax rules strongly depend on union preferences

Consider specific union utility function

\[ \Omega = \left[ LV_e(w-\tau_L, \tau_T, a) \right]^\beta \left[ (m-L)\nu_u(\tau_T, a) \right]^{1-\beta} \]

Implies that the union ‘accepts’ worker preferences with respect to transport taxes and congestion
Role of union preferences II

Specification implies that following relations hold:

\[
\frac{\partial w}{\partial \tau} = (\bar{T}e + T^e) \frac{\partial w}{\partial \tau} + c n \frac{\partial L}{\partial \tau} \\
\frac{\partial L}{\partial \tau} = (\bar{T}e + T^e) n \frac{\partial L}{\partial \tau}
\]

\[
\frac{\partial w}{\partial a} = \theta e (\bar{T}e + T^e) \frac{\partial w}{\partial \tau} + L n \frac{\partial L}{\partial \tau} \\
\frac{\partial L}{\partial a} = \theta e (\bar{T}e + T^e) L \frac{\partial L}{\partial \tau}
\]

- Relative wage effects of labour and transport taxes (congestion) reflect their relative marginal indirect utilities for workers.
- Only transport demand of the employed matters for the relative impact of labour and transport taxes on negotiated wage.
Role of union preferences III

- Using in general optimal transport tax rule we find:

\[ \tau_T = MEC - \left( \frac{\gamma - 1}{\gamma} \right) \left[ \frac{(1 - \rho)}{(S)} + \theta^u a^u \right] (1 - L) T^u \]

- Optimal tax equals \textit{MEC} if all demand comes from people employed

- Note difference with models of competitive labour markets (Van Dender 2003)

- Reason
Role of union preferences IV

- In principle, optimal tax can be > or < MEC depending on time values of users that do not work (pensioners, unemployed)
- Two issues at stake
  - Tax shifting of employed to broader tax base (tax > MEC): labour tax paid by employed only, transport tax by all users
  - People not employed suffer from congestion and are not compensated through wage adjustments (tax < MEC)
Role of union preferences V

Do unions care about congestion and congestion taxes?

- Suppose union cares much less about congestion taxes than its members do
  - Optimal transport tax above MEC, even if all demand comes from employed only
  - Intuition: small employment effects

- Suppose union does not care about congestion
  - Reduce optimal transport tax
Role of union preferences VI

Let

$$\Omega = L^\delta \hat{w}, \quad \hat{w} = w - \tau L - \varepsilon T - \sigma a$$

Parameters reflect importance of transport tax and congestion relative to labour tax from union’s perspective.

Optimal transport tax rule (zero demand people not working)

$$\tau_T = MEC - \left(\frac{1 - \gamma}{\gamma}\right) \left[\delta La' - MEC\right] + \left[L(\varepsilon - T^e)\left(\frac{1 - \rho}{S}\right)\right]$$

Low valuation congestion: low transport tax.

Low valuation transport tax: high transport tax.
Tax differentiation I

- Adapt model on two accounts:
  - Differentiate taxes on commuting, non-commuting $\tau_c, \tau_n$
  - Relax assumption of perfect complementarity commuting-work
- Optimal tax rules for initial specification of union preferences
- Different countries have very different policies: US, Canada etc. versus Germany, France, Sweden, etc.
Tax differentiation II

- Standard view on commuting subsidies (Borck-Wrede (JUE (2005, 2008))
  - Depends to large extent on relative flexibility labour versus housing markets
  - Flexible housing markets: no reason to subsidize commuting
  - Rigid housing markets, flexible labour markets: subsidies can be justified
Tax differentiation III

- **Optimal tax rules**
  \[ \tau_c = MEC + \left( \frac{1-\gamma}{\gamma} \right)(1-L)\theta^u T^u a' \]
  \[ \tau_n = MEC + \left( \frac{1-\gamma}{\gamma} \right) \left[ \frac{1}{S} + \theta^u a' \right] (1-L)T^u \]

- **Subsidize commuting?**
  - Tax commuting below external cost
  - Tax less than leisure traffic

\[ \tau_n - \tau_c = \left( \frac{1-\gamma}{\gamma} \right) \left[ \frac{(1-L)T^u}{S} \right] \geq 0 \]
Extensions I: Spatial or temporal differentiation

- Model assumed all transport uses same link at same time
- Suppose non-commuting uses different link or travels at different time. We then find:

\[ \frac{\tau}{c} = MEC \]

\[ \tau_n = \left( \frac{1 - \gamma}{\gamma} \right) \frac{T}{S} \]

- Commuters pay external cost, non-commuters contribute to financing
Extensions II: multiple transport modes

- Suppose there is an uncongested alternative (rail) apart from car travel
- Assume all transport demand is commuting, so with car transport only tax would equal $MEC$
- Let taxes be denoted $\tau_{\text{car}}, \tau_{\text{rail}}$
Multiple transport modes

- Tax rules (Z<0)

\[ \tau_{\text{car}} = MEC + \left( \frac{1 - \gamma}{\gamma} \right) \frac{[B]}{[K]} \left( -(L + T_{\text{rail}} Z) \frac{\partial T_{\text{rail}}}{\partial \tau_{\text{car}}} + T_{\text{rail}} Z \frac{\partial T_{\text{car}}}{\partial \tau_{\text{car}}} \right) \]

\[ \tau_{\text{rail}} = \left( \frac{1 - \gamma}{\gamma} \right) \frac{[B]}{[K]} L \frac{\partial T_{\text{car}}}{\partial \tau_{\text{car}}} \]

\[ B = \tau_{\alpha} \frac{\partial w}{\partial a} a' Z (T_{\text{car}} - T_{\text{rail}}) \frac{\partial T_{\text{car}}}{\partial \tau_{\text{rail}}} \]

\[ K = (L + T_{\text{rail}} Z) \left( \frac{\partial T_{\text{car}}}{\partial \tau_{\text{car}}} \frac{\partial T_{\text{rail}}}{\partial \tau_{\text{rail}}} - \frac{\partial T_{\text{car}}}{\partial \tau_{\text{rail}}} \frac{\partial T_{\text{rail}}}{\partial \tau_{\text{car}}} \right) \]

- If car demand exceeds rail demand and car and rail are substitutes, then  B<0, K>0
Optimal rail tax

- If congestion raises wages and reduces employment, this is an argument to subsidize rail:
  \[ \tau_{\text{rail}} = \left( \frac{1-\gamma}{\gamma} \right) \left[ \frac{B}{K} \right] \left\{ L \frac{\partial T_{\text{car}}}{\partial \tau_{\text{car}}} \right\} < 0 \]

- Doing so reduces congestion and raises employment.

- Rail subsidy despite the availability of an optimal car tax.
If labour market effects of congestion are small, then $\tau_{car} < MEC$

If effects are large, then $\tau_{car} > MEC$

So:

- If road demand exceeds rail demand, if the modes are substitutes and if congestion strongly affects the labour market, then subsidize rail but not car (tax>MEC)
- Similar conditions but small labour market effects of congestion, then subsidize rail and tax road below MEC
Extensions III: allow telecommuting

- Allow people to work at home, but let there be productivity differences
- Bargaining: more efficient telecommuting reduces wages and raises employment
  - Makes union members better off, hence reducing wage claims
- Telecommuting does not affect optimal tax structure, but does affect optimal taxes
  - It reduces congestion at given employment
  - It raises employment, hence congestion
Conclusions I

- The structure of the labour market does matter for optimal congestion taxes.
- Under plausible conditions, both congestion itself and congestion tolls will affect negotiated outcomes on the labour market.
- Uniform transport taxes depend on the effect of transport taxes (-) and congestion (+) on negotiated wages.
Conclusions II

- The optimal uniform transport tax directly depends on the share of road users that do not work.
- If taxes can be differentiated, commuting ‘subsidies’ are justified if at least some demand comes from people inactive on the labour market and their time values are limited:
  - Tax commuters below external cost
  - Higher tax on non-commuters
- Role of union preferences is crucial
- Important to learn more about union attitudes towards congestion and its solutions
Part III: Numerical application

- Compare bargaining and competitive labour market structure in a simple model with telecommuting
- Bargaining Right to Manage versus Nash
- There is only one mode (car)
- Taxes can be differentiated or uniform
- Calibration with Belgian data
## Results I

<table>
<thead>
<tr>
<th></th>
<th>Competition</th>
<th>Bargaining I</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial situation (1)</td>
<td>Uniform (2)</td>
</tr>
<tr>
<td>Employment</td>
<td>3.510.088</td>
<td>3.541.867</td>
</tr>
<tr>
<td>Wage</td>
<td>130</td>
<td>128.059</td>
</tr>
<tr>
<td>Labour tax</td>
<td>52</td>
<td>35.964</td>
</tr>
<tr>
<td>Commuting transport tax</td>
<td>0.062</td>
<td>0.394</td>
</tr>
<tr>
<td>Non-commuting transport tax</td>
<td>0.062</td>
<td>0.394</td>
</tr>
<tr>
<td>MEC</td>
<td>0.767</td>
<td>0.357</td>
</tr>
<tr>
<td>Total traffic</td>
<td>187.054</td>
<td>169.365</td>
</tr>
<tr>
<td>Commuting traffic</td>
<td>133.014 (71.11%)</td>
<td>125.370 (74.02%)</td>
</tr>
<tr>
<td>Non-commuting traffic</td>
<td>54.040 (28.89%)</td>
<td>43.996 (25.98%)</td>
</tr>
<tr>
<td>Average speed</td>
<td>38.798</td>
<td>53.442</td>
</tr>
<tr>
<td>Total days of homework</td>
<td>369.483</td>
<td>815.246</td>
</tr>
</tbody>
</table>

- **Employment**: Number of full time jobs
- **Wage**: €/day
- **Labour tax**: €/day
- **Commuting transport tax**: €/km
- **Non-commuting transport tax**: €/km
- **MEC**: €/km
- **Total traffic**: million vehicle kilometres
- **Commuting traffic**: million vehicle kilometres (the share of commuting traffic in total traffic is given between brackets)
- **Non-commuting traffic**: million vehicle kilometres (the share of non-commuting traffic in total traffic is given between brackets)
- **Average speed**: km/hr
- **Total days of homework**: Number of (8 hour) days that are worked at home
Results II

- Higher tolls under competitive labour markets
- Small difference between different bargaining models
- Substantial differentiation commuting versus non-commuting
Results III: varying telecommuting efficiency

![Graph showing the relationship between efficiency of telecommuting and optimal transport tax (€/km). The graph indicates a decreasing trend as efficiency increases.](image-url)
Does the structure of the labour market matter?

- **Competitive models**: Tax effects on labour supply depend on consumer preferences.
- **Bargaining model**: Effects of taxes on bargaining outcomes driven by union preferences.
- **Two issues**:
  - Is the difference quantitatively important?
  - What do we know about union attitudes towards transport issues?