Road use charging and inter-modal equilibrium: the Downs-Thompson paradox revisited

Michael G H Bell and Muanmas Wichiensin
Centre for Transport Studies
Imperial College London

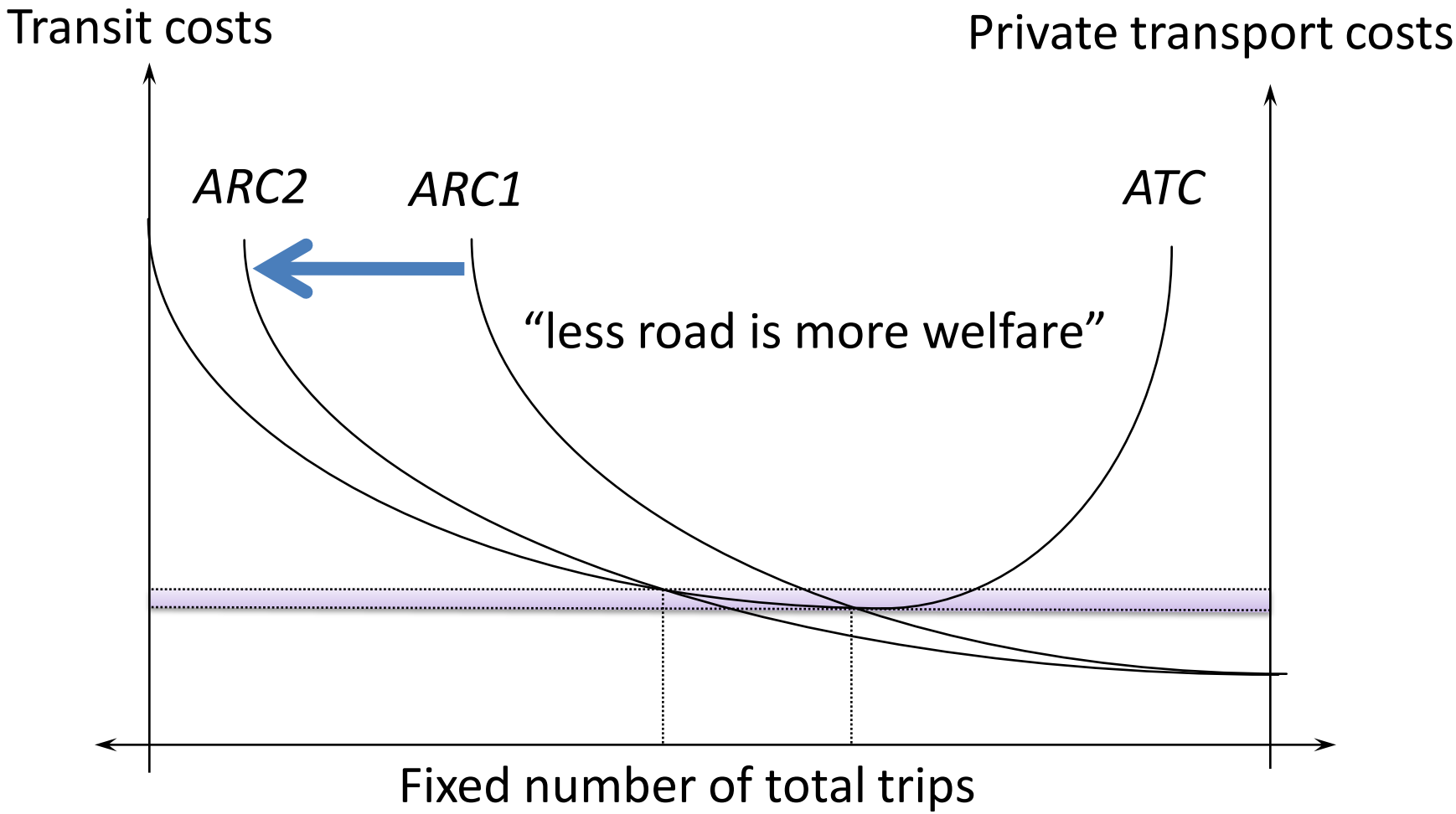
Introduction

- CC has been considered, and is still being considered (Beijing?), for many cities but implemented in few
- The merits of CC for congested road networks has been well understood, at least since the diagrams of Tim Hau
- This presentation looks at another dimension, namely the inter-modal equilibrium
- Concern where PT private that CC boosts PT profits (Wiechiensin et, 2007; Wichiensin and Bell, 2008; Bell and Wichiensin, 2008)
- We start with the Downs-Thompson paradox

Downs-Thompson revisited

- New highway can make matters worse (new trips + diverted trips + worse PT)
- Rather than the impact of new road capacity, we look at the impact of a CC
- We assume that there are *efficiency gains* to be had with transit
- We look at two cases:
  - Efficiency gains are passed on to passengers
  - PT maximises profits (minimises losses)
- To simplify matters we consider a linear model of the inter-modal equilibrium

Inter-modal equilibrium: Downs-Thompson Paradox



Linear inter-modal equilibrium model

Demand curve: $q = a - bp$

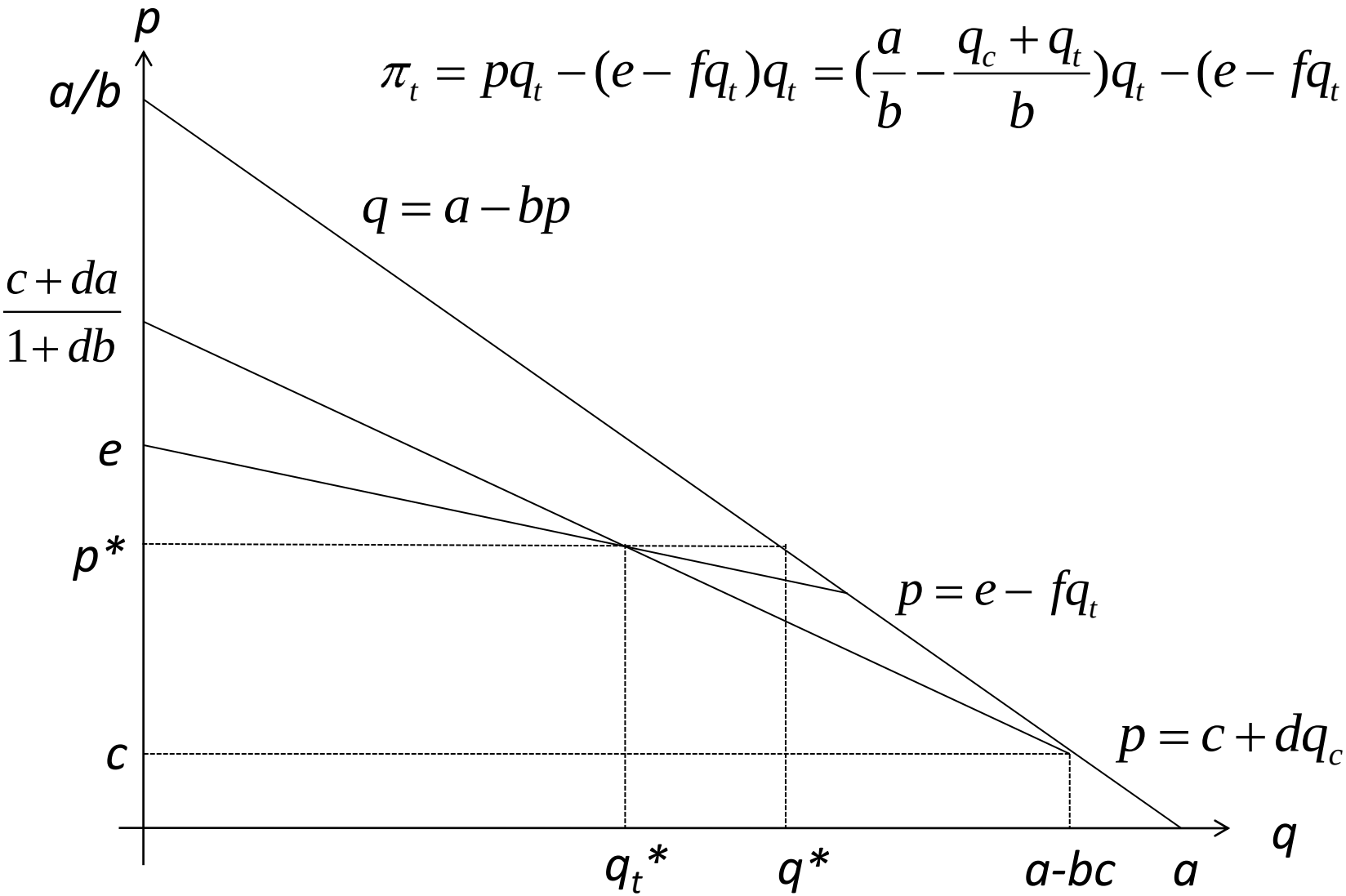
Average cost of travel by car: $p = c + dq_c$

Average cost of travel by transit: $AC_t = e - fq_t$

Total travel: $q = q_c + q_t$

Cost-covering transit operator(s)

$$\pi_t = pq_t - (e - fq_t)q_t = (\frac{a}{b} - \frac{q_c + q_t}{b})q_t - (e - fq_t)q_t$$



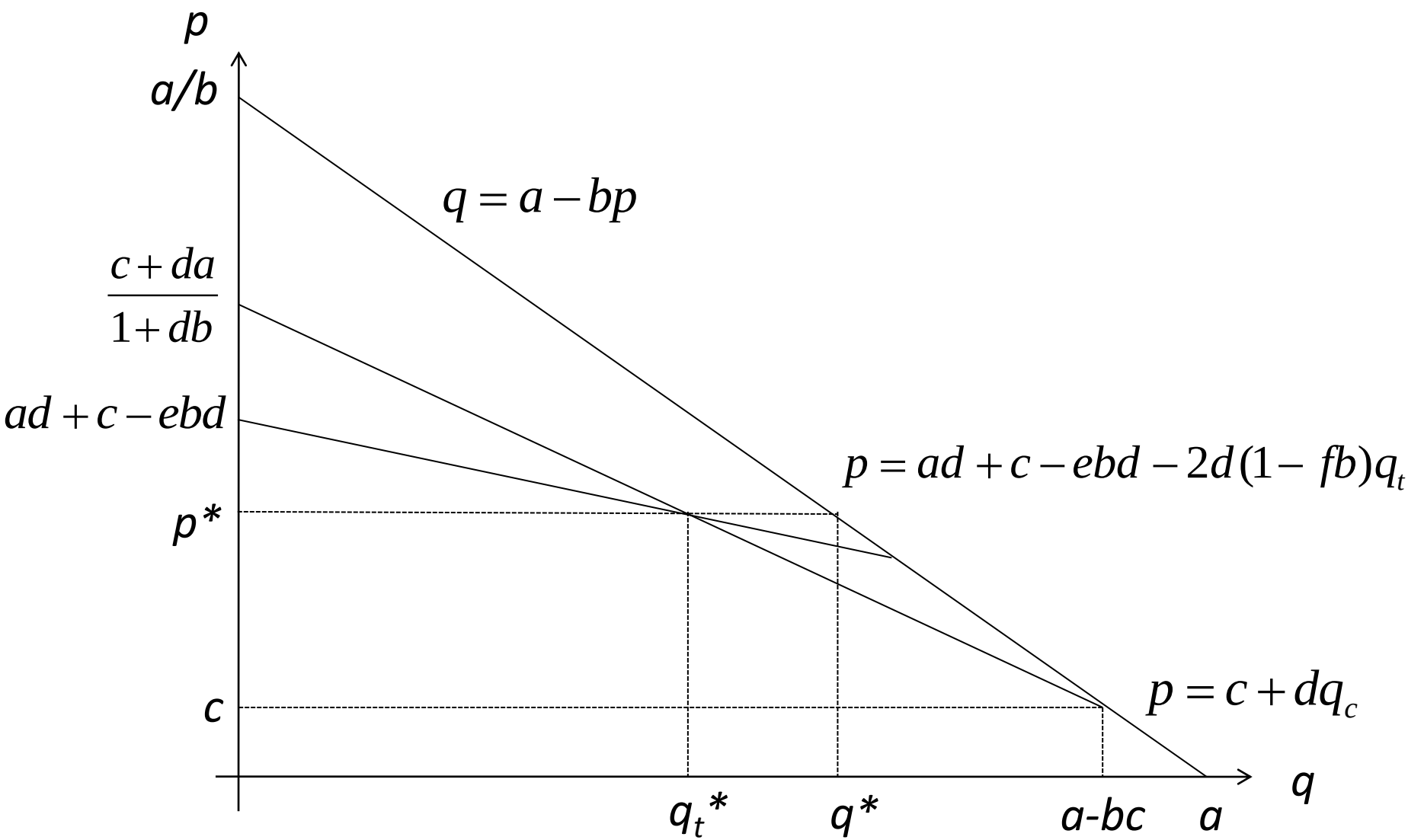
Inter-modal equilibrium (1)

$$p^* = \frac{c + da - \frac{de}{f}}{1 + db - \frac{d}{f}}$$

- Effect of *c* (and therefore a CC) depends on the sign of the denominator
- Stability of the inter-modal equilibrium requires:

$$\frac{d}{f} > 1 + db$$

Monopolist transit operator(s)



Inter-modal equilibrium (2)

$$p^*(1+\frac{1}{bd}-\frac{1}{2bd(1-fb)})=c(\frac{1}{bd}-\frac{1}{2bd(1-fb)})-\frac{ad-ebd}{2bd(1-fb)}+\frac{a}{b}$$

- A Downs-Thompson effect requires

$$1>\frac{1+2bd}{2+2bd}>fb$$

- Unfortunately stability requires

$$fb>\frac{1+2db}{2+2db}$$

Conclusions

- If transit operator(s) pass on efficiency gains, there will be a Downs-Thompson effect
- If transit operator(s) behave like a profit maximising (loss minimising) monopolist, there will be no Downs-Thompson effect
- In the presence of a CC, there is a need for fare regulation to ensure that passengers are protected