Slaying the DI dragon

Taxation mechanisms as precommitment devices.

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Outline

1. Background
   - What are we tackling?
   - Inconsistency in the 'real' world
2. Jump state inconsistency
   - Model
   - Benchmarks
   - The solution
3. Hyperbolic discounting
   - Framework
   - Implementing delegation
4. Conclusions

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We attempt to fix two problems with one tax and no rule of law!

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- Optimal taxation of polluters is a time honoured topic.
- Overcoming dynamic inconsistency is less well known but has been tackled before.
- Here we attempt to tackle both problems simultaneously through a single taxation mechanism.

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Setting the scene

- A regulator is faced with the problem of correcting the externality created by a polluting firm.
- The regulator suffers from dynamic inconsistency and is unable to commit to future actions.
- Depending upon the cause of the time inconsistency, the regulator can be modelled in either of two ways.
- Once the regulator's problem has been modelled we can look for a taxation scheme that gets as close to the first-best outcome as possible.

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A player in a dynamic game is dynamically inconsistent if he will, in future, wish to deviate from a currently optimal plan of action.

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For example:

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Consequences of jump states

If your current payoff depends on future actions then

- you predict the future action based on your currently preferred future action,
- you get to the future and have to decide what to do,
- but you no longer care about the effect on your past payoff because that's sunk,
- so your preferred action differs from what you expected it to be, since your objective function for the period has changed,
- which means you won't maximise your lifetime utility because you keep changing your mind.

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- Empirical research suggests that peoples' discount rate declines as he consider decisions further in the future
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Situations which give rise to inconsistency

- Jump states commonly arise in the modelling of:
  - Durable goods producers
  - Addictive goods producers
  - Exhaustible resource extraction.
- Hyperbolic discounting is used in many contexts since it is presented as a descriptive model of normal human behaviour.
- Our regulator could suffer from time inconsistency due to either of these factors and both would inhibit him from efficiently controlling pollution.

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Implications for regulators

- A regulator who encounters jump states, or whose preferences exhibit hyperbolic discounting, may not be able to achieve the first best action path.
- In our context that might result in under-regulation of pollution, which could have irreversible consequences for the environment.
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The model

A model of a durable good producing monopolist who pollutes is used for exposition.

- Heterogeneous consumers each purchase one unit of a durable good that gives them a stream of benefits in perpetuity.
- Over time the price of the durable good declines as the keenest consumers purchase it.
- Consumers decide when to purchase the good and exit the market. He weigh the decreasing price against his valuation of the good in order to make his decision.
- Thus, consumer demand depends upon his expectations of future prices. Consequently, the monopolist's profits and the welfare function also depend upon expected future prices.

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Benchmarking the regulator

Suppose that the regulator can directly choose prices in the market. The first-best price path is the one that a regulator who could perfectly precommit would choose in order to maximise welfare.
In this case, the regulator would solve

$$\max_{\mathbf{p}^t} \sum_{t=1}^{\infty} \delta^{t-1} w(p^{t-1}, p^t, p_e^{t+1}). \tag{1}$$

The solution to this problem will satisfy the following DEs

$$w_2^t + \delta w_1^{t+1} = 0, \quad t = 1 \tag{2}$$

$$w_3^{t-1} + \delta w_2^t + \delta^2 w_1^{t+1} = 0, \quad t \geq 2. \tag{3}$$

The source of the time-inconsistency in is the term w_3^{t-1}, which shows the effect of a change in the current period's price on the previous period's welfare.
When optimisation occurs only the future periods' welfare is considered and the effect on the previous period is disregarded.

Second-best regulation

If the regulator is unable to precommit then he can still act in a time consistent fashion by anticipating his future deviations. He will solve the Bellman equation

$$V(p^{t-1}) = \max_{p^t}\left\{w(p^{t-1}, p^t, f_e(p^t)) + \delta V(p^t)\right\} \qquad \forall\, t \geq 1 \quad (4)$$

for an equilibrium strategy, $f(p^t)$, that satisfies

$$w_2^t + w_3^t f_1^{t+1} + \delta w_1^{t+1} = 0. \qquad (5)$$

Inefficiency

- The time consistent regulator realises that he will have an incentive to deviate in future, so he sets the current price such that the incentive is removed.
- Constraining the regulator to be time consistent forces him to deviate from the first-best price path, even when he has direct control over the good's pricing.
- If profits are a large part of total welfare then this is likely to result in too much pollution, as the price path will be inefficiently low.

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Delegation and precommitment

- The value of precommitment in games has long been recognised. The difficulty is in finding an effective precommitment mechanism.
- Work on strategic delegation has focussed on using a manager as a commitment tool. By contracting with a manager the form's owner can remove themselves from the current period's output decision.
- The key aspect of the delegation is that an agent is paid to make the current decision for you. The sum you pay him now thus credibly commits the owner to a particular decision in the next period.
- Here we can achieve the same thing by using the regulated polluter as a commitment tool for the regulator. The 'payment' here is the tax that is levied on the polluter.

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Taxation

- The regulator now levies a tax τ^t on the monopolist's output/emissions, so the monopolist's profit becomes dependent upon the tax rate: $\pi(p^{t-1}, p^t, p^{t+1}, \tau^t)$.
- The regulator receives a revenue valued at $\alpha\tau^t\psi(x^t)$ from the revenues. The tax rate can be altered each period, but there is a cost to doing so of $\theta\left(\tau^t - \tau^{t-1}\right)^2$. Thus, the welfare function is dependent upon current and past taxes: $w^t\left(p^{t-1}, p^t, p^{t+1}, \tau^{t-1}, \tau^t\right)$.
- There is still a jump state in the welfare function, but the regulator now chooses τ^t when maximising welfare, and leaves the choice of price to the monopolist.

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- Let $\tau^t = f(p^{t-1}, \tau^{t-1})$ be the regulator's period-t taxation strategy and $p^t = g(p^{t-1}, \tau^{t-1})$ be the monopolist's period-t pricing strategy.
- In equilibrium, the regulator solves the Bellman equation

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Equilibrium strategies

- The key to this formulation is that the welfare value function no longer depends upon any future decision of the regulator, since the future decision has been delegated out.
- The regulator thus chooses his tax rate such that the price path will replicate the first-best outcome and pollution levels will be optimal.
- If there is a positive cost to policy adjustment, or the regulator and monopolist value tax revenue differently, then the price path will be distorted away from the first-best.

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Delegation

- A model of a polluting monopolist in the context of a regulator with quasi-hyperbolic preferences was constructed to explore whether a similar delegation mechanism would work in this setting.
- Since the regulator is only time inconsistent between the current and next periods, delegation easily solves this problem and renders the price path time consistent.
- This model also depends on simultaneous decision making, but the quasi-hyperbolic formulation is also essential. A truly hyperbolic discount rate would not be amenable to such a solution.

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Take-home lessons

- Regulators (might) need to think about the time consistency of his decisions if he want to save the world from global warming.
- Overcoming time inconsistency doesn't need to involve external precommitment mechanisms. First best outcomes can be achieved within the regulator/polluter relationship if the institutional framework is correctly structured.
- The key to the framework we propose is controlling the information that parties have when he make his decisions. The monopolist can't know the current tax rate when he make his decision.

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