The effect of CO_2 pricing on conventional and non-conventional oil supply and demand

Aurélie Méjean

Electricity Policy Research Group

Centre International de Recherche sur l'Environnement et le Développement (CIRED)

EPRG Winter Research Seminar
Cambridge, 10^{th} December 2010

Outline

Introduction

- *Question*

What is the effect of a CO_2 tax on fuel use on oil supply and demand?

- *Methodology*

Model of the interaction between conventional and non-conventional oil under CO_2 pricing

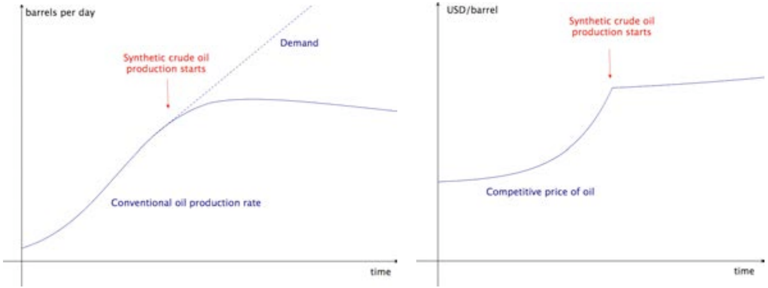
Subjective probability: a probability value or distribution determined by an individual's best estimate based on personal knowledge, expertise, and experience.

The cost model takes into account: depletion, experience and the social cost of CO_2

The price net of extraction costs rises at the rate of interest (Hotelling, 1931):

$$p_t = p_{t_0} \cdot e^{r \cdot (t - t_0)}$$

Model: Interaction between conventional and non-conventional oil



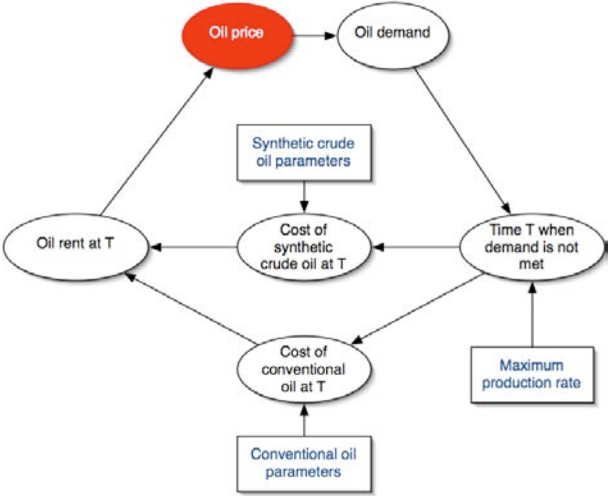
T = time when conventional oil production is unable to meet demand

Price of oil at T = initial cost of producing synthetic crude oil

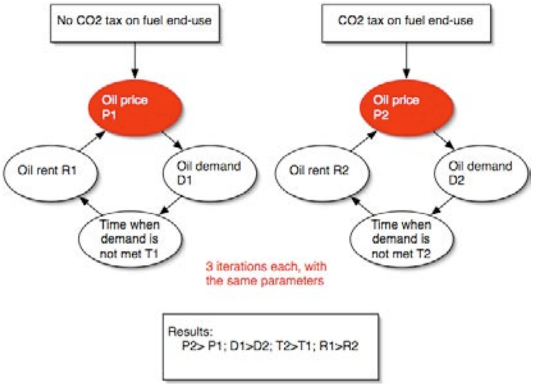
Model assumptions

- Synthetic crude oil is a substitute of conventional oil
- At the beginning of the period, only conventional oil supplies the market. The price is determined by the Hotelling rule.
- Synthetic crude oil production starts when conventional oil production is unable to meet demand
- At that time T, the price of oil is set at the initial cost of producing synthetic crude oil
- The social cost of CO_2 is included in the calculations

Model structure



Model structure



CO_2 tax $\rightarrow$ higher price $\rightarrow$ lower demand $\rightarrow$ later T $\rightarrow$ lower rent $\rightarrow$ lower price $\rightarrow$ higher demand, etc.

As the model converges one effect takes over, leading to either higher or lower demand and extraction.

Main model parameters

The cost of conventional oil is modelled as a function of cumulative production, driving experience and resource depletion.

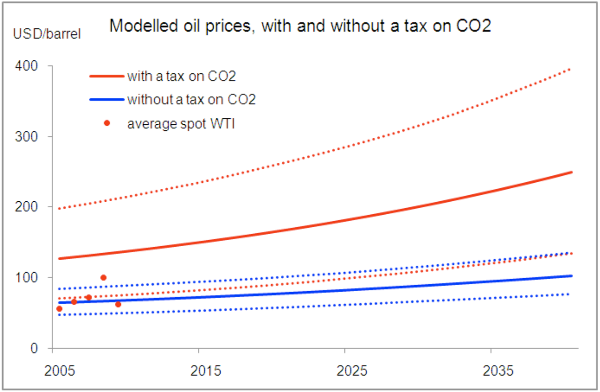
- *The social cost of CO_2*
  Initial cost of CO_2 (26, 100, 322) USD/tCO_2
  Social cost of CO_2 growth rate (2.0, 2.5, 3.0) % per year

- *Production and demand (conventional oil)*
  Maximum production rate (90, 101, 121) million barrels per day
  Price elasticity of demand (-0.6, -0.3, 0.0) no unit
  Exogenous demand growth (1.2, 2.1, 3.0) % per year

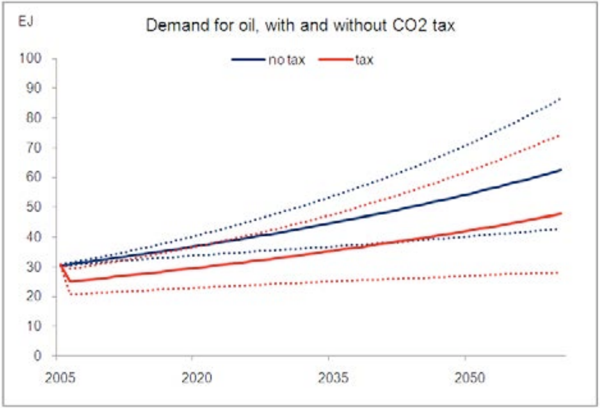
- *Cost of synthetic crude oil from Canadian in-situ bitumen*
  Initial cost of SCO (without CO_2) (41, 47, 52) USD/barrel
  Initial emissions (0.09, 0.16, 0.23) tCO_2/barrel SCO
  Cost of synthetic crude oil at T: (45, 100, 156) USD/barrel

- *Discounting*
  Consumption discount rate (0.9, 2.6, 4.2) % per year

Results: Oil price

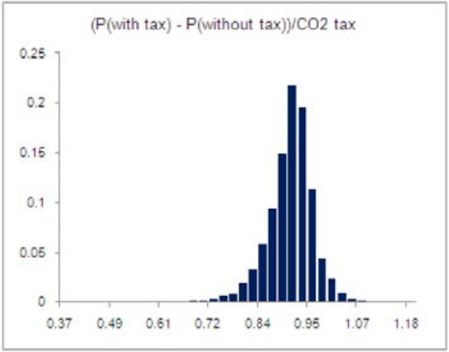


Results: Oil demand



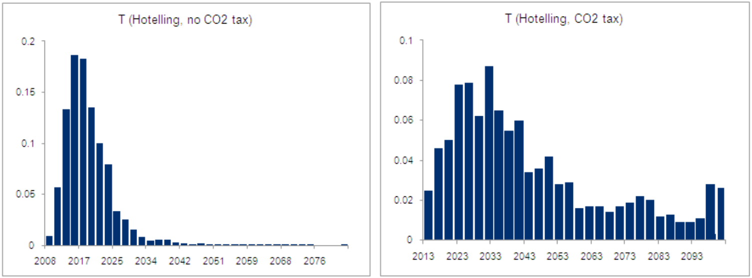
A tax on CO_2 from fuel use would reduce demand and extraction, despite the effect of the reduced rent.

Results: CO_2 tax carried into the final oil price



Between 81 and 99% of the CO_2 tax is carried into the oil price.

Results: Time T with and without a CO_2 tax

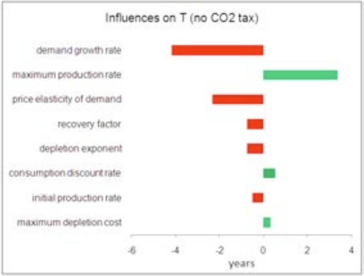


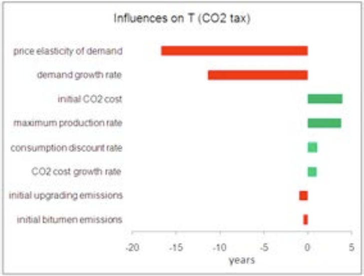
Without a CO_2 tax on fuel use
T between 2012 and 2030
(mean value: 2019)

With a CO_2 tax on fuel use
T between 2018 and 2090
(mean value: 2044)

Influences on T with and without a CO_2 tax

Influences show the change of T (years) when a parameter is increased by one standard deviation.





Large influence of the price elasticity of demand and the demand growth rate parameters, with and without a CO_2 tax on fuel use.

With a CO_2 tax, an increase of 0.12 unit of the price elasticity would delay T by over 15 years.

Reduction of the demand growth rate of 0.4% per year: T delayed by 10 years.

Conclusion

- Between 81% and 99% of a CO_2 tax would be carried into the final oil price.
- Oil prices seen by countries outside of an international agreement would be 1 to 19% lower than without the tax.
- A CO_2 tax enforced worldwide would still reduce oil demand and production, hence CO_2 emissions from oil production and use.
- A CO_2 tax on fuel use would delay T (by about 25 years, mean value)
- T is very sensitive to the price elasticity of demand and the demand growth rate: great potential of demand-side measures to smooth the transition to low-carbon liquid fuel alternatives.