The Push for Renewables in India: A Real Options Approach

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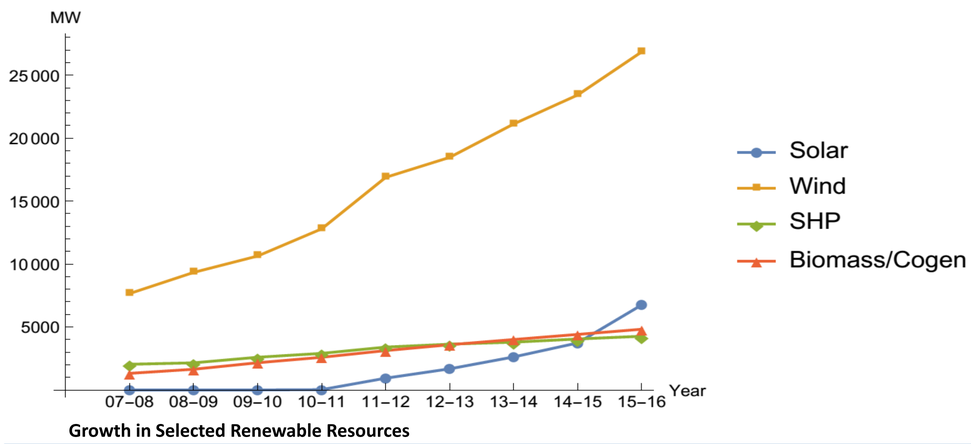
Abstract

The Indian government announced plans in 2014 to add 175 GW of renewable energy capacity to the electricity sector in India by 2022. We focus on targets of 100 GW of solar and 60 GW of wind. An objective of the Indian government has been to reduce its growing coal import bill which rose from US $ 12.4 Billion in 2011-12 to over US $ 14.5 Billion in 2013-14 (fiscal year Apr 1-Mar 31). For 2014-15, coal accounted for 75.61% of electricity generation while the share of imported coal was 10.28%. The corresponding share of wind and solar was 5.31%. Using a real options approach and stochastic global coal prices, we find if India can replace the share of imported coal with wind and solar in total electricity generation. With a long time horizon, results show social planner waits before investing in additional solar and wind and replacing imported coal at a `trigger price' of US $ 51.83 per ton of coal. A shorter time horizon implies switching away from imported coal immediately. We include pollution from coal fired power plants which is a major contributor of pollution in Delhi and in light of India's Paris agreement goals.

Introduction

In 2014, India announced targets of adding 175 GW Renewable Energy Capacity by March 2022. This includes capacities of 100 GW of solar, 60 GW of Wind and 15 GW from other sources small hydro ($\leq$ 25 MW capacity), biomass and urban and industrial waste.



Growth in Selected Renewable Resources

Over 2011-12 to 2014-15, shares (in gross electricity generation) has been about 12% on average for hydro, about 3% for Nuclear, has fallen steadily from 10% to a liitle above 3.5% for Gas, has been steady at about 5% for renewable sources and has increased steadily for coal from 66% to 75%. **Significant capacity addition for coal fired power plants at average of 20 GW/year in recent years. And installed capacities in coal include imported coal. Share of imported coal in electricity generation for 2014-15 was 10.28%. India Coal Statistics:**

	2007-08---	2012-13	2013-14
Coal Imports (Mt)	49.79--	145.79	166.86
Coking Coal Share-Total Imports (%)	44.2--	24.4	22.1
Non-Coking Coal Share-Total Imports (%)	55.8--	75.6	77.9

<u>Reducing reliance on (imported) coal for electricity generation</u>

1. Energy Security
2. India´s huge coal import bill which was US $ 14.5 Billion in 2013-14
3. WHO (2016) reports Delhi to be one of most polluted cities (PM 10/PM 2.5)
4. Meeting India's Paris Agreement committment targets

Methods and Materials

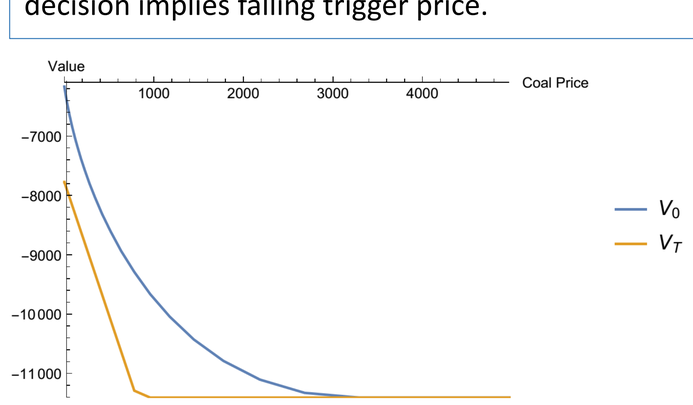
We use a real options approach to analyze if and when **India can replace electricity generated from imported coal with energy generated from wind and solar: to raise the share of wind of solar to 15% of the current electricity generation mix?** *Real options considers the flexibility of a manger to undertake a decision based on arrival of further information: considering global coal prices are stochastic, the value of the option for India to invest* in greater amounts in wind and solar (and switch) is low when coal prices fall and the option value increases for high global coal prices. If India has x years to decide whether to move away from imported coal or not, **what is the "trigger" price for which switching to wind and solar is optimal today?** For a trigger price $P_{C,t}^{T}$, India must switch whenever for t, $\mathrm{P_{C,t}} > P_{C,t}^{T}$

Stochastic Price Process

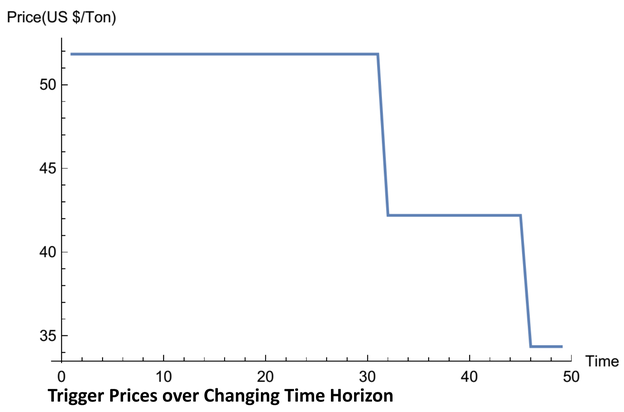
Changes in global coal prices with Geometric Brownian Motion (GBM)
$dP_C = \alpha P_C dt + \sigma P_C dz$ such that $dz = \epsilon_t \sqrt{dt}$, $\epsilon_t \sim N(0,1)$; null hypothesis of unit root cannot be rejected

Results

Trigger Price at US $ 51.83 per ton of coal. A shorter time horizon to make a decision implies falling trigger price.



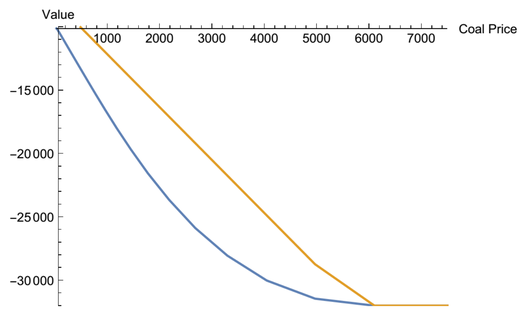
Option Values: Baseline Case



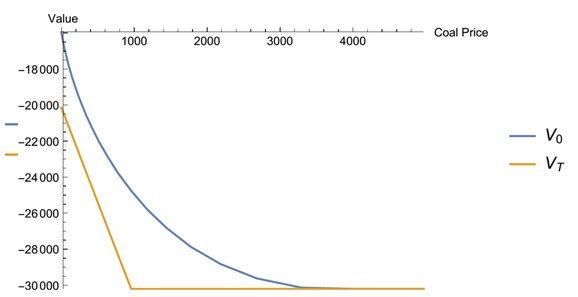
Trigger Prices over Changing Time Horizon

Discussion

India is **strictly bound by Paris Agreement targets of 40% of electricity from non-fossil fuel sources by 2030**, then the value of *waiting* is zero! India needs to invest about US $539 billion and install more than 250 GW of solar and 100 GW of wind



40% from Wind and Solar share by 2030



40% from Wind and Solar share by 2065

If time horizon to meet Paris targets is extended to 2065, then there is a value to waiting and trigger price is US $ 63.67 per ton of coal. In addition, higher volatility in the coal price process raises trigger price and planner waits longer to invest

Conclusions

- We investigate social planner solution for India replacing imported coal with Wind and Solar in electricity generation **(share rising from current 5% to 15%)**
  - Problem posed as a real options optimal stopping problem with stochastic world coal prices
  - Trigger price of US $ 51.83 per ton of coal if India has 50 years to switch
- **To meet Paris Agreement targets by of 40 % of electricity from non-fossil fuel sources by 2030, value of waiting is zero and India should invest right away**
  - Insurmountable amounts of investment needed in wind and solar and country better off investing in other renewables such as hydro and nuclear
- **If Paris targets are extended until 2065, then trigger price of US $ 63.67 per ton of coal**
- Higher volatility in price process raises trigger price

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