Journal of Economic Dynamics & Control 48 (2014) 159–175

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Resource prices and planning horizons

Daniel Spiro [a,b,*]

[a] Department of Economics, University of Oslo, P.O. box 1095, Blindern, 0317 Oslo, Norway
[b] CREE — Oslo Centre for Research on Environmentally Friendly Energy, Norway

ARTICLE INFO

Article history:
Received 12 February 2014
Received in revised form
29 May 2014
Accepted 4 August 2014
Available online 9 September 2014

JEL classification:
D80
Q31
Q41

Keywords:
Resource extraction
Oil price
Rolling horizons
Decision-making under uncertainty

ABSTRACT

This paper shows that a seemingly simple assumption – that agents use a rolling planning horizon – can reconcile the puzzling long run price dynamics of exhaustible resources such as oil, gas and metals. A rolling horizon has the effect of removing the scarcity consideration of resource owners when stocks are large. Hence, extraction will be non-decreasing and resource prices non-increasing for a long period of time and there will be no connection between the price growth and the interest rate – in line with the trends of a majority of exhaustible resources in the last century. A calibration of the model to the oil market yields a price which closely fits the gradually falling real oil price after WWII and the sharply increasing price after 1998. This suggests that, while long run scarcity was not an important parameter on the oil market in the 20th century, it has been important in shaping the oil price from around 1998 and onwards.

1. Introduction

The long run price evolution of exhaustible resources such as oil, natural gas and metals and the functioning of these markets are central for a variety of public policy issues. These range from climate policy (e.g. Golosov et al., 2014; Van der Ploeg and Withagen, 2012), to issues of sustainability and intergenerational consumption smoothing (e.g. Hartwick, 1977; Smulders and De Nooij, 2003) to national exploration investments and unilateral taxation (e.g. Liski and Tahvonen, 2004). But what shapes the long run price trends of exhaustible resources? Three stylized facts are at the heart of this question:

1. *The long run pattern of prices was falling or constant during the 20th century*. This can be seen in the upper panel of Fig. 1 which shows a composite price index of 57 resources. Apart from temporary spikes during the first world war and the oil crisis years of the 70s, the price was secularly falling or constant up until the turn of the century.
2. During the 20th century there does not seem to have existed any substantial scarcity rents for resources. In particular, and in opposite to standard theory, *the empirical literature does not support an increasing scarcity rent and a positive connection between price growth and the interest rate.*[1]

* Correspondence address: Department of Economics, University of Oslo, P.O. box 1095, Blindern, 0317 Oslo, Norway. Tel.: +47 22855137.
E-mail address: daniel.spiro@econ.uio.no

[1] The theoretical prediction is explained below. Examples of empirical studies are Heal and Barrow (1980), Abgeyebge (1989) and Hamilton (2009). It should be noted that the scarcity rent is not directly observable. To get around these issues some studies have used indirect measures of scarcity. For instance, Halvorsen and Smith (1984, 1991), Chermak and Patrick (2001) and Ellis and Halvorsen (2002). For a further discussion of those empirical results

http://dx.doi.org/10.1016/j.jedc.2014.08.002
0165-1889/

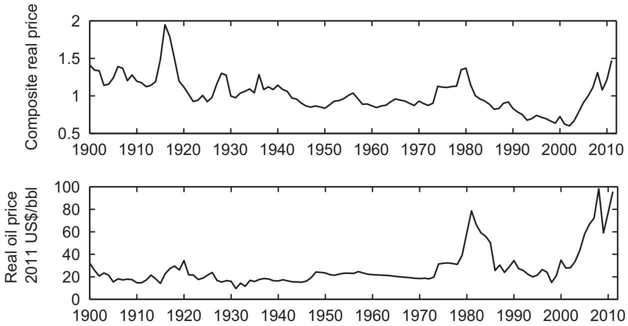

Fig. 1. Upper panel: Real resource price composite. It consists of 57 mineral and energy commodities, weighted equally. Prices are normalized so that the average price for each commodity over the period equals one. Lower panel: Real oil price. *Sources*: www.usgs.gov, www.eia.gov.

3. *The price of many resources, and in particular oil, started increasing sharply around the turn of the millennium* (see the lower panel of Fig. 1 for the oil price). This seems to have been accompanied by substantial and increasing rents for, in particular, oil and other energy resources (Hamilton, 2009).[2]

Put together, these three facts are puzzling and remain largely unexplained by theory to date. To see why, consider a basic exhaustible resource model (due to Hotelling, 1931). The logic of no-arbitrage in such a model suggests that, in a general equilibrium, resource owners need to be indifferent between either keeping the resource in the ground or extracting it and putting the money in the bank. This leads to the conclusion that the resource price (net of marginal extraction costs) should rise at the rate of interest or, at the very least, that there should be a positive correlation between price growth and the interest rate.[3] Such a model can therefore possibly explain facts one and three, if extraction cost parameters can be chosen freely, but naturally it cannot explain fact number two.

If we instead assume the resource is inexhaustible (i.e., that it is in infinite supply), then fact two can be explained (since there is no scarcity). However, to explain facts one and three one would need to show that extraction costs first fell secularly for a century and then increased suddenly at the turn of the century. This does not have empirical support (see Lin and Wagner, 2007).

One supposed explanation for falling prices, which perhaps is mainly common in the public debate, is that the world keeps finding new deposits of various resources. However, as has been shown by Arrow and Chang (1982), this explanation is a misconception. If agents are forward looking they will incorporate the possibility of new reserve findings and form beliefs over the total reserves, including those not yet discovered. The price may drop or jump temporarily as beliefs are updated. But with beliefs which are correct "on average" the price must rise over the long run for most resources as the current reserves and those expected to be discovered become more scarce as extraction is taking place. What is in particular problematic with this explanation is that, even if the market would be constantly surprised by new reserve findings, it will still imply a correlation of price growth and the interest rate in between the surprises which leaves fact two unresolved.

Another extension is to introduce a backstop technology which makes the resource worth little or nothing. Kamien and Schwartz (1978) and Davison (1978) have shown that if the arrival date of the backstop is uncertain this will essentially only add a component of discounting (due to the additional risk to the owner) thus leaving the basic predictions of the Hotelling model intact. For a backstop model to alter the basic results, of increasing prices and a correlation with the interest rate, one needs to assume that the backstop arrives with certainty after a known date. For instance, economic agents today need to be entirely sure that cold fusion will arrive in no more than, say, 30 years. Such an assumption may be reasonable for some resources but not for others, such as fossil energy resources. Supposing that the assumption holds, the model then produces either a price which decreases throughout, increases throughout, or first increases and then decreases (see for example Heal, 1976, or Tahvonen and Salo, 2001). None of these alternatives will be compatible with both facts one and three simultaneously.

Assuming instead, like Gerlagh and Liski (2011) do, that there is strategic interaction between a buyer and a seller of a resource, one may get a non-monotonic path for the price and scarcity rent. In general it will be hard to explain facts one and two by this model as it predicts an initial phase of rising prices and rents. Furthermore, although modeling the oil

(*footnote continued*)
see Hart and Spiro (2011). In the forecasting literature it has been found that the interest rate does not add accuracy in predicting oil prices (Alquist et al., 2012).

[2] Historically there are several examples of temporary price (and profit) spikes for various resources. E.g., during the oil crisis in the 70s. However, the explanations for those spikes (e.g. Barsky and Kilian, 2002; Hamilton, 2003) do not seem suitable to explain the surge in oil and other resource prices and profits during the last 10–15 years. For instance, Hamilton (2009, p. 180) has expressed that with regard to oil "… the scarcity rent may have been negligible for previous generations but may now be becoming relevant".

[3] See Hotelling (1931) and Dasgupta and Heal (1974) for the basic model and Weinstein and Zeckhauser (1975) and Solow and Wan (1976) for the addition of extraction costs.