ECO 203: Environmental and Resource Economics

Group-B: Resource Economics

Unit-2: Exhaustible Resources

Lecture-VI

A diagrammatic Exposition of Optimal Resource Use

Q. Show that P_0 is the initial optimal price?

Q. How we determine P_0 in Hotelling rule?

We are now in a position to show the Hotelling use in diagrammatic form. We have the result:

$P_t = P_0 \, e^{st}$

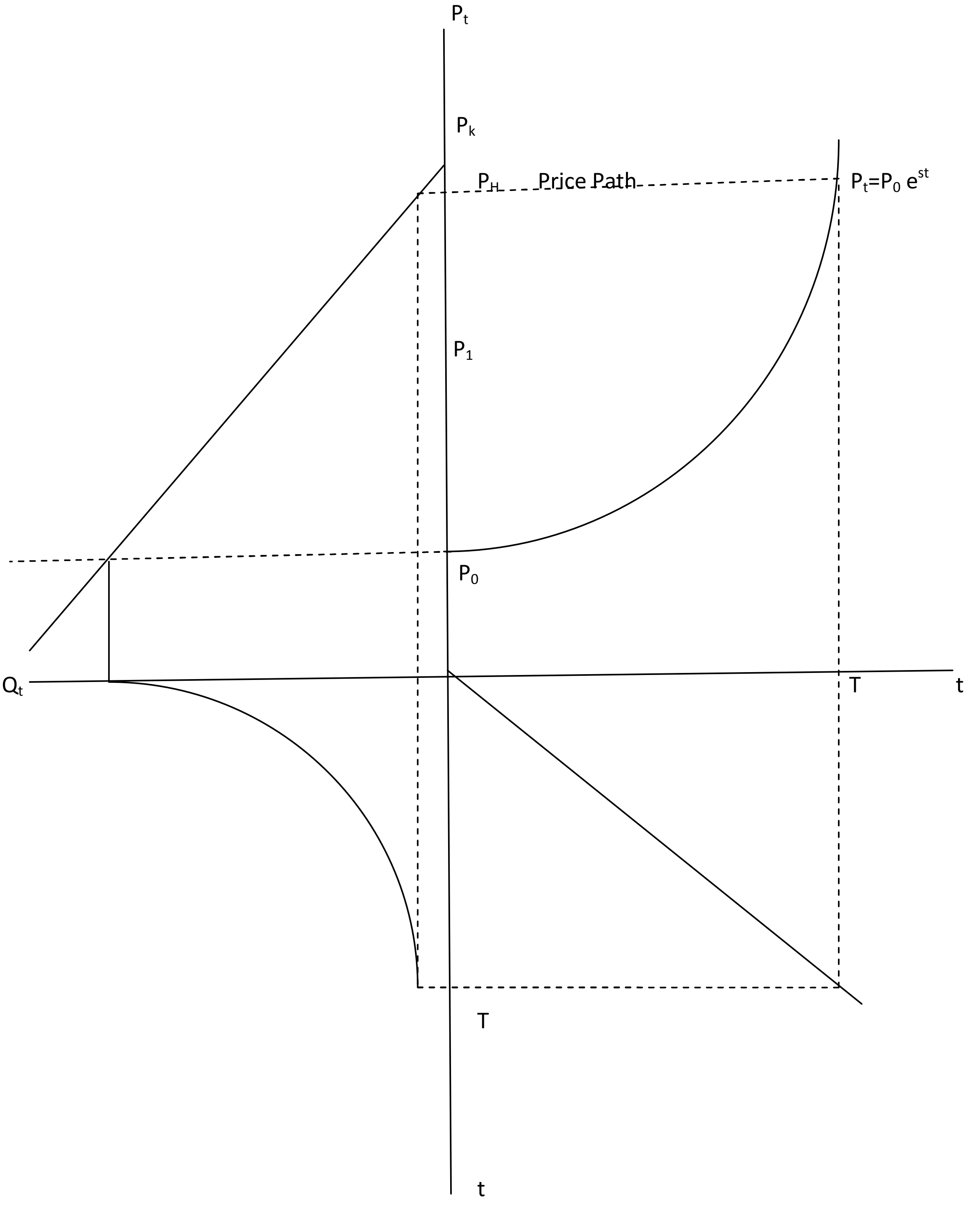
But we didn't say how P_0 was determined. P_0 has itself to be an optimal price. Moreover, we need to investigate how long it takes to exhaust the resource. We call the time period in which the resource is exhausted T. We wish to know how to determine P_0 and T. To do this we make use of a diagrammatic approach. Figure-1 shows four quadrants. **The top R-H quadrant shows the price path of the resource against time.**

[Insert Figure-1 about here]

The path shown is actually the optimal path and exhaustion occurs at T. The shape of the time path of price is determined by the Hotelling rule, i.e., price rises at the rate of discount (interest). In the top L-H corner we show the demand for the resource "back to front", that is, it is a conventional demand curve but it is presented in reserve. The higher the price of the resource the lower is the quantity demanded under cet-par. The bottom R-H quadrant is a dummy quadrant: the 45^0 line simply permits on the downwards vertical axis on to the horizontal rightwards axis. The bottom L-H quadrant shows the relationship between quantity demanded (and hence extracted), time and the cumulative amount of extraction. The area under the curve in this quadrant shows cumulative extraction. Since the stock is finite, we fix the area such that the cumulative production levels equal the stock of the resource. To see that P_0 and T are the right values we consider P_1 as the initial price. It is noteworthy that P_1 is an arbitrary choice. Our objective here is to show that P_1 is not an optimal initial price. Given P_1 as the initial price the price in the next period will be P_1e^s, and for any period t will be P_t e^{st}. Thus the path of the price with P_1 as the initial price will be everywhere above the path shown in the top R-H quadrant. Cumulative extraction will therefore be less and hence the stock will last longer than T. The fact that P_1 is not an optimal initial price depends on the price P_B, which we have not yet considered. P_B, is the price of the "*back stop technology*", which means that as the price of the finite resource rise there will be some substitute for resource. For example, oil from conventional sources is much less expensive than oil from tar sands or shale. As the price of oil rises it must eventually "hit" the cost of extracting oil from these more expensive sources. P_B thus serves to "anchor" the demand, price and production system in figure-1.

The reason that P_1 is not an optimal initial price can now be seen. The path of prices with P_1 as the initial price will "hit" P_B before the path of the price with P_0 as the initial price. But if demand is less, cumulative production is less and stock will be exhausted at the time when P_B is reached. Effectively we shall have run the stock down in such a way that some is left over just at the time when it will become cheaper to switch to an alternative source- the "backstop" source. Exactly the same reasoning can be applied to an initial price below P_0.

We will have exhausted the resource only to find that the backstop resource is either not available or is available but at a significant "jump" in the price. Thus P_0 is the optimal initial price since it permits a price path that will deplete the resource at a rate which "smoothly" permits the transition from the existing resource to backstop resource.



Pt
Pk
PH
Price Path
Pt=P0 est
P1
P0
Qt
T
t
T
t