**THE HUBBERT CURVE: ITS STRENGTHS AND WEAKNESSES**

M.King Hubbert was a distinguished scientist who published on many aspects of petroleum geology, but he is most remembered for his 1956 work on forecasting production, in which he introduced a special bell-curve that bears his name. He was also remarkable for his interest in the social implications of resource depletion.

In 1974, he presented several production curves for both the World and the United States, but was somewhat reticent in explaining the mathematical basis of his work. He referred to a bell-shaped curve, of which the most commonly used are the Normal or Gauss curve, and also to the derivative of the logistic curve (Bartlett 1999), but he gave no equations. He based his study on Ultimate Recovery, taking 170 Gb (billion barrels) for the USA; and low cases and high cases for the World of respectively 1350 Gb and 2100 Gb. His initial study concerned the US Lower 48 States, which had a single cycle of continuous exploration in a large number of basins. He referred also to the relationship between discovery and production. The discovery cycle peaked in the late 1930s and was followed by a corresponding production cycle peaking around 1970. But as explained below not all countries are characterised by a single discovery cycle; and there are other constraints to the Hubbert model that need to be better understood. It is to be noted in particular that it is a symmetrical curve whereas the production curve of an individual field is generally asymmetrical. As discussed below, the Hubbert curve is in fact the derivative of a logistic curve.

**Constraints**

A simple Hubbert curve may be ideally applied only in the following cases:

-Where there is a large population of fields, such that the sum of a large number of asymmetrical distributions becomes symmetrical (normal) under the Central Limit Theorem of statistics. There are several examples of inadequate populations, as Illinois and Ohio with few fields (highlighted by McCabe in his criticism of Hubbert) or Alaska and the North Sea, where a few giant fields came on production simultaneously when the pipeline connections were made.

-Where exploration follows a natural pattern unimpeded by political events or significant economic factors, as for example when OPEC artificially cut production: Hubbert modelling should not be used for the swing producers (Persian Gulf).

-Where a single geological domain having a natural distribution of fields is considered, political boundaries should be avoided.

Hubbert himself did not appreciate these constraints since he worked on the US Lower 48 and the world as a whole, prior to significant OPEC intervention.

**Conclusions**

Hubbert’s modelling technique has been variously applauded and criticised, but the constraints to its application have not been widely appreciated. It works well only where applied to a natural domain, unaffected by political or significant economic interference; to areas having a large number of fields; and to areas of unfettered activity. Hubbert himself worked primarily on the US-48, which had the necessary characteristics to be well modelled by a single cycle.

We may note in passing that many other natural phenomena follow a bell-shaped curve as illustrated for example by the number of mad cows in the United Kingdom.

But the application of multiple Hubbert curves, which was not developed by Hubbert, has much wider application, and has proved to be an exceedingly valuable modelling tool not confined to the oil industry, as population studies confirm.

Hubbert modelling gives fair results only when the past data series has not been disturbed by economic and political factors and when the inflection point has been passed. Good results are achieved only when the past data series has passed the peak and when there is one single cycle for discovery.

The procedure of relating the discovery curve with the subsequent production curve after a time shift of a certain number of years is an indispensable tool to obtain a reliable forecast on production. The discovery curve itself, which is commonly volatile, needs to be smoothed. The time-lag is of varying duration. It is 33 years for the USA; 11 years for the United Kingdom; 17 years for the Former Soviet Union; and about 30 years for the world as a whole, although affected by the impact of the Middle East swing producers. This shift gives a reliable trend for coming production except in the unlikely event that a major new cycle of discovery arises.

There is no doubt that Hubbert modelling is a valuable tool but like all tools, it needs to be used properly for the right job. It is important to understand its strengths and weaknesses and to know when to apply single or multi-curve approaches. Knowing backdated annual discovery is a must, but it has to be the annual discovery based mean not proved reserves. Hubbert’s model only from production data is an insufficient tool.