The New Pessimism about Petroleum Resources: Debunking the Hubbert Model (and Hubbert Modelers)

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Recently, numerous publications have appeared warning that oil production is near an unavoidable, geologically-determined peak that could have consequences up to and including "war, starvation, economic recession, possibly even the extinction of homo sapiens" (Campbell in Ruppert 2002) The current series of alarmist articles could be said to be merely reincarnations of earlier work which proved fallacious, but the authors insist that they have made significant advances in their analyses, overcoming earlier errors. For a number of reasons, this work has been nearly impenetrable to many observers, which seems to have lent it an added cachet. However, careful examination of the data and methods, as well as extensive perusal of the writings, suggests that the opacity of the work is—at best—obscuring the inconclusive nature of their research.

Some of the arguments about resource scarcity resemble those made in the 1970s. They have noted that discoveries are low (as did Wilson (1977) and that most estimates of ultimately recoverable resources (URR)[2] are in the range of 2 trillion barrels, approximately twice production to date. But beyond that, Campbell and Laherrere in particular claim that they have developed accurate estimates of URR, and thus, unlike earlier work, theirs is more scientific and reliable. In other words, this time the wolf is really here. But careful examination of their work reveals instead a pattern of errors and mistaken assumptions presented as conclusive research results.

The Hubbert Curve

The initial theory behind what is now known as the Hubbert curve was very simplistic. Hubbert was simply trying to estimate approximate resource levels, and for the lower-48 US, he thought a bell-curve would be the most appropriate form. It was only later that the Hubbert curve came to be seen as explanatory in and of itself, that is, geology requires that production *should* follow such a curve. Indeed, for many years, Hubbert himself published no equations for deriving the curve, and it appears that he only used a rough estimation initially. In his 1956 paper, in fact, he noted that production often did not follow a bell curve. In later years, however, he seems to have accepted the curve as explanatory.

This particular example demonstrates a major theoretical flaw underlying the curve: for a closed system, such as the US gas market, demand determines production, not geology. (High gas transportation costs mean that overseas gas plays a trivial role in the US market.) Thus, the political collapse of the Soviet oil industry was interpreted by

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[2] URR refers to the amount of oil which is thought recoverable given existing technology and economics (price and costs). It includes estimates of undiscovered oil, but is only a fraction of the total resource.

Wattenberger (1994) as evidence supporting a Hubbert model. Globally, the recent slowdown in demand has suggested to some that the peak has already occurred.[3]

That the curve appears to have some validity can be easily explained: a bell (or logistic or Gaussian) curve represents exponential growth and decline, which is typical of large populations and/or persistent capital stock. Oil production can only grow slowly in any mature province, as no new field will represent more than a small proportion of existing supply. And the amount of equipment operating can usually only grow fractionally, as industry finds it inefficient to maintain the capacity necessary to double its manufacturing stock in a brief period. Conversely, even with no additional investment, production decline will be slow as existing producing capital has been paid for and is allowed to decline and depreciate, but is not immediately closed in. Therefore, exponential growth and decline is normal, and while the bell curve is not necessarily the precise path likely to be followed, its presence is hardly proof of an immutable, natural, scientifically-determined law.

Revival of the Hubbert Method

The recent authors, notably Campbell and Laherrere have apparently rediscovered the Hubbert curve, but without understanding it, at least initially. Campbell and Laherrere initially argued that production should follow a bell curve, at least in an unconstrained province. But this is demonstratively not the case in practice: most nations' production does not follow a Hubbert curve. In fact, Campbell (2003) shows production curves (historical and forecast) for 51 non-OPEC countries, and only 8 of them could be said to resemble a Hubbert curve even approximately.

The authors initially responded to this weakness by arguing that the Hubbert curve could have multiple peaks, which of course means it would not follow a bell curve at all, and destroys the explanatory value of the bell curve. As the alleged value of the Hubbert curve lies partly in demonstrating the production decline post-peak, not knowing whether any given peak is the final one renders this useless, nor would the peak imply that midpoint production had been reached (indicating URR).

Recognizing this, the theory has been modified again, to "The important message from Hubbert's work, which is often forgotten by economists, is that oil has to be found before it can be produced." (Laherrere 2001b, p. 4) In other words, the Hubbert curve, originally held as scientific and inviolable, is of no particular value. Yet the authors have not only mistakenly believed in its properties, they have not been forthcoming about their own errors.

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[3] Deffeyes quotes Henry Groppe as saying world oil production peaked in 2000. "Current events," February 23, 2003, http://www.princeton.edu/hubbert/current-events.html.

The New Research

Campbell and Laherrere claim to have improved on the work of their predecessors and resolved many of the problems cited by critics. (Bentley (2002) provides a good summary.) They actually use a variety of methods, although readers are not told precisely what methods are employed when. Two methods determine field sizes, one, usage of geologists' estimates of field size, reported by IHS Energy, rather than proved reserves from corporate reports or the trade press, to avoid the problem of reserve growth. And second, by graphing production against cumulative production for some fields, they claim to "correct" estimates for field size.

These estimates are then used in two ways: plotting cumulative discoveries against cumulative wildcats (exploratory wells) for countries and/or regions to estimate an asymptote, or leveling off, which represents the ultimately recoverable resource for that area. These are referred to as creaming curves. And cumulative discoveries are plotted over time and then shifted into the future to match against cumulative production. When cumulative discoveries begin to peak, so, to, does cumulative production, albeit as much as several decades later.

Opaque Work, Unproven Assertions

The lack of rigor in many of the Hubbert modelers' arguments makes them hard to refute. The huge amount of writing, along with undocumented quotes and vague remarks, necessitates exhaustive review and response. A later paper will provide more complete coverage of the debate, but the focus here will be on the primary substantive shortcomings.

Perhaps because they are not academics, the primary authors have a tendency to publish results but not research. In fact, by relying heavily on a proprietary database, Campbell and Laherrere have generated a strong shield against criticism of their work, making it nearly impossible to reproduce or check.[4] Similarly, there is little or no research published, merely the assertion that the results are good. (See below.)

There are a number of points that are taken by the Hubbert modelers that are crucial to their work which have no evident empirical or theoretical support. For example, while Campbell and Laherrere (1998) states that "in any large region, unrestrained extraction of a finite resource rises along a bell-shaped curve that peaks when about half the resource is gone." The first shortcoming of this argument is that no countries have 'unrestrained extraction'—everywhere, a host of regulations and taxes, among other policies, affect the level of exploration and production. And in fact, few countries exhibit production in a classic bell curve, which is sometimes admitted by Hubbert modelers. (Laherrere 2000)

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[4] In Deffeyes (2002), he says "Here in the back of the book, where my editor isn't likely to look, we can derive the equation…." (p. 201). While many editors abhor equations, it seems odd that a university press should be so hard to dissuade.

Similarly, the so-called "optimists'" claim that technology increases the recoverability of oil resources is said to be incorrect without evidence.[5] Rather, historical production curves are presented and said to reflect pre-determined production patterns—determined by "the immutable physics of the reservoirs." (Campbell 2002) For example, a graph of production versus cumulative production in the Forties field is said to prove that technology added no reserves since the graph follows a fairly straight line in later years, and even the use of gas lift did not change the apparent ultimate recovery. (Laherrere (1999))

This assertion, however, is not supported with any further evidence—initial field development plans, etc. While the authors appear to have direct knowledge of some field developments, most of the results apparently come from visually comparing the curves produced on their graphs and *assuming* the behavior is pre-determined. The curve, viewed in hindsight, is presumed to follow the path expected from initial development, with no evidence presented of that. In fact, many of the curves might vary substantially from what was initially projected as a result of changes in investment, taxes, or technology.

Some anecdotal examples are provided, as when Campbell notes that Prudhoe Bay's proved reserves have grown, but are actually just approaching the operators' initial estimates of 12.5 billion barrels (Campbell 2000). Aside from the lack of citation for this anecdote, it is assumed, not demonstrated, that the reported reserves will not surpass that number. However, BP recently put them at more than 13 billion barrels.[6] Campbell states that he has many similar examples, but does not provide them.

Technical Data

A specific, telling example of this shortcoming relates to the proprietary nature of the database being used. Many acknowledge that the Petroconsultants (now IHS Energy) database is high quality, however, since it is only available for a large fee, few have been able to access it and double-check the results which Campbell and Laherrere claim to have achieved.

That lack of access has served as the first line of defense for the two, who often respond to criticism with comments such as (in response to Lynch) "*Your problem is that you do not have any reliable database (and the experience to use it).*"[7] Accepting that the IHS Energy database represents more accurate assessments of reserves than corporate reports, relying on P50 instead of P90 estimates,[8] this still leaves unanswered the question of whether or not the field size estimates will grow due to technical advances, better understanding of the geology, and so forth. Campbell and Laherrere insist that it doesn't,

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[5] "While technology has enhanced the production of conventional reserves, it has had little impact on ultimate reserve values." Laherrere (1999).

[6] "Arctic Energy: For Today and Tomorrow," http://alaska.bp.com/alaska/Alaska2001/Arctic_Energy/AE-page%206.htm.

[7] Post of 9/21/2002 on http://groups.yahoo.com/group/energyresources/.

[8] P50 estimates reflect those which have a 50% probability of being either too low or too high, while P90 are considered 90% likely to prove valid.

without providing evidence.[9] If, indeed, the estimates of field size tend to grow over time, then the creaming curves would not be accurate, as the later part of the curve would be underestimated.

Finally, those who have had access to the IHS Energy database dispute the findings of Campbell and Laherrere, including the geologists of the USGS, who relied on the database in concluding that reserve growth is not only real but substantial (600 billion barrels; see USGS 2000). Perhaps more damning, personnel at IHS Energy themselves estimate global reserve growth at 373 billion barrels and total URR at over 3000 billion barrels. Where Campbell and Laherrere foresee remaining recoverable resources of conventional petroleum limited to 1100 billion barrels, IHS estimates it at over 2200 billion, a huge difference. (Stark 2002) Perhaps the creators of the database understand it less perfectly than Campbell and Laherrere, but that is hard to accept without further evidence.

Unsubstantiated Results

Virtually all of the work by Campbell, Deffeyes, and Laherrere relies heavily on graphs, with claimed correlations but no statistical results provided. Campbell (1997), is typical, where graphs are published showing giant discoveries, historical production and projected production for 22 countries. However, nowhere is there any indication of how a few data points yield a rich, even complex trajectory. (Note that no future giant discoveries are expected.)

It also appears that the authors fall prey to statistical illusions. "Creaming curves" are published for some regions, where the fields, when ordered by size, appear to yield an asymptote which is interpreted as evidence of an approaching limit. But ordered by date of discovery, the asymptote is not as clear, as Figure 1 shows for the UK. No explanation is given as to why ordering by size is more appropriate than by date of discovery, and in fact, the asymptote appears to be nothing more than a statistical artifact—that is, use of a large population, ordered by size, will frequently yield an exponential curve with an apparent asymptote. This is especially true of oil and gas exploration, where basins usually hold many more small fields than large ones.[10] And indeed, when the 2001 discovery of the giant Buzzard field, estimated at 500 million barrels (Dafter 2003) or 70 million tones, is added to the UK curve, the new asymptote will be even less obvious.

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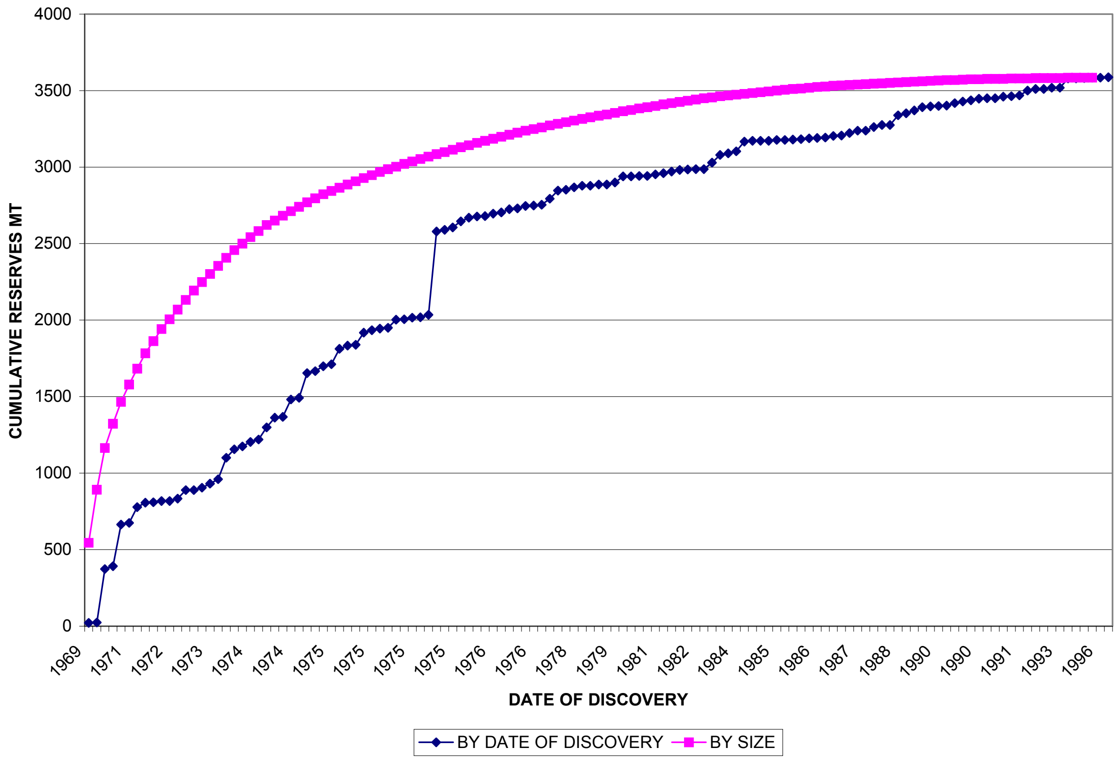
9 When queried by email as to whether or not he had examined the database for evidence that field size estimates were static, Laherrere replied that he only had access to two versions of the database, for his 1993 and 1997 reports, but that they showed a net increase of 20 billion barrels between the two. In a subsequent email, he claimed that this would be offset, as the field size estimates tended to be eliminated upon abandonment without development. No evidence was provided that would suggest 5 billion barrels a year of recoverable oil is reported by IHS Energy, and then never developed. Post of 9/21/2002 on http://groups.yahoo.com/group/energyresources/ For an example of the opposing view, see Smith and Robinson (1997).

10 This has been the subject of much work by geologists, statisticians and economists, though none of the Hubbert modelers seem familiar with it. See, for example, the section by G. Kaufman in Adelman et. Al. (1983).

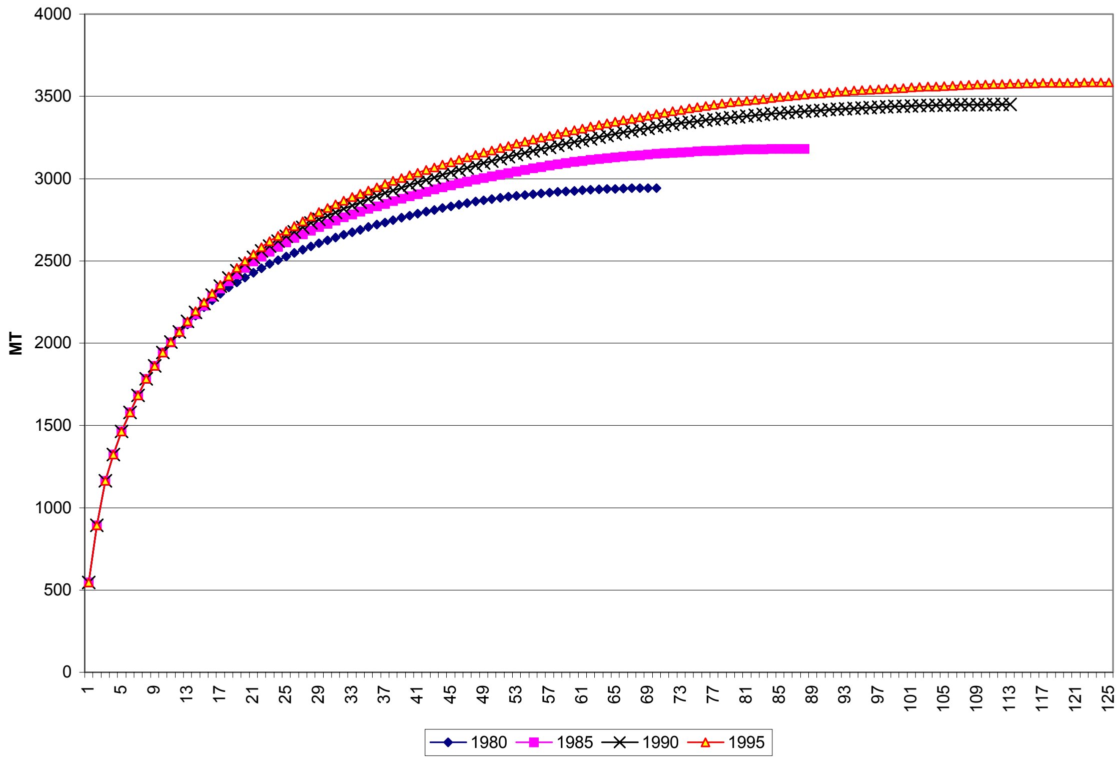
Figure 1
UK Reserves, Ordered by Field Size and by Date of Discovery



Data is from UK Department of Trade and Industry (2001). Developed fields only.

And it is hard to accept that this method generates a robust or stable estimate, when it can easily be seen that these curves can be created at different points in time, always showing a clear asymptote, *but at different levels*. In Figure 2, reserve estimates for the UK fields in production on different dates are used to generate hyperbolic curves, and they clearly grow over time. Once again, it appears that by ordering the fields by size, a false asymptote is generated.

Figure 2
Creaming Curves in the UK on Different Dates



Laherrere also notes the "good fit" in a number of instances between cumulative discovery and cumulative production, but has apparently done no statistical analysis of the actual correlation. Some countries, in fact, do not show a good fit, including China, France, Norway and the UK.[11] In this, he appears to merely be trying to connect the peak year of discovery and the peak year of production, primarily by shifting the former curve to match what he believes to be the two peaks. Since there appears to be no particular lag time nor any way of predicting it,[12] his primary conclusion from this approach is that a peak in production comes after a peak in discovery. The utility (and novelty) of this is hard to comprehend.

And in Laherrere (2001b), where he uses cumulative discovery and cumulative production, he again claims a good fit (admitting it is more qualitative than quantitative for France and the UK), but even for non-Middle East production (excluding deepwater), the precision of the fit is debatable. (ibid., figure 13) Since no quantitative details are provided, and twenty years of data represented by a line of ½ an inch on the figure, the validity of the claimed correlation is difficult to judge.

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[11] Laherrere (2001a) has the most complete collection of graphs.

[12] For the US, he gives 30 years, UK 10, France 20, Mexico and Colombia 5, and so forth. Laherrere (2001a)

Deffeyes, for his part, publishes a total of two graphs relevant to his argument about a coming peak in oil production (pp . 147, 157). The first shows a Gaussian curve assuming two levels of ultimate recoverable reserves compared to world oil production. (The next section explains the error in this approach.) The second plots discoveries and production (in percent) versus cumulative amounts, with a line which he says moves towards an asymptote. No statistical or quantitative data is published with it, and the fit of the discovery curve looks poor, with recent large discoveries suggesting that the asymptote is not valid. Certainly for such a startling conclusion as he reaches, more evidence is needed than one poorly fitting curve.

Misinterpretation of Causality

The primary error for Hubbert modelers is the assumption of geology as the sole motivator of discovery, depletion and production. In the work of Campbell, Deffeyes, and Laherrere, they go further, equating causality with correlation. This is one of the most basic errors in (physical or social) scientific analysis.

"Oil is ultimately controlled by events in the Jurassic which are immune to politics" (Campbell 2000) and "…discovery and depletion are set respectively by what Nature has to offer and the immutable physics of the reservoirs." (Campbell 2002) The idea that production is influenced by oil prices (which determine the amount of capital available for drilling) and by policy choices in producing governments, which decide when exploration will be allowed, and/or set production ceilings, is considered foolish.[13] And yet, they do acknowledge restrictions on operations, particularly in the Middle East.

The argument that the drop in global discoveries proves scarcity of the resource is the best example of the importance of understanding causality. While it is true that global oil discoveries dropped in the 1970s from the previous rate, this was largely due to drop in exploration in the Middle East. Governments nationalized foreign operations and cut back drilling as demand for their oil fell by half, leaving them with an enormous surplus of unexploited reserves. It is noteworthy that none of those pessimistic about oil resources show discovery over time by region, which would support this.

And two recent discoveries, Kashagan in Kazakhstan and Azedagan in Iran, reportedly would together equal over ten percent of Campbell and Laherrere's estimates remaining undiscovered oil. Statistically speaking, this is unlikely. Laherrere's argument that the Middle East is near the end of its undiscovered oil is entirely based on the assumption that the observed fall-off in discoveries was due to a lack of geological opportunities, rather than government decision-making. (Laherrere 2001b) To an economist, the drop in exploration reflects optimal behavior: they do not waste money exploring for something they will not use for decades.

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[13] Bentley (2002), p. 197, for example criticizes Schollnberger (2001) by saying, "This paper has serious weaknesses. Its lines of argument on oil are: Economics dictates reserves. (But see the US experience during the 'oil frenzy' following the oil shocks, when some gas, but little extra oil, was found.)" In fact, before 1980, oil production in the lower-48 US was declining by over 3% per year, then grew slightly from 1980 to 1985.

A more technical example is telling. Laherrere notes that the first 1920 new field wildcats in the Middle East discovered 723 billion barrels by 1980, while by the year 2000, a subsequent 1760 had found a mere 32 billion barrels. From this he concludes that the Middle East is essentially played out, extrapolating the falling returns to drilling and stating that "This graph shows clearly that the belief by some economists that the Middle East has a great potential left is wrong" (Laherrere 2002, p. 10). He achieves similar results for OPEC as a whole.

There are three primary errors here. First, the assumption that the discoveries in 2000 will not be revised upwards (an error as discussed above), but more important, the presumption that geology is driving the trend and thus, it is immutable. But finally, the third error is more basic: equating all wells in the Middle East, regardless of location. In fact, analysis of country drilling activity shows what should be obvious: drilling in Iran and Iraq dropped sharply in 1980, following the Iran/Iraq War, and sanctions have kept Iraqi drilling at a minimum in the past decade. At the same time, lesser provinces like Oman, Syria and Yemen have seen increased amounts of drilling. Thus, by lumping them together with Saudi Arabia, Kuwait, etc., as "Middle Eastern," treating all wildcats as equal and extrapolating the success rate of pre-1980 and post-1980 wells yields fallacious results.[14]

And Deffeyes, relying on global production and the declining growth in production as evidence of resource scarcity is falling into a similar trap. National or regional production may reflect resource scarcity, but global production is driven by demand, and the declining demand growth since the price shocks in the early 1970s is evidence of greater efficiency and fuel switching, not scarcity. He is confusing geology as the driving factor, not demand.

Production Profile to Estimate Field Size

Finally, Campbell and Laherrere use production data to estimate field size, 'improving' on the IHS Energy data. By graphing production against cumulative production, as in Figure 3, they claim that a clear asymptote can be seen, allowing for a more accurate estimate of ultimate recovery from the field. The first problem with this is that there is no explanation for how often the method is employed. Laherrere (2001a) has many examples from around the world, but only a few per country. And some of the figures he used in Laherrere (1999), such as East Texas, which didn't seem to conform to his argument, have not been published in later works, unlike Forties, which is.

Again, field production data is not publicly available in most instances, so the method's reliability is difficult to test. But also, there is an astonishing presumption of causality, that the production profile was determined by the geology and nothing can alter it, and

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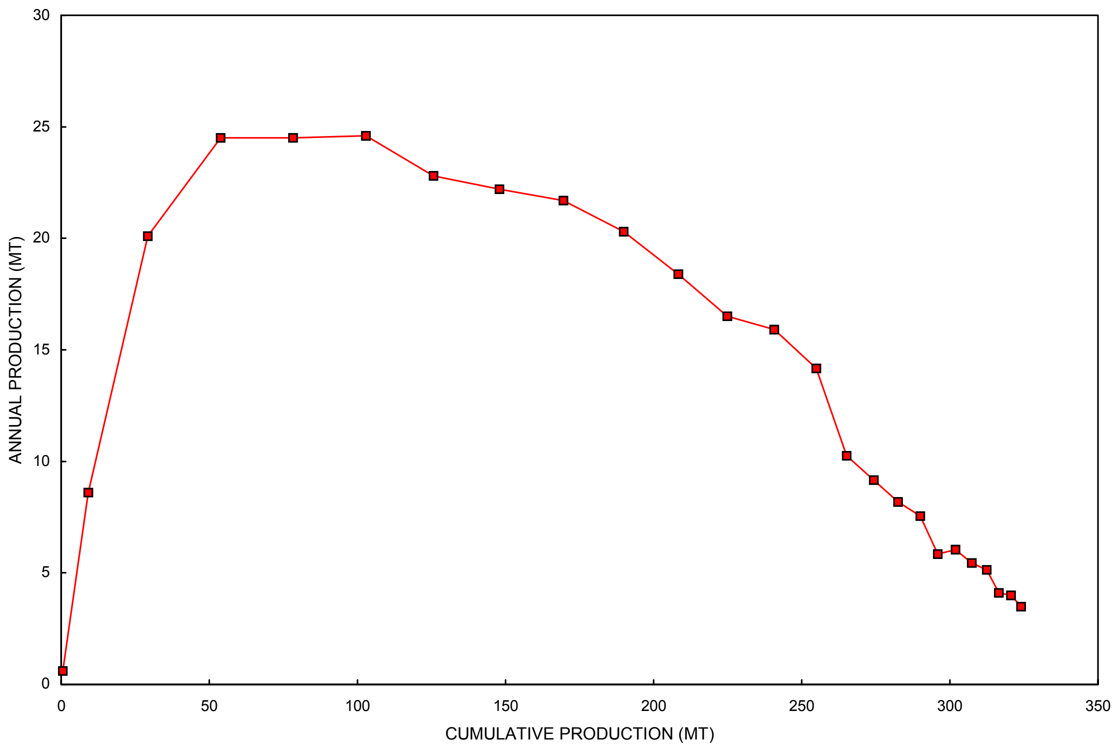
[14] I do not have access to either data on wildcats or pre-1976 rig usage data, but from 1976 to 1980, Iran and Iraq were running an average of 80 rigs each year. After 1980, the typical number was 20. And Oman, Yemen and Syria were probably not the source of most drilling or discoveries in earlier years. The data is from *International Energy Statistics Sourcebook*, Pennwell, annual.

that the historical curve is exactly as anticipated from the discovery of the field. Because the line appears straight, they extrapolate it to the zero point. However, this is an assumption, and as shall be seen, an incorrect one.

Figure 3
Forties Production, Annual vs. Cumulative



Fortunately, the UK publishes historical production for all fields, allowing it to serve as a test case. (UK Department of Trade and Industry) Examining this data does confirm that some fields display a clear-cut asymptote. However, out of 21 fields whose peak production was above 2 mt/yr (or 40 tb/d), only 7 show such behavior. The rest do not show a clear asymptote (as in Figure 4), or worse, show a false one, as Figure 5 indicates. Clearly, this method is not reliable for estimating field size.

Figure 4
N. Comorant Production Curve

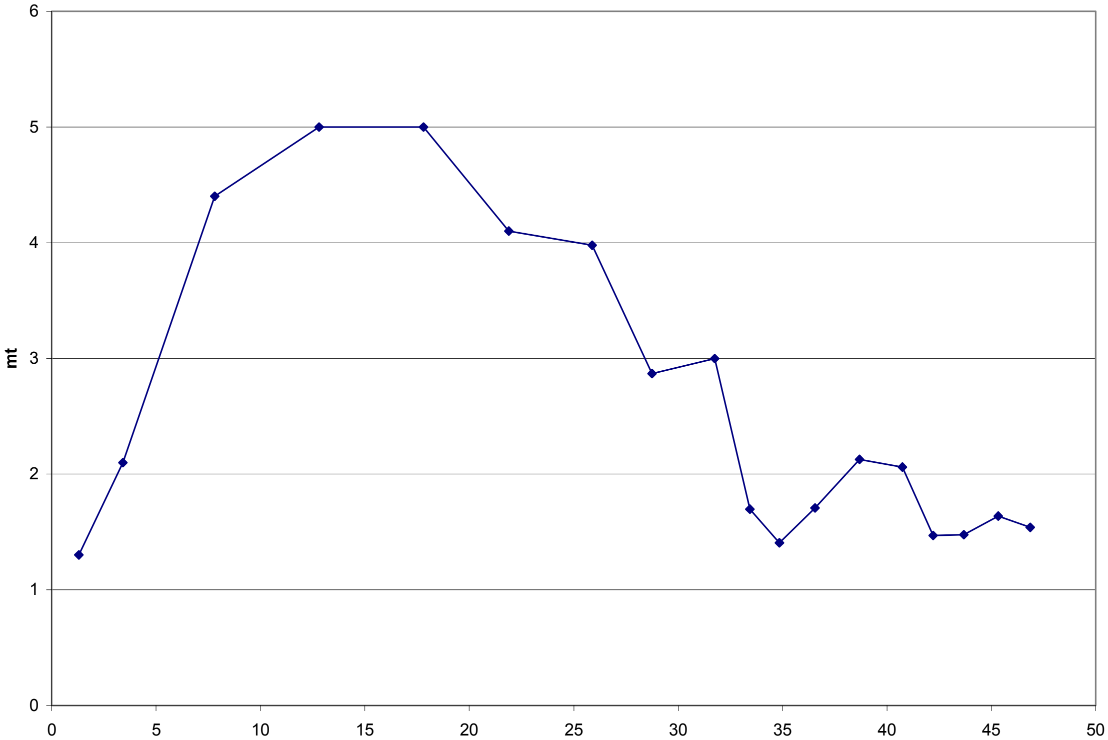
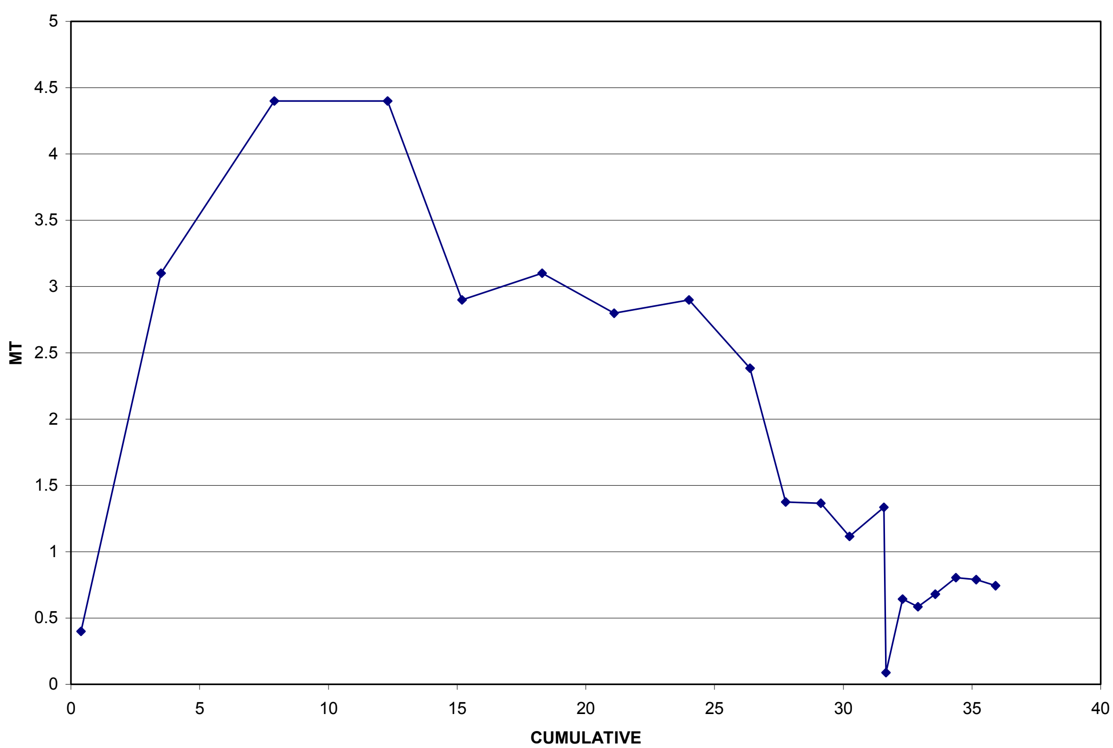


Figure 5
Murchison Production, Annual vs. Cumulative



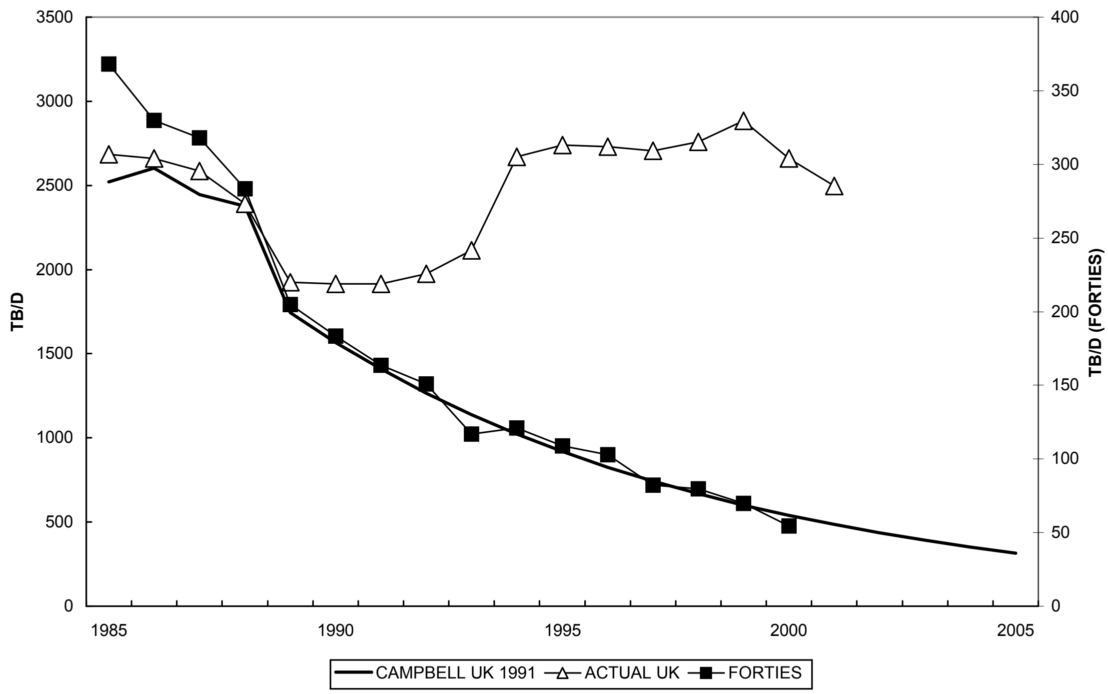
Particularly damning is the failure of Campbell and Laherrere to admit that some fields do not generate stable production curves, or to address the implications of this. If the behavior only shows a correlation in a fraction of the instances, then how can it be based on universal physical factors? If not, then why have the authors not explained how and when it works—or doesn't—and what they have done to avoid misinterpretation? What assurances are there that Forties will not plateau, as N. Comorant did?

In any large, complex problem, there is typically a lot of conflicting evidence, and it is the proper role of a scientist to consider all of it, acknowledging that which doesn't support the theory and attempting to explain it. The repeated failure of these authors to do so implies that their work in general cannot be considered reliable.

Effect of these Errors on the Research Results

The various problems have a clear impact on the results of the forecasts generated by these modelers, particularly Campbell and Laherrere. (The former has been prolific in publishing production forecasts for regions and countries.) In a classic instance, Campbell (1991) projected UK production to decline at a rate of 10% per year, the same as the Forties field (Figure 6). This implies that there would be no additional supplies from reserve growth, new large discoveries, or small and medium fields. Yet as Figure 6 shows, this was not the case—despite a lack of large discoveries. Indeed, as much as 400 tb/d of 1995 production was from small fields that were discovered before 1980, but not put on production until subsea technology made them recoverable—a clear example of technology enhancing supply. (Adelman and Lynch 1997)

Figure 6
Forties Production and the Campbell Forecast for UK Total



Although Campbell claims to have updated his estimates from the 1991 book using more precise field size data from Petroconsultants, it is clear that his work is still lacking. In his 1997 book, he projected that W. European production would peak in 1999, then drop by over 7% per year. In fact, production did decline by 2.4% in 2001 from 2000, but 2002 saw a drop of less than 1%. (The IEA projects an increase for this year, but that is not necessarily reliable.)

Another instance is the use of FSU discoveries to forecast that production will, "after a small rebound during the first half of the present decade, decline significantly after." (Laherrere 2001, p. 6). Compare that to the increase of 1.5 mb/d from 2000 to 2002, which is continuing; also, see Lynch (1997) which analyzed resource and cost data to argue that FSU oil was abundant and cheap, meaning that production would grow rapidly when fiscal, legal, political and transport obstacles were cleared.

And although they claim their methods yield reliable, stable URR estimates, this is far from true. Not only have they repeatedly increased their estimates of URR (from 1575 in Campbell 1989 to 1950 in Campbell 2002), but on an individual country basis, the amount of discovered oil now exceeds their 1997 estimates of URR for 30 out of 57 countries! (Table 1) If these estimates do not prove valid for as short a time as five years, how can they be expected to hold true for the long term, as claimed?

Table 1
Assessments of Reserves and Ultimately Recoverable Resources

	URR	Discovered	URR
	1997	2002	2002
Saudi Arabia	300.00	299.00	320.00
FSU	275.00	239.15	271.00
Russia		187.00	200.00
US-48	210.00	189.00	195.00
Iraq	115.00	**121.00**	135.00
Iran	120.00	**123.00**	130.00
Venezuela	90.00	88.00	95.00
Kuwait	85.00	**86.00**	90.00
Abu Dhabi	80.00	77.00	80.00
Mexico	50.00	**54.00**	62.00
China	55.00	52.00	57.00
Nigeria	40.00	**50.00**	52.00
Libya	45.00	**48.00**	51.00
Kazakhstan		30.00	40.00
Norway	27.00	**31.00**	34.00
UK	30.00	30.00	32.00
Indonesia	25.00	**28.00**	30.00
Algeria	23.00	**27.00**	30.00
Canada	28.00	27.00	28.00
Azerbaijan		15.00	18.00
N. Zone	12.00	**15.00**	15.50
Oman	12.00	**13.00**	15.00
Egypt	11.00	**13.00**	14.00
Qatar	10.00	**12.00**	13.00
India	11.00	11.00	12.00
Australia	7.00	**10.00**	11.00
Argentina	10.00	**11.00**	11.00
Colombia	10.00	9.50	10.00
Malaysia	8.50	**8.60**	10.00
Angola	9.00	8.40	9.50
Romania	7.00	6.90	7.50
Ecuador	5.50	**7.09**	7.50
Brazil	12.00	6.00	7.00
Syria	5.50	**5.60**	6.00
Turkmenistan		4.50	6.00
Dubai	5.00	4.50	4.75
Brunei	4.00	**4.40**	4.50
Trinidad	3.75	**4.15**	4.50
Gabon	3.75	**3.77**	4.00
Ukraine		3.40	4.00
Peru	3.50	3.26	4.00

Yemen	4.00	2.80	3.50
Vietnam	1.50	**2.68**	3.00
Uzbekistan		2.65	3.00
Denmark	2.00	**2.40**	3.00
Congo	2.50	2.18	2.50
Germany	2.30	2.30	2.40
Tunisia	1.75	**1.85**	2.20
Italy	1.75	1.60	1.75
Bahrain	1.20	**1.38**	1.60
Thailand	0.75	**1.20**	1.50
Sudan		0.95	1.50
Cameroon	1.20	**1.27**	1.30
Netherlands	1.10	**1.13**	1.25
Bolivia	0.70	**1.07**	1.20
Turkey	1.10	1.07	1.20
Croatia		0.86	1.00
France	0.90	0.88	0.95
Austria	0.90	0.90	0.95
Papua	1.10	0.80	0.90
Hungary	1.00	0.81	0.90
Albania	0.80	0.72	0.80
Sharjah	1.20	0.60	0.80
Pakistan	0.70	**0.71**	0.75
Chile	0.60	0.50	0.50
	1777.6	1760.5	1898.2

Sources: Campbell (1997) and (2002). Countries whose discovered reserves in 2002 were greater than the 1997 estimate of ultimately recoverable resources are bold-faced.

Conclusions

The many inconsistencies and errors, along with the ignorance of most prior research, indicates that the current school of Hubbert modelers have not discovered new, earth-shaking results but rather joined the large crowd of those who have found that large bodies of data often yield particular shapes, from which they attempt to divine physical laws. The work of the Hubbert modelers has proven to be incorrect in theory, and based heavily on assumptions that the available evidence shows to be wrong. They have repeatedly misinterpreted political and economic effects as reflecting geological constraints, and misunderstood the causality underlying exploration, discovery and production.

The primary flaw in Hubbert-type models is a reliance on URR as a static number rather than a dynamic variable, changing with technology, knowledge, infrastructure and other factors, but primarily growing. Campbell and Laherrere claim to have developed better analytical methods to resolve this problem, but their own estimates have been increasing, and increasingly rapidly.

The result has been exactly as predicted in Lynch (1996) for this method: a series of predictions of near-term peak and decline, which have had to be repeatedly revised upwards and into the future. So much so as to suggest that the authors themselves are providing evidence that oil resources are under no strain, but increasing faster than consumption!

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