

CORRESPONDENCE

China's green policy has some way to go

The ambitious environmental and energy targets set out in China's latest five-year plan (*Nature* 471, 149; 2011) should be considered in relation to the economic realities of environmental decline and of China's governance.

Lowering growth targets for gross domestic product (GDP) and focusing on environmental and energy issues should not be viewed as a complete shift away from the 'economy first' paradigm that has driven China's national agenda for the past 30 years. The new policies are aimed at a more socially inclusive view of economic development, in line with recent criticisms of GDP as a measure of social welfare (see, for example, go.nature.com/to4ppq).

Despite China's remarkable growth rate, a report released by its government in 2006 revealed that roughly 3% of the country's annual GDP had been

offset by economic loss through environmental degradation — a figure that some think is too conservative (*Nature* 448, 518–519; 2007). China's present and future environmental policies should continue to acknowledge the high economic cost of environmental problems in sustainable development.

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Financial model failed in real world

David Lindley cites the Black-Scholes model as a means of calculating and predicting stock-market variations (*Nature* 471, 255–256; 2011). But the model has its pitfalls.

For example, the US hedge-fund firm Long-Term Capital Management used this approach to direct its fund. The fund crashed in 1998 because the

An insight into Maxwell's mind?

Among the comments on the 150th anniversary of James Clerk Maxwell's groundbreaking paper *On Physical Lines of Force* (*Nature* 471, 289–291; 2011), nothing was said about what drove the thinking of this great physicist.

Personal perspectives can provide insight into the dynamics of scientists' behaviour. As the Victorian age matured, science leaders became increasingly materialistic. At a meeting of the British Association in 1874, president John Tyndall took the opportunity to advance his world view of materialism. Maxwell was in the audience and crafted a poem to express his disquiet, the first verse of which runs:

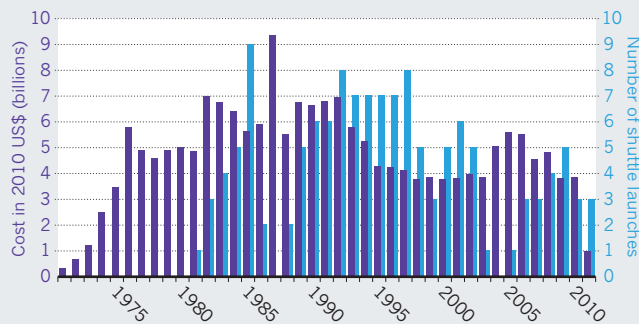
In the very beginnings of science, the parsons, who managed things then,
Being handy with hammer and chisel, made gods in the likeness of men;
Till Commerce arose, and at length some men of exceptional power
Supplanted both demons and gods by the atoms, which last to this hour.
Yet they did not abolish the gods, but they sent them well out of the way,
With the rarest of nectar to drink, and blue fields of nothing to sway.
From nothing comes nothing, they told us, nought happens by chance, but
by fate;
There is nothing but atoms and void, all else is mere whims out of date!

Such thorny issues may well have influenced Maxwell's perspective on science.

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A COSTLY ENTERPRISE

The average cost per launch was about \$1.5 billion over the life of the US space-shuttle programme.



predictions diverged sharply from reality. The US government had to bail the firm out at a cost of about US\$4 billion.

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Shuttle programme lifetime cost

With the final two flights of the NASA space-shuttle programme scheduled for later this year, we can now evaluate the lifetime cost of the programme.

Some 20 years ago, we found the programme to be slightly over budget and severely short in capability (R. A. Pielke and R. Byerly in *Space Policy Alternatives* Ch. 14, 223–245; 1992). We used 8 years of cost and schedule experience to predict performance for the subsequent 20 years of the shuttle programme.

The US Congress and NASA spent more than US\$192 billion (in 2010 dollars) on the shuttle from 1971 to 2010 (see 'A costly enterprise'). The agency launched 131 flights; two ended in tragedy with the loss of *Challenger* in 1986 and *Columbia* in 2003. During the operational years from 1982 to 2010, the average cost per launch was about \$1.2 billion. Over the life of the programme, this increases to about \$1.5 billion per

launch (R. A. Pielke *Space Policy* 10, 78–80; 1994).

For the period 1991–2010, we originally projected an average cost per flight of about \$800 million. The actual cost was about \$1 billion. We overestimated both the flight rate during this time (8 predicted flights versus 4.7 actual) and the annual costs (about \$6.2 billion predicted versus \$4.7 billion actual).

The actual cost for each flight of the programme falls squarely in the middle of the envelope we constructed, with projected uncertainties. Thus, our 1992 projection indicates that the performance of large-scale technologies might be predictable if projections are based on past experience.

The shuttle is the costliest US spaceflight programme ever undertaken. As it comes to an end, we should celebrate its successes, and draw lessons to inform future human spaceflight ventures.

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