cording to Ivan Oransky, co-founder of Retraction Watch, a pressure group, questionable journals now also occasionally retract articles in a bid to appear responsible, in what can only be described as a superb piece of subterfuge.

None of this would matter if institutions hiring academics were appropriately vigilant about checking candidates' publication histories against blacklists, and similarly inquisitive about the publications of those already employed. But some, apparently, are not. According to Brian Nosek, head of the Centre for Open Science, a not-for-profit organisation in Virginia that studies the matter, many institutions that hire and promote researchers seem unconcerned about where those researchers have been publishing—a problem made worse by recent requirements by the American and Canadian governments that taxpayer-funded research must be published in open-access journals.

Unsurprisingly, this is an area in which data are hard to come by. But one academic has been prepared to stick his neck out and investigate his own institution. Last year Derek Pyne, an economist at Thompson Rivers University's business school, in British Columbia, published a paper in the *Journal of Scholarly Publishing*, itself published by the University of Toronto Press. In it, he reported that many of the business school's administrators, and most of its economics and business faculty with research responsibilities, had published in journals on Mr Beall's blacklist. Dr Pyne also claimed that these papers seemed to further their authors' careers. Of the professors who had published in the blacklisted journals, 56% had subsequently won at least one research award from the school. All ten instructors promoted to full professor during the study period had published in a journal on Mr Beall's list.

Subsequently, Dr Pyne told school officials that an administrator up for promotion had published widely in blacklisted journals. This earned Dr Pyne an e-mail from the university's human-resources department on June 15th, threatening him with disciplinary action for "defamatory language and accusations". When asked, the university declined to comment.

Review peer review

What can be done about all this is hard to say. Dr Pyne thinks part of the problem is that too many academic administrators have no research experience, and so either cannot tell good publications from bad, or do not care. Few researchers, though, thrill to the idea of a career in administration, so changing that might be difficult. An extreme reaction, albeit one supported by a growing minority of researchers who think the peer-review system is anyway creaking under the weight of publication pressure, would be to abandon anonymous peer review altogether, and make the process open and transparent. This could be done (as sometimes happens already) by publishing unreviewed papers on special servers and then inviting criticism conditional on the name of the critic being public. That, though, brings other risks. Anonymous critics often find it easier to be honest, especially in fields where most researchers know each other.

One far-fetched solution is a return to journal subscriptions. These have for so long been excoriated as rent-seeking profit-inflators restricting the flow of information that a change of course would now be unthinkable. But those who pushed for their elimination might be wise to pause for thought. As the old proverb has it, be careful what you wish for. You might get it. ■

Football penalties

The lucky 12 yards

There is an optimal strategy to penalty shoot-outs

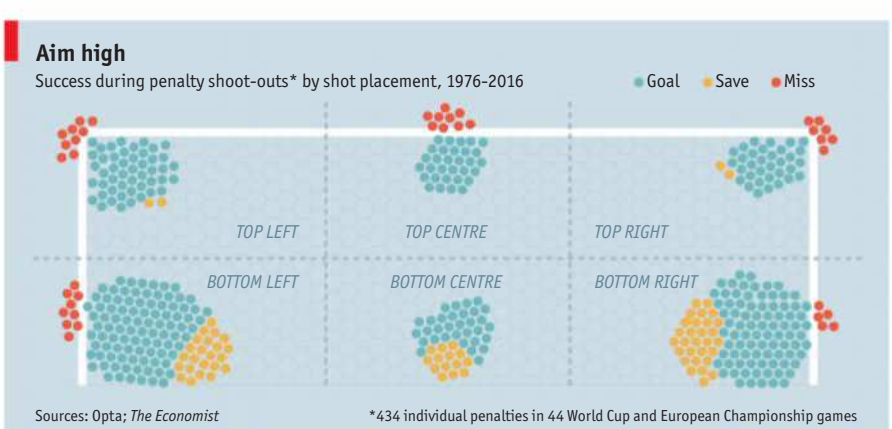
WHEN the World Cup, now under way in Russia, progresses to the knockout phases of the competition on June 30th attention will focus on the dreaded penalty shoot-out. Forty years ago, if a game was level after 120 minutes, the winner was decided by luck: a simple coin-flip. But in 1978 the rules were changed to create results that, at least in some sense, depend on skill. The question is, how much skill? Since 1982, the first competition in which penalty shoot-outs actually happened, there have been 26 of them—with seven of the 18 teams in the nine pertinent finals having arrived there thanks to success at penalties, and two of the finals themselves having been decided by them.

The format of a shoot-out is simple. Teams take it in turn to try to kick five penalties past the opposing team's keeper into the goal. If the score is even after five penalties a side then "sudden death" ensues: victory is achieved by a single winning kick that is not successfully replied to. Whether this is truly less dependent on luck is moot. Analysis suggests that no relationship exists between a team's general quality and its success in such shoot-outs. What analysis does suggest, though, is ways to improve the odds of victory.

The first is to go first, if given the option. That option is, admittedly, dependent on the toss of a coin. But if you win the coin toss you should take it, according to Ignacio Palacios-Huerta of the London School of Economics. After analysing data on 1,000 penalty shoot-outs in the World Cup and other competitions, Dr Palacios-Huerta found that teams which kick first win 60% of the time. Moreover, toss-winning captains do usually take this option, so FIFA, world football's governing body, is trying out a system similar to a tiebreak in tennis, in which teams A and B take turns to shoot first: AB then BA then AB and so on. The current World Cup, however, will keep the AB then AB format.

The toss having been won or lost, the teams decide the order in which players will take their kicks. Coaches typically select the best players to kick first, leaving the worst until last. Kickers are successful three-quarters of the time, on average, according to an analysis of penalties by *The Economist*. Yet the success rate falls by 12 percentage points for the fourth of the five pre-sudden-death penalties. This is where first-mover advantage appears to matter. The success rate in the fourth penalty for the team shooting first is 70%, whereas for the team shooting second it is just 56%. Thorough analysis of player sequencing by Dr Palacios-Huerta suggests that the importance of the five penalties is U-shaped: the first and fifth matter most; the third, least. So the best penalty takers, either in technique or those who can cope with stress, should be selected with that in mind.

Once the sequence of kickers is settled the ball is placed on the spot, 11 metres (36 feet) from the goal, the mouth of which is 2.4 metres high and 7.3 metres wide. A well-



struck ball arrives at the goal line in just half a second, meaning that the goalkeeper must dive pre-emptively in the direction that he expects the kicker to shoot. Goalkeepers find high balls the hardest to deal with—just 3% of penalties aimed halfway up the goal or more are saved. Yet there is a tendency for these shots to miss the target: 18% of high shots do so, as opposed to 5% of low shots. Overall, though, allowing for misses and saves, high shots are successful 79% of the time compared with 72% for low shots (see chart on previous page).

As to the direction, left, right or centre, of both the kicker's shot and the goalkeeper's pre-emptive dive, it is best to be as unpredictable as possible. The data suggest there is little difference in success rates between shots that are aimed left, right or down the middle. Yet it is easier for a right-footed player to give the ball speed by aiming towards what is, from his point of view, the left-hand side of the goal (the keeper's right), and vice versa for left-footed players. On average, kickers strike the ball in this more natural direction 25% more frequently than in the other direction. Goalkeepers know these preferences and dive in those directions in matching proportions, in an attempt to exploit this bias.

Preparation helps, too. The Netherlands substituted in a specialist penalty stopper, Tim Krul, just ahead of their shoot-out with Costa Rica in the 2014 World Cup. It worked. He dived in the correct direction all five times and saved two penalties. Conversely, there is no substitute for kicking accuracy. Germany, with an 86% penalty success rate, has the best record of any top international team. England's record, by contrast, is a dismal 66%. ■

Commercial space flight in China

Fire arrows

BEIJING

A Chinese company plans to launch a rocket into orbit this year

THE first rockets were Chinese. In the 1230s the armies of the Song dynasty, who were fighting Mongol invaders, started launching "fire arrows" propelled by gunpowder some 300 metres into enemy lines. When the Song's artillerymen realised that these arrows continued to fly straight even after their fiery exhaust had burned away their feathers, they removed the fletching and the rocket was born.

Almost eight hundred years later Shu Chang, the head of a company called OneSpace, is trying to build on that historical tradition—though not for military purposes. The charred and twisted remnants of OS-X, the firm's first launch, are strewn across the floor of its laboratory in Daxing, a suburb of Beijing. The launch took place in May, from an undisclosed location in the north-west. OS-X, nine metres tall, climbed to an altitude of 40km and travelled 287km downrange. It remained airborne for five minutes before crashing into desert sands.

This lift-off was a first not only for OneSpace but also for China, for it was the first in that country of any rocket built by a private space company rather than a government agency. It was also the world's first flight of a rocket intended to pave the way for a commercial, solid-fuelled orbital launcher.

Solid fuel is easier and cheaper to handle than the liquid variety, which requires tanks and pumps, and its higher density means that rockets which use it can be made smaller than their liquid-fuelled brethren of equivalent lifting capability. Fine-tuning the flight of a solid-fuelled rocket is harder, though, because the supply of fuel to the motor cannot easily be regulated. For that reason American space companies have followed the liquid-fuelled path trodden by government space agencies around the world. The relative disadvantages of solid fuel do, however, diminish as rockets get smaller. And since OneSpace is not planning to hoist into orbit the multi-tonne loads carried by, say, the Falcon Heavy lifter of SpaceX, America's leading private space company, the firm hopes that the simplicity of solid fuel will offset its disadvantages.

OS-X was assembled in the laboratory where its remnants now reside. But OS-M, the next generation, will be built in a factory now nearing completion in Chongqing. These solid-fuelled rockets will be 20 metres tall and are destined for orbit. They will be able to launch payloads of up to 205kg—a load the firm hopes eventually to increase to 750kg by adding four booster rockets to the main one.

OneSpace's target is the rapidly growing market for small, short-lived satellites that will observe Earth's surface for various purposes. At the moment these devices, which weigh only a kilogram or two, are launched mainly as makeweights on missions whose principle purpose is to put a large satellite into space. Demand for small-satellite launches is now so great, though, that businesses can be built on it. Rocket Lab, an American firm, has recently begun offering dedicated small-satellite launches, using a liquid-fuelled rocket. OneSpace hopes the first OS-M should be launched before the end of the year.

The firm, which was founded in August 2015, owes its birth to government policies, promulgated a year earlier, that permitted private capital to enter the space industry—previously a state monopoly. It is backed by several Chinese venture-capital firms, including Legend Star, Zhengxuan Capital and the Hongtai Fund. It says it has already signed a number of contracts to launch small satellites for Chinese customers. It may not, though, keep its lead for long. Several other firms, including LandSpace and LinkSpace in Beijing, and ExPace, in Wuhan, have similar plans and are pressing it hard.

It seems, then, that in the small-satellite-launch market the Chinese are coming in earnest. With luck, at least from the customer's point of view, OneSpace and its modern fire arrows are about to ignite a private space race. ■

Archaeology

Dead apes telling tales

A new species of gibbon is found in a 2,200-year-old tomb

ROYAL burials are just not what they used to be. While still a child, Qin Shihuang, who founded the Qin dynasty and unified China in 221BC, ordered a mausoleum built for himself that would measure 6.3km across at its widest point and include over 8,000 terracotta figures. His grandmother, Lady Xia, was also buried with several companions. When her tomb near Xi'an was excavated in 2004, archaeologists found in it the remains of a leopard, a lynx, a crane and a gibbon—a type of small ape.

Gibbons were treasured in ancient China. They served as pets for the elite in Lady Xia's time and as models for fine art a few