

The Tour de France

BREAKING DOWN THE BREAKAWAY



This summer the world's most famous cycle race, the Tour de France, takes to the road in one of Frontier's home cities – Brussels – in recognition of the 50th anniversary of five-time winner Eddy Merckx's first Tour victory. The Belgian capital, of course, has another reason to celebrate this year: 2019 is the 20th anniversary of Frontier's founding. Did this form part of the decision to begin the Tour in Brussels, ending as it does, rather fittingly, in Paris – another Frontier home city?¹ To mark this serendipitous coincidence, some of Frontier's domestiques² have turned their minds to the sport sometimes described as “chess on wheels”.

The breakaway

Tune into the early stages of the Tour de France, and you'll likely see a small group of cyclists (aka a “breakaway”) valiantly ploughing a lone furrow through the French countryside for hours on end. More often than not, this small group will be caught by the rest of the 200 cyclists (the “peloton”) with less than 20km remaining to the finish, after as much as 200km of fruitless hard labour.

To the uninitiated (and often the initiated) eye, this type of behaviour looks illogical.

- How do they get so far in front, only to be reeled in so predictably? Are they really the fastest cyclists in the pack, or just the most unfailingly over-optimistic in the early parts of stages?
- Why do they do it? If the breakaway rarely yields a winner, why don't they just bide their time in the peloton instead of wasting energy riding faster in the irrelevant early hours of the stage?

What can economics, and game theory in particular, tell us about the decisions that give rise to these strange outcomes?

Broken records

To try and answer some of these questions, the Frontier domestiques have collected data from every stage of the previous six Tours. This includes details on the type of stage (its length and the nature of the terrain, for example); some key statistics on how the race developed on the road (how large was the breakaway³, when it formed and who was in it); and what the final outcome was (who won and whether they were part of the breakaway).

Across the 114 road stages (excluding time trials and prologues), there were breakaways in all 114, consisting of a combined 1,230⁴ riders on the attack. But only 31 of these stages (27%) were won from

¹ If you're interested, the answer is no.

² In cycling parlance, “domestiques” are the hard-working team members who selflessly support their leaders – carrying drinks and clothing from the team car to the “star” riders, protecting them from the wind and chasing down rivals on their behalf, all so that their leaders can conserve every last ounce of energy for the skirmishes that decide the winner.

³ This presented a challenge in itself. Each stage can be a complex story of thrust and parry, which makes it far from an exact science to identify the definitive breakaway of a stage (if such a thing even exists). Often riders may escape briefly from the peloton only to be caught within a few minutes, or an early break might be caught mid-way through a stage and a separate breakaway re-form. In order to take an objective view, we have defined the breakaway as the first group of the stage which establishes a consistent gap to the peloton, as per CyclingNews.

⁴ This figure represents the sum of the number of riders in each breakaway. It therefore includes riders who were present in multiple breakaways.

the breakaway, meaning that – on average – the probability of victory for each rider in a breakaway is just 2.5%.

To understand why, we need look no further than physics. A recent study⁵ showed that riding in a tightly packed group of 121 cyclists reduces wind resistance by up to 96% compared to cycling alone, making the peloton far more efficient in covering ground than a smaller group. It is therefore no surprise that the peloton, once it decides it means business, can sustain much higher speeds than a breakaway and reel the escapees in quite comfortably.

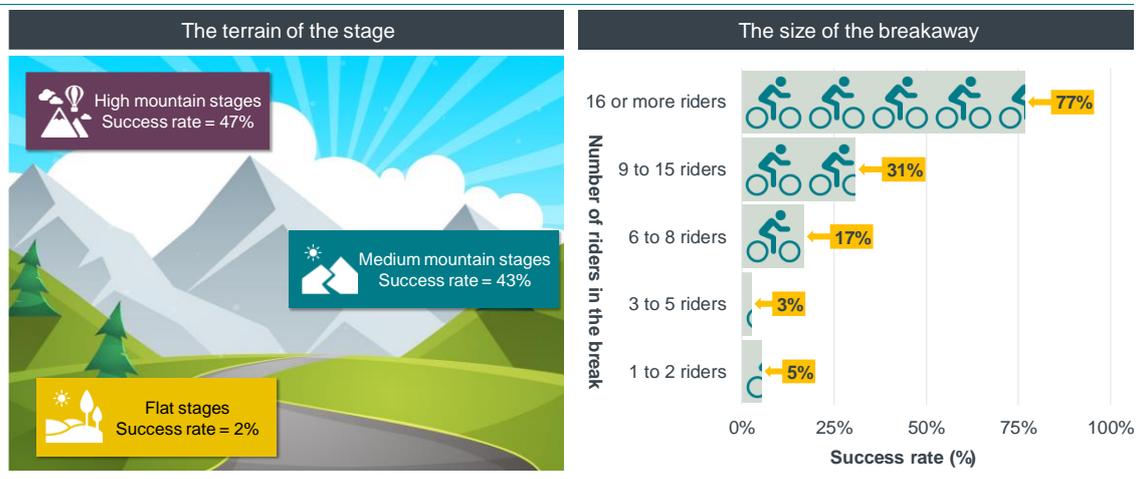
2.5%

On average, each rider in the breakaway has only a 2.5% chance of winning the stage

Breaking the mould

So how do breakaways ever succeed if the deck is so stacked against them? From a look at our database of past stages, we see that no two stages (and no two breakaways) are the same. A breakaway stands a much better chance of winning depending on certain factors, some of which are shown below in Figure 1.

Figure 1 – the success rate of breakaways



- The terrain. A stage with more hills reduces the importance of wind resistance. As the road tilts upwards, and speeds fall, the benefits of drafting are vastly reduced and the key factor becomes riders’ power-to-weight ratios as they battle with gravity. In such a scenario, the peloton has less of an advantage over the breakaway. Indeed, our data shows that more than four out of 10 high or medium mountain stages were won by a breakaway.
- The size of the breakaway group. A larger break means more shelter from the wind (and greater sharing of the hardest work), and thus less of a clear advantage to the peloton. The success rate is much higher for larger breakaway groups – of the 30 stages in which the breakaway consisted of more than 16 riders, the breakaway succeeded in 23 of them (77%).
- The importance of the stage win. In hillier stages, where the competitors for the Tour’s overall crown are to the fore, the primary objective for them and their teams is not to win the stage per se, but to finish as far ahead of their main rivals as possible. This is because the overall winner of the Tour de France is the rider with the lowest cumulative time after all stages, rather than the most stage wins. In contrast, on a flat stage, the objective for the contenders for the stage win (the more gravitationally-challenged “sprinters” who have the muscle to achieve the highest top speeds in the peloton), is to cross the line first and only to cross the line first. And this means every effort will be made by them and their team, to reel in the breakaway before crossing the line. Indeed, in our dataset, we observed that breakaways have a vanishingly small chance on a flat

⁵ Blocken et al, “Aerodynamic drag in cycling pelotons: New insights by CFD simulation and wind tunnel testing”, Journal of Wind Engineering and Industrial Aerodynamics, ISSN: 0167-6105, Vol: 179, Page: 319-337. Available at <https://doi.org/10.1016/j.jweia.2018.06.011>

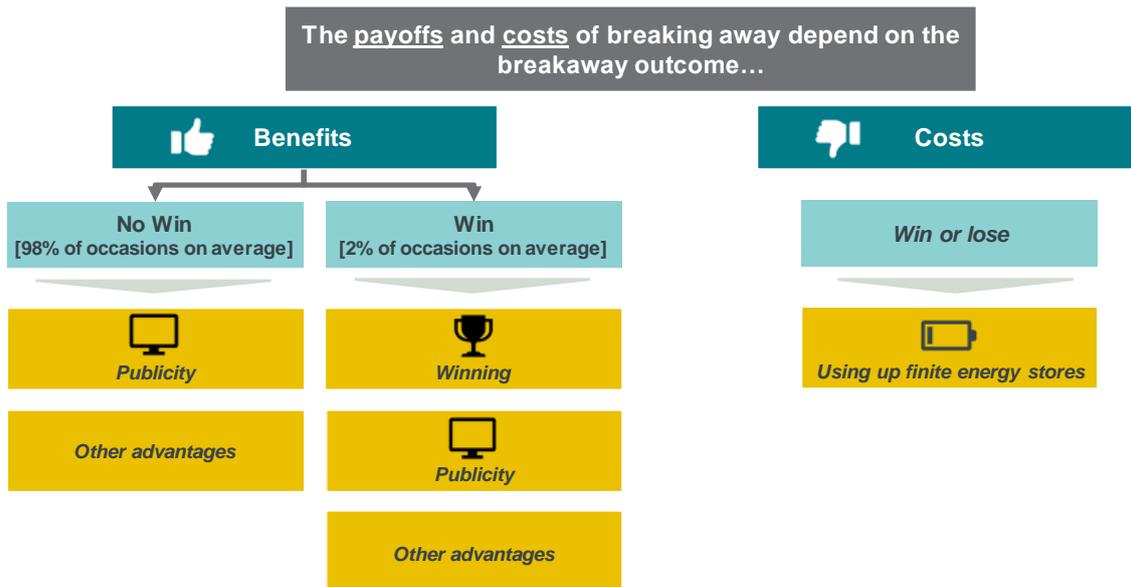
stage – just 2% of flat stages were won by breakaways, and on average each individual rider in the breakaway on a flat stage has a probability of winning of just 1 in 200.

In some circumstances, then, the breakaway looks like a credible option for success. But on flat stages it seems futile, so why do we always see that some riders persist? For the answer to this question, we turned from physics to economics. Or more precisely, game theory.

To break or not to break

To look at the decision to participate in a breakaway through an economics lens, we consider the potential positive and negative payoffs from doing so.

Figure 2 – the payoffs and costs for a rider considering joining the breakaway



■ **Payoffs.**

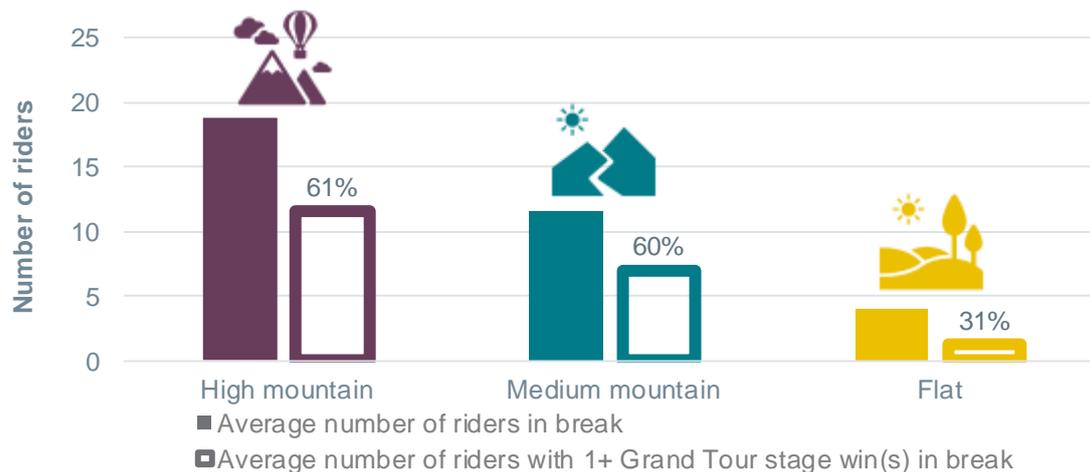
- **Winning.** There is a non-zero probability of winning the stage from the breakaway. Clearly this depends on many variables – the nature of the stage, who else joins the breakaway and a myriad of other factors which play out on the road.
- **Publicity.** In addition, the riders also get a much more predictable benefit – TV exposure. A professional cyclist’s kit makes him or her a walking (well, cycling) billboard. Getting in the breakaway will guarantee that billboard an appearance on the television screens of a claimed 3.5bn viewers worldwide.⁶
- **Other advantages.** In addition, there are other less tangible benefits of being in the breakaway, such as the lower risk of being caught behind one of the pile-ups that are inevitable in a tightly-packed group of more than a hundred cyclists, or the chance to pick up a prize for being the first rider to reach the top of intermediate climbs.

■ **Costs.**

- **Using up finite energy stores.** The main downside of taking your chance in the breakaway is the use of significant quantities of energy, which could potentially have been employed for any number of other roles (supporting teammates in the peloton, or sprinting at the end of the stage, for example).
- The balance of this trade-off will be different for each rider and for each stage.
- Some riders have an alternative goal which makes the downside of wasting energy unacceptable. This is particularly the case for those who are chasing the overall victory and who must save energy for skirmishes with their rivals; and for the sprinters (and their teams) who stand the best chance of winning flat stages from a late sprint. For this reason, it is rare to see a sprinter in the breakaway on a flat stage, and even rarer to see an overall contender contemplate a long-distance breakaway.

⁶ This somewhat implausible sounding figure was quoted by the Tour’s organisers, and has raised some debate – see for example <https://www.bbc.co.uk/news/blogs-magazine-monitor-28264183>.

- For other riders, the opportunity cost of a tough day in the breakaway is more limited. For example, some teams do not have a sprinter fast enough to win the mad dash that typically occurs at the end of a flat stage. For riders in these teams, the publicity of being part of the breakaway may be ample reward for the loss of energy, even where there is little to no chance of the breakaway succeeding in contesting the stage victory.
- If riders are indeed behaving in the logical manner that game theory predicts, one would therefore expect to see the following patterns in the number and types of riders in the breakaway.
- On flat stages, with little chance of holding off the peloton, the breakaways should be made up of fewer riders, typically comprising less successful riders. For example, they could be from the Tour de France's "wildcard" teams, who will place a high value on publicity and for whom consuming a lot of energy has limited opportunity cost.
- On hillier stages, where the breakaway stands a higher chance of success, we should observe larger groups, which will also contain more accomplished riders who are now willing to accept the energy costs in return for a greater chance of a stage victory.
- So is this really what we see? Are cyclists actually acting rationally, as predicted by game theory?
- Well, according to our data, yes. Figure 3 below shows the average number of participants in the breakaway and the average number of riders with at least one Grand Tour stage win⁷ (a crude proxy for more successful competitors), for different stage types.
- **Figure 3 – the riders in the breakaway, by stage type**



- This shows that, on average, only four riders join the breakaway on a flat stage of whom three will have had no previous Grand Tour stage victories. In contrast, the average breakaway on a high mountain stage attracts 19 riders, of whom 12 will have won a Grand Tour stage. For those at the top of their game, only a realistic prospect of winning is enough to take them out of the relative comfort of the peloton.

Breaking point

- Of course, this static description is an oversimplification of how each stage plays out. Each rider would (at least in theory) be constantly weighing up these trade-offs and re-assessing the chance of victory depending on how many – and which – other riders attempted to get into the break. Should they see more rivals succeeding in bridging the gap to the breakaway, their expectation that the effort will succeed might increase, prompting a decision to throw caution to the wind and join them.
- Again, this appears to be consistent with the patterns of the data. For instance, the 16th stage of last year's Tour could be considered a prime breakaway opportunity. It was a mountainous stage which would negate the sprinters, but ended with a downhill that would make the overall contenders unlikely to race flat-out to the finish and deprive the break of victory. The riders seemed to share this logic. It took around two hours, 100km and countless attempts before a breakaway was successfully formed without being overwhelmed by the weight of riders trying to join it. In

⁷ The Grand Tours are the Tour de France, Vuelta a Espana, and Giro d'Italia.

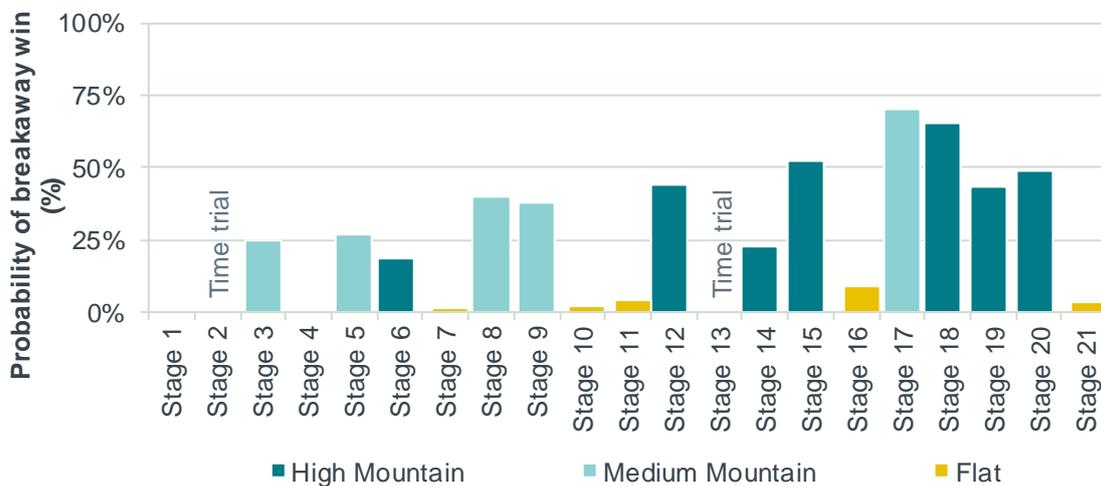
contrast, on the seven flat stages in the 2018 Tour⁸, the break formed – on average – after less than 10km of racing.

- With these constant adjustments of expectations, and the optimum behaviour to suit it, it's little wonder that cycling has been called chess on wheels.

So, when will the break win this year?

- We have used the data collected from previous years to model the probability that a breakaway will succeed, based on the terrain, the length of the stage and its relative position within the race.
- We find that – as expected – breakaways are 43% and 35% more likely to be successful on medium or high mountain stages respectively as compared to a flat stage. Interestingly, we also find that the probability of breakaway success increases by almost 2% per stage as the Tour progresses, even when controlling for the terrain. This may reflect the fact that, as the Tour goes on, more of the top riders fall by the wayside in the overall standings, and instead turn their considerable talents to fighting for stage wins as part of the breakaway.⁹
- So when to tune in this year if you'd like to see a breakaway win?

■ **Figure 4 – the predicted probabilities of a breakaway win for each stage the 2019 Tour de France**



- According to the predictions from our model, summarised above in Figure 4, Stage 17 from the Pont du Gard to Gap is the stage to watch to see a breakaway win in the 2019 Tour, with a predicted 70% chance of the break going all the way. History suggests this is a reasonable bet – of the previous three stages that finished in Gap, all were won by a rider from the day's breakaway. Maybe this year will continue the trend. And if not, perhaps the Frontier domestiques will have to stick to their day jobs.

⁸ Excluding the final stage into Paris, as this is traditionally processional only until the riders reach a circuit in central Paris.

⁹ For example, in recent years, stages have been won from a breakaway late in the Tour by riders who would be considered contenders for the overall victory before losing significant time earlier in the race (for example, the stage wins by Bauke Mollema (2017), Primož Roglič (2017) and Vincenzo Nibali (2014)).