

<p>Institution: Oxford Brookes University</p>
<p>Unit of Assessment: 19 - Business and Management Studies</p>
<p>Title of case study: The Duckworth/Lewis Method <i>Professional Edition</i>: operational research principles ensure a fairer outcome for interrupted limited-overs cricket matches</p>
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>The Duckworth/Lewis Method <i>Professional Edition</i> is the standard adopted globally by the International Cricket Council, for resetting the total run target for interrupted (such as rain affected) limited-overs cricket matches, enabling fairer match outcomes benefitting the teams, their fans and the games' regulatory bodies. The <i>Professional Edition</i>, applied universally in top-level cricket, is developed from research undertaken by Anthony Lewis, Oxford Brookes University, in collaboration with Frank Duckworth. The <i>Professional Edition</i> made advances over the original formula by improving the parameters where the total run target was above average. This refinement of the original D/L method led to the widespread publication, dissemination and endorsement of the D/L method <i>Professional Edition</i> and demonstrates the diverse applications of academic research.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>Dr Anthony Lewis' research interests are in the application of operational research techniques and methodology to performance measurement, decision making and strategy planning to individual and small-group human endeavours. The impact claimed within this case study is derived from research undertaken at Oxford Brookes University that built upon the innovative and acclaimed original Duckworth/Lewis (D/L) method (Duckworth & Lewis, 1998)¹. The original D/L method was published, in collaboration with Dr Frank Duckworth, whilst Lewis was employed by the University of West England. In 2004, employed as a Senior Lecturer at Oxford Brookes University, an article by Lewis (co-authored with Duckworth) reviewed the robustness of the original D/L method whilst providing fuller details of the model behind the method. The paper confirmed the D/L method's suitability for use in interrupted limited-overs cricket matches but also indicated a need to update the model's parameters.</p> <p>The original model is a simple two factor exponential relationship:</p> $Z(u,w) = Z_0 F(w) [1 - \exp \{ - bu/F(w) \}]$ <p>Where $Z(u,w)$ is the average further number of runs made when there are u overs remaining and w wickets down. $Z_0 F(w)$ is the asymptotic value of further runs expected with w wickets down as u tends to infinity, $F(0)$ being set to unity. The parameters, b, Z_0 and the nine values of $F(w)$ were estimated from an analysis of a one-day database.</p> <p>The Duckworth & Lewis (2004)² paper drew upon several years of data from international matches and demonstrated that the original model was representative of average runs scored in limited-overs cricket matches. However, the original model relied on the assumption that performance was proportional to the mean, irrespective of the actual score. In the majority of matches, the assumption held true but when very high scores were involved, the simple approach started to break down and consequently targets could be less equitable for both sides. Data indicated that certain parameters of the original model required updating to reflect the changing nature of the game since the method's inception. Data also indicated a need to upgrade the model to cope with high scoring matches where the original model's assumptions no longer hold.</p> <p>The upgraded formula (the D/L <i>Professional Edition</i>) proposed was:</p> $Z(u,0, \lambda) = Z_0 F(w) \lambda^{n(w)+1} \{ 1 - \exp (- bu / [\lambda^{n(w)} F(w)] \}$ <p>The additional parameter, λ, had to be determined for every Team 1 innings, allowing for any stoppages in that innings. This gave fair targets even at the very highest score made, but could no longer be implemented manually.</p>
<p>3. References to the research (indicative maximum of six references)</p> <ol style="list-style-type: none"> 1. Duckworth, F.C., Lewis, A.J. (1998). A fair method of resetting the target in interrupted one-day cricket matches. <i>Journal of the Operational Research Society</i>. Vol. 49 No. 3. pp. 220-227. DOI:10.1057/palgrave.jors.2600524

Impact case study (REF3b)

Journal article describing the original D/L method that gave rise to the Standard Edition. We do not claim impact from this research, as it was undertaken at the University of West England, but cite it to indicate how the impact that we do claim is distinct from it.

2. Duckworth, F.C., Lewis, A.J. (2004). A successful operational research intervention in one-day cricket. *Journal of Operational Research Society*. Vol. 55 No.7. pp 749-759.
DOI:10.1057/palgrave.jors.2601717

Journal article that upgrades the original D/L method, and led to the Professional Edition adopted by the International Cricket Council from 2003. At the time, Anthony Lewis was employed as a Senior Lecturer at Oxford Brookes University. Indeed, this article was included as one of Lewis' four outputs submitted to RAE2008, UoA36 - Business and Management Studies [AJ Lewis, RA2, Output 2] (the ABS journal quality list rating for this journal is 3-star).

4. Details of the impact (indicative maximum 750 words)

The D/L method *Professional Edition* is the standard mechanism for resetting targets in limited-overs cricket matches at many levels of the game. It has time and time again been proven to be robust and reliable. Whilst sometimes controversial and occasionally questioned, the important contribution that the D/L method has made to a popular pursuit has led to an increasing awareness of the value of the mathematical sciences in areas far removed from academia.

On October 1st 2003, the International Cricket Council (ICC) introduced the upgraded D/L method (Duckworth & Lewis, 2004) to all one day international (ODI) matches. It is referred to as the *Professional Edition* of the D/L method and since 2008 has been used in over 500 top-flight cricket matches enabling more equitable outcomes, following stoppages in play, for the competing teams, their fans and the governing bodies that regulate the games.

Prior to the D/L method of scoring there had been two other methods of setting targets. The traditional method had just made use of proportions of overs to revise targets (Average Run Rate) e.g. in a fifty over match the team batting second because of rain only had thirty overs to chase the required score, they would have a revised score to beat of 60% of the original. This method was generally more favourable to teams batting second though and made it a lot easier to chase scores down. The Australians adopted a method (Most Productive Overs) that saw economical bowling overs from the first innings removed to increase the difficulty of chasing. This though ended in farce, as South Africa playing England in the 1992 World Cup went from needing 22 runs in 13 balls to requiring 22 runs from one ball because of a short downpour³. Retrospective application of the D/L *Professional Edition* to this match shows that South Africa would have needed four runs to win from that final ball – an achievable and fair target⁴. There are several examples that demonstrate the *Professional Edition's* impact on individual cricket games and the following narrative presents notable examples of these.

In the ODI between England and India on September 11, 2011⁵, the match was frequently interrupted by rain in the final overs, and a ball-by-ball calculation of the Duckworth-Lewis 'par' score played a key role in the tactical decisions made during those overs. At one point, India were ahead according to this calculation, during one rain delay (and would have won if play was unable to be resumed). At a second rain interval, England, who had scored some quick runs (precisely because they were aware of the need to get ahead in terms of D/L) would correspondingly have won if play had not resumed. Play was abandoned with seven balls remaining and England's score equalled the Duckworth-Lewis 'par' score, therefore resulting in a tied match. This example illustrates the extent of the important and difficult decisions that match officials have to make, such as assessing at exactly what point the rain is heavy enough to justify ceasing play. If they had done so one ball earlier, England would have been ahead on D/L, and so would have won the match. Alternatively if play had stopped one ball later, without England scoring off that ball, India would have won the match.

Recently, the *Professional Edition* was applied to the popular and commercially lucrative Twenty20 game (ICC Twenty20, Indian Premier League Twenty20). A review in 2009 of 500 ODI and 200 Twenty20 matches showed that the average scores in Twenty20 format were consistent with the

pattern in 50-over matches⁶. During the 2010 World Twenty20 series, England felt they were denied a fair chance of victory against the West Indies (WI) due to the D/L method *Professional Edition* (notably Captain Paul Collingwood "There's a major problem with Duckworth-Lewis in this form of the game"⁷). England scored 191 in their 20 overs (including 60 for one wicket in the 6 'PowerPlay' overs [In a PowerPlay, restrictions are applied on the fielding team]). During the second innings, WI who started very well, were 30 for no wickets in 2.2 PowerPlay overs. Rain intervened and 14 overs were lost. Following the interruption, the target was revised to 60 runs in six overs leaving WI with 30 runs to get in the remaining 3.4 overs; the WI won with one ball to spare⁸. Analysis following the match demonstrated that WI's overall requirement was exactly what England had scored in their 6 PowerPlay overs and, as WI only had 2.2 PowerPlay overs, the revised run target was fair⁹.

In June 2012 the ICC Cricket Committee, following a challenge by V. Jayadevan for a new way of working out run chases for reduced overs matches (VJD method) decided to keep the D/L method for calculating one-day targets when weather intervenes. The ICC said in a statement "The committee unanimously agreed that there was no evidence of any significant flaws in the D/L method nor did the committee believe that any improvements could be offered by the VJD method. Therefore the committee decided to continue with D/L,".¹⁰

In June 2010 Dr Lewis was awarded the MBE for his services to mathematics and cricket¹¹. There are also broader, more general, secondary impacts arising from the research observed through the D/L method's influence on popular culture and society. For example, 'the Duckworth-Lewis Method' is now an accepted part of everyday language and used as an allegory for complexity¹². The Irish pop group took this name and produced a 'cricket concept' album that was nominated for an Ivor Novello Award in April 2010¹³ and, on 1 July 2013, they released a second album 'Sticky Wickets'.

5. Sources to corroborate the impact (indicative maximum of 10 references)

3. '22 off one ball' Andrew Miller, ESPNcricInfo (<http://www.espncricinfo.com/wc2007/content/story/280142.html>)
4. 'The D/L method: answers to frequently asked questions (updated September 2012)', ESPN CricInfo (<http://www.espncricinfo.com/ci/content/page/581925.html>) Question 26 'What would have been the situation under the D/L method in the CWC1992 semi-final match between England and South Africa in Sydney?'
5. England Vs India. 4th one day international at Lord's 11 September 2011. Commentary (<http://www.espncricinfo.com/england-v-india-2011/engine/match/474480.html?innings=2;page=1;view=commentary>) and Match report (<http://www.espncricinfo.com/england-v-india-2011/content/story/531989.html>) via ESPN CricInfo
6. Duckworth Lewis, 2009 update (<http://www.espncricinfo.com/ci/content/page/428215.html>) via ESPN CricInfo
7. 'Collingwood wants Duckworth-Lewis overhaul' Andrew McGlashan, ESPNcricInfo (<http://www.espncricinfo.com/world-twenty20-2010/content/story/458375.html>)
8. West Indies Vs England. ICC World Twenty20 - 8th match, Group D at Providence Stadium, Guyana 3 May 2010. Commentary (<http://www.espncricinfo.com/world-twenty20-2010/engine/match/412685.html?innings=2;page=1;view=commentary>) and Match Report (<http://www.espncricinfo.com/world-twenty20-2010/content/story/458345.html>).
9. 'The D/L method: answers to frequently asked questions (updated September 2012)', ESPN CricInfo (<http://www.espncricinfo.com/ci/content/page/581925.html>) Question 27. 'In the 2010 WT20 in West Indies weren't England denied of a fair chance of victory against the West Indies?'
10. 'ICC decides to keep Duckworth Lewis and DRS' Reuters, 1 June 2012 (<http://in.reuters.com/article/2012/06/01/cricket-icc-duckworth-lewis-drs-idINDEE8500DY20120601>)
11. Queen's Birthday Honours List 2010 (<https://www.gov.uk/government/news/queens-birthday-honours-list-2010>)
12. *Selected examples of the D/L method as an 'allegory for complexity'*
 - i. 'Basel II: The Duckworth-Lewis of banking' <http://saqa.vn/view.aspx?id=4087>;

Impact case study (REF3b)

- ii. 'UPA floats Duckworth-Lewis bill to decide fate of bills blocked by adjournment'
<http://www.theunrealtimes.com/2012/09/08/upa-floats-duckworth-lewis-bill-to-decide-fate-of-bills-blocked-by-adjournment/>;
 - iii. 'Out for a Duckworth?'<http://www.uk.capgemini.com/blog/business-analytics-blog/2010/11/out-for-a-duckworth>
13. Tuesday 20th April 2010 BASCA in association with PRS for Music presents The Ivors Nominations Announcement 'Album Award'
(<http://www.prsformusic.com/aboutus/press/latestpressreleases/Pages/IvorNovellonominationsannounced.aspx>)