Operations Research Society of South Africa

At the Forefront of Analytics in Africa

ORSSA Newsletter December 2015

www.orssa.org.za

What o(u)r Members Are Up To

DJ Human
Member Since: 2014
Chapter: Western Cape
Age: 25
Studies: BComm(Hons) Operations Research (Cum Laude)

Where do you currently work: First National Bank

Any interesting OR related work done?: I applied to pursue my masters part time from 2016 at Stellenbosch. I'm currently exploring the use of various machine learning algorithms in customer profiling.

Jacobus Johannes Potgieter
Member Since: 2005
Chapter: Western Cape
Age: 34
Studies: BSc (Mathematical Sciences); BSc Hons (Operations Research); MSc Eng

Where do you currently work: In 2014 I started my own company called Zurion Solutions, focussed on the design and development of complex software systems. I am also involved with an NGO called Living Legends (which is also in its start-up phase) and another venture - the development of a platform/application for businesses to partake in the e-commerce space.

Any interesting OR related work done?: As part of Zurion I am re-implementing a supply and demand model for vessels transporting commodities across the word. The model considers internationally recorded import and export transaction data, but the interesting part is how vessels move between unloading cargo at one port and loading cargo at the next.

Pieter de Wet
Member Since: 2014
Chapter: Western Cape
Age: 25
Studies: BComm(Hons) Operations Research (cum laude) at Stellenbosch University

Where do you currently work: I am a full-time MCom student in Operations Research at the Department of Logistics, Stellenbosch University, with study leader Dr Linke Potgieter.

Any interesting OR related work done?: I am currently working on my masters thesis titled "Improving agricultural landscape structures for integrated pest management". The population dynamics of a pest species is simulated by using a cellular automaton for a number of different configurations of differently aged crops across a spatial domain, where the harvesting of these fields occurs at different points in time. The model is applied to the pest species Eldana saccharina Walker in sugarcane, with the objective to identify a field configuration for which the average infestation levels are minimised in an integrated pest management scenario.

JHB Chapter Event

Optimisation of the Sekwa Blended-Wing-Body Research UAV by Dr Bennie Broughton

CHECK OUT OUR FACEBOOK PAGE FOR MORE

From The Editor

By Berndt Lindner (berndtlindner@gmail.com)
ORSSA Newsletter Editor

Bernie Lindner

Welcome and merry Christmas to all our members. I hope you have a safe an enjoyable season ahead and may 2016 be even more busy or relaxed compared to, which ever you prefer.

This newsletter focusses on gambling and investing (some would argue they are one and the same). Both of these words have a common denominator, risk, which is why you will find an article on page 3 on risk, oh wait it's just the board game Risk.

Sticking with the same theme and main co-author for the Newsletter's featured articles, Linke Potgieter, page 9 contains an article on a mathematical model to help to decide whether or not to invest in certain investment portfolios.

A review on the movie 21 can be found on page 13 by our local movie critic Brian van Vuuren, who I am sure takes his job of sitting and watching movies very seriously.

Hans Ittman has his book review (which also appeared in the September issue of the IFORS newsletter) on page 14. Hans has also kindly provided a memoriam to a late and dear member of the Society on page 16.

I really enjoyed the main articles by Pieter de Wet *et al.* and Gillian Toplis *et al.*, they are quite a high standard for the newsletter, I hope you enjoy them and the rest of the newsletter, please feel free to contact me for ideas/suggestions/comments and articles.

Warm Regards
Bernie

Features — Page

SOCIAL MEDIA

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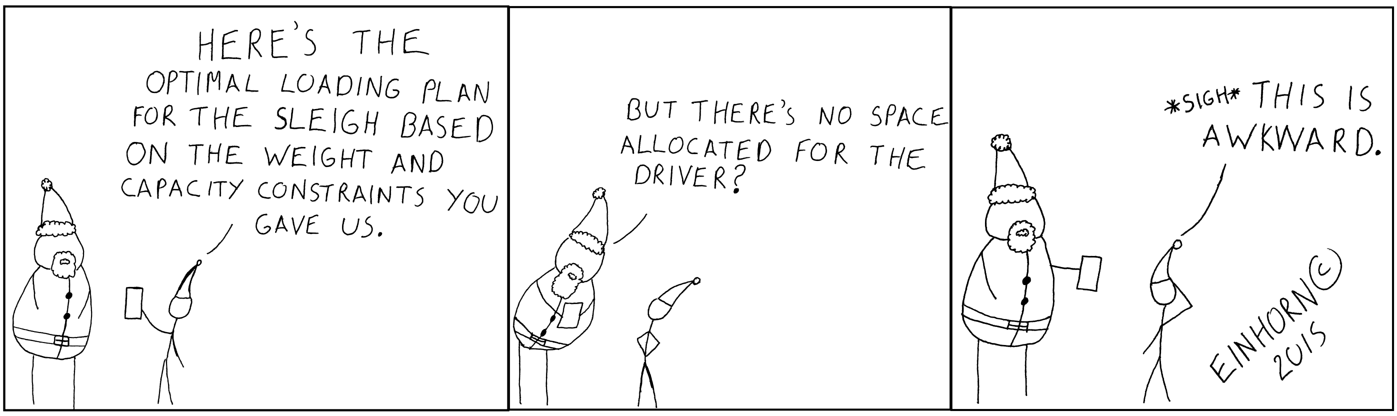


From The President's Desk

By Hennie Kruger
(Hennie.Kruger@nwu.ac.za)
ORSSA President


Hennie Kruger

The past two years have flown by and I have come to my last contribution for this column. Before I say the final thank you and good bye, I would like to reflect very briefly on some of the Society's activities during 2015.

I am pleased to report that most of our chapters have been active this year. Some of the chapter AGMs have already taken place where new chapter Executive committees were elected. Congratulations to these new chapter executive members – we are looking forward to a productive and interesting 2016. Thanks to the outgoing chapter executive members – your hard work during 2015 is greatly appreciated.

We had once again a very successful annual conference in September at Pecan Manor in the Hartbeespoort Valley. A large variety of papers was accepted and presented at the conference which was attended by a large number of delegates. The annual conference is also an opportunity to celebrate the achievements of our members and during the gala dinner the Tom Rozwadowski, Theodor Stewart and Gerhard Geldenhuys medals were awarded. A number of recognition awards were also awarded to members. Congratulations again to all the awardees. The October edition of the Newsletter contains all the details of the conference and the awards.

We have also made progress in some other areas which can be briefly summarised as follows.

- ORSSA is now registered as a Non-profit Organistaion which enables us to prepare our accounting records and statements in accordance with Article 17 of the Non-profit Organisations Act.
- Our national Treasurer is currently actively busy with a process to obtain a BEE certificate which will have certain advantages for the Society.
- An initiative was started to liaise more closely with the South African Institute of Industrial Engineers (SAIIE) and as a result our annual conference is now accredited by the Engineering Council of SA (ECSA) so that SAIIE members can earn continuing professional points (CPD) by attending the ORSSA conference.
- Another project that is still in the planning phase is to increase the Society's marketing efforts to school children. More information on this will follow in the 2016 Newsletters.
- The Society's online database and website has been in need, for a long time, of urgent maintenance. In certain instances new functionality was needed. Our webmaster, with the help of other exec members, has initiated a new project to develop and maintain a significant number of new functions in the website and online database. I believe that we will see the first results early in 2016.
- ORSSA as a society has to comply with the new Protection of Personal Information Act (POPI) and members are urged to familiarise themselves with the requirements of the act. Information on the act was published in the October Newsletter and will also be available on our website.

A few members are leaving the national Executive Committee at the end of the year. They are Tiny du Toit (National Treasurer), Louzanne Oosthuizen (Additional member) and Margarete Bester (Additional member). I would like to express my sincere thanks to these three members for their hard work and commitment during the past few years. Newly elected members that will join the Executive Committee are Isabel Nieuwoudt (National Tresurer) and Brian van Vuuren (Additional member). Welcome to Brian and Isabel (who rejoins the exec after a period of respite) and thank you for your willingness to serve on the Executive Committee – we are looking forward to your contributions.

Winnie Pelser has served as vice-president during 2015 and will become the 30th president of ORSSA on 1 January 2016. She will then lead the Executive Committee in serving ORSSA until the end of 2017 after which she will become the vice-president again for a further year. I would like to thank Winnie for all her support during 2015 and wish her all the best for her term as president.

Finally, I want to thank each and every member and especially the members of the Executive Committees of 2014 and 2015 for their support, goodwill and friendly assistance during the time that I served as president. It has been an honour and a privilege for me to serve on ORSSA's Executive – a truly enjoyable experience that I will never forget. Thank you.

All that remains now is to wish you all a prosperous festive season and new year. I trust that the festive season will be an opportunity to rest and a time to experience peace and goodwill before we take on the new 2016 challenges.

With best wishes / Alles van die beste
Hennie Kruger

Risk Game: Luck or Strategy?

By PD de Wet (15691640@sun.ac.za), L Potgieter (lpotgieter@sun.ac.za), Stellenbosch University, Department of Logistics & JJ Potgieter (cobusp@zurion.co.za), Zurion Solutions, Stellenbosch

Pieter de Wet

Among their cuisine, champagne, films, the metric system, Jules Verne (the father of science fiction) and Louis Pasteur (the father of microbiology), to name but a few, the game *Risk* (created in 1959 by Albert Lamorisse) is considered by some to be one of those undeniably great things to come out of France. Others may want to argue the opposite. The most common feelings towards the game may perhaps be summarised by:

1. *You're winning.* Risk is the greatest board game, ever!
2. *You're losing.* Risk is the most retardedest game ever, and I'm never going to play it again!

Risk was published about 50 years ago by the Parker Brothers, the same people who created Monopoly. The game is a complex and dynamic board game which involves both luck and skill to accomplish the simple goal - try to take over the world (yes...just like *Pinky and the Brain!*). It is a war based board game played on a board depicting the world map divided into 42 territories, which are also grouped into 6 continents, as shown in Figure 1. Players attempt global domination by eliminating all other players from their territories. Up to six players can play simultaneously, using different coloured troops to distinguish between players. Players are eliminated when they lose all of their troops on the game board. The objective is then to occupy every territory on the board and thus obtain world domination.

Figure 1: Example of a *Risk* board game.

Linke Potgieter

To initialise a game, all the territory cards are shuffled and dealt to the players. Players must then place one soldier on each of the territories for which they received a territory card. Each player will have a remaining number of soldiers which are placed, one at a time and in turn, to fortify territories (initial reinforcement). After all the cards have been returned and shuffled, the game may commence with turn based play. A turn of play in *Risk* consists of seven phases:

1. *Determining how many soldiers to obtain this round.* The number of new soldiers per round depends on the number of territories as well as whole continents controlled, and cards traded for reinforcements.
2. *Placement of new soldiers.* New soldiers may be placed on any territories controlled by the player.
3. *Attack phase.* The player may attack another player by initiating a battle between a territory controlled by the player and an adjacent enemy controlled territory. The outcome of a battle is determined by the roll of dice. This can be repeated multiple times during a turn.
4. *End of attack phase.* The end of the attack phase occurs when the player decides not to or is not able to initiate another battle. The player is not able to initiate another battle if all of the player controlled territories neighbouring enemy controlled territories only contain one soldier.
5. *Choice to make free moves if possible.* The player may choose to perform a single troop movement from one territory to an adjacent territory, while at least one soldier remains at the origin.
6. *Take a card.* The player may take a territory card if he has conquered a territory during the turn. A maximum of one card may be taken per turn.
7. *End of play.* A player ends his turn by passing the dice to the next player.

Apart from the luck aspect in throwing dice, *Risk* is also a game of strategy. In order to win, it helps if players are skilled in troop deployment and are aware of the underlying probabilities present in the game. The strategies used to play the game may be divided into two types, namely global strategies and sub-strategies.

Sub-strategies focus on the individual phases of play, whereas global strategies consist of multiple sub-strategies to accomplish a certain goal. A global strategy is decided upon before the start of the game and will usually remain constant throughout the game, while the sub-strategies used will most likely change during the progression of the game. Everybody adopts their own strategy through experience, but the question remains: which strategy is the best, or if there even is an optimal strategy versus the player's luck in rolling the dice? Pieter de Wet, currently a MCom (Operations Research) student at the Department of Logistics, Stellenbosch University, decided to try and address this question (or at least partially), in his honours year research assignment. The study focussed on comparing different strategies for the two phases of the game, namely the *initial reinforcement* and *attack* phases. A simulation model of the board game was developed to test the success of the various strategies. Simulation was used instead of experimental observation, since obtaining real-life data from actual games played can be very time consuming. It will also be very difficult to be certain if the same strategy was maintained throughout the game, as human players are easily influenced and even small changes may lead to a different strategy altogether.

Previous research

Many articles have been written about stochastic outcomes in the context of board games. After Ash and Bishop [1] applied Markov chains to determine the steady state probabilities for occupying certain properties in the game Monopoly, Tan [10] showed how Markov chains can be used to model the probabilities of the stochastic dice roll outcomes in the game *Risk*. The joint distributions if both players used more than one dice was, however, miscalculated and was later corrected by Osborne [9], who obtained the correct transition probabilities while also calculating the different probabilities of winning given the attacker and defender's initial army size. Koole [5] used dynamic programming to determine the optimal dice rolling strategy for the defender, while Maliphant and Smith [8] also applied dynamic programming to *Risk* in calculating, like Osborne, the probabilities of the attacker winning the battle given the initial army sizes. Harju [4] calculated winning probabilities by also considering the attacking of a single territory from multiple territories. He concluded that the game is almost solely dependent on luck, based on the large variance he obtained in his calculations. Lee [6] made use of Markov chains and Monte-Carlo simulation to consider the number of attacking soldiers used and concluded that it is optimal to attack with three soldiers if possible but otherwise to not attack at all. In the field of computer science, many Artificial Intelligence (AI) algorithms have been written to play the game of *Risk*, also producing versions of the game on computers, tablets and phones [3]. One of these versions is Domination, an open-source implementation of *Risk* created by Yura Mamyrin [7].

Methodology

An open-source computer-based *Risk* game, written in Python 2.7 by Bauman [2], was used as a basic framework from which to further develop a number of artificial intelligence (AI) players that utilise different initial reinforcement and attack strategies. The code makes use of a graphical interface where *Risk* may be played and the progression of the game may be witnessed. Many features of the code were not required for the purposes of this study, therefore the code was adjusted to only simulate games played between the multiple AI players that was developed in this study. The code was also adapted to run in Python 3.3.

Assumptions

Risk can be very complex, therefore a simplified version of the game was adopted with the following assumptions being made.

1. *Allocation of territories*
   The territories were allocated randomly, as to replicate the handing out of territory cards.
2. *Number of dice.*
   Both attacker and defender were assumed to always use the maximum allowed number of dice during battle.
3. *Cards*
   Cards are only traded in once the player has a total of five cards and therefore needs to trade in cards before allowed to acquire another card.
4. *Game objective*
   The only objective considered is where the player has to conquer all the territories in order to win.

Initial reinforcement strategies

Four initial reinforcement strategies were identified, with each of these strategies differing in respect to how territories are selected for the purpose of initial reinforcement. The four strategies considered are the *uniform*, *border*, *double* and *group* reinforcement strategies. In the *uniform* reinforcement strategy, all territories controlled by the player is allowed to be reinforced (an equal placement of soldiers in all territories). In the case of *border* reinforcement only territories that has non-player controlled neighbours are reinforced. The *double* reinforcement strategy has two lists of allowed territories with the first similar to the *border* reinforcement strategy and the second list containing all the player controlled territories which have a neighbour in the first list, but with no non-player neighbours. Soldiers are spread uniformly across the territories in both lists, but with the first list having priority over the second list. Lastly, the *group* reinforcement strategy allows placement of extra soldiers only on those territories which have both player and non-player controlled neighbours. In all cases, during each turn, a territory with the lowest army size is selected from the list of territories allowed to be reinforced according to the strategy. Once this territory is selected the player will place an additional soldier on this territory, repeating this process until no more soldiers remain for initial placement. Algorithm 1, for example, was developed for the *group* reinforcement strategy.

Algorithm 1 *Group reinforcement*

```
Require: Player, Player Territories
 1: tlist is an empty list
 2: a = 1
 3: ter = None
 4: while ter == None do
 5:    for t in Player Territories do
 6:       e = 0
 7:       f = 0
 8:       if armies on t == a then
 9:          for x in neighbours of t do
10:             if x is controlled by Player then
11:                f = f + 1
12:             else
13:                e = e + 1
14:          if f > 0 and e > 0 then
15:             append t to tlist
16:    if tlist == empty then
17:       a = a + 1
18:    else
19:       ter = random choice from tlist
20: return ter
```

The algorithm requires that the territories controlled by the player are known, after which an empty list, *tlist*, is created. In lines 2 and 3, the variables *a* and *ter* are initialised with 1 and "None", respectively. The algorithm continues until a territory has been chosen, each time determining which of the player controlled territories are eligible for selection. Two additional variables, *e* (line 6) and *f* (line 7), are introduced for each player controlled territory, after which line 8 ensures that only territories with army size *a* are considered further. In lines 9 to 13 each neighbour of the player controlled territory is inspected and the variables *e* and *f* updated, with *e* the number of opposing neighbours and *f* the number of player controlled neighbours. In line 15, only territories which have opposing and player controlled neighbours are included in *tlist*. After all territories have been considered, the contents of *tlist* are inspected in line 16. If *tlist* contains territories, a territory is randomly selected from the list, otherwise the variable *a* is increases by one and the algorithm goes back to line 5. This is then repeated until a territory has been selected.

Attack strategies

Two different types of attack strategies were identified, with each of these strategies differing in respect to how many territories are attempted to be conquered during each turn. The two types of attack strategies considered are the *fixed* and the *increasing* attack strategies. When using a *fixed* attack strategy, the limit on the number of territories that a player may possibly attempt to conquer during each turn is a fixed number decided upon at the start of a simulation. This number is referred to as the α value for the strategy. When using an *increasing* attack strategy the limit on the number of territories that a player may possibly attempt to conquer during each turn increases over time with a fixed value or according to a certain ratio of available versus conquered territories. In this case, the α value represents the target number or ratio at the start of the game. In both types of attack strategies, territories to be attacked are selected based on a two step procedure. The first procedure is aimed at conquering continents. If only one territory is required to control a continent, that territory will be targeted first. The second procedure is then aimed at selecting territories using the ratio between attacking and defending army sizes, with the most favourable ratio chosen first (this process is given in Algorithm 2). Once a battle is started it will only end if the player succeeded or ran out of usable soldiers.

Algorithm 2 requires the player controlled territories and the α parameter determined by the player strategy. In line 1, the algorithm checks whether another battle is allowed according to the player strategy, not selecting any territories if the limit has been reached. All the player controlled territories are inspected in line 7 to ensure that each territory has opposing neighbours and enough armies to initialise a battle. The opposing neighbour with the smallest army is determined in line 8, after which the ratio of the armies on the player territory compared to armies on the opposing neighbour is calculated. Line 10 ensures that

Algorithm 2 *Select attack territories*

Require: Player, Player Territories, α
if *conquered territories* $= \alpha$ **then**
    return None, None
FromTerr $=$ None
ToTerr $=$ None
MaxRatio $= 1$
for t **in** Player Territories **do**
    if at least one neighbour of t in not controlled by Player **and** armies on $t > 1$ **then**
        te $=$ neighbour not controlled by Player with smallest number of armies
        ratio $=$ armies on t / armies on te
        if *ratio* $>$ *MaxRatio* **then**
            MaxRatio $=$ *ratio*
            FromTerr $= t$
            ToTerr $= te$
return *FromTerr*, *ToTerr*

only territories where the player territory has more armies than the opposing neighbour are considered, with the choice of territories being updated if a higher ratio has been found.

Implementation of AI algorithms

An AI player was created for each combination of reinforcement and attack strategies, for example, the BIN1 player indicates that the *border* initial reinforcement strategy is used together with an *increasing* number attack strategy using the α value of 1, whereas the DIR5 player indicates that the *double* initial reinforcement strategy is used together with an *increasing* ratio attack strategy using the α value of 5. During the initialisation of a game, each player is randomly allocated territories, after which the territories are reinforced according to the player's initial reinforcement strategy. Once the turn based play starts, each AI player makes a number of decisions during their turn as may be seen in Figure 2.

The first decision each player needs to make is whether to trade in cards for extra reinforcements. If the player currently has five cards then the three cards given the most reinforcements will be traded in. The free armies obtained for the turn will then be allocated, where territories with the greatest risk from enemy troops are reinforced first. The player then decides whether or not to attack an enemy territory, with this decision based on the player's attack strategy as explained earlier. After the attacking phase is completed the final phase of fortification commences. During the fortification process the player territory with the greatest risk from enemy troops is selected to be fortified, with the fortifications coming from a neighbouring territory that has no enemy neighbours (if there is such a territory available). If such a territory cannot be found, the neighbouring territory with the largest army is selected and the number of armies moved is such that both territories have armies of equal strength.

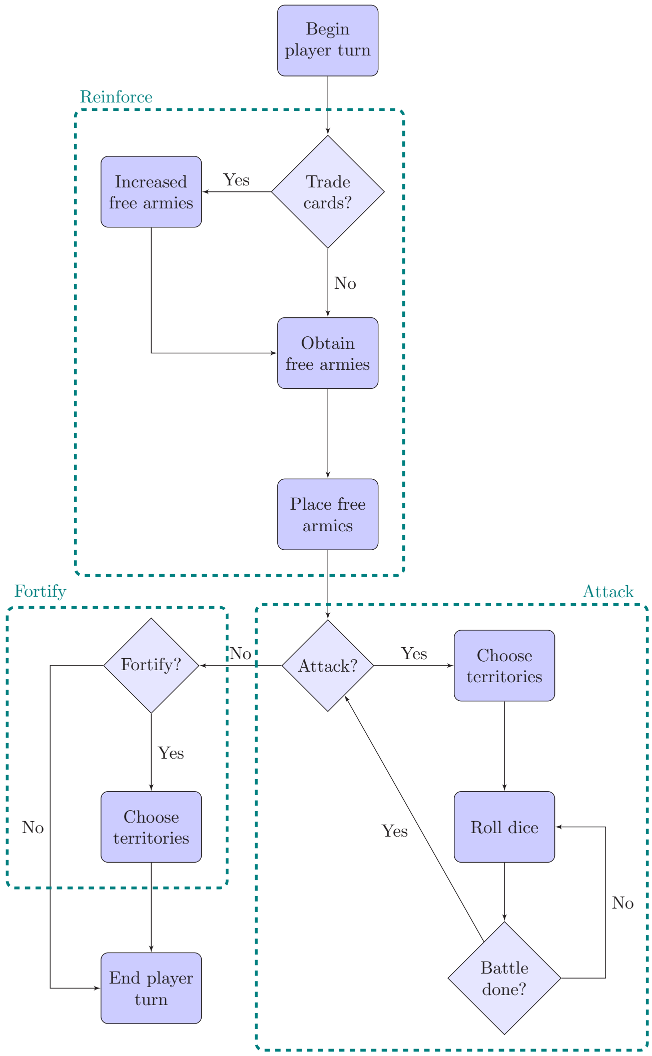


Figure 2: Flowchart for decisions of AI player during its turn.

Results

Games with different AI players playing against each other were simulated. The strategies utilised by the different players were compared using both the percentage of games won and the average length of a game based on a thousand games. The results of all the two-player games between different AI players are given in Table 1, where the win percentage is averaged over all games played. There seems to be a correlation between the aggressiveness and success of attack strategies, with no correlation between the initial reinforcement strategy used and the success achieved. The analysis of initial reinforcement and attack strategies was further extended by considering cases with more than two players.

Strategy	Average win %	Strategy	Average win %	Strategy	Average win %	Strategy	Average win %
BFN1	9.68%	DFN1	9.32%	GFN1	8.99%	UFN1	9.13%
BFN3	52.93%	DFN3	52.75%	GFN3	49.97%	UFN3	50.61%
BFN5	71.56%	DFN5	71.72%	GFN5	68.52%	UFN5	70.00%
BIN1	11.24%	DIN1	10.93%	GIN1	10.76%	UIN1	11.14%
BIN3	54.99%	DIN3	55.21%	GIN3	52.07%	UIN3	53.32%
BIN5	71.55%	DIN5	70.92%	GIN5	68.87%	UIN5	69.66%
BIR1	30.13%	DIR1	30.10%	GIR1	29.25%	UIR1	29.08%
BIR2	70.39%	DIR2	69.78%	GIR2	66.70%	UIR2	68.61%
BIR5	71.66%	DIR5	71.14%	GIR5	68.52%	UIR5	70.07%

Table 1: The average winning percentage for each AI player in a two-player game.

Initial reinforcement

To determine if a dominating initial reinforcement strategy exists, four-player games were simulated. For each instance, players had a different initial reinforcement strategy while having the same attack strategy. As may be seen in Figure 3, the *group* initial reinforcement strategy obtained the highest winning probability in all cases but one. The averages over all the different attack strategies were also calculated and it was found that the *group* initial reinforcement strategy outperforms all the others on average.

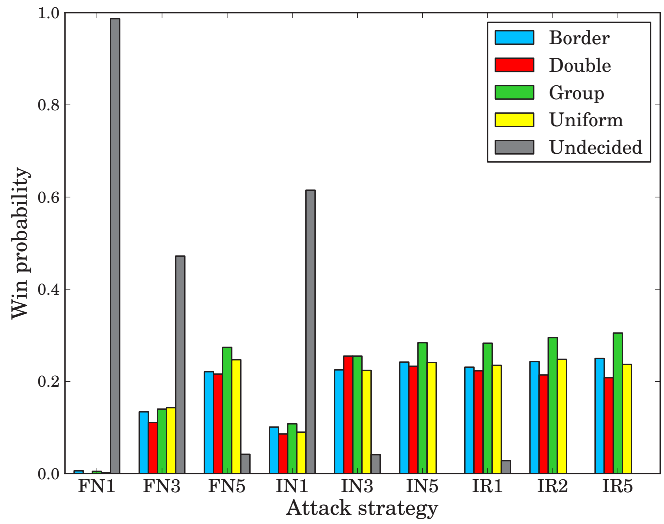


Figure 3: The average win probability for initial reinforcement strategies per attach strategy.

for all initial reinforcement strategies. The average game lengths were also inspected where it was clear that when FN1 was the winner, the games were much longer compared to when one of the more aggressive players won.

An example of the case where the defensive player wins may be seen in Figure 5, where the game is very long. In this game, the defensive player's army steadily increases while the other players mostly attack each other, after which the defensive player easily defeats

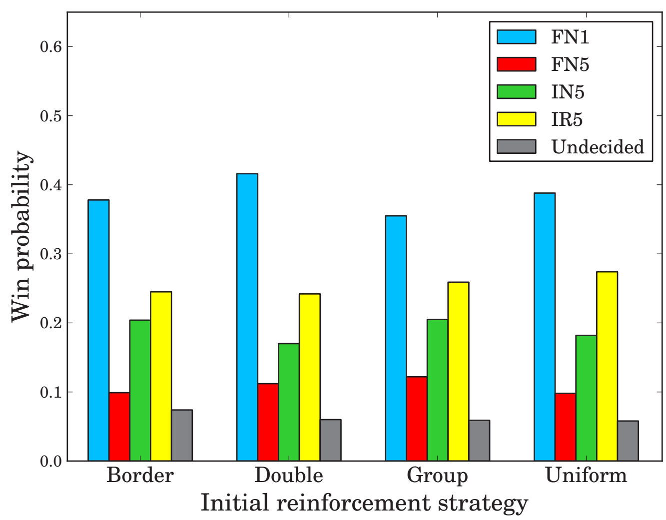
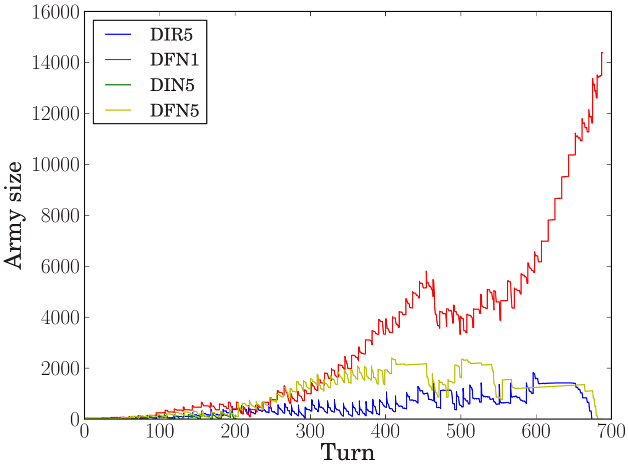


Figure 4: The average win probability for the best α values for each type of attack strategy.

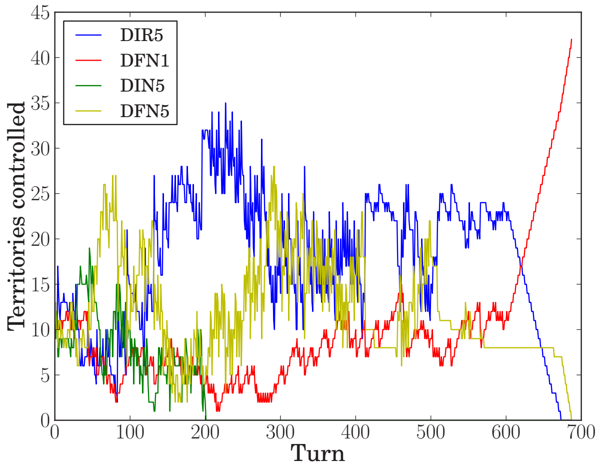
Attack strategies

Attack strategies were compared using three-player games, where all players had the same initial reinforcement strategy as well as the same type of attack strategy, but with different α values. The three types of attack strategies were tested separately, thereby obtaining results about which α value is best given the attack strategy. These results were then used to compare the different types of attack strategies, where only the best performing α values for each type were considered. In the case of the fixed number attack strategies, the α values of 1 and 5 both performed well and were therefore both considered. The results are illustrated in Figure 4, where it may be seen that the defensive strategy, FN1, outperformed all other strategies,

the two weakened opponents one territory at a time with its overwhelming military force. An aggressive player would therefore need to win a game as quickly as possible to avoid the scenario seen in Figure 5. This makes the aggressive player very high risk and dependent on the luck of the dice. An example of where the aggressive player won by achieving victory before the opponents' armies are too large, is given in 6. Here it is clear that from the start, the momentum was on the aggresive player's side with the player always controlling the majority of territories. The large number of territories led to an ever increasing supply of soldiers and the game quickly reached a point where the other players could not compete any more.

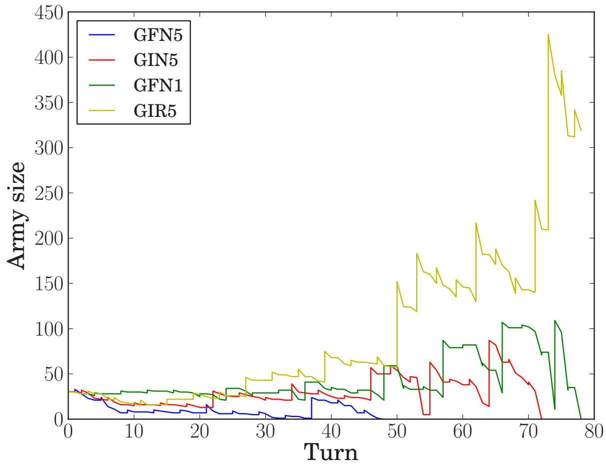


(a) Progression of army size

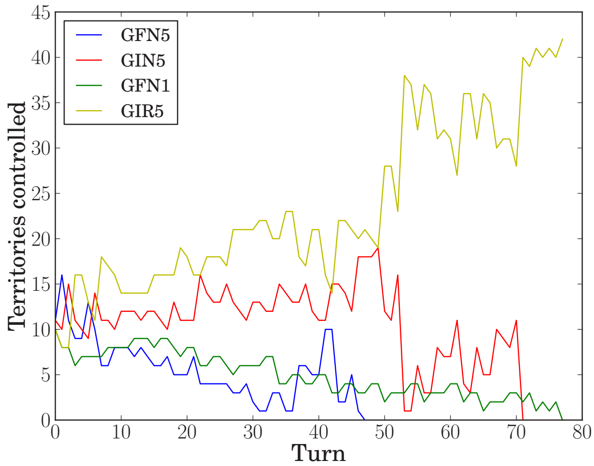


(b) Progression of territories

Figure 5: An example of the progression during a four-player game where DFN1 was the winner.



(a) Progression of army size



(b) Progression of territories

Figure 6: An example of the progression during a four-player game where GIR5 was the winner.

Recommendations

There are clear differences in the outcomes between the two-player case compared to the case where more than two players are playing the game. Therefore, recommendations are made subject to the number of players playing the game. The initial reinforcement strategies did not influence the winning probability for the two-player case, however, when more than two players partake in the game, the *group* initial reinforcement strategy emerges as a dominating strategy. It is therefore recommended that this strategy be adopted, even for the two-player case. In the two-player case it was found that adopting a more aggressive attack strategy had the highest probability of success. Further analysis on three-player games, and later four-player games, was done with the more defensive strategy, FN1, outperforming all the rest. It is therefore recommended to play defensively until only two players are left, after which a more aggressive approach should be adopted.

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To Invest or Not to Invest?

by GJ Toplis(15337138@sun.ac.za), L Potgieter (lpotgieter@sun.ac.za) & JH Nel (jhnel@sun.ac.za), Stellenbosch University, Department of Logistics

Linke Potgieter

Peter Lynch, an American businessman and the manager of the Magellan Fund at Fidelity Investments between 1977 and 1990, once said that an investment is simply a gamble in which you have managed to tilt the odds in your favour. In fact, he managed to tilt the odds to such an extent so as to obtain an averaged 29.2% annual return, consistently more than doubling the S&P 500 market index – the gold standard in the stock market – and making it the best performing mutual fund in the world. During his tenure, assets under management increased from $18 million to $14 billion. As a result of his performance record, he is frequently described as a *legend* in the financial media. Sam Stovall, chief investment strategist at S&P Capital IQ, made the following comment: "A lot of people regard investing as gambling, but I frequently say no. Which casino in Atlantic City, Las Vegas or Macau pays the bettor 73% of the time?". That's the percentage of time that Stovall's research shows the S&P 500 has increased in value during the years since 1926. One would think those are pretty good odds, with very low downside risk. So although some would argue that investing in the stock market has lots in common with gambling, gambling entails much more downside risk than investing, making it in the long run a much riskier thing to do, and the stock market a lot more forgiving.

So how do you manage to tilt the odds in your favour and make investment less of a gamble? Peter Lynch also made the following comment: "If you don't study any companies, you have the same success buying stocks as you do in a poker game if you bet without looking at your cards." So the secret in changing your investment to less of a gamble is in doing proper research. Selecting a portfolio of stocks in which to invest is, however, an extremely challenging endeavour as there are so many factors to take into consideration regarding the current state of the financial market, historical performance of the stocks and which stocks to combine in a portfolio. This is exactly the problem that Gillian Toplis, a BCom Honours (Quantitative Management) student at the Department of Logistics, Stellenbosch, decided to tackle for her year project. She wanted to know if there was any chance in tilting the odds when applying something even as basic as modern portfolio theory to selecting a portfolio from the Johannesburg Stock Exchange Top 40 companies.

Gillian Toplis

Markowitz first introduced the use of mathematical modelling to aid in the selection of a portfolio when he developed the mean-variance model that maximises the expected return of a portfolio given a certain level of risk, or minimises the risk given a certain level of expected return [1,2]. This formed the basis of modern portfolio theory (MPT). Markowitz received the Nobel Prize for his contribution to financial economics in 1990. His research aimed to provide decision support as to what securities to include in a portfolio by making use of historical data to estimate future performance, and by also taking into account diversification and the investor's preferences. Diversification is a key element in MPT as it is argued that a balanced (diverse) portfolio consisting of more than one security may produce an overall lower risk compared to single securities regardless of the movements in the financial markets. MPT makes a number of simplifying assumptions that have, in the meantime, been proven to be rather unrealistic: the monthly returns are normally distributed; the risk associated with a portfolio is defined as the variance (or standard deviation); the correlation between assets are fixed throughout the period; investors are rational and are seeking a high return, with the lowest risk possible.

For the purposes of her project, the mean-variance model that was developed by Markowitz was altered to formulate a multi-objective non-linear programming model that allows for the simultaneous maximisation of return and minimisation of risk. Furthermore, an additional constraint was also added to limit the number of securities in which may be invested to investigate the effect of diversification. A multi-objective approach was chosen as it was deemed more practical to ask an investor what their risk preference is relative to their required rate of return, compared to that of asking for a specific level of return or variance. The multi-objective non-linear programming problem is given by

$$\text{Minimise } (1-\alpha)\,\frac{V_p - T_v}{T_v} - \alpha\,\frac{R_p - T_r}{T_r}, \tag{1}$$

$$\text{s.t.} \sum_{i \in \mathcal{A}} X_i = 100, \tag{2}$$

$$X_i \geq 0 \qquad i \in \mathcal{A}, \quad (3)$$

$$\sum_{i\in\mathcal{A}} U_i \leq s, \quad (4)$$

$$-(X_i - 1) \leq Mt_i \qquad i \in \mathcal{A}, \quad (5)$$

$$U_i \leq M(1 - t_i) \qquad i \in \mathcal{A}, \quad (6)$$

$$U_i \geq X_i m \qquad i \in \mathcal{A}. \quad (7)$$

where A denotes the set of securities in which to be invested, X_i denotes the weight invested in security i (given as an integer between 0 and 100), R_p denotes the monthly return of a portfolio and V_p denotes the variance of a portfolio. Furthermore, in order to combine the two different objectives, each objective is standardised to a percentage from a certain target value. The target values of the maximum return, T_r, and minimum variance, T_v, are obtained by using the single objective Markowitz model. Finally, the binary decision variable U_i is introduced where

$$U_i = \begin{cases} 1 & \text{if } X_i > 0 \text{ then security } i \text{ is used,} \\ 0 & \text{otherwise.} \end{cases}$$

Constraints (2) and (3) ensure that the full amount is invested and that there is no short selling, respectively. Constraint (4) enables a specification of the number of securities in which may be invested within the portfolio by using the constant s. Constraints (5) and (6) are the linking constraints of the binary variable U_i with X_i where M is a large number, and t_i is a binary variable that is introduced for the use of this if-then constraint. These constraints ensure that, should the security be selected for investment, with $U_i = 1$, that a percentage is invested in that security, i.e. $X_i > 1$. Constraint (7) ensures that U_i is selected if $X_i > 0$, where m is a small number. Therefore, should $t_i = 0$ then $X_i \geq 1$ due to constraint (5), and $U_i = 1$ in order to satisfy constraint (7) Should $t_i = 1$ then $U_i = 0$ due to constraint (6), and $X_i = 0$ because of constraint (7). By altering the value of α in the multiple objective model, low, medium and high risk portfolios may be obtained.

The results from this model was used to select nine portfolios, which included portfolios of 5, 10, and 15 securities with a low, medium and high risk preference. An alpha value of 0.2 was chosen to represent a low risk preference, 0.5, a medium risk preference, and 0.8, a high risk preference. The portfolios selected were evaluated by comparing their respective returns to the Johannesburg Stock Exchange Top 40 Index, as well as by using the performance measures of the Sharpe [3], Treynor [5], and Sortino [4] ratios. Historical data [6] from January 2002 until December 2011 were used to calculate the expected return and variance of the various securities for portfolio selection, whereas the performance of portfolios was evaluated from January 2012 until April 2015. The portfolios selected are shown in Tables 1–3, with the respective

Low Risk		**Medium Risk**		**High Risk**	
Company	X_i (%)	Company	X_i (%)	Company	X_i (%)
*Mediclinic	41	*Mediclinic	58	*Shoprite	39
*Growthpoint Properties	32	*Shoprite	17	*Aspen Pharmacare	26
*IntuPlc	13	*Growthpoint Properties	15	*Mr Price	22
Sasol	8	Aspen Pharmacare	9	Anglo	7
Discovery Holdings	6	Mr Price	1	MTN	6
Total	100	**Total**	100	**Total**	100
Alpha (α)	0.2	**Alpha** (α)	0.5	**Alpha** (α)	0.8
Return	0.01191	**Return**	0.01760	**Return**	0.02578
Variance	0.18262	**Variance**	0.24031	**Variance**	0.30917

Table 1: The percentage invested in portfolios of 5 securities with varying risk preferences.

Low Risk		**Medium Risk**		**High Risk**	
Company	X_i (%)	Company	X_i (%)	Company	X_i (%)
*Mediclinic	19	*Mediclinic	18	*Shoprite	32
*Growthpoint Properties	17	*Shoprite	17	*Aspen Pharmacare	18
*Shoprite	13	*Growthpoint Properties	16	*Mr Price	15
*IntuPlc	12	*Sasol	11	*Sasol	13
*Sasol	11	*Aspen Pharmacare	9	Mediclinic	9
*Tiger Brands	8	*IntuPlc	8	Tiger Brands	5
SAB	7	Tiger Brands	7	BHP Billiton	3
Aspen Pharmacare	6	SAB	6	Growthpoint Properties	3
Discovery Holdings	6	Discovery Holdings	5	MTN	1
Nedbank	1	AngloGold	3	SAB	1
Total	100	**Total**	100	**Total**	100
Alpha (α)	0.2	**Alpha** (α)	0.5	**Alpha** (α)	0.8
Return	0.01445	**Return**	0.01596	**Return**	0.02285
Variance	0.14026	**Variance**	0.14248	**Variance**	0.21718

Table 2: The percentage invested in portfolios of 10 securities with varying risk preferences.

Low Risk		Medium Risk		High Risk	
Company	X_i (%)	Company	X_i (%)	Company	X_i (%)
*Mediclinic	18	*Mediclinic	17	*Shoprite	31
*Growthpoint Properties	16	*Shoprite	17	*Aspen Pharmacare	18
*IntuPlc	13	*Growthpoint Properties	14	*Mr Price	14
*Shoprite	12	*Sasol	10	*Sasol	12
*Sasol	8	*Aspen Pharmacare	9	*Mediclinic	9
*AngloGold	6	*IntuPlc	7	BHP Billiton	3
*Discovery Holdings	6	*Tiger Brands	7	Growthpoint Properties	3
SAB	6	Discovery Holdings	5	Tiger Brands	3
Aspen Pharmacare	5	SAB	5	AngloGold	1
Tiger Brands	5	AngloGold	4	Discovery Holdings	1
Bidvest	1	Barclays Africa	1	MTN	1
Nedbank	1	BHP Billiton	1	Naspers	1
Netcare	1	Mr Price	1	Netcare	1
RMBH	1	Netcare	1	SAB	1
Sanlam	1	Remgro	1	Woolworths	1
Total	100	**Total**	100	**Total**	100
Alpha (α)	0.2	**Alpha** (α)	0.5	**Alpha** (α)	0.8
Return	0.01364	**Return**	0.01624	**Return**	0.02280
Variance	0.13679	**Variance**	0.14461	**Variance**	0.21760

Table 3: The percentage invested in portfolios of 15 securities with varying risk preferences.

percentage invested in each security and the value of the return and variance of the portfolio. The securities that fall within the top 80% of the percentage invested are shown using an asterisk (*). The most prominent securities are Aspen Pharmacare, Growthpoint Properties, Mediclinic and Shoprite, which are included in 8 out of the total 9 portfolios, Sasol which is included in 7 of the 9 portfolios, and Discovery, SAB and Tiger Brands which are included in 6 of the 9 portfolios. The securities that fall into all three types of risk are AngloGold, Aspen Pharmacare, Discovery, Growthpoint Properties, Mediclinic, Netcare, SAB, Sasol, Shoprite, and Tiger Brands. The portfolio with the highest expected return and variance is the high risk, 5 securities portfolio. The portfolio with the lowest expected return is the low risk, 5 securities portfolio, and the low risk, 15 securities portfolio has the lowest variance.

All the portfolios constructed using the multi-objective model performed better than the Johannesburg Stock Exchange Top 40 Index over the performance period, with the 5 securities, medium risk portfolio performing the best according to its cumulative monthly return. The second highest is that of the low risk, 5 security portfolio, and the third is between the high risk portfolio of 15 securities and the high risk portfolio of 5 securities. The cumulative return of each portfolio, as well as that of the JSE Top 40 Index is shown in Figure 1, assuming that R100 is invested at the beginning of January 2012.

The performance measures of Sharpe, Treynor, and Sortino were also calculated for the nine portfolios. The Sharpe ratio was compared using two observation dates, namely, the date the portfolio was selected (January 2012) and the end of the performance peri-

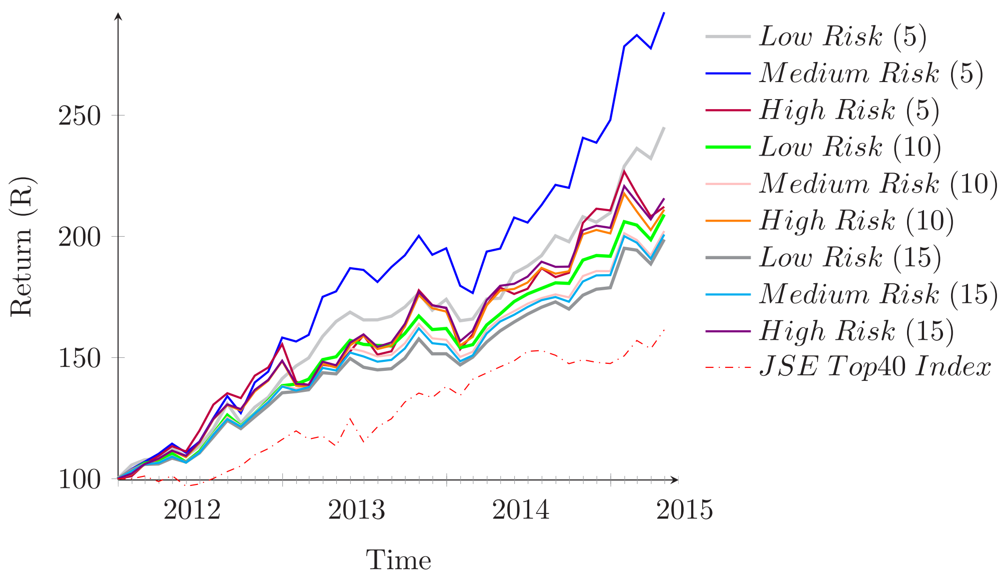

Figure 1: Cumulative return of all portfolios compared to the JSE Top 40 Index over performance period.

Securities	Risk Preference	01/12/2011		01/04/2015	
		T-Bill (91 day)	Jibar (3 month)	T-Bill (91 day)	Jibar (3 month)
	Low	0.077	0.074	0.149	0.142
5	Medium	0.183	0.180	0.245	0.239
	High	0.308	0.306	0.285	0.280
	Low	0.155	0.152	0.186	0.179
10	Medium	0.194	0.191	0.210	0.203
	High	0.305	0.302	0.284	0.278
	Low	0.135	0.132	0.166	0.158
15	Medium	0.200	0.197	0.214	0.206
	High	0.304	0.301	0.289	0.283

Table 4: The Sharpe ratio at the two observation points.

od (April 2015). When the portfolios were selected, the best portfolio was the high risk, 5 securities portfolio, however, at the end of the performance period the more favourable portfolio was the 15 securities portfolio with a high risk preference. The second and third best portfolios in January 2012 are the high risk, 10 securities portfolio and the high risk, 15 securities portfolio, respectively. At the end of the performance period, the second and third best portfolios are the high risk, 5 securities portfolio and high risk, 10 securities portfolio. The worst portfolio at both the beginning of the portfolio selection, and at the end of the performance period, is the 5 securities portfolio with a low risk preference.

The Treynor and Sortino ratios were calculated in April 2015, where the Treynor ratio showed the 5 securities, high risk preference portfolio to be the best. The Sortino ratio for a minimum return of 1% evaluated the high risk, 15 securities portfolio to be the best, whereas for a 2%, 3%, 4%, and 5% minimum acceptable return the best portfolio was that of the high risk, 5 securities portfolio. The Treynor and Sortino ratios are given in Table 5. The Sortino ratio is shown for varying minimum acceptable returns R_{min} ranging from 1–5%.

Overall, when looking at which portfolio is the best investment option to recommend, according to the cumulative return, the 5 securities portfolio with a medium risk preference is most preferable, however, the performance measures evaluate the 5 securities, high risk portfolio to be preferable. The 5 securities portfolios perform better than that of the 10 and 15 securities portfolios, so it is recommended that a smaller amount of securities with diversification be selected to invest in. For all the risk preferences the 5 securities portfolios did marginally better than the 10 and 15 securities portfolios. While this suggests that a portfolio does not necessarily need to be diversified, the companies within a 5 securities portfolio are from diverse industries including pharmaceutical, retail, telecom, and mining securities, amongst others. This shows that diversification is still imperative to portfolio selection and the correlation between securities that is taken into account with the covariance ensures the model selects a diversified portfolio. Also noteworthy, is that for all the portfolios, 80% of the portfolio is invested within 5 to 7 of the securities, therefore the rest of the securities in the 10 and 15 securities portfolios do not have a significant effect on the performance of the portfolio. Therefore, diversification is not necessarily correlated with investing in more securities, but rather investing in securities from diverse industries.

These calculations are, however, based on the key assumptions of MPT, namely that the monthly returns of the securities are normally distributed, that risk is quantified by the use of the variance, and that the correlation between two securities remains constant, which have been proven to not always be the case in practice. Despite these unrealistic assumptions, this study did point out that it is possible to tilt the odds in your favour. So to invest or not to invest...invest smartly!

Securities	Risk Preference	Treynor ratio		Sortino ratio				
		T-Bill (91 day)	Jibar (3 month)	$R_{min} = 1\%$	$R_{min} = 2\%$	$R_{min} = 3\%$	$R_{min} = 4\%$	$R_{min} = 5\%$
	Low	0.144	0.131	0.097	-0.332	-0.610	-0.787	-0.897
5	Medium	0.402	0.389	0.335	-0.087	-0.375	-0.574	-0.710
	High	1.166	1.147	0.505	0.159	-0.101	-0.296	-0.444
	Low	0.263	0.249	0.255	-0.244	-0.539	-0.719	-0.829
10	Medium	0.336	0.323	0.340	-0.174	-0.476	-0.659	-0.775
	High	0.718	0.704	0.503	0.092	-0.195	-0.398	-0.543
	Low	0.201	0.189	0.225	-0.292	-0.583	-0.752	-0.852
15	Medium	0.329	0.316	0.353	-0.161	-0.463	-0.648	-0.764
	High	0.690	0.676	0.525	0.094	-0.203	-0.411	-0.557

Table 5: The Treynor and Sortino ratios of the nine portfolios.

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Movie Review: 21

by Brian van Vuuren (16057651@sun.ac.za), Department of Industrial Engineering, Stellenbosch University

Brian van Vuuren

If gambling really were only about winning, casinos would surely fail to ever make a profit. Everybody knows the odds always favour the house – that the bettors are many, but the winners are few. And yet, gambling is still a multi-billion dollar industry worldwide. It's because, they don't just sell steep odds: they sell 'the rush'. The notion that, however irrational or unlikely, maybe the dice will roll, the cards will arrange themselves or the slot reels will align in your favour tonight - and prove that perhaps there is such a thing as a free lunch…

So what if someone devised a system for playing blackjack that increased your edge over the dealer. A strategy that, if carefully observed by a team of highly intellectual participants, helped you beat the house, get the 'rush' and take home hundreds of thousands of dollars every weekend? Inspired by the real-life story of a group of M.I.T students who took Las Vegas casinos for millions in 1993, 21 is the story of a team who did exactly that.

Ben Campbell (Jim Sturgess) is an MIT senior math major who has been accepted to Harvard Medical School, but cannot afford the $300 000 fees. After challenging Ben in class with the Monty Hall problem in one of his lectures, Micky Rosa (Kevin Spacey) recognises Ben's intellectual ability and asks him to join his blackjack team. Reluctantly, Ben joins in an attempt to fund his studies. The team of students uses card counting to up their odds and take Las Vegas casinos for huge sums of money during luxurious weekend trips to the gambling capital of the world.

Card counting is a strategy employed by teams during gambling to determine whether the next hand is more likely to be of advantage to the player or the dealer. Most commonly, the premise of card counting is based on the statistical evidence that high cards (particularly 10s – Jacks, Queens and Kings also count as 10s - and aces) benefit the player more than the dealer, whilst low cards (3s, 4s, 6s and especially 5s) hurt the player whilst helping the dealer. Furthermore, when a high concentration of 10s remain in the 'shoe' (the gaming device from which the dealer pulls the cards), players have a better chance winning when doubling up. Low cards benefit the dealer since, when the dealer has a stiff hand (12-16 total), he has to 'hit' (draw another card) whilst the player has the option to hit or stand. This means a 10 will always cause the dealer to go bust when drawn, making it essential to track during counting.

In very basic terms, card counting assigns positive, zero or negative value to each card value available. When a particular card is dealt, the count is adjusted by that card's counting value. Low cards increase the count since they increase the percentage of high cards remaining in the shoe, whilst high cards decrease the count for the opposite reason. Neutral cards neither increase nor decrease the count. Different counting strategies allocate the count in a variety of manners, deciding what constitutes addition, subtraction or no change.

In essence, a team is divided into 'spotters' and 'big players'. Spotters occupy tables, playing the minimum bet and keeping count. Once the table count becomes favourable, they secretly signal the 'big players' to join the tables, communicate the value of the count using a pre-devised code words linked to each number, and let the statistical advantage do the rest.

As Ben and the M.I.T team make frequent successful visits, he comes to enjoy the luxurious life as a 'big player'. His performances also impress fellow teammate Jill (Kate Bosworth) who develops a mutual attraction to him. Back home, Ben's consistent absence begins estranging him from his friends and family and he begins to blur the line between funding his future, and living the 'high life'.

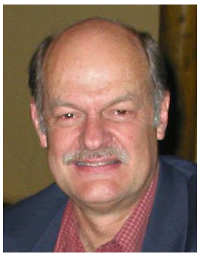
21 is an intellectual film which, refreshingly, doesn't shy away the maths and statistics behind card counting and gambling in general, whilst still entertaining an underlying romantic subplot, as well as a fair helping of action when old-school casino security chief Cole Williams (Lawrence Fishburne) begins monitoring the high-flying team.

Released in 2008, 21 still entertains a diverse audience even today and is a fun watch in particular for a scientifically-inclined audience. Don't expect to get too many tips to make you rich since card counting today has been heavily combatted by automatic shufflers, as well as multiple revolving card decks being used at one table. None-the-less, whatever your appetite for risk or gambling, it is 123 minutes well spent and an interesting story set against the age-old gambling ideology that "the house always wins".

Ratings:
IMDB: 6.8/10
Rotten Tomatoes: 36%
Metacritic: 48%

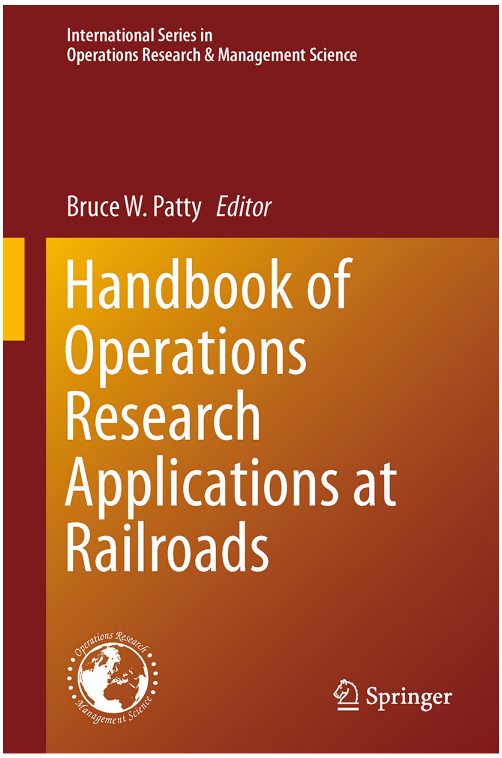
Book Review: Handbook of Operations Research Applications at Railroads

by Hans Ittmann (hittmann01@gmail.com), University of Johannesburg



Hans Ittmann

The history of rail transport dates back to the time of the ancient Greeks. "Wagonways" were relatively common, especially for mining purposes in Europe during the 1500s through to the 1800s. Mechanised rail transport systems using steam locomotives first appeared in England during the late 1700s and early 1800s when the first public steam railway in the world started operating in 1825. Railroads played a critical role during the Industrial Revolution and have since remained the primary form of land transport across most of the world. Today, they are certainly the most cost effective means of transporting freight over long distances. While providing enormous opportunities for applying Operations Research, the area is full of challenges even in gaining an understanding of railroad terminology and concepts, and in dealing with operational complexities.



Initially working on airline problems, the editor found a striking difference in problem complexity, namely: connecting a rail-car from an inbound train to an outbound train takes time and requires people, tracks and locomotives; on a specific railroad, one can only have "one-way traffic", i.e., a train cannot travel over another; where the same line is used for passenger and freight transport, passenger trains, in some cases, always get priority; it is possible to carry more passengers or freight with an additional engine; having to deal with axle load of a track, network electrification varying along older tracks, track capacity which can be increased by adding train passing sidings or "crossing loop lengths" and easing critical curves and gradients.

The aim of the handbook is clearly stated as "exposing the reader to the complete spectrum of the role Operations Research has played and can play in the improvement of freight railroads". Although all the material presented in the handbook originates from applications in Northern America, it is of universal interest. However, differences in terminology, operating rules and procedures are noted. The book explores how decisions are made at railroads with examples of mathematical programming formulations to address the complex problems and tools being used with the associated IT challenges. The emphasis is clearly on operational railroad aspects.

There are eleven chapters in the book, each addressing a clearly defined railroad topic. The authors of the various chapters are experts in their respective fields with extensive knowledge and understanding of the topics covered. Topics of the various chapters follow:

- **Train Scheduling** – covers the role of the train schedules, schedule data elements, design and real-time management. The critical concept of rail car blocks is explained in detail. A block is a grouping of rail cars that have disparate origins and destinations, transported by a train or multiple trains, as one grouping from a common assembly point to a common disassembly point where, in turn, cars can be broken up and where the process can be repeated till the railcar arrives at its final destination.
- **Locomotive Scheduling** – involves assigning a set of locomotives to each train so that the assignment satisfies hard and soft business constraints while minimizing total costs. The critical concept of consist-busting is explained. (A consist is a set of locomotives assigned to a train.)
- **Simulation of Line Road Operations** – devotes a lot of analytic effort on these methodologies used extensively by line road operations and railroad planning departments to justify capital investments. Simulations are used to analyse whether the envisaged capacity (and capacity expansion) on a line can in fact be achieved. Here, the meet-pass planning process is critical. (A process where a set of trains, either following or opposing one another - a pass or a meet, respectively - will be routed to resolve any conflict in a network of more than one track.)
- **Car Scheduling/Trip Planning** – involves modelling that answers two main questions: In what block should a shipment be placed given its current location? What train should be used to advance the block to its destination?
- **Railway Blocking Process** – links with the chapter on train scheduling as it explains what is required to design a blocking plan. Two issues addressed are: What is the overall number of blocks that must be created at a location? Which traffic should be placed into each block?
- **Crew Scheduling** – minimizes operating costs while satisfying regulations and work rules that ensure quality of life for the crew.
- **Empty Railcar Distribution** – deals with the rail-owned empty railcar return to the shipper. This is called the empty railcar distribution problem. A whole range of considerations are given that contributes to problem complexity.
- **Network Analysis and Simulation** – considers a range of disparate changes effecting decisions using network analysis and simulation, deterministic simulations with fixed plans and no capacity constraints, capacitated simulations with dynamic plan elements, among others.
- **Simulation of Yard and Terminal Operations** – includes methodologies leading to: improved operations through training or improved processes; identification of capital investment requirements; evaluation of train schedule feasibility; and providing a replay capability within the simulation.
- **Operations Research in Rail Pricing and Revenue Management** – deals with improved revenue management since deregulation in the US through a whole range of analytical techniques.
- **Intermodal Rail** – considers the movement of containerized cargo using rail in combination with road/truck and ship. Intermodal rail is shown as a critical element in efforts to shift freight from road to rail. The chapter addresses aspects such as pricing, size of the container fleet, container assignment, etc. Clearly a whole multitude of issues are considered.

The Handbook of Operations Research Applications at Railroads succeeds in its objective of exposing the reader to the use and implementation of OR within railroads. Every topic is clearly outlined with an explanation of issues that need to be considered. Every model formulation with its constraints, objective function and solution approach is presented well. The book focusses largely on railroad operating applications and is an ideal resource for academics, experienced researchers, and consultants in the field. Aspects falling outside the operating environment such as railroad planning, freight demand modelling (mainly forecasting), prioritisation of investment decisions, are not covered. Even though railroad related terminology and concepts are explained in detail in all the chapters, those not familiar with the railroad environment will need to invest a lot of time in gaining the full value of the material covered in this book.

Handbook of Operations Research Applications at Railroads edited by Bruce W. Patty, 2015. Springer, US. pp. 278, ISBN: 978-1-4899-7570-6, US Dollars 129 (Hardcover) and ISBN: 978-1-4899-7571-3, US Dollars 99 (e-book).

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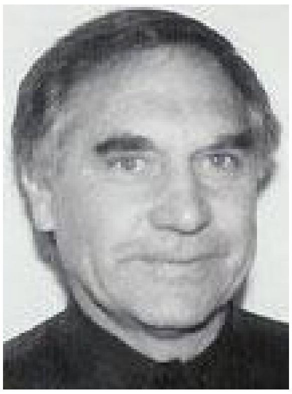
In Memoriam: Dave Masterson 1939-2015

by Hans Ittmann (hittmann01@gmail.com), University of Johannesburg

In October 2015 ORSSA received the news that Dave Masterson passed away on 18 May 2015 after suffering a bad heart attack whilst hiking on the Whale trail and then a long struggle to recover. It is with sadness that we as an OR community take note of this. Dave was one of the founding members of ORSSA and played a significant role in ORSSA during the early years.

David Desmond Masterson was born in Durban on 21 July 1939. He grew up on the Bluff in Durban and matriculated at Durban High School. After completing a Bachelor of Science at the University of KwaZulu-Natal, majoring in Mathematics and Chemistry, Dave obtained a Master of Science in Operations Research at the University of Birmingham during the sixties; in the days before Operations Research courses were available in South Africa. The University of Birmingham attracted him because some of the key proponents of OR at the university were expanding their ideas into the evolving civilian business world. Dave was an extremely active pioneer, practitioner and supporter of the use of Operations Research in the banking sector. He was instrumental in starting the first Operations Research/Quantitative Management team in a South African bank. The next few decades were exciting times for rapid growth and changes in industry aided by growth in the area of computers. In this regard Dave was at the forefront of analysing and pricing new banking services developed in South Africa ranging from the first ATM's, tele-banking to credit scoring and innovative loan products. He had huge foresight in identifying the contribution that Operations Research could bring to the financial services industry.



Dave Masterson

Dave started his career as senior analyst at International Computers Ltd. in 1960. Five years later he joined ORSAS as an Operations Research consultant; in 1967 he was appointed as a consultant with Computers: CAI Services and in 1969 he became senior manager at the Central Merchant Bank. In 1974 Dave joined Standard Bank of South Africa where he started the Operations Research department and worked for more than 25 years. He built a team of Operations Research professionals, who brought management science into the SA banking world. Looking back in time, it is amazing how the banking world has changed and more than 30 years on from the time that Dave Masterson started the Operations Research department at Standard Bank, the banking sector is now hugely dependent on the quantitative skills, science and "art" of Operations Research. During his life at Standard Bank, Dave played various roles. He moved from the Operations Research world into Information Technology, where he also made an immense contribution. He continued to bring management science into the decision making processes of the wider organization, as well as the Information Technology environment. He had an ability to select and pick teams of exceptional people from diverse cultures long before anyone knew anything about transformation, the DTI code of conduct, BEE, or employee equity forums and targets.

His involvement with ORSSA was immense. On 18 April 1968 a meeting of individuals interested in Operations Research was held at the Gatehouse at the Sunnyside Hotel in Johannesburg, as a result of initiatives taken by Dave Masterson and several others. This led to the founding of the Operations Research Society of South Africa (ORSSA) in Johannesburg on Thursday, 20 November 1969. Dave was elected National Treasurer at that meeting. What had, until that time, been the Johannesburg Operations Research Group, in which Dave had already been very active, seamlessly became the first regional branch of ORSSA. The executive committee for the Johannesburg Chapter was elected on 18 February 1970, with Dave Masterson as the Chairman. The second annual congress of ORSSA was held in November 1970 at Iscor in Pretoria, and Dave was elected as Vice President. He was National President in 1971–1972, and again in 1982–1983, and remained active at both national and chapter level (Johannesburg) in various capacities over many years. Dave also was a member of the South African Council for Natural Scientists from 1985 to 1999 and a member of the Advisory Committee to the National Research Institute of Mathematical Sciences of the CSIR from 1985 to 1987.

According to Dave's son Taun, his dad was "extremely proud of the work that he did with Prof. Herbert Sichel and others, not just in day to day business work and in establishing ORSSA, but also pushing for recognition of the discipline as a science both in the scientific community and the business arena. His commitment to technical analysis accompanied by his broad general knowledge and common sense approach to practical applications drove his many successful projects and his passion for OR. His commitment to ORSSA extended beyond SA too as he attended many international conferences over the years while communicating and liaising with many of his associates from Europe to Asia".

Paul Fatti remembers Dave as: "a great guy and an ORSSA stalwart. It is through him that I got involved in OR in Banking and Finance".

Jos Grobbelaar, the second ORSSA President, reminisces about Dave's determination when he put his mind to something. When Dave was elected President of ORSSA in 1971 he had to say a few words. At that stage it was expected that the incoming President also say a few words in Afrikaans. Dave, not well versed in Afrikaans, requested Jos to write him a paragraph in Afrikaans which he could then read. A year later, Dave's presidential address was partly delivered in Afrikaans, all his own work, while he also interacted spontaneously during discussions in Afrikaans. It was typical of the man, he learnt Afrikaans in one year, since he considered it important in performing his responsibilities.

In 1965 Dave married the late Pamela and leaves his son, Taun, daughter, Mandy, and a number of grandchildren. Dave enjoyed windsurfing and road running. Whilst semi-retired, he still kept his hand in Operations Research, serving as Director: Operations Research & Systems at Advisory Services Management Consultants since 2001. He still attended the 2010 conference in Limpopo. Dave was a fellow of ORSSA and a member of the Computer Society of South Africa, a registered natural scientist with SACNASP, and served on the Professional Advisory Committee for Mathematical Sciences.

ORSSA honours a man that made huge contributions to the OR discipline and the society. Our condolences go to his relatives.

(Contributions from Dave Evans, Taun Masterson, Mandy Verolini, Paul Fatti and Jos Grobbelaar are gratefully acknowledged.)

Dave Masterson (right) receiving a Fellow of the Operations Research Society of South Africa award in 2008 (www.orssa.org.za).

Dave Masterson with colleagues and friends at ORSSA's 2010 Annual conference held in Polokwane (www.orssa.org.za).

Dave Masterson at ORSSA's 2010 Annual conference held in Polokwane (www.orssa.org.za).

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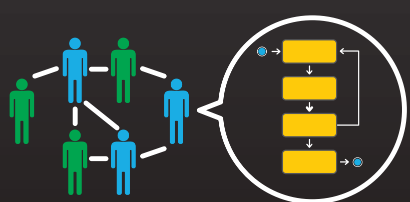

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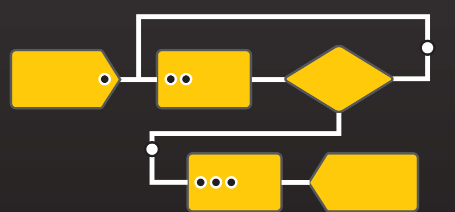
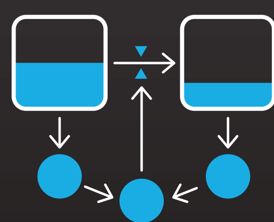


PROCESS-CENTRIC (DISCRETE EVENT)



SYSTEM DYNAMICS

- Health Care/Pharma
- Military/Defense
- Airports/Stations/Malls
- Transportation/Rail
- Manufacturing
- Supply Chains
- Logistics/3PL
- Insurance/Finance
- Marketing/Social Media
- Business Processes

DECISION SUPPORT

RISK REDUCTION

CHANGE SIMULATION

OPTIMIZATION

VISUALIZATION

“WHAT-IF” ANALISIS