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On the Peter Principle: An agent based investigation into the consequential effects of social networks and behavioural factors

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ABSTRACT

The Peter Principle is a theory that provides a paradoxical explanation for job incompetence in a hierarchical organisation. It argues that should staff be competent at a given level, their competence may not be implicit at higher levels due to the differences in the skill set required. Furthering the work of a recent investigation into the Peter Principle utilising agent based simulation, this paper explores external factors upon varying promotion strategies to assess efficiency. Through additional elements of social networks and organisational thought, a more representative view of workplace interaction is presented. Results of the simulation found that although the Peter Principle affects efficiency, it may not be to the levels previously suggested. Furthermore promotion on merit provided the most favourable maximum and minimum efficiency margins, given the absence of clear evidence pertaining to the existence of the Peter Principle.

1. Introduction

"My manager is completely incompetent"—a phrase that can be heard reverberating from the walls of many workplaces on a daily basis. While it may be simple to attribute this ineptitude to an inherent product of the individual, an explanation may also be provided by promotional circumstance.

Peter attempted to conceptualise this circumstantial phenomenon in 1969, entitling it as the "Peter Principle" (PP) [1]. The PP states that all members of a hierarchical organisation are promoted to their maximum level of incompetence; once this has been achieved, career progression is halted and the employee is left stagnant in a role they can no longer effectively fulfil. This incompetence has then been shown to manifest within the organisation causing ultimately detrimental effects to productivity [2] and subsequently impacts upon revenue.

Yet the consequences may be further reaching than just organisational incompetence. Additional applications of the theory have been used in an attempt to quantify the often counter intuitive elements of everyday life. Examples of such eventualities include the drop in quality experienced on the second visit to a restaurant and the disappointment expressed at movie sequels [3]. Anecdotal advice on how to negate this seemingly unavoidable organisational corruption has been provided by Peter in later work [4], but further research has also suggested hiring external personnel [5] and establishing promotional schemes [6] may be beneficial.

The PP evidently opposes many notions one assumes to be present when analysing promotional competence. Common Sense (CS) alludes to the belief that should a candidate be competent at a given level, their competence will remain relatively unaltered on promotion to a higher level. It is under such assumptions that a criteria for candidate promotion may be based, assuming competent individuals are adaptable to the necessary requirements of higher level occupations.

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The most recent addition to the Peter discussion utilises an agent based simulation approach [7] to ascertain the effect of distinctive promotion rules on the efficiency of an organisation. "The Peter Principle Revisited: A Computational Study" [8] creates two realms of an organisation following either a CS or a PP structure. These dynamics represent either a marginal change or a random redistribution of employee competence after promotion respectively. The two assumptive paradigms may then assess whether promoting the most competent (best), the least competent (worst) or a random candidate (random) as the most beneficial in terms of efficiency.

Results from [8] demonstrated that promotion of the best candidate in a PP structure proved most destructive to overall efficiency. Additionally promotion of the worst candidate proved more beneficial under PP circumstances than promotion of the best candidate under CS conditions. The overall conclusion recommended that, in the absence of a clear understanding of promotional governance, decisions should be made at random or through an alternating best–worst strategic decision.

Should this recommendation be taken at face-value, it evidently violates many of the inherent thought processes that control promotion on merit [9]. The theory being further refuted by the literature suggesting that the Peter Principle is just a "catchy title" coupled with "simplistic logic" that "cannot stand the light of even the most elementary analysis or logical inquiry (sic)" [10].

Supplementing said discussion further, this paper aims to build upon the work of [8] while including a more representative view of organisational thought. Additional elements incorporated, previously unexplored through computer simulation methods in the context of the PP, include the following.

- *Social networks*—the formation of social contacts in the workplace, categorised by three selected topologies (Small World, Scale Free and Random).
- *Reactive behaviour*—envy and its affect upon productivity.
- *Social capital*—the benefits of knowledge gained from social contacts.

Initially, a verification model of the original work [8] is produced as a basis to assess the implications of the addition elements outlined (Section 2). A review of the relevant literature for said elements is presented (Sections 3 and 4), followed by a description of the modified computer simulation structure (Section 5), its subsequent results (Section 6) and the conclusions drawn (Section 7).

Through the integration of an underlying social network structure coupled with behavioural elements, it is hoped that a more contextualised representation of the PP may be explored. The PP has previously been somewhat presented as an inevitability; the aim of this work is to determine if basic representations of human nature may instinctively rectify its outwardly destructive nature.

2. Review of previous work

To further the work of [8], we start by investigating the methods adopted therein. An arbitrary hierarchical organisation was selected as a conduit for further investigation into the PP. Utilising Agent Based Simulation (ABS) methods to facilitate the exploration of varying promotional schemes, and their effect upon efficiency (based upon job responsibilities and competencies, see below), the computer simulation package Netlogo [11] was selected to construct the model.

It has been widely accepted that computer simulations containing underlying statistical methods are an effective method of gauging social group behaviour [12–14]. Furthermore, such collective behaviour often allows unexpected individual behaviours to emerge [15–17]. The ability to customise individual agent thought processes based upon external environmental factors, along with the freedom to define agent specific variables, implies the suitability of ABS to investigate the aforementioned problem.

2.1. Model dynamics

The pyramidal organisation of [8] is comprised of 160 agents, distributed across six tiers. The lowest tier consists of 81 agents, followed by 41, 21, 11, 5 and finally 1 agent (the boss) as the hierarchy is climbed to reach its highest tier (see Fig. 1). The agents are given two variables on entry into the simulation, age and competence, the distributions of which are said to be normally distributed. Age is distributed with mean 27 and standard deviation 5, while competence is distributed with mean 7 and standard deviation 2.

Competence is an indicator of job performance and ranges from 0 to 10. Should this drop below 4, the agent is deemed incompetent and fired. Age, subsequently, is used to assess turnover if an agent eludes falling below the given competence threshold—incrementation occurring upon each time step. Should an agent achieve sixty, they retire and vacate their position in the organisation, allowing this to be filled by an agent residing on the tier below. Should this vacancy occur on the lowest tier, a new recruit enters the system adhering to the same normally distributed principles of behaviour as previous agents.

Three methods of promotion allow either the most competent ("best"), least competent ("worst") or a random agent ("random") ascension to the next level. Furthermore a candidate may be promoted under CS practices – retaining their competence from the previous level with a small change δ ($\delta \in [-1, 1]$) – or the PP, where competence becomes randomly redistributed post promotion. Efficiency (E) may then be calculated following each round of promotions to assess the consequential effects.

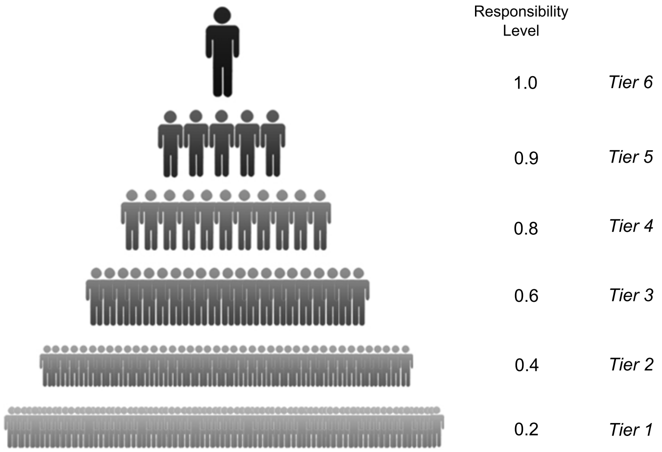

Fig. 1. Six tier model hierarchical organisation comprised of 160 agents. Reported are the responsibility levels alongside the relevant tier.

The manner in which E is calculated utilises a tier based job responsibility scale (r_i) ranging from 0.2 to 1. This is then multiplied by the sum of the competence from each tier (C_i) to give the following equation:

$$E = \frac{\sum_{i=1}^{6} C_i r_i}{\max(E)} \tag{1}$$

$\max(E)$ being defined as the maximum possible efficiency $\sum_{i=1}^{6} 10 \cdot n_i r_i$ (n_i, number of agents on tier i) [8].

The authors of [8] later revised their work to include a more pragmatic view of hierarchical dynamics [18]. Through the inclusion of a modular tree network of subordinates, representing the departmental structures within an organisation, the affect of a varying percentage of random promotions were assessed. The random method of promotion saw a substantial efficiency gain across all experimentation within [18] and therefore seeks to cement the notion of effective random promotion.

Given that the conclusions of [18] have not diminished the notions of [8], the decision was taken to retain the simplistic hierarchy of [8] – as opposed to the modular structure of [18] – due to the ease in assessing the impact of social networks and behavioural factors upon the hierarchy. Should these elements be seen to affect efficiency, the introduction of a modular structure may be considered for future work.

2.2. Verification

The verification procedure began by recreating the model dynamics (Section 2.1) of [8]; to maintain consistency at this stage no further elements were incorporated. Should this sample model produce results resembling that of [8], verification of baseline procedures could be completed allowing for network/behavioural factors to be included and assessed accordingly.

Result collection and exportation occurred in a graphical manner, documenting the change in efficiency across 1000 time steps over the course of 50 runs. Figures calculated were converted into the form of a percentage, as per the criteria referenced by Pluchino et al. [8]. A graph of the output can be seen in Fig. 2, alongside an equivalent representation of the results produced by Pluchino et al. [8].

The graphs are organised such that steady state-values of the relevant principle and the promotion method are clearly displayed. Exhibited is the same counter intuitive behaviour previously discovered in reference to PP, promotion of the worst agent being the most efficient. Differences do occur between models however, sample PP worst and CS best see a marginal reduction to efficiency when compared with original model results. Methodological differences in model construction may be the cause of these inconsistencies, highlighting issues of comparability.

On further investigation, replication of the results from [8] could be achieved on alteration of the method in which random sampling occurs. Competence of an agent is said to be normally distributed with mean 7 and standard deviation 2, yet elements outside the scale of ten to zero become irrelevant. Rectifying this issue, the sample model takes the decision to discard any value outside this region and resample (a graph of the resulting distribution of competence can be seen in Fig. 3(a)). Removing this condition and including the addition of fixed distribution boundary conditions proved successful in recreating the results of the original model.

The boundaries themselves cap competence values to ten and four should the Normal distribution produce figures extraneous to this range. The resultant distribution produced is visible in Fig. 3(b) and evidently contrastive to that of Fig. 3(a). Given that the two methods produce such a diverse range of competence values, reasoning behind the disparate efficiency results is evident.

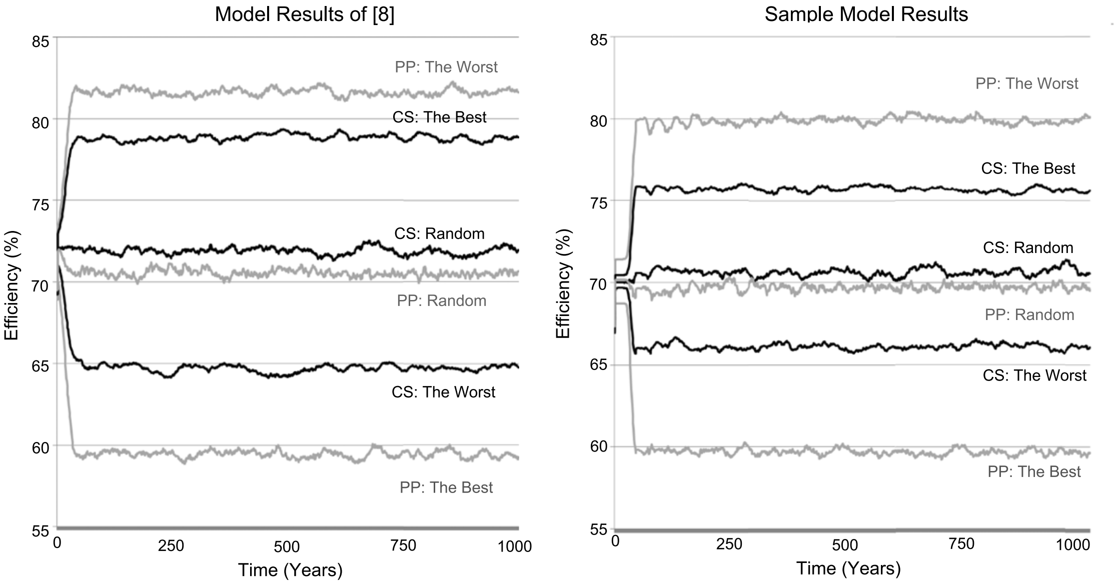

Fig. 2. Comparison graphs of [8] and Sample Model, displaying steady state efficiency values across varying promotional practices.

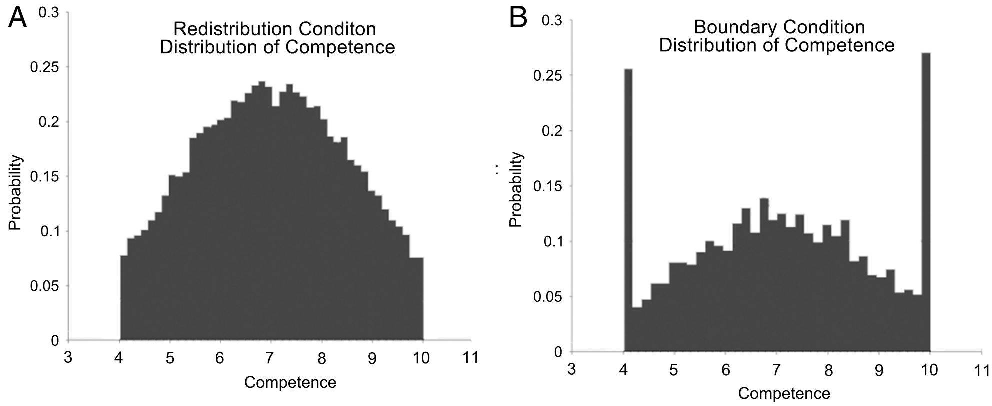

Fig. 3. Comparison of competence distribution graphs for redistribution and boundary conditions, respectively.

While effective at producing comparable results, the boundary conditions do not take into consideration agents entering the system with a competence below four; consequently no agent from the bottom tier is ever fired and may only leaving the system through retirement. Furthermore, the boundary conditions do not produce a graph indicative of the Normal distribution, while the resampling method produces curvature more akin to said distribution. In light of these facts, the sample model will maintain its construct and disregard any addition parameters relating to boundary distributions.

While this decision may make any further developments to the sample model inexact in reference to [8], given that the structures produce a similar and more realistic pattern of results, comparisons may be drawn under the appropriate context.

2.3. Limitations

The results of [8] show that promotion of the best candidate under PP conditions has detrimental effects to efficiency, concluding that random promotion should be used to limit the spread of incompetence. This evidently provides an interesting account of the PP effects and aids the discussion sparked by Peter in Ref. [1]. It must be remembered, however, that this conclusion is drawn from a hierarchy of passive agents unaffected by their surroundings.

When Peter first devised his theory, many real world examples were given to justify the existence of this counter intuitive phenomenon. Discussion also touched upon the idea of organisational "pull", the notion that "an employee's relationship by blood, marriage or acquaintance with a person above him in the hierarchy" may offer promotional gains, resulting in the "pullee" becoming unpopular [1]. However, elements of such behaviour and social network structure are somewhat overlooked by Pluchino et al. [8].

Furthermore, to suggest a random promotion method based upon a passive computer simulation begs the question: "what happens in the real world when people realise they do not have to work hard because promotion occurs at random?" This issue was however commented upon in later work by the authors of [8] in Ref. [18], through the suggestion of offering rewards/prizes to the most competent workers.

To give a more encompassing view of events, and to harness the power of ABS effectively, the sample model will be extended accordingly. While a computer simulation may not be able to model the exact nuances of human behaviour accurately, the features described below may be able to give an insight into possible negators of the Peter Principle. Additionally, it is hoped that further interest can be piqued into the use of statistical simulation methods (such as ABS) as viable approaches to explore artificial behaviour.

3. Networks

While the workplace may be viewed as an arena in which to conduct one's contractual obligations, it is also undoubtedly an environment which fosters social relations. Research into the dynamic of workplace interaction has been vast [19]. Topics of discussion range from the intricacies of e-mail grouping [20] to the complexities surrounding office romance [21]; although a selection of employees may make a conscious decision to exclude themselves from such relationships, those who do engage find it to be a beneficial exercise [22].

The mechanics behind relationship formation draws upon elements of proximity, status [23] and social capital [24] (described in Section 4.2), resulting in a diverse and vibrant network of connections. To formalise these networks in the context of PP, three social network topologies have been selected to govern the structure of link formation. The aim of these structures is to recreate possible workplace associations with a view to assess their impact upon efficiency in conjunction with the PP, while analysing the sensitivity of results to the underlying social structure.

Including social networks into the sample model created in Section 2.2, involves a two step process. The first is an initialisation step executed on set up, creating a basic structure of social links from which to begin simulation. The second step is repeated each time a promotion occurs, allowing the promoted agent to make one link to a colleague on their new hierarchical tier. The mechanics behind this process are described in Section 5; a brief review of each topology may be found in Sections 3.1–3.3.

3.1. Scale Free

Brought to the fore by Albert–László Barabási in 1999, Scale-Free networks have been a suitable framework for a variety of real world scenarios, quantifying areas as diverse as internet composition and the connections between Hollywood actors [25]. Prior to Barabási, some exploration into this field of reference had been conducted by Derek de Solla Price in the explicit context of the scientific literature citations [26] and the formulation of a cumulative attachment model [27].

Constructed through a large number of individual nodes connecting to a relatively small collection of highly linked hubs. The emergent behaviour is characterised by a power law distribution; for further details, see [28,29]. The inclusion of Scale-Free networking as a viable topology to contextualise office relations is evident from its prior application to a plethora of tangible affiliations [25,30,31].

While it has been argued that the methodology in which the links form create "first mover advantage" – earlier nodes being predisposed to having higher degrees than later nodes [32] – sexual contacts [30], the rise of English Protestantism in 1550 [31] and of course the work of Barabási himself [25], have all been shown to follow this power law distribution. It can therefore be concluded that a Scale-Free network is a suitable conduit for investigation under the conditions of the Peter Principle.

3.2. Small World

Colloquialised as "six degrees of separation", Stanley Milgram happened across the Small World network in 1967 through a sociological investigation into the transference of a letter between two seemingly unconnected individuals [33]. This path-breaking study began as an expansion of the "lost letter technique" from two years prior [34]. Findings concluded that a letter could be passed across state boundaries through an average of just 5.2 intermediaries.

The network later became mathematically formulated as a class of random graphs through the Watts and Strogatz model [35], supplemented by two key components—clustering coefficient (C) and average path length (L). These additions attempted to address the cliquishness of real world social networks, giving a greater depth of understanding into these complex structures. A full account of the mathematical properties are available in [36].

The relevance of a Small World system in terms of social networking has been made evident by Milgram's original work, but the methodology is still very much an active topic amongst researchers today. A modern take on the original "lost-letter technique" utilising e-mail was conducted in 2003 [37] and a current on-line open search to find a target individual [38] is still in the process of collecting data. However, its applications are by no means confined to the area of social network analysis, the computational aspects applied to map neural architecture [39] in a manner that can be utilised to investigate Alzheimer's [40] and Schizophrenia [41].

The clustering elements inherent in a Small World are what make this network attractive for investigation in terms of the Peter Principle. Fractal grouping is a common eventuality in many workplaces [42] and therefore an explicit representation of this notion is undoubtedly beneficial. The theory also provides balance to the investigation, opposing the highly linked individuals of the Scale-Free network to give nodes a more equal distribution of vertices.

3.3. Random

A random network is the most simplistic in construction of the three networks investigated. Elegantly defined in parallel by both Erdos & Renyi [43] and Gilbert [44] in 1959, the Gilbert model states that should N points exist,

$$\frac{N(N-1)}{2} \tag{2}$$

links may connect them.

The structure created by a random graph is often distributed in a manner that results in most nodes exhibiting approximately the same number of links (should the network be large enough) [45]. Research argues this is often not indicative of real-world reticulation [28,46], with further development of the construct being produced to illicit a more demonstrative representation [35].

The justification of its application within this context is vindicated through its use as a base-line procedure, offering an architecture that opposes the systematic fluidity of a small world network while contrasting the skewed nature of Scale-Free dynamics. Furthermore it provides a harmonious synchronicity to the random method of promotion which drives the conclusion that underline the basis of this investigation.

4. Behaviour

Aside from social networking, the second element not discussed by Pluchino et al. [8] is the reactive aspects of behaviour. As previously stated, employees in the simulated organisation had been assumed to be passive individuals, remaining unaffected by colleague promotion. In reality, the application and selection process for any position is not as clinical as one would hope—as made evident by the wealth of literature discussing the topic [47,48].

To provide an additional facet of behaviour, inter-office politics are also a necessary discussion point. Social networks do not only provide an assessment of popularity, but they may also be exploited as a vehicle for important informational gains. A candidate may not always be promoted because they were the "best" person for the job, therefore to quantify these extraneous assistive factors the concept of social capital has been incorporated [49].

4.1. Reaction

Humans are predisposed to react to changes in circumstance, the workplace being no exception. Following on from the construction of the link formation amongst employees in Section 3, colleagues now have a vested interest in one another—whether this has positive or negative connotations depend upon the circumstances in which promotions occur.

Research has shown that if an employee's application for promotion is rebuffed in place of a co-worker, it insights a tendency to work harder and succeed [50]; the cognitive explanation to this improvement is associated with envy. This primitive emotion is described as a coping mechanism when a person's self image is threatened [51], often said to occur when another's success is a threat to our own self evaluation [52].

Envious tendencies are said to be active under these conditions, especially when a successful individual is seen as a role model or to have high similarity to oneself [53]. In the context of the workplace, Schaubroeck [50] found that envy positively influences "post-rejection job performance", coinciding with previous research actively discussed amongst the references therein. From this it can be extrapolated that envy has a positive effect on competence, suggesting an impact to organisation dynamics.

While this conclusion is sufficient for applicants who have been rejected in place of the "best" candidate, this environment may not be as encouraging should the "worst" individual succeed; failure in career progression coupled with the success of an incompetent colleague, offers a different prospective on envy and the behaviour resulting from it. The perceived fairness of proceedings may be called into question, a component said to be integral to work ethic, having the potential to foster counter productive employee behaviour should fairness be absent [54].

These counter productive behaviours may relate to self perception, job satisfaction and stress—however, inter-personally this may have more serious ramifications [55]. Cohen-Charash and Mueller [56] found that unfairness coupled with episodic envy produces negative outward emotions. These emotions are not only harmful to the work ethic of the employee but, in some cases, has led to harm being inflicted on the envied other. A full scope of the literature can be found in Ref. [56], but implications of the research relate closely to conditions being created here for simulation.

It would seem that during a "fair" promotion method (and when similarities can be identified between linked employees), the spirit of healthy competition is active suggesting an increase in competence. On the other hand when the promotion is seen as "unfair", responses between linked employees become far more auster; work attitudes drop, impacting negatively on competence.

Table 1
Summary of dynamic model rules.

Type	Name	Description
Promotion	Best	Agent with highest competence is promoted
	Worst	Agent with lowest competence promoted
	Random	Equal probability of any agent being promoted
Network	Small world (SW)	Distance based connections with random parameter
	Scale-Free (SF)	Highly connected "hubs" of agents
	Random (RAN)	Equal probability of one agent connecting to any other agent
Behaviour	Envy	Drives agent to work harder and succeed
	Unfairness	Disillusioned agent displays counter productive behaviour
	Social capital	Agent exploits network to get ahead

These reactive inclinations may have further significant effects to the friendship links themselves, [56] finding that promotee likeability dropped by 60.7% after promotion. This gives weight to the argument of Berman [22] who found that managers tended to have very few vertical links – links to a working level below one's own – even when a connection was present prior to promotion.

4.2. Social Capital

Defined as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalised relationships of mutual acquaintance or recognition" by Pierre Bourdieu [57], social capital has been analysed in relation to individual aspects of organisational thought for many years.

A specific example is that of Brass [58] investigating the career progression of men and women. Results of this study confirmed workplace stereotypical notions suggesting men had more access to social capital, in turn creating more promotional momentum than women [58]. Similar findings were also concluded when the variable factor was ethnicity; Caucasian employees promoted more often than those of Black ethnic origin due to a heightened currency of Social Capital [59].

Investigation into the effect of complete social networks upon career mobility, as opposed to the individual variables detailed above, advanced towards the theory of Social Capital aided by Burt [60]. In an attempt to explain this fruitful precedent, Burt analysed "structural holes" within networks. It was identified that two unconnected nodes – mediated by one connected node – presented an opportunity to extract potentially lucrative informational rewards. It also allowed for the connected entity to broker connections between unconnected entities, leading to the inference of Social Capital amongst organisational networks.

This has since been refined in later works by Burt [49,61] and through the inclusion of informational time sensitivity [24], but the initial incarnation is still applicable in the context of a hierarchical network. The structural holes theory presented by Burt infers that being a highly connected individual in an organisation will present more opportunity for promotion, regardless of actual job competence. This definition is conditional however, suffice that "highly connected" is a concept relative to other members of the organisation.

5. Networked behavioural model

The Networked Behavioural Model serves to expand the sample model of Section 2.2, created as a replication of the work of [8]. The model foundations remain the same, measuring the efficiency of three promotional rules (best, worst and random) upon two realms of hierarchy (PP and CS), but with the additional elements of Sections 3 and 4 converted into simplified dynamic model rules (as summarised in Table 1).

On initialisation of the simulation, a network is selected from those discussed in Section 3: "Scale-Free" (SF), "Small World" (SW) and "Random" (RAN). The initial structures act on a discrete tier-by-tier basis, creating six topological layers of the hierarchy functioning in an autonomous manner. The consequence of this, dependent upon the conditions selected, is to have either six Small World or Scale Free networks categorised by managerial level. However, this segregation is only active amongst the defined structures; elements of variability, such as the SW P-value and the RAN network structure itself, allow for cross tier links to occur.

The overarching topological structure is strictly defined upon initial construction, but the framework of link formation evolves to become more complex as time progresses. Promotions begin disseminating the isolated network layers, as each agent is required to form an additional link to their higher level colleagues. The composition of this link is dictated by the overarching network dynamic, described graphically in Fig. 4.

Once the initial network set up procedure is complete, the behavioural elements of Section 4 can then be exacted to affect career advancement procedures. To include Social Capital in the progressive model of the PP, it will be assumed that the most connected individual on a given level will be the first promoted. This effectively allows a highly linked agent to bypass all other dynamic rules regarding promotion, meaning this agent is not necessarily the most/least competent (dependent upon the simulation conditions) and has only received their position based upon their networking skills.

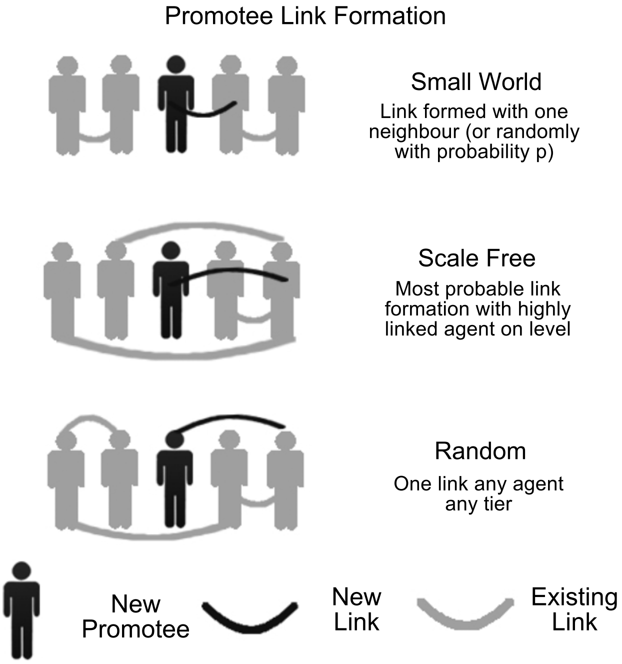

Fig. 4. Diagram of promotee link formation. Detailed is the dynamic of each link formation on candidate promotion under the respective network topology.

This leniency to allow an agent promotion outside of the governing best/worst/random rules only occurs once on each tier at each time step. To illustrate this further, an example follows.

Tier two has six positions available for agent promotion from the tier below (tier one). If the governing promotion method is "best", then the six most competent agents will be selected and queued to fill the available positions from tier one. However, before the promotions occur, the agent with the most social contacts from tier one will fill one of the available positions on tier two, leaving five positions available. The remaining positions on tier two will be filled by five of the six most competent agents queued. Similar rules apply for "worst" and "random" promotional rules, whereby the least competent and randomly selected agents will be queued respectively.

This social capital rule attempts to incorporate the structural holes theory developed by Burt, detailed in Section 4.2, where a highly linked agent may exploit information from unconnected agents for promotional gains. In the real world, the colleagues of the agent promoted may feel that such a move is unfair; similarly the colleagues of a highly competent agent may experience positive reactions to an agents promotion. The next step for the Networked Behavioural Model is to include the reactive behaviour detailed in Section 4.1.

On completion of all promotions across each tier, the promoted candidates are given the ability to influence agents that share a social link with them. The lower level collegues of a promoted agent will experience a representation of envy. If the promotee has a similar or greater level of competence to the envious agent, said agent will increase their competence $(+1)$ to attain the same accolades achieved by the envied agent (i.e. promotion). However if the promotee has a level of competence below that of the envious agent, the said agent will feel that the promotion criteria is unfair, lowering their competence (-1) in a display of counter productive work behaviour.

The influential changes that occur (named the γ effect) are dependent upon competence possessed by the promotee prior to promotion. It is important to note this, as the promotee's competence may vary post-ascension according to either CS (small change δ) or PP (random redistribution) principles. The final step is to apply likeability factors which, according to the relevant literature, sever 60% of inter-tier links. The efficiency calculations may then be performed, allowing the process to repeat.

6. Results

Data was collected across 1000 timesteps, each step representing one year in the lifespan of the simulated organisation. Data was categorised by structure, the PP and CS, subdivided by the promotion method—best, worst and random. Three asymptotic values for each of the six categories were calculated, each one representing a network topology—SF, SW and RAN. Simulation output is presented in both graphical (Fig. 5) and tabular form (Table 2).

Each individual graph of Fig. 5 displays the six construction categories – CS worst, PP worst, CS best, PP best, CS random and PP random – subdivided to represent one of the three network topologies. The figures shown illustrate the percentage efficiency of the organisation at each timestep, averaged from 50 runs of the simulation. For comparative purposes, the averaged steady state efficiency figures are given in Table 2.

Table 2
Average steady state efficiencies for each promotion method and network topology. As confidence intervals spanned a length less than one, integer values have been provided.

	PP-best	PP-worst	PP-random	CS-best	CS-worst	CS-random
Sample	60	80	70	76	66	71
SF	65	73	69	77	66	71
SW	65	74	69	81	61	71
RAN	65	74	69	80	62	71

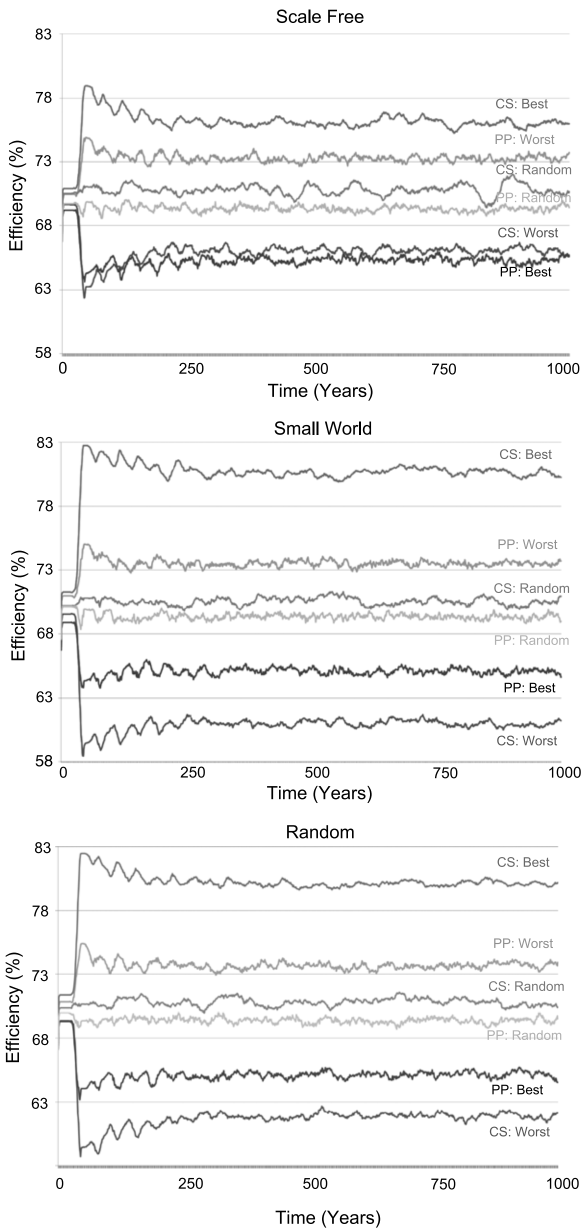

Fig. 5. Comparison graphs for steady state efficiency values across varying promotional practices and network topologies.

Large fluctuations in efficiency are observed during the initial years of the model, indicating a simulation warm-up period. This initial instability can be attributed to the method in which competence is allocated: on commencement, set up conditions may assign a number of agents positions of power with a competence below the required threshold. The concurrent timestep eradicates these agents, granting more competent individuals the opportunity to occupy a vacant position. The high level of agent turnover experienced during this tumultuous process eventually becomes relatively stable, as more proficient individuals are assimilated into the organisation. Once complete, the system achieves the steady state condition required for comparative analysis.

Results produced on promotion of the worst candidate indicate a difference in outcome dependent upon the network structure. Analysing CS worst, the efficiency of the system is greatly reduced for both RAN and SW, while the SF network displays minimal changes. Similar reductions can be seen on analysis of PP worst, however the effects are uniform across all three network topologies. These effects are reversed when the best method of promotion is assessed. Both CS best and PP best graphs highlight substantial increases to efficiency, with the exception of CS–SF whose results remain similar to the output of the sample model.

The differences between network structures indicate that behaviour is not acting autonomously, but in unison with the network construction selected. This may be explained on further analysis of the number of contacts each agent possesses within a network. An SF network will have a small number of highly linked agents, while an SW network will contain a large number of moderately linked agents. Therefore, as the first individual promoted is the most connected, an SF agent will have a greater impact upon other agents in the system than their SW counterpart.

In the context of the CS worst results, the socially connected agent may (by chance) possess a high level of competence. When an SF network is active, this highly connected agent has the power to inspire positive envy in a large number of agents, increasing competence and overall system efficiency. This effect is reduced on activation of an SW network, as agents have a smaller selection of contacts to inspire, counterbalanced by the worst promotees negative influence on their social contacts. The reverse is true of CS best, whereby incompetent socially connected SF agents are promoted. This decreases the competence of their social contacts and overall system efficiency.

The SF social agent effect does not impact upon PP conditions however. Reasoning behind this may be provided by the redistribution of competence that occurs after promotion. Although a highly competent SF promotee will still affect a large number of candidates in the initial promotion step, the longer lasting effect is truncated by the possibility of competence at their new position becoming reduced. This in turn will reduce the number of linked agents affected by later promotional advances, minimising the overall effect to system efficiency.

Efficiency levels of the CS best category, regardless of network topology, have increased such that this methodology is now the most efficient. This suggests an important departure from the results produced by the sample model whereby PP worst was deemed the most efficient. Random methods remain relatively unchanged however, neither network nor behaviour modifying efficiency substantially. Also remaining unchanged is the notion that, in the absence of definition between the PP and CS, promoting at random is the most efficient compromise.

With regard to network topology development, it would seem that the defining features of each construction remain intact as the simulation progresses. The SF and RAN mean degree statistic was calculated across the steady state region and found to be higher for the SF network agents. As results remained comparable across all promotional schemes, those of CS-Worst have been selected for illustration.

The SF mean degree was found to be 0.98 while that of RAN was lower at 0.87. This may not demonstrate a large decrease but does indicate some retention of the specified topology. Furthermore when calculating the global clustering coefficient of the SW network, figures increased from 0.0039 (RAN) to 0.0058 (SW), again indicating some alignment with topological behaviour.

As the initial construction of the SW network creates a globally disconnected network (six separate small worlds), the inverse average path length (also known as network efficiency) has been taken to analyse the structure. SW produces an inverse average path of 0.18 compared with the equivalent value of 0.64 for RAN. Given that a value closer to one indicates a fully connected graph and therefore lower average path length, the values produced are found to be indicative of SW behaviour. While the figures may not retain their exact logarithmic proportionality, the SW "style" of link attachment performs well to maintain such parallels.

The ideologies implemented in the Networked Behavioural Model have caused a shift in efficiency when compared with the sample model, irrespective of network topology. To investigate this further, supplementary results examining the scale of reaction to promoted agents have also been included (Fig. 6). During the initial instance of results collection, the competence effect of a promoted linked member of the hierarchy (γ) was set at $+1$ (envy) or -1 (unfairness). A range of γ values ($\gamma \in [0, 5]$) were explored to assess behavioural impact upon efficiency.

Graphs for the γ effect on the CS best and the PP worst can be seen in Fig. 6. CS best peaks in efficiency at $\gamma = 2$, dropping substantially from this point as γ reaches 5. The cause of this may be due to the system actively encouraging such positively envious individuals that the peak of competence (10) is being achieved. When $\gamma = 2$ a large majority of individuals are earning a competence of 10; therefore as γ increases this cannot be exceeded allowing unfairness ($-\gamma$) to act more significantly.

The resulting behaviour is such that a decrease in efficiency is perpetrated by moderately competent individuals being passed over for promotion – feeling this act is unfair – and with a high γ are forced to leave the system only to be replaced by less competent agents. The reverse is true of PP worst however as unfairness peaks at $\gamma = 2$, only to increase the number of highly competent individuals as $\gamma \to 5$. This in turn causes efficiency to increase, producing the dip highlighted in Fig. 6.

Overall, results of the Networked Behavioural Model demonstrate a deviation in results from that of the sample model. Efficiency of the PP worst system has reduced, being replaced as most efficient by CS best. A similar role reversal can be seen at the lower end of the spectrum as CS worst replaces PP best as the least efficient. The indicated results serve to highlight

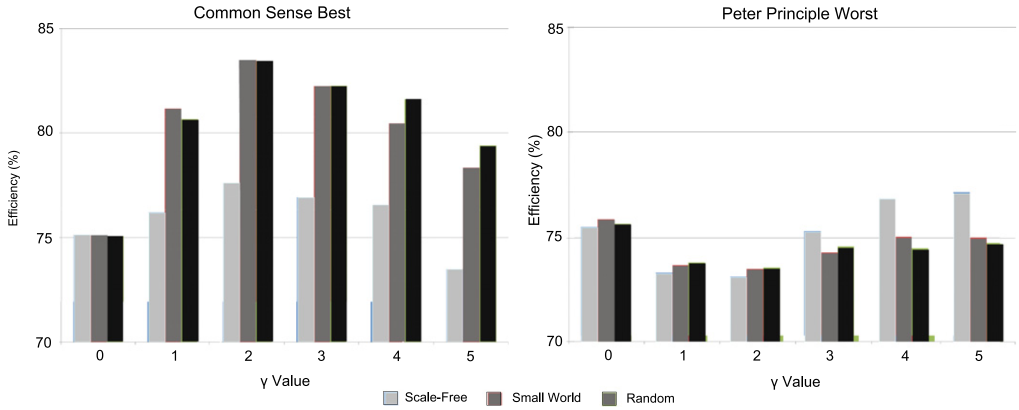

Fig. 6. Comparison of varying γ effect upon averaged steady state efficiencies.

the effect of a networked behavioural structure to the hierarchy and the impact of taking into consideration a more detailed insight into organisational thought.

7. Discussion and conclusion

The aim of this investigation was to delve deeper into the bold claims of "The Peter Principle Revisited: a Computational Study" [8]. Promotion at random was said to be the most favourable method of maximising efficiency in the absence of a clear understanding of promotional dynamics. The addition of social networks and behavioural minutia have not changed this conclusion, but brought to the fore a number of questions about the extent to which the effect of the PP emanates.

The PP worst dropped in efficiency around six points while PP best results showed a small increase, bringing the PP results as a whole closer to the efficiency figures of the random promotion method. A similar behaviour can be seen to occur when analysing the results of CS–SF; best results saw a notable drop in efficiency while worst results saw a considerable rise when compared with their respective network counterparts (SW and RAN). Once again this has had the effect of bringing SF efficiency figures closer to the results produced from promotion at random.

It therefore seems that the configuration of these systems is producing an incidental element of random promotion within PP, regardless of the selected method and principle. While the Agent Based Simulation created may not capture the full dynamic of workplace interaction, it has successfully shown that a reduction to the effects of the Peter Principle may be achieved with even a small selection of organisational rules. This suggests that should a larger scale behavioural model be created, PP effects may achieve the efficiency levels of random promotion across all promotional methods.

Due to the time frame in which results achieve steady state conditions, it is acknowledged that a 1000 year collection period may be considered unnecessary. The value of such results is also questionable, given that a 1000 year heritage is often not considered the norm for a large majority of organisations. This issue has also been acknowledged and addressed in Ref. [18], which adopts a revised time resolution of 1000 months. Taking into consideration this work was intended to replicate the basic hierarchy of [8], the interval specified therein has been retained to allow a like for like comparison. As this comparison has been successfully achieved and verified, it may be appropriate to consider a significantly reduced resolution for future investigations.

To further expand the current work, a larger scale model including the following items could be created.

- *Dominant coalition*—the Dominant Coalition is said to be a group of high level managerial staff that predominantly control the mission and goals of an organisation [62,63]. Exploration into the effect of Peter related incompetence upon the Dominant Coalition, may alter effects on efficiency in conjunction with varying promotional schemes. Furthermore, the significance of being socially linked to the Dominant Coalition may provide more social capital, creating more opportunity for promotion.
- *Promotion control*—as previously discussed, the Peter effect may corrupt any hierarchical system and also our everyday surroundings. It therefore stands to reason that the panel who assess a candidate for promotion may also be incompetent; the outcome is such that the candidate promoted may not be suitable for the position based upon their previous work. However, in a PP world this would translate into an incompetent candidate being removed from their position – competence being randomly redistributed – resulting in a higher level efficient candidate-position match.
- *External hires*—the model created for investigation contains only one entry route for new agents, the lowest tier. In the real world, positions are often advertised outside the domain of the internal hierarchy. It may be the case that fresh agents revitalise the system, boosting efficiency. Conversely, it may also be the case that agents transferring from other institutions may not be able to adapt to their new surroundings, reducing efficiency further.
- *Rewards and prizes*—the topic of providing agents with an incentive scheme to counteract the negative psychological effect of the PP has been suggested in Ref. [18] and also discussed at length in Ref. [6]. Given that a basic interpretation

of the psychological aspects of promotion have been included in the Networked Behavioural Model, it offers a platform upon which to assess the impact of a reward scheme and the subsequent changes (if any) to the results profile.

- *External systems*—this paper focuses on a closed hierarchical system, but there may be external factors that affect efficiency and the Peter Principle. Creating a number of competing organisations and incorporating an element of the current financial climate may offer a more contextualised insight. Making agents acute to the internal dynamics of the hierarchy has changed the efficiency profile of results, therefore making agents perceptive to the wider social and organisational climate may also be significant.

It is assumed in the real world that promotion on merit (best) is the factor that decides our ability to secure higher level positions. This method produces efficiency figures on average nine points higher (CS) and four points lower (PP) than the random method of promotion. While random promotion may offer a compromise in the absence of true understanding surrounding competence transition, the effect of the Peter Principle may be diminished enough that promotional governance becomes irrelevant. On balance, given the significant gains outweigh the losses, it is recommended that promoting the best candidate will maximise potential efficiency.

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