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TODOS OS TEXTOS SÃO DA RESPONSABILIDADE EXCLUSIVA DOS RESPECTIVOS AUTORES

Major-General João Jorge Botelho Vieira Borges
Comandante da Academia Militar

Os Alunos são a razão de ser das Instituições de Ensino Superior Universitário e a Academia Militar não constitui exceção. Ao ter como missão prioritária a formação dos oficiais do Exército e da Guarda Nacional Republicana (GNR), a Academia Militar tem nos seus jovens Cadetes uma fonte importante de criação de saber, designadamente ao nível da investigação, desenvolvimento e inovação. Neste número da Proelium, damos assim o devido espaço aos mais jovens alunos, no caso em apreço são três artigos escritos por cadetes da Academia Militar no âmbito dos ciclos de estudo que frequentam.

Por outro lado, continuamos a construir e a transmitir conhecimento não só pela palavra dos docentes da Academia Militar, como também pela palavra de docentes externos, de discentes externos e de muitos outros investigadores que, seja na área das Ciências Militares, seja em outras áreas científicas, honram a Academia Militar com a sua disponibilidade e empenho em "fazer acontecer".

Decorrente dos mais diversificados eventos académicos e científicos realizados pela e na Academia Militar (seminários, conferências, congressos, lançamentos de livros, etc.) ao longo do ano letivo, temos tido o grato prazer de contar com a excelente participação de muitos colaboradores, numa transdisciplinaridade crescente que nos deixa particularmente reconhecidos e agradecidos.

Este número da Proelium é um reflexo disso mesmo, com a apresentação de vários artigos enquanto *Proceedings* relativos ao *XXIV International Joint Conference on Industrial Engineering and Operations Management*, realizado na Academia Militar entre os dias 18 e 20 de julho de 2018. Tratou-se de um grande evento que a Academia Militar, enquanto Estabelecimento de Ensino Superior Público Universitário Militar, teve a honra e o privilégio de acolher.

Esta conferência conjunta, foi o resultado de um acordo entre a ABEPRO (Associação Brasileira de Engenharia de Produção), a ADINGOR (*Asociación para el Desarrollo de la Ingeniería de Organización*), o IISE (*Institute of Industrial and Systems Engineers*), a AIM (*European Academy* *for Industrial Management*) e a ASEM (*American Society for Engineering Management*). O lema que titulou o evento foi: *"O Papel da Engenharia Industrial e da Gestão de Operações na Era da Transformação Digital"*.

Promoveram-se inúmeras ligações entre investigadores e profissionais de diferentes especialidades e ramos, com o intento de melhorar a perspetiva interdisciplinar da engenharia e da gestão industrial, tendo-se alcançado uma conferência com padrões muito elevados e baseada na enorme experiência de edições anteriores das conferências da IJCIEOM (*International Joint Conference on Industrial Engineering and Operations Management*), da ADINGOR, da IISE, da AIM e da ASEM. E, com efeito, esta edição da IJCIEOM foi uma excelente oportunidade para *networking*, e também para desfrutar de um programa científico de alta qualidade e de um importante programa social.

Neste evento, como em muitos outros, a Academia Militar tem assumido uma postura de confiança e de seriedade na comunidade universitária, afirmando-se como um parceiro válido para o desenvolvimento de projetos e de outras demandas científicas. Temos tomado opções difíceis e temos assumido riscos, sempre com a consciência das nossas capacidades, da nossa especificidade, da importância do reforço das ciências militares e do bem comum. Continuaremos em frente neste caminho e com esta postura, porque é na complementaridade dos nossos recursos humanos com os recursos externos que colaboram connosco (sejam eles do IUM, da EN, da AFA, ou de outras instituições universitárias ou não) que está a consolidação da Academia Militar enquanto instituição de ensino superior militar, nos pilares do ensino, da investigação e da internacionalização.

Termino como comecei, pelos Alunos. São eles o nosso maior ativo. São eles a razão da existência da Academia Militar. É neles que deve estar centrada a "antecipação do futuro" do Exército e da GNR, em linha com o desiderato da nova Universidade, referido pelo Senhor Presidente da República, Marcelo Rebelo de Sousa, na reunião de reitores em Salamanca.

Honra e Glória à Academia Militar.

O Paradoxo de Ser Oficial e Contratado: Contributos Para a Formação de Oficiais RC

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ABSTRACT

The following essay discusses the importance and the problems of the Portuguese Army short-career officers' training system. After a literature review focusing on the positive effects of leader training on organizational results, the Portuguese and German officer training systems between 1880 and 1910 are compared to form a baseline for the description of the system being analyzed. Then, the Portuguese short-career officers' training course is described through the results of two instruments: a test and a questionnaire. After the analysis and discussion of data it is concluded that not only the course contents are insufficient, but also that there is an important category of military occupational specialties that is not being used in its intended role. It is proposed that the unneeded military occupational specialties should be discontinued, that the course and its contents should be expanded and that these officers' careers should be revised in order to better reflect their de-facto status as specialists.

Keywords: Military Training; Officer; Portugal; Career Management; Education Management.

RESUMO

O artigo que se segue discute a importância e os problemas do sistema de formação dos oficiais em regime de contrato do Exército Português. Após uma abordagem teórica acerca dos efeitos positivos da formação de líderes nos resultados das organizações, são comparados os sistemas de formação de oficiais português e alemão entre 1880 e 1910 para que sirvam de base à descrição do sistema em análise. O curso de formação de oficiais em regime de contrato é descrito com base nos resultados de dois instrumentos: uma prova de aferição e um inquérito por questionário. Através da análise de resultados conclui-se como não só os conteúdos do curso são insuficientes como há uma categoria importante de especialidades que não está a desempenhar as funções que lhe são próprias. Propõe-se que sejam descontinuadas as especialidades que não são necessárias, que o curso e os seus conteúdos sejam expandidos e que as carreiras dos oficiais em regime de contrato sejam revistas de forma a refletir melhor as suas funções de especialistas.

Palavras-chave: Formação Militar; Oficiais; Portugal; Gestão de Carreiras; Gestão da Formação.

1. INTRODUÇÃO: O PROBLEMA EM MÃOS

Não é segredo nem deve ser tabu admitir que o nosso Exército atravessa uma das suas maiores crises desde a sua (re)formação durante a Restauração da Independência. Temos tido grande dificuldade em recrutar e formar, especialmente os militares em Regime de Contrato, e urge pensar em soluções antes que nos tornemos num exército de quadros, um mero "exército-esqueleto". Vale quase a pena recordar a piada de Viktor Suvorov[1], que descrevia em *The Liberators – My Life in the Soviet Army* (1981, p. 68) essas "unidades-esqueleto" não pelo seu nome oficial de "Kadriro-vannye" (unidades de quadros), mas por "Kastriro-vannye" (unidades castradas).

Neste contexto grave, a formação deve tornar-se a tarefa crítica do Exército. Uma boa formação deve estar orientada para as necessidades reais do Exército, não para o estado ideal que alguns dos nossos quadros-orgânicos refletem; deve atrair e não repelir os nossos candidatos; e, principalmente, tem de ser *boa*, ou seja, tem de ser eficaz a criar os militares profissionais que ambicionamos e não os paisanos de uniforme que muitas vezes obtemos. Se isto acontece, proponho que antes de correr a analisar as faltas na sociedade e nas novas gerações nos analisemos a nós, Exército, para reconhecer e corrigir as nossas falhas.

O presente artigo é o meu contributo para essa finalidade. O seu objetivo é discutir o estado da formação de Oficiais em Regime de Contrato (RC), identificando os seus problemas e propondo para estes as soluções pragmáticas que requerem.

Esta é uma tarefa que me diz respeito enquanto profissional – Oficial do Exército – e enquanto parte interessada – Cidadão de Portugal –;

simultaneamente, é uma tarefa para a qual me considero apto. Em primeiro lugar, porque eu próprio sou um produto de um sistema de formação de oficiais, a nossa Academia Militar. Durante a sua frequência tive também, em visitas e missões, a oportunidade de tomar contacto direto com outros modelos de formação enquanto cadete (na *United States Military Academy*, em West Point) e enquanto aspirante (na *Academia General Militar*, em Saragoça).

Segundo, porque sou membro de um projeto de investigação (patrocinado pelo CINAMIL[2] e liderado pelo Tenente-Coronel de Cavalaria Miguel Freire) intitulado "Uma forma portuguesa de comando e liderança militar na Grande Guerra – África". O objetivo deste estudo é caracterizar o desempenho dos comandantes de nível tático em África no contexto das expedições para Angola e Moçambique de 1914 a 1918, procurando associá-lo aos resultados (menos que impressionantes) obtidos. Para atingir este objetivo há que descrever a formação destes oficiais, e identificar nela pontos fortes e pontos fracos que possam ajudar a explicar o desempenho que os comandantes tiveram, e a mim coube–me a tarefa de a estudar e comparar a formação dos oficiais portugueses com a dos seus equivalentes opostos, os alemães. Apresentei recentemente as minhas conclusões numa comunicação intitulada *Professionals or amateurs? Army Officer selection and training in Portugal and Germany, 1880–1910* e apresentada no contexto de um workshop subordinado ao tema "Command and Combat Effectiveness" que decorreu na Academia Militar no dia 30 de janeiro de 2018.

Finalmente – e acima de tudo o resto –, porque fui Comandante de Pelotão de Formação e fiz parte da equipa que ministrou dois Cursos de Formação de Oficiais: o 2º CEFO/CFO RC 2016 e o 1º CEFO/CFO RC 2017. É nas minhas experiências enquanto formador de oficiais que assenta este artigo, auxiliadas pela minha perspetiva enquanto aluno e pelas minhas conclusões enquanto membro de um projeto de investigação.

Assim, proponho-me a abordar este problema em quatro partes: uma primeira analise a relação entre forças eficazes, comandantes eficazes e um bom sistema de formação de oficiais; uma segunda que apresente as conclusões da comparação entre os sistemas de formação de oficiais português e alemão entre 1880 e 1910, para que possam servir de base a todo o raciocínio; uma terceira que identifique os problemas com o modelo atual de formação de oficiais em regime de contrato; e uma última que proponha soluções pragmáticas e de implementação realista.

Solucionar a formação de oficiais RC é uma tarefa mais importante do que aparenta ser: têm sido eles os agentes, as *boots on the ground* responsáveis por divulgar o Exército no Dia da Defesa Nacional, nos centros de recrutamento e nas plataformas digitais; têm sido eles quem seleciona os candidatos nos centros de classificação e seleção; e têm sido eles, cada vez mais, os Comandantes de Pelotão de Formação nos Cursos de Formação Geral Comum de Praças do Exército. Solucionar a formação de oficiais RC é, portanto, uma ação decisiva que contribui diretamente para uma das melhores soluções para ultrapassar a crise que atravessamos: formar melhor.

2. UM BOM EXÉRCITO ESTÁ ASSENTE NUMA BOA FORMAÇÃO DE OFICIAIS

Reconhecemos instintivamente que um bom sistema de formação de líderes seleciona e forma bons líderes, e que bons líderes levam a que as organizações atinjam melhores resultados. Apoiar este silogismo com dados empíricos provará ser uma tarefa muito mais complexa. Requererá, antes de mais, que adotemos sistemas claros para medir os desempenhos das organizações, dos seus líderes e dos seus sistemas de formação. Será também necessário identificar e isolar todos os fatores que contribuem para as medidas anteriores[3], relacionando-os com as variáveis em estudo. Só então poderemos investigar a correlação entre as variáveis, cientes de que a nossa amostra dificilmente será suficiente – quer em tamanho, no intervalo temporal ou na variedade dos dados – para formar uma teoria universal da influência da formação no desempenho organizacional.

Não obstante a complexidade deste problema, esta relação entre a qualidade do treino, a qualidade dos líderes resultantes e a qualidade do desempenho nas empresas tem sido alvo de algum estudo pela área da Gestão de Recursos Humanos. Barba Aragón e Sanz Valle (2013) estudaram a relação entre a formação dos gestores e o desempenho das organizações, acerca da qual foram construídas quatro hipóteses com base na revisão da literatura (Ilustração 1). As hipóteses foram testadas com recurso à análise dos resultados de um inquérito por questionário enviado às 3456 maiores empresas de Espanha (9,14% respondentes) e da informação financeira referente a cada empresa inquirida, disponível no *Sistema de Análisis de Balances Ibéricos*.

Hipótese	Resultado
H1.: A formação dos gestores tem um efeito positivo nos resultados da organização	H1 é **parcialmente suportada** pelos dados
H2.: Há uma relação positiva entre a **proporção** de gestores formados formalmente e os resultados da organização	H2 **não é suportada** pelos dados
H3.: Há uma relação positiva entre o **tempo** despendido na formação dos gestores e os resultados da organização	H3 é **parcialmente suportada** pelos dados
H4.: Há uma relação positiva entre os **recursos** gastos na formação dos gestores e os resultados da organização	H4 é **suportada** pelos dados

Ilustração 1: Resultados do Estudo Does training managers pay off?
Fonte: Barba Aragón & Sanz Valle (2013)

O estudo concluiu que a formação dos gestores afeta positivamente as suas capacidades; mais relevante é a conclusão que entre a proporção de gestores treinados, o tempo de treino e a quantidade de recursos investidos na formação, a quantidade de recursos investidos na formação (um indicador da qualidade da formação) é o único fator que afeta de forma significativamente positiva os resultados financeiros das organizações.

Naturalmente, é impossível aplicar totalmente as conclusões do estudo de Barba Aragón e Sanz Valle às organizações militares. Ao contrário das empresas, as organizações militares são geradas, equipadas e treinadas para defenderem uma certa entidade política de ameaças externas, não para gerarem lucros. Desta forma, os seus resultados só podem ser realmente medidos quando estas organizações são necessárias[4], não continuamente (como os lucros de uma empresa). O corolário disto é que é necessário medir de forma diferente o desempenho de uma dada força em tempo de paz e em combate, sabendo que o seu desempenho em combate será sempre mais importante, uma vez que é a razão de ser da sua existência. Assim, caso uma dada força tenha de combater, os seus únicos resultados relevantes serão os resultados desse combate, não o garbo das suas formaturas nos meses que o antecederam.

O estudo de Stephen Biddle, descrito em *Military Power: Explaining Victory and Defeat in Modern Battle* (2004) procura entender qual o fator que melhor prevê o sucesso (vitória) de uma força em combate: quantidade numérica, vantagem tecnológica ou qualidade do emprego da força. Para obter conclusões, Biddle analisa várias operações militares de média e alta intensidade entre 1900 e 1992[5], os resultados de simulações de combates produzidas a partir de modelos desenvolvidos pelas forças armadas americanas e as ações e os resultados de três operações consideradas significativas – Operação Michael, 1918; Operação Goodwood, 1944; Operação Desert Storm, 1991. Após o tratamento dos dados, Biddle conclui que a forma de emprego da força é o fator que melhor prevê a vitória em combate: a tática sobrepõe-se aos números e à tecnologia. Assim, um bom desempenho de uma força em combate deverá estar positivamente correlacionado com a boa qualidade do seu comandante.

O Tenente-Coronel britânico Jim Storr vai além do reconhecimento da influência de um bom comandante numa força, inferindo no seu livro *The Human Face of War* (2009, p. 192) que o treino e a formação dos oficiais são um fator mais importante para o sucesso operacional do que é comummente suposto. Como um exemplo é apresentada a experiência da *Wehrmacht*, que se recusou a abreviar os cursos de formação de oficiais apesar da falta grave de oficiais que sentia na fase final da 2ª Guerra Mundial: piores oficiais resultariam em baixas mais pesadas para toda a força; assim, era menos grave ter menos, mas melhores, oficiais (Dupuy, 1977, p. 237 *citado por* Storr, 2009, p. 192).

Terminamos então onde começámos: uma boa formação contribui para bons comandantes, que contribuem para um bom Exército. Como prova derradeira da importância crucial da formação de oficiais basta-nos apenas recordar o quanto a emergência de uma profissão militar no seu sentido moderno[6] pode ser traçada até à fundação da *Allgemeine Kriegsschule* em 1810, pela mão do Conde Gerhard von Scharnhorst (Ryan, 2017). O conceito de uma academia militar dirigida a todos os oficiais (e não apenas aos oficiais de engenharia e de artilharia) espalhar-se-ia e seria adotado pela maior parte dos exércitos; hoje, é ainda o sistema dominante. Recorde-se a posição do filósofo Nassim Taleb (2018, pp. 213-221): é racional tudo o que sobrevive.

3. A FORMAÇÃO DOS COMANDANTES DA PRIMEIRA GUERRA MUNDIAL

Em finais do século XIX, os sistemas de formação de oficiais português e alemão eram opostos. No sistema português os oficiais eram selecionados principalmente pelas qualificações académicas que possuíam e eram formados durante vários anos[7] numa instituição de ensino superior, a Escola do Exército (antecessora da Academia Militar). Inversamente, no sistema alemão os candidatos eram principalmente selecionados por critérios sociais e ideológicos e eram formados durante pouco tempo através de instrução prática. Um sistema produzia profissionais; o outro, meros amadores.

Em Portugal, o tipo de ensino praticado era essencialmente teórico[8], e a Engenharia tinha primazia enquanto arma e enquanto área de estudos. É revelador como do currículo académico de 1897 (o que mais tempo esteve em vigor entre 1880 e 1910), o rácio médio "tática–material" de todos os cursos[9] era apenas 0,51; ou seja, numa dada arma, em média, por cada matéria relacionada com o comando de forças em combate existiam duas relacionadas com o funcionamento do material utilizado para combater, portanto, matérias mais próximas da engenharia. Um dos objetivos deste tipo de ensino era equiparar a formação dos oficiais a outras profissões de elevado estatuto, legitimando os vários oficiais que enveredavam pela política, pela carreira académica, (um exemplo de ambos é o então Major de Artilharia Sidónio Pais), ou por outras áreas de destaque.

Pelo contrário, todo o processo de formação de oficiais alemão demorava em média apenas um ano, dividido entre o período que os candidatos a oficial passavam nas fileiras como *Fahnenjünkers*, (de posto equivalente a cabo, desempenhando funções equivalentes a um no regimento em que iriam ingressar como oficiais), e o período de instrução essencialmente prática e militar (o seu rácio tática-material era de 1,11) ministrada numa das várias *Kriegschule*. Porém, a verdadeira distinção entre os dois sistemas residia na seleção dos candidatos: no sistema alemão todos os candidatos a oficiais tinham de ter a aprovação do comandante do regimento a que se iriam juntar, o que garantia que o candidato era seguro ideologicamente, que a sua origem era aceitável e que a sua mentalidade era compatível com a cultura do Exército e do Regimento. Vários filtros – ou barreiras – como este existiam durante todo o processo de formação, culminando numa *Offizierswahl* (uma "eleição de oficiais") em que o novo *Leutnant* (Alferes) tinha de ser aprovado unanimemente pelos oficiais do seu futuro regimento para poder ingressar nele (caso contrário, teria de procurar um regimento que o aceitasse). Tudo isto garantia que o corpo de oficiais alemão era, acima de tudo, coeso, ainda que com uma educação científica incompleta na maior parte dos casos. Isto era compensado pela existência de uma *Kriegsakademie,* que selecionava os melhores oficiais subalternos e os preparava num curso muito exigente de três anos de duração para desempenhar funções no famoso Estado–Maior alemão e, eventualmente, para comandar as grandes unidades e até o exército inteiro.

Em suma, se no sistema português se selecionava pouco e formava muito, especialmente em engenharia, no sistema alemão selecionava–se muito e formava–se pouco tempo, mas com este quase todo gasto em instrução militar.

Avaliar qual dos sistemas produzia os melhores oficiais é um problema complexo, mas podemos arriscar uma aproximação através da comparação do desempenho das forças por eles comandadas em combate uma contra a outra. Tomando como amostra as nossas campanhas em África durante a 1.ª Guerra Mundial, vemos como os seus resultados face a forças alemãs de quantidade e nível tecnológico semelhantes ao nosso[10] apontam para um emprego de forças superior por parte dos alemães, o que pode ser explicado por uma melhor qualidade de oficiais. Isto é consistente com a maior importância que estes atribuíam à seleção dos candidatos: a coesão resultante poderá ter sido a principal razão por detrás da emergência de uma cultura de *Auftragstaktik* (Comando–Missão), em que os superiores determinam os objetivos e os meios dos subordinados, confiando neles a escolha dos métodos para os atingir[11]; isto garante que as decisões são tomadas por quem as vai executar, (melhorando a sua qualidade), e acelera o ciclo da sua tomada, (melhorando a sua relevância).

Um indicador mais sinistro, mas não menos revelador da importância da coesão é o destino dos corpos de oficiais português e alemão após a 1ª Guerra Mundial: ao passo que o português, vencedor, se desintegrou em várias fações políticas durante a 1.ª República, o alemão sobreviveu unido à derrota, permitindo uma reconstrução total das suas forças armadas.

A fórmula alemã continua atraente, mas é impossível de aplicar nos dias de hoje. A "aristocracia" das sociedades ocidentais contemporâneas não é a casta militar que os *junkers* foram e por isso não se pode simplesmente selecionar um "aristocrata", ensiná-lo a marchar, atirar-lhe uma espada para a mão e esperar que ele resulte num bom comandante. Assim, a formação é essencial para criar os comportamentos correspondentes às funções de um oficial, quer em quartel, quer em operações. A crescente complexidade destas funções face ao final do séc. XIX requer também uma preparação científica e cultural mais sólida e mais complexa, o que tende a favorecer o modelo que combina o ensino superior com a formação de oficiais. Porém, a seleção continua a ser essencial para identificar terreno fértil para plantar esses comportamentos e valores. Só isso garante condições para a existência de uma cultura comum que permita a coesão necessária para o sucesso de uma força.

4. A FORMAÇÃO DOS OFICIAIS RC NA ATUALIDADE

Oposto a ambos os sistemas de formação de oficiais está o Curso de Formação de Oficiais em Regime de Contrato (CFO): a sua curta duração (ainda menor que o sistema alemão) e os seus critérios de seleção significam que nele se forma pouco e se seleciona pouco.

O principal critério de seleção aplicado nos CFO é que o candidato tem de ter concluído pelo menos uma licenciatura, sendo todos os outros critérios semelhantes aos aplicados para os cursos das outras classes do Exército. Da mesma forma, a maior parte da fase de formação geral militar (a Instrução Básica, IB, e a 1ª parte da Instrução Complementar, IC1) é semelhante ao que é aplicado no curso de praças, sendo as restantes partes (a 2ª parte da Instrução Complementar, IC2, e a Especialidade) semelhantes ao Curso de Formação de Sargentos em Regime de Contrato; no total, o curso dura entre quatro e nove meses, dependendo da duração de cada especialidade.

A formação praticada nos CFO é essencialmente prática. O objetivo da IB e a IC1 é a criação de competências individuais, ao passo que a IC2 procura transmitir competências de liderança através de um conjunto de formações de alunos para alunos (as "práticas pedagógicas") e de algumas horas de formação acerca de procedimentos de comando de pequenas unidades. Finalmente, as especialidades – comuns entre oficiais e sargentos RC – abordam diretamente as áreas funcionais em que os futuros graduados irão ingressar, quer estas sejam "Infantaria – Comandos" ou "Serviço Geral do Exército – Secretariado". Ausente do programa em qualquer capacidade significativa está muito do conhecimento teórico necessário para um desempenho equivalente ao de um oficial QP, tal como noções de organização militar e de tática geral. Está também ausente qualquer veículo para transmitir a cultura e as tradições do Exército de forma sistemática. Em suma, não é difícil ver como do CFO não resultam subalternos equivalentes aos resultantes de (pelo menos) cinco anos de seleção, aculturação e formação na Academia Militar.

Para ilustrar o problema serão apresentados os resultados de um teste e de um inquérito por questionário. O primeiro visa entender a qualidade da formação e o segundo ilustra a utilidade da seleção feita e a adequação da formação e da especialidade atribuída às funções reais.

O teste – a "Prova Brigadeiro D. Carlos de Mascarenhas" – foi aplicado sem aviso prévio ao 1º CEFO/CFO 2017 (responderam à prova 35 Soldados-Cadetes) poucos dias antes da fase de Formação Geral Militar terminar. O seu objetivo foi avaliar qual o conhecimento à saída do curso que os futuros aspirantes possuíam quanto a três áreas consideradas críticas pela equipa de instrução: Cultura e Tradições do Exército Português, Tática Geral e Procedimentos de Comando; cada uma destas áreas foi avaliada numa das três partes da prova. Destas três áreas, apenas os Procedimentos de Comando constam no referencial de curso, ao passo que as outras foram informalmente ensinadas durante a instrução; por esta razão, o teste não teve quaisquer efeitos diretos na nota dos formandos.

De forma a ilustrar o nível de conhecimento de um Soldado-Cadete à saída da instrução geral serão apresentadas as médias dos resultados (em percentagem) de quatro perguntas consideradas representativas de cada uma das partes (Ilustração 2).

Área	Pergunta	Resultados (%)
Cultura e Tradições do Exército Português	"Quem pode usar as seguintes boinas?" [Castanha, Vermelha, Verde-Musgo, Verde-Vivo, Preta]	**93,1%**
	Indicar Patrono/Padroeiro, Dia e Lema das Armas de Infantaria, Artilharia e Cavalaria[12]	**36,5%**

Tática Geral	"Relacione cada Arma [do Exército] com um tipo de unidade [NATO: Combate, Apoio de Combate, Apoio de Serviços e Apoio de Comando] e explique sumariamente porquê".	**38,5%**
Procedimentos de Comando	Tema Tático (Planeamento de uma Emboscada). Pedidos: Missão Restabelecida Fita do Tempo Ordem de Operações (ênfase no Conceito de Operação e na Fita do Tempo definitiva)	**32,5%**

Ilustração 2: Resultados (em percentagem) de quatro perguntas representativas da "Prova Brigadeiro D. Carlos de Mascarenhas".
Fonte: Prova realizada ao 1º CEFO/CFO 2017 na Escola das Armas em 28 de julho de 2017

Dos conhecimentos avaliados pelas perguntas feitas, o conhecimento da cor das boinas em uso no Exército Português é, literalmente, conhecimento superficial e diretamente observável. Pelo contrário, associar as Armas a que as respetivas especialidades pertencem à função que as forças que estas geram têm em operações demonstra compreensão das noções básicas de organização militar, tática geral e operações militares e do ambiente operacional do Exército, noções essenciais para um oficial. Finalmente, a capacidade de interpretar uma situação/problema, entender a sua missão/tarefa e produzir um conceito de operação/solução é também uma capacidade essencial para qualquer comandante. Os resultados acima mostram que a formação de base conferiu apenas um conhecimento superficial das três áreas consideradas críticas, sendo eficaz apenas a transmitir o conhecimento mais facilmente assimilável.

A falta de conhecimentos dos avaliados quanto às áreas críticas deve-se à estrutura do curso. Das matérias avaliadas, o referencial em uso apenas prevê o ensino dos Procedimentos de Comando, apesar de o colocar numa altura dominada por momentos de avaliação[13], o que impede uma instrução com uma duração e com os momentos de prática adequados. Já as noções de tática geral, organização militar e operações não constam dos objetivos específicos da fase de Formação Geral Militar Comum dos CEFO/CFO (Exército Português, 2015a).

Para medir o quanto a formação (matéria ensinadas na fase de Formação Geral Comum e nas Especialidades) e a seleção (qualificações académicas) estão a ser úteis, foi feito um inquérito por questionário (difundido através da plataforma *Google Forms*) aos Aspirantes formados no 2º CEFO/CFO 2016 e no 1º CEFO/CFO 2017, sendo esta amostra dividida em três grupos: "CEFO" se a sua especialidade requerer um curso superior específico (ex.: Licenciatura em Psicologia, Licenciatura em Direito), "CFO-Armas" se a sua especialidade se inserir numa das Armas (ex.: Aquisição de Objetivos, Atirador) e "CFO-Serviços" se a sua especialidade se inserir num dos serviços (ex.: Secretariado, Administração e Finanças). De uma amostra de 86 Aspirantes obtiveram-se 42 respostas (Ilustração 3).

	Respondentes		***2º CEFO/CFO 2016***		***1º CEFO/CFO 2017***		***Total da Amostra***	
CEFO	17	40,5%	31	58,5%	6	18,2%	37	43,0%
CFO-Armas	15	35,7%	12	22,6%	19	57,6%	31	36,0%
CFO-Serviços	10	23,8%	10	18,9%	8	24,2%	18	20,9%
Total	42	100,0%	53	100,0%	33	100,0%	86	100,0%

Ilustração 3: Comparação respondentes-amostra relativa ao inquérito por questionário realizado.
Fonte: Inquérito por questionário disponibilizado entre 04 de março de 2018 e 16 de abril de 2018.

Neste inquérito foram feitas cinco perguntas relacionadas com a utilidade da seleção e da formação que foi aplicada; os resultados são apresentados abaixo (Ilustrações 4 a 8).

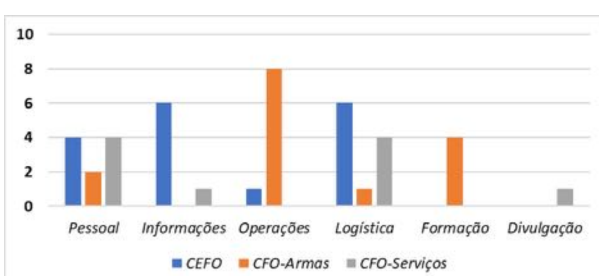

Ilustração 4: Natureza das Funções desempenhadas por área funcional[14].
Fonte: Inquérito por questionário disponibilizado entre 04 de março de 2018 e 16 de abril de 2018

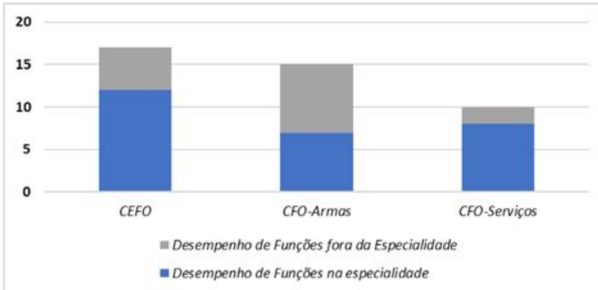

Ilustração 5: Natureza das funções desempenhadas face à especialidade atribuída.
Fonte: Inquérito por questionário disponibilizado entre 04 de março de 2018 e 16 de abril de 2018

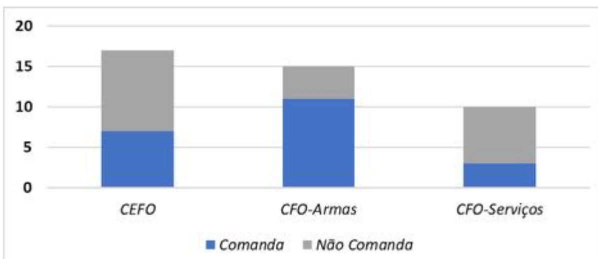

Ilustração 6: Natureza das funções desempenhadas quanto ao comando de militares.
Fonte: Inquérito por questionário disponibilizado entre 04 de março de 2018 e 16 de abril de 2018.

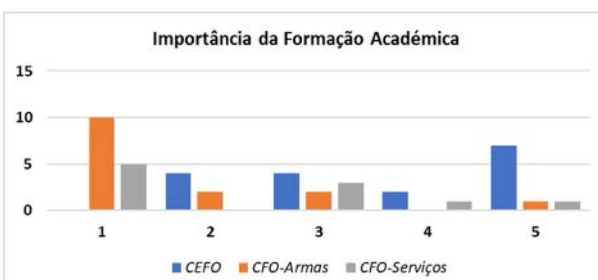

Ilustração 7: Importância atribuída à formação académica (1- Inútil; 5 - Essencial).
Fonte: Inquérito por questionário disponibilizado entre 04 de março de 2018 e 16 de abril de 2018.

Ilustração 8: Importância atribuída à formação militar (1- Inútil; 5 - Essencial).
Fonte: Inquérito por questionário disponibilizado entre 04 de março de 2018 e 16 de abril de 2018.

É difícil formar uma única imagem do "Oficial Contratado" a partir das respostas ao inquérito por questionário realizado. Pelo contrário, os resultados sugerem que há diferenças importantes entre os três grupos da amostra:

A maior parte dos membros do grupo dos CEFO desempenha funções relacionadas com a sua especialidade; estas funções não envolvem geralmente comando direto de homens nem se inserem na área funcional de Operações. Quanto à seleção, os CEFO são selecionados com base nas qualificações académicas que possuem, necessárias para desempenhar as funções que lhes vão ser atribuídas uma vez terminada a formação; desta forma, são o grupo que atribui um valor mais elevado à formação académica que possuem (média: 3,71). A importância que atribuem à formação militar é ligeiramente negativa (média: 2,59), o que é consistente com a natureza especializada das suas funções, geralmente sem relação com a componente operacional do Exército.

A maior parte dos membros do grupo CFO-Serviços também desempenha funções relacionadas com a sua especialidade, que na sua maioria fazem parte das áreas funcionais de Pessoal e Logística e não envolvem comando direto de militares. Da mesma forma, atribuem uma importância ambivalente à formação militar (média: 3,10), consistente com a natureza das suas funções. A principal diferença deste grupo face aos CEFO reside na importância atribuída à formação académica (média: 2,30), o que sugere que a mera conclusão de um curso do ensino superior (não importando qual o curso em si) não contribui decisivamente para o desempenho das suas funções.

Oposto a ambos os grupos anteriores está o grupo CFO-Armas. Cerca de metade dos membros deste grupo não desempenha as funções para as quais foram treinados, apesar de a maior parte ter comando de militares e de as suas funções se enquadrarem nas áreas funcionais de Operações e Formação. Os membros deste grupo são quem atribui menor importância à formação académica (média: 1,67) e, surpreendentemente, quem atribui menor importância à formação militar (média: 2,33). Os resultados sugerem que uma parte significativa dos membros do grupo CFO-Armas desempenha funções indiferenciadas, fora da especialidade e sem relação com a formação que receberam ou com a preparação académica que possuem, o principal critério de seleção para o ingresso no Curso de Formação de Oficiais.

Segundo o seu Referencial, o Curso de Formação de Oficiais em Regime de Contrato tem como objetivo formar quadros intermédios que desempenhem funções equivalentes às dos oficiais do Quadro Permanente (QP) (Exército Português, 2015b, pp. 1, Doc. II). Contudo, através dos resultados do inquérito realizado e da prova aplicada vemos que nem a sua formação é adequada ou equivalente à de um Oficial QP, nem a seleção está a ser feita com base num critério relevante para as funções que estes oficiais acabam por desempenhar. A quantidade de membros do grupo CFO-Armas que desempenha funções fora da especialidade pode ser explicada pela insuficiência do CFO em ambos os critérios, muito mais acentuada em funções sem equivalente civil (as Armas) do que em funções com equivalente civil (os Serviços e os CEFO) [15].

O oficial subalterno do Quadro Permanente que os oficiais RC procuram emular é um membro da profissão militar no seu sentido restrito. Ainda que imperfeitas, a seleção e formação de um Oficial QP estão orientadas para as funções que este irá desempenhar a curto médio prazo como subalterno, preparando-o também para a promoção a postos que dão acesso a funções de maior responsabilidade e abrangência; preparam-no para ser membro de uma *profissão*, não para desempenhar um *contrato*. Um outro benefício intangível é a cultura comum que é transmitida na Academia Militar, que aglutina os oficiais QP e transmite aos cadetes-alunos muitos dos comportamentos que caracterizam as funções de um oficial. Apesar de um oficial QP possuir formação superior e de esta em si mesma ser importante (mais importante quanto mais abrangentes são as funções e mais alto o posto), é a transmissão de cultura que a acompanha que deixa a marca mais profunda. Assim, estabelecer a conclusão do ensino superior (independentemente da natureza do curso concluído) como o principal critério de seleção para o CFO é um erro comparável a copiar em barro a forma de um carro, esperando que as suas partes internas e o seu funcionamento sejam semelhantes a um carro real.

5. AS RECOMENDAÇÕES

Ainda que a seleção e a formação dos oficiais RC sejam insuficientes e que nem estes nem as suas funções sejam equivalentes completos a um oficial subalterno QP, os oficiais RC desempenham funções necessárias, muitas delas (como vimos inicialmente) muito importantes na presente conjuntura. Ou seja, existe uma necessidade real de complementar os oficiais QP, necessidade essa suprida de momento pelo Curso de Formação de Oficiais.

Existem, no entanto, problemas neste curso – quer na formação, quer na seleção – que identificámos através dos instrumentos aplicados (a prova e o inquérito). Resolvê-los será essencial para melhorar a qualidade dos militares por ele formados, o que terá o efeito de melhorar a qualidade das funções por eles desempenhadas e, em última análise, o Exército.

Finalmente, o problema só fica completo após considerar as motivações e a satisfação dos oficiais RC em si. Não ambicionei medir estas dimensões no inquérito que fiz, mas não é difícil falar com um oficial RC e descobrir que ele está descontente com o que está a fazer, ou porque não é o que lhe indicaram no momento em que se propôs para o curso, ou porque a sua formação académica não está a ser aproveitada nas funções que desempenha. Muitos têm o objetivo de exercer no Exército as qualificações académicas e profissionais adquiridas antes de incorporarem, com o objetivo de ganhar experiência profissional que os auxilie no mercado de trabalho assim que o seu contrato terminar. Estas qualificações são necessárias e úteis ao Exército, mas podem não estar previstas em quantidade suficiente nos Quadros Orgânicos das unidades que precisam delas, o que explicaria o número de Oficiais RC fora da sua especialidade (não é raro encontrar, por exemplo, um oficial RC formado em Direito com uma especialidade de Armas a desempenhar as funções de oficial de justiça). A grande vantagem em incorporar pessoal com diversos cursos superiores é dispor deles como especialistas; assumir que qualquer curso superior é suficiente para as funções de oficial é desperdiçar esse curso superior e aceitar um oficial mal preparado.

Assim, proponho três conjuntos de recomendações para melhorar a formação dos oficiais RC: um conjunto a curto prazo, um a médio prazo e um a longo prazo.

A **curto prazo**, as especialidades que menos são desempenhadas na realidade deverão ser identificadas e eliminadas da oferta do Exército aos CFO. Em paralelo, as funções desempenhadas ao invés dessas especialidades deverão ser codificadas nos quadros orgânicos das unidades, órgãos e estabelecimentos. A essas funções identificadas, (geralmente com equivalente civil), deve ser associada a formação civil mais próxima possível, para que sirva de pré-requisito para essas funções.

Para ilustrar este conjunto de medidas, imaginemos que a maior parte dos Aspirantes RC com a especialidade "Infantaria – Armas Pesadas, Anticarro" não desempenha a sua especialidade, sendo colocados nas Companhias de Comando e Serviços ou em funções de adjunto no Estado-Maior das unidades. Se esse for o caso, os quadros orgânicos devem ser alterados para refletir essas necessidades, e a especialidade "Infantaria – Armas Pesadas, Anticarro" descontinuada de imediato.

A **médio prazo**, a estrutura e os conteúdos dos CEFO/CFO têm de ser reformulados, reforçando os conteúdos teóricos indispensáveis (noções de organização militar e de tática geral) e a ênfase nos Procedimentos de Comando e no comando de pequenas unidades. A localização ideal para estes CFO reformulados é a Academia Militar, para que haja economia de escala quanto a algumas matérias do currículo (que podem ser ministradas pelos professores que as ensinam na sua forma extensa aos cadetes-alunos), mas também para que passe a ser a casa de todos os oficiais, passando os futuros oficiais RC a interagir (ainda que por um tempo limitado) com o ambiente que forma os oficiais QP.

A **longo prazo**, o sistema de pessoal deverá ser reformulado para voltar a permitir maior permeabilidade entre as categorias de sargento e oficial, idealmente a par de outras reformas nas carreiras dos militares das forças armadas (que excedem o âmbito deste artigo). Uma oportunidade de passagem à categoria de oficial como é a *École Militaire Interarmes* em Saint-Cyr[16] contribuiria para fornecer oficiais subalternos em quantidade suficiente para limitar o emprego de "contratados" às funções de especialistas em que a sua formação académica pode ser bem aproveitada.

Finalmente, os militares que desempenham estas funções de "especialista" devem deixar de ser considerados oficiais, visto que nenhuma das suas funções possíveis envolve o comando de forças. Pelo contrário, pode ser emulada a categoria dos *Warrant Officers* em uso nas forças armadas americanas ou dos *Commissaires des Armées* em uso nas forças armadas francesas. Um *Warrant Officer* tem autoridade equivalente a um oficial, mas apenas na sua área de especialidade, o que descreve o que acontece na prática com um oficial vindo de um Curso Especial de Formação de Oficiais. Como referido, executar o conjunto destas recomendações requereria uma reforma profunda nas carreiras dos militares das forças armadas.

As conclusões e recomendações acima têm ainda de ser temperadas com um reconhecimento sóbrio das limitações do método. O estudo teve um início informal e é indissociável da minha experiência enquanto comandante de pelotão de formação, que afeta sem dúvida a minha abordagem e, consequentemente, os resultados obtidos. Nunca pretendi que fosse mais do que uma "primeira machadada" no problema, mas pretendi sempre que fosse uma que sinalizasse ao Exército o quanto temos a ganhar se este problema for resolvido.

Em suma, a forma como a formação deve servir as necessidades do Exército lembra a forma que o apoio de fogos deve de servir as necessidades das unidades de manobra: formar ignorando as funções que quem está a ser formado vai desempenhar é comparável a executar uma Missão de Tiro pela carta, sem um observador avançado que corrija os efeitos do tiro. Apesar das melhores intenções da bateria ou da entidade formadora, tudo indica que o tiro não atingirá o objetivo. O mesmo se passa com os Cursos de Formação de Oficiais. Assim, as recomendações e os dados apresentados acima não devem ser entendidos como soluções e valores seguros. Apresento-os como uma correção que um observador avançado – mais moderno que o comandante de bateria – enviaria para levar o tiro ao objetivo desejado: mesmo com todas as imprecisões da sua perspetiva limitada, o objetivo será atingido após um número suficiente de correções.

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Notas Finais

[1] Oficial soviético e mais tarde dissidente no Ocidente.

[2] Centro de Investigação da Academia Militar.

[3] O desempenho de uma organização, por exemplo, não depende apenas dos seus líderes, mas também do ambiente que a envolve, do desempenho dos restantes colaboradores e de tantos outros fatores quantos quisermos considerar. Teríamos ainda de considerar a intensidade com que cada um destes fatores afeta o desempenho da organização. Para agravar o problema, é evidente como cada um dos fatores imediatos que considerámos depende de tantos outros fatores que os compõem: o desempenho dos líderes depende, entre outras coisas, da sua formação.

[4] Rupert Smith é famoso pelo seu conceito da "Utilidade da Força". Segundo ele, o emprego de uma força militar é útil se contribuir para atingir os objetivos políticos que justificam o emprego dessa força (2006, p. 6).

[5] A análise estatística das operações militares foi feita através dos dados contidos em de três bases de dados diferentes: Correlates of War, da Universidade do Michigan, que cobre os conflitos interestaduais entre 1802 e 1992; CBD90, do Exército Americano, que cobre 660 batalhas entre 1600 e 1982; finalmente, um dataset da sua autoria, cobrindo a disparidade tecnológica dos beligerantes de 16 conflitos entre 1956 e 1992.

[6] A natureza da profissão militar foi discutida recentemente pelo Brigadeiro australiano Mick Ryan na sua série de artigos *Mastering the Profession of Arms*, no primeiro dos quais (*Part I: The Enduring* Nature) faz uma descrição das características constantes

da profissão militar (Ryan, 2017). Baseando-se sobretudo no trabalho do sociólogo Samuel Huntington, Ryan propõem que a Profissão Militar se distingue por quatro características que a acompanham desde a sua emergência (no início do séc. XIX): *Expertise* (proficiência em aplicar a violência), *Stewardship* (responsabilidade pelos homens e pelos meios que o estado coloca à sua disposição), *Corporateness* (existência de uma cultura própria) e *Service to the State* (devoção dos seus esforços em prol do estado-nação a que pertence).

[7] A duração de cada curso variava com a Arma: 3 anos para a Infantaria e Cavalaria, 4 para a Artilharia e 5 para a Engenharia, já contando com o ano que os Aspirantes de cada arma passavam nas respetivas Escolas Práticas.

[8] O Capitão de Artilharia J. M. D'Oliveira Simões descreve em 1892 o problema do sistema de ensino da Escola do Exército da seguinte forma: "O defeito que porventura a inquinava desde a origem, era a falta de exercícios e aplicações das matérias professadas nas cadeiras. Nas sucessivas remodelações com que se alterava a economia do estabelecimento, procurava-se acentuar a necessidade de atender mais cuidadosamente a esta parte do ensino, mas é certo que o legislador não lograva ver traduzidos por factos os bons desejos que formulava" (1892, p. 19).

[9] Este rácio foi calculado através da análise dos currículos das diferentes instituições e sistemas de formação de oficiais. Primeiro, classificaram-se as matérias desses currículos em grupos vastos que as conseguissem agrupar: tática", "material e tiro", "engenharia", "direito", "estratégia", "minas" e "topografia". De seguida, para entender se o foco de cada currículo era ou não o ensino da tática calculou-se um "rácio" da percentagem de matérias desta com a percentagem de matérias de "material e tiro". No caso dos diferentes cursos da Escola do Exército, apesar das suas diferenças em duração, esses rácios mantiveram-se sempre semelhantes entre os cursos, permitindo-nos resumi-los numa média. (Citação)

[10] Durante a Primeira Guerra Mundial, Portugal interveio nas suas colónias em África através de seis expedições: duas expedições em Angola (1914 e 1915) e quatro em Moçambique (1914, 1915, 1916 e 1917). Destas, apenas na primeira expedição a Angola e nas duas últimas expedições a Moçambique ocorreram combates contra forças alemãs, apesar todas terem tido presente essa possibilidade. Os combates que ocorreram resultaram em derrotas táticas portuguesas. Hew Strachan relata sumariamente na sua obra *The First World War in Africa* os resultados das expedições portuguesas contra os alemães em Angola (2004, pp. 79-80) e em Moçambique (2004, pp. 160-184), descrevendo (infelizmente) os comandantes portugueses nos piores termos. A título de exemplo, sobre o comandante da terceira expedição a Moçambique, o General José César Ferreira Gil, Strachan (2004, p. 163) descreve-o a jogar às cartas na retaguarda enquanto as suas unidades efetuavam a marcha para o contacto sem reconhecimento

devidamente organizado. O resultado do seu comando foi o cerco e rendição de parte da sua força às mãos de uma força alemã de 800 homens, cujo núcleo era a tripulação do SMS *Königsberg*, um cruzador da marinha alemã. Para que haja termo de comparação, no total a terceira expedição era composta por 4 462 homens organizados em três batalhões de infantaria, três baterias de artilharia, três baterias de metralhadoras, uma companhia de engenharia e um conjunto de unidades de apoio (Trindade, 1921, p. 55).

[11] É importante notar que isto implica supervisão e confiança constantes por parte do superior; os subordinados não devem ser deixados "órfãos".

[12] No 1º CEFO/CFO 2017, a maior parte dos Soldados-Cadetes (19 em 33) tinha especialidades pertencentes às Armas de Infantaria, Artilharia e Cavalaria.

[13] A IC2 está dividida em 10 módulos (Exército Português, 2015a), sendo o módulo A2 "Métodos de Formação", o módulo A4 "Tática" e o módulo A9 "Exercício de Comando e Liderança" (Exercício Tático). O módulo A2 prevê que para cumprir o objetivo específico "A.2.2.3 Conduzir sessões de Prática Pedagógica de Formação" sejam precisas 10 horas. O módulo A4 prevê que para cumprir o objetivo específico "A.4.2.9 Executar uma emboscada a uma foça *(sic)* inimiga" sejam precisas uma hora de instrução teórica e uma hora de instrução prática. Assumindo que um pelotão médio terá 15 soldados-cadetes e que cada sessão de prática pedagógica dura uma hora (10' de preparação, 20' de sessão e 20' de avaliação e comentários), vemos o quanto o planeamento (10 horas) é irrealista. Não é estranho que durante a IC2 cada comandante de pelotão tenha mais de 15 soldados-cadetes, o que obriga a que o número de horas atribuídas às Práticas Pedagógicas (avaliativas) seja maior do que o previsto. Tal efeito leva a que o tempo disponível para os módulos A4 e A9 seja menor do que o previsto. Finalmente, tudo isto é dificultado pelas previsões de tempo irrealistas feitas para cada objetivo específico nos módulos A4 e A9: quem quer que tenha sido instrutor de um Curso ou que tenha alguma experiência como formando em instruções de Tática de Pelotão/Patrulha sabe que uma hora teórica e uma hora prática é um tempo insuficiente para ensinar uma força a planear e executar uma emboscada em teoria e na prática. Mais, nada no referencial indica a finalidade destas instruções: é irrealista pensar que um Aspirante que vai desempenhar as funções de psicólogo vai conseguir planear e executar uma emboscada se a estas só estão atribuídas duas horas de formação. O verdadeiro mérito do ensino da tática é o ensino de um processo de pensamento/resolução de problemas (os Procedimentos de Comando), o que requer que haja tempo alocado para que todos os formandos possam desempenhar as funções de comandante da unidade numa operação.

[14] "Informações" pretende descrever principalmente as funções de assessoria técnica: psicólogos e sociólogos militares ou engenheiros do ambiente, por exemplo. "Operações" representa, para além do comando de forças em exercícios e operações, ações de apoio militar de emergência (no âmbito do Plano Lira, por exemplo).

[15] Como exemplo, um comandante de pelotão de reconhecimento ou um oficial observador avançado não têm função equivalente fora das forças armadas, ao passo que não é difícil imaginar funções equivalentes às de um comandante de pelotão de reabastecimento e transportes em várias organizações.

[16] Contrariamente ao antigo Instituto Politécnico do Exército, dirigido para Sargentos-Ajudantes e mais antigos, a *École Militaire Interarmes* está dirigida a sargentos em início de carreira, que uma vez oficiais têm uma carreira semelhante à dos oficiais formados na *École Spéciale Militaire de Saint-Cyr*.

Da Estratégia Oceano Azul à Inovação Distuptiva: Benchamarking, Crowdsourcing e Objetivos Estratégicos

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ABSTRACT

The purpose of this research is the theme: "Blue Ocean Strategy to Disruptive Innovation: Benchmarking, Crowdsourcing and Strategic Objectives".

We adopted the case study, as research methodology. Basically, this research is composed by two fundamental parts: the first part, a Literature Review on the Concept of Business Strategy, Strategy of the Five Competitive Forces, Blue Ocean Strategy, Disruptive Innovation, Benchmarking and Crowdsourcing; in the second part is developed an analysis and discussion of the results, but also the conclusions of the investigation.

Given the constant changes in global markets, organizations find themselves obliged to define a strategy to achieve success, the market leadership. This leadership may pass through a Blue Ocean or Red Ocean strategy or through Disruptive Innovation strategy.

In this way, the research guide aims to define these strategies and to verify the importance of crowdsourcing and benchmarking instruments in their application.

Benchmarking despite being an instrument of comparison and market analysis, this hardly fits the Blue Ocean Strategy, since this tool is not based on the creation of goods and services. This tool, in the strategy of Disruptive Innovation, can become relevant as it allows to face the competition.

Opposed to benchmarking, crowdsourcing is a tool that fits both strategies, Disruptive Innovation and Blue Ocean, as it opens the door to the creation of new markets.

KEYWORDS: Blue Ocean, Disruptive Innovation, Benchmarking e Crowdsourcing.

RESUMO

O presente Trabalho de Investigação de Grupo encontra-se subordinado ao tema: "Da Estratégia Oceano Azul à Inovação Disruptiva: *Benchmarking*, *Crowdsourcing* e Objetivos Estratégicos".

Na condução da investigação adotámos o estudo de caso. Este é composto por duas partes fundamentais: numa primeira parte, realiza-se uma Revisão da Literatura procurando definir os conceitos de Estratégia Empresarial, Modelo das Cinco Forças Competitivas, Estratégia Oceano Azul, Inovação Disruptiva, *Benchmarking* e *Crowdsourcing*; na segunda parte é desenvolvido a análise e discussão dos resultados, mas também as conclusões da investigação.

Face às mutações constantes nos mercados globais, as organizações veem-se obrigadas a definir uma estratégia a fim de atingir o sucesso, liderança de mercado. Esta liderança pode passar por uma estratégia do Oceano Azul ou Oceano Vermelho, através ou não da Inovação Disruptiva.

Deste modo o farol da investigação visa definir estas estratégias e verificar a importância dos instrumentos de *crowdsourcing* e *benchmarking* na aplicação destas.

O *Benchmarking* apesar de ser um instrumento de comparação e análise de mercado, dificilmente se enquadra na Estratégia de Oceano Azul, visto que esta ferramenta não tem como base criação de bens e serviços. Esta ferramenta na estratégia da Inovação Disruptiva, pode tornar-se relevante, pois permite enfrentar a concorrência.

Em oposição ao *benchmarking*, o *crowdsourcing* é uma ferramenta que se adapta às duas estratégias, Inovação Disruptiva e Oceano Azul, pois abre as portas à criação de novos mercados.

PALAVRAS-CHAVE: Oceano Azul, Inovação Disruptiva, Benchmarking e Crowdsourcing.

LISTA DE ABREVIATURAS, ACRÓNIMOS E SIGLAS

AM	Academia Militar
BO	Blue Ocean

BOS	Blue Ocean Strategy
GNR	Guarda Nacional Republicana
ID	Inovação Disruptia
ONU	Organização das Nações Unidas
PD	Pergunta Derivada
PP	Pergunta de Partida
RO	Red Ocean
TIG	Trabalho de Investigação de Grupo

1. INTRODUÇÃO

"Blue ocean strategy is not about being first to market. It's about being first to get it right."

W. Chan Kim

No âmbito da Unidade Curricular H134 – Gestão Estratégica, inserida nos planos dos ciclos de estudos do Mestrado Integrado em Administração Militar e do Mestrado Integrado em Administração da GNR, ministrados na Academia Militar, foi proposto o Trabalho de Investigação de Grupo com o tema "Da Estratégia Oceano Azul à Inovação Disruptiva: *Benchmarking*, *Crowdsourcing* e Objetivos Estratégicos". Este artigo é a sua consequência em termos de publicação.

Para o desenvolvimento desta temática, optámos por uma abordagem qualitativa, com o objetivo de aprofundar conhecimentos nesta área e fazer uma oportuna revisão da literatura.

O objetivo de qualquer organização é a maximização do lucro, através do aumento das suas receitas e a redução dos seus custos, na tentativa de domínio do mercado (Rossetti, 2003, p. 469). Face a estes objetivos as organizações têm recorrido à crescente inovação tecnológica para a criação e produção de novos bens e serviços e até mesmo novos modelos de produção. Como defende Porter, a tentativa de domínio do mercado passa pela definição de uma estratégica por parte das empresas, sendo este um ponto fulcral para *"se defender das forças competitivas ou até mesmo influenciá-las para seu proveito"* (Porter, 1989, p. 23).

Dada a diversidade de estratégias empresariais, o nosso foco principal incide sobre a Estratégia Oceano Azul e a Inovação Disruptiva. Desta forma, urgia a necessidade de recorrer a uma pergunta de partida para guiar a nossa pesquisa.

Segundo Rosado (2015, p. 79) a PP é aquela "*que orientará, tal e qual um farol, toda a sua investigação".* A PP elaborada para o nosso TIG é a seguinte: "Qual é a relevância da utilização da Estratégia Oceano Azul e Inovação Disruptiva na Gestão Estratégica Empresarial?".

Definida a PP, existe a necessidade de definir a problemática associada ao assunto em estudo. Para isso, foram conceptualizadas três perguntas derivadas (PD). Segundo Rosado (2015, p. 79) as Perguntas Derivadas "*tem um âmbito mais restrito que a pergunta de partida, aquilo que são os setores respetivos onde o investigador incidirá o seu esforço*".

Tendo em conta a PP formulada, as PD que desta surgem são:

1. Qual é a relação entre a Inovação Disruptiva e a Estratégia Oceano Azul e a Estratégia Oceano Vermelho?;
2. De que forma é o Benchmarking uma mais-valia para a Estratégia Oceano Azul, Estratégia Oceano Vermelho e Inovação Disruptiva?;
3. De que forma é o Crowdsourcing uma mais-valia para a Estratégia Oceano Azul, Estratégia Oceano Vermelho e Inovação Disruptiva?.

Ao iniciar qualquer trabalho de investigação é necessário ter em linha e conta os objetivos que se pretendem alcançar com o estudo. O objetivo do estudo "*indica o porquê da investigação. É um enunciado declarativo que precisa de orientação da investigação segundo o nível de conhecimentos estabelecidos no domínio em questão*" (Fortin, 1999, p. 100).

Desta forma, o objetivo geral desta investigação é compreender o processo de implementação da Estratégia Oceano Azul e da Teoria da Inovação Disruptiva na gestão estratégica empresarial.

Acrescentando a este objetivo geral, foram definidos objetivos específicos que nos auxiliam e guiam para a concretização do nosso resultado final, pois *"o objetivo do estudo indica a principal intenção da investigação"* (Sousa & Baptista, 2011, p. 26). Assim, os objetivos específicos são:

1. Aferir os conceitos associados à temática em estudo;
2. Identificar as ligações existentes entre as concetualizações enunciadas;
3. Identificar quais os benefícios e desvantagens da aplicação dos conceitos.

Pergunda de Partida:
Qual é a relevância da utilização da Estratégia Oceano Azul e Inovação Disruptiva na Gestão Estratégica Empresarial?

PD 1:
Qual é a relação entre a Inovação Disruptiva e a Estratégia Oceano Azul e a Estratégia Oceano Vermelho?

PD 2:
De que forma é o Benchmarking uma mais-valia para a Estratégia Oceano Azul, Estratégia Oceano Vermelho e Inovação Disruptiva?

PD 3:
De que forma o Crowdsourcing é uma mais-valia para a Estratégia Oceano Azul, Estratégia Oceano Vermelho e Inovação Disruptiva?

Ilustração 1: Quadro Conceptual da Investigação
Fonte: Elaboração própria

2. REVISÃO DA LITERATURA

2.1. Estratégia Empresarial

Face a um mundo cada vez mais global, impulsionado pelos avanços tecnológicos, este é marcado por uma concorrência crescente, sobretudo na esfera económica. De facto, a própria ONU refere que um dos principais fatores para o aprofundamento da globalização é a expansão dos mercados: "*a globalização actual está a ser guiada pela expansão* *do mercado – abrindo as fronteiras nacionais ao comércio, capitais e informação – ultrapassando a governação desses mercados e as suas repercussões para as pessoas*" (PNUD, 1998).[1]

Primordialmente, a palavra "Estratégia" estava, sobretudo, relacionada com a guerra militar. Esta advém do grego das palavras *strato,* que significa exército, e *agein*, que quer dizer liderar. Sendo definida então como "*ciência que, tendo em vista a guerra, visa a criação, o desenvolvimento e a utilização adequada dos meios de coação (...) para se atingirem os objetivos fixados"*.[2] Ao longo do tempo, esta passou a abranger outros domínios, desde a política e a economia até ao desporto.

Sobretudo no domínio económico e empresarial, vários autores e investigadores verificam similaridades entre a estratégia empresarial e estratégia militar. Freire (1997) defendia que o estudo do planeamento militar podia fornecer *inputs* importantes para o desenvolvimento da estratégia empresarial, com base na obra "A Arte da Guerra" de Sun Tzu. Já Bracker (1980) considerava que a estratégia empresarial nascera verdadeiramente e ganhara grande realce após a Segunda Guerra Mundial pela brusca mudança de um ambiente externo estável para um ambiente bastante mais mutante e competitivo.

Pode-se definir Estratégia Empresarial como o conjunto de ações e de decisões "*conotadas com a formulação de um plano que reúne, de uma forma integrada, os objetivos, políticas e acções da organização, com vista a alcançar o sucesso*" (Santos, 2011, p. 7).

Portanto, a realização de um **planeamento estratégico** é crucial para fazer face ao ambiente externo instável, tendo este como objetivo "*maximizar os resultados e diminuir as deficiências da organização através de princípios e critérios de gestão como: eficiência, eficácia e efetividade"* (Chiavenato & Sapiro, 2004 *apud* Vargas *et al.*, 2013, p. 12). Conforme defende Ansoff (1990), o planeamento é um processo analítico que, além de se preocupar com a tomada de decisões estratégicas, analisa variáveis económicas, empresariais e tecnológicas.

	Meio Empresarial	Meio Militar
Objetivo	- Conquista e controlo de mercados.	- Conquista e controle de territórios.
Análise	- Estudo do mercado; - Estrutura da indústria; - Pontos fortes e fracos; - Organização e liderança.	- Condições climatéricas; - Condições do terreno; - Distribuição das forças; - Estrutura do comando.
Resultados	- Estratégia empresarial; - Plano Estratégico.	- Estratégia militar; - Plano de Campanha.

Ilustração 2: Comparação entre estratégia no meio empresarial e no meio militar
Fonte: Adaptado de Freire (1996 *apud* Serra & Ferreira 2012, p. 6)

2.2. Modelo das Cinco Forças Competitivas

Os estudos de Michael Porter nos anos 80 deram uma nova perspetiva ao conceito de estratégia competitiva. Este representa o comportamento competitivo das organizações em resposta às decisões estratégicas dos seus concorrentes, de forma a ganhar uma vantagem competitiva sustentável sobre eles. A estratégia não passa apenas pelo foco no produto, mas sim pelo conjunto da indústria, grupo de empresas fabricantes de produtos muito semelhantes entre si (Carrilho, 2009, pp. 31-32).

Segundo Porter (1980) existem **cinco forças competitivas** que se deve ter em conta no seu conjunto para se proceder ao desenvolvimento de uma estratégia empresarial competitiva. Estas causam um impacto sobre a atratividade de um setor ou empresas, a longo prazo, bem como os proveitos. Estas cincos forças são:

1. Rivalidade entre empresas concorrentes;
2. Poder de negociação dos fornecedores;
3. Poder de negociação dos clientes;
4. Ameaça de entrada de novos concorrentes;
5. Ameaça de aparecimento de novos produtos ou serviços (substitutos).

Michael Porter defende que o sucesso de uma organização passa por uma pesquisa exaustiva e pela análise das fontes de cada força, que permitirá contornar tais forças, diferenciando-se assim dos seus rivais. Esta pesquisa irá permitir o desenvolvimento e definição de uma estratégia para a organização: "*O conhecimento destas fontes, que estão na base da pressão competitiva, evidencia os pontos fortes e os pontos fracos de uma organização, melhora o seu posicionamento no setor, identifica as áreas em que as mudanças estratégicas podem resultar e identifica, ainda, as áreas no setor que podem constituir potenciais oportunidades e ameaças*" (Porter, 1980 *apud* Rodrigues, 2010, p. 28).

A entrada de novos concorrentes e o surgimento de novos produtos ou serviços substitutos, a dita dimensão vertical, assume um carácter essencialmente competitivo, enquanto que os fornecedores e os clientes, a dimensão horizontal, se assume como maioritariamente cooperativo (Rapp, 2001 *apud* Rodrigues, 2010).

2.3. Estratégia Oceano Azul

A *Blue Ocean Strategy* (BOS) foca-se na criação de novos mercados, uma vez que a natureza e o objetivo de cada empresa é gerar lucro, e essa zona de lucro está sempre a movimentar-se, é importante para as organizações alterar a sua conceção de negócio, pelo menos a cada cinco anos. Para que desta forma se evite a entrada no ciclo rotineiro comercial e tecnológico, que se denomina por "**oceano vermelho**" (Jussani, Krakauer & Polo, 2010). No entanto, a análise desta estratégia de rotina e competição ajuda na criação do Oceano Azul desejado pelas empresas.

Segundo Kim & Mauborgne (2005), "*chama-se "oceanos vermelhos" às arenas competitivas em que os concorrentes lutam entre si e, consequentemente, se enfraquecem uns aos outros*" (Berg & Pietersma, 2015, p. 46). Referem também que este tipo de estratégia baseia-se na competição com o mercado existente, tendo por objetivo bater a concorrência. Com esse fim, exploram a procura e alinham todo o sistema de atividades da empresa com a escolha estratégica de diferenciação ou baixo custo, criando assim, na maioria das vezes, margens de lucro muito baixas (Kim & Mauborgne, 2005). Para se conseguir oferecer um produto com qualidade superior à da concorrência e a um custo inferior, de forma a agradar o cliente, é preciso um grande esforço financeiro, operacional e de marketing por parte da empresa.

De modo a contrapor essa rotina, foi criada a estratégia Blue Ocean (BO) a qual descreve essencialmente o que fazer para tornar a **concorrência irrelevante**, sem competir com ela. E este é o ponto essencial nesta estratégia, não consiste em reavivar produtos do passado nem fazer o mesmo produto a preço diferente da concorrência (Ghura & Hattangadi, 2012). Deve-se começar do zero, tentando procurar quais são os fatores da nossa indústria que devemos aumentar, reduzir, eliminar ou criar, para se consigamos satisfazer o cliente. Desta forma, podemos criar dois tipos de oceano azul, um que seja inteiramente novo e outro dentro da indústria que já existe, abrindo um novo leque de oportunidades (Berg & Pietersma, 2015).

De acordo com Kim e Mauborgne (2005), a fim de se conseguir ser bem-sucedido na realização da estratégia do Oceano Azul e se conseguir fugir do sangrento e competitivo Red Ocean (RO), é crucial respeitar seis princípios:

1. **Reconstruir as fronteiras do mercado**, de modo a se libertar da concorrência e em que o risco de pesquisa seja mínimo;
2. **Concentrar-se no quadro geral e não só nos números**, focando os factos existentes e atenuando deste modo o risco de planeamento;
3. **Visar para além da procura existente**, não pensando apenas nos clientes já existentes e criando novos. Lida com o risco de alcance;
4. **Acertar na sequência estratégica**, procurando a forma de criar um modelo que gera lucro a longo prazo. A sequência correta é 1º utilidade para o cliente, 2º preço, 3º custo e 4º adoção. Desta forma reduz-se o risco do modelo de negócio;
5. **Superar as barreiras organizacionais**, controlando o risco organizacional. Essas limitações geralmente são: cognitivas, recursos, motivação e política.

2.4. INOVAÇÃO DISRUPTIVA

A Teoria da Inovação Disruptiva sofreu uma grande evolução até aos dias de hoje para ter o alcance que agora conhecemos. Verificam-se que existem várias publicações que salientam, indiretamente, a Inovação Disruptiva (ID) (Ilustração 3), mas foi de facto Clayton Christensen que a desmitificou na sua obra, publicada em 1997, designadamente, *The Innovator's Dilemma*. Sendo assim, apoiar-nos-emos essencialmente nas suas obras e publicações para decifrar esta teoria.

Esta teoria nasce da necessidade de explicar como é que grandes empresas perdem a sua enorme dimensão no mercado para pequenas empresas, que à partida não apresentavam qualquer valor competitivo. Foi introduzida pelo investigador Christensen, que analisa a indústria dos Discos Rígidos (Christensen, 1997). Visto que as grandes empresas possuem uma elevada fatia do mercado, estas baseiam-se numa Inovação Sustentável dos seus produtos/serviços (King & Baatartogtokh, 2015). Isto é, melhoram os seus produtos/serviços através da redução dos defeitos, com base no feedback dos consumidores e clientes, de modo a melhorar a sua performance.

Devido à sua grande percentagem de mercado, estas empresas não sentem necessidade nem lhes é apelativo inovar de forma disruptiva. Os recursos gastos num pequeno nicho de consumidores e/ou oportunidades não comprovadas, poderiam estar a ser dedicados na melhoria do produto/serviço. Por outro lado, na Inovação Disruptiva, os produtos têm uma performance reduzida, mais defeitos e nascem de dois tipos de necessidade (Raynor, McDonald, & Christensen, 2015), necessidades de preços baixos ou através de novos mercados. A necessidade de produtos com preços baixos "*existe porque as grandes empresas, tipicamente tentam fornecer aos seus consumidores mais rentáveis e exigentes, produtos/serviços cada vez melhores, e prestam menos atenção a consumidores menos exigentes*" (Raynor, McDonald, & Christensen, 2015, p. 5) deixando a porta aberta para uma inovação disruptiva com o objetivo de providenciar os consumidores menos rigorosos. Temos o exemplo da Amazon.com (Raynor & Christensen, 2003). Quanto aos novos mercados, a inovação disruptiva "*encontra uma maneira de tornar não-consumidores em consumidores*" (Raynor, McDonald, & Christensen, 2015, p. 5). Foi o caso da Xerox (Raynor & Christensen, 2003).

A Teoria da Inovação Disruptiva, segundo o seu fundador, assenta sobre quatro princípios chave, são eles (King & Baatartogtokh, 2015):

1. As grandes empresas crescem de acordo a trajetória de uma inovação sustentável;
2. Ultrapassam as necessidades dos clientes;
3. Têm capacidade de responder a ameaças de inovações disruptivas;
4. Acabam por ter dificuldades, devido às inovações disruptivas.

Ilustração 3: Modelo da Inovação Disruptiva
Fonte: Adaptado de King & Baatartogtokh (2015, p. 80)

A **inovação disruptiva** é um processo que pode demorar, "*e as grandes empresas podem tornar-se criativas*" (Raynor & Christensen, 2003, p. 6) para defender a sua fração de mercado. Portanto, não podemos dizer que é uma inovação revolucionária ou instantânea; ela **leva tempo** (os sublinhados são nossos).

O mecanismo que causa a queda de grandes empresas é ascensão da empresa que estava no fundo do mercado (Ilustração 2), através de inovação disruptiva. Enquanto a sua inovação tiver potencial para melhorar a sua prestação num mercado pequeno (nicho), estas pequenas empresas terão tempo para afinar o seu serviço/produto e não têm de se preocupar com as grandes empresas (Raynor & Christensen, 2003).

Ilustração 4: Evolução do Conceito da Teoria de Inovação Disruptiva no tempo
Fonte: Adaptado de Yu & Hang (2010, p. 436)

2.5. Benchmarking

A produção mundial e as empresas têm vindo a crescer significativamente nos últimos anos, consequentemente, urgiu a necessidade por parte das empresas em aprimorar técnicas ou estratégias de produção de modo a puder ultrapassar as capacidades produtivas das outras empresas e sobre tudo facilitar a distribuição de bens e serviços. Assim, surgiram variadíssimas ferramentas empresariais, uma delas é o *benchmarking*.

Podemos definir *benchmarking* como *"comparação sistemática de processos e desempenhos organizacionais, baseada em indicadores pré-definidos"* (Berg & Pietersma, 2015, p. 114). O grande objetivo desta ferramenta é procurar melhorias, analisando as melhores práticas de mercado e comparando-as com o desempenho atual de uma organização. Muitas vezes, o *benchmarking* é confundido como cópia da estratégia empresarial alheia, mas esta estratégia serve para aprender com a concorrência através da observação e comparação.

Portanto, a essência do *benchmarking* consiste na ideia de que nenhuma organização é a melhor em tudo, o que implica reconhecer que existe alguém dentro do mercado que faz algo melhor do que nós (Cardia e Grings, 2013).

No que diz respeito aos autores Carvalho & Reis (2006), estes optam por uma visão mais complexa, considerando que o essencial é perceber os "meios e não os fins". Portanto é primordial analisar os processos que nos conduzem à aquisição de dados, visto que estes processos levam as melhores empresas a atingir o sucesso.

Desta feita, constatamos que existem três razões para aplicar esta metodologia (Carvalho & Reis, 2006, p. 47):

1. *"É a forma mais eficiente de proceder a melhorias, eliminado procedimentos baseados em tentativa/erro/tentativa, para se concentrarem esforço na aprendizagem e aplicação de processos já testados e com resultados provocados;*
2. *Contribui de forma clara para a rapidez de implementação, dessas mesmas melhorias, e, dado que o recurso tempo não é reciclável, as poupanças no consumo do mesmo são relevantes em gestão e refletem-se na rendibilidade;*
3. *Permite, caso se estenda a todo um conjunto económico, a elevação do potencial do mesmo, seja um sector de atividade, um "cluster" ou um país, em que todos os agentes seguem esta filosofia".*

Segundo Berg & Pietersma (2015), pode-se dividir o instrumento benchmarking em cinco tipos:

1. **Histórico** – A comparação da produtividade e desempenho da organização no passado com o momento atual da organização;
2. **Interno** – A comparação pelas melhores práticas ocorre dentro da própria organização em unidades diferentes. Por exemplo: departamentos, sedes etc.;

3. **Competitivo** – A comparação dos indicadores e desempenhos de uma organização e dos seus oponentes diretos;
4. **Funcional** – A comparação numa função específica, que pode existir ou não na própria organização, e serve para trocarmos informações sobre uma atividade bem definida. Como por exemplo: distribuição, facturamento ou embalagem;
5. **Genérico** – A comparação baseada num processo que atravessa várias funções da organização e pode ser encontrado na maioria das empresas do mesmo porte. Por exemplo: o processo desde a entrada de um pedido até a entrega do produto aos clientes.

Benchmarking é...	**Benchmarking não é...**
um processo contínuo	um evento isolado
uma investigação que fornece informações valiosas	uma investigação que fornece respostas simples e "receitas"
um processo de aprendizado com os outros	cópia, imitação
um trabalho intensivo, consumidor de tempo, que requer disciplina	rápido e fácil
uma ferramenta viável a qualquer organização e aplicável a qualquer processo	mais um modismo da administração

Ilustração 5: Relação do que é ou não *Benchmarking*
Fonte: Adaptado de Spendoloni (1993, p. 34 *apud* Semedo, 2017)

2.6. CROWDSOURCING

O *Crowdsourcing* é uma alternativa contemporânea que tem lugar quando uma organização delega determinadas tarefas ou decisões a um público ("*the crowd*"). Estas são feitas de forma gratuita ou por um valor muito reduzido face ao impacto que esta contribuição tem no valor da organização. Estas contribuições passam sobretudo pelo design do produto, publicidade, monotorização da qualidade e ajuda na resolução de problemas técnicos do produto.

Como referem Kleemann, Vob & Rieder (2008) este fenómeno só foi possível com o surgimento das novas tecnologias associada à "Web 2.0", estando a contribuir para o aparecimento de um novo tipo de consumidores: os "**working consumers**".

Crowdsourcing representa o início de uma nova forma de socialização entre o indíviduo para com o trabalho: uma nova forma de trabalho dissimulado e gratuito ou insuficientemente remunerado (Kleemann & Rieder, 2008).

Reichwald e Piller (2006) definem duas formas de *crowdsourcing*: "**customização de massa**" e "**inovação aberta**". A primeira refere-se ao reforço das operações de uma organização, de modo a permitir que os consumidores possam adquirir produtos únicos, personalizados, produzidos especialmente para eles. Já a "inovação aberta" representa uma cooperação entre uma firma e os seus clientes com o objetivo de desenvolver um novo produto para benefício de um leque alargado de potenciais consumidores. Enquanto, que na "customização de massa" o contributo do consumidor é individual para a criação de uma peça única, na "inovação aberta" o contributo é coletivo para a criação de algo que favoreça uma população específica.

As organizações que adotem este instrumento podem ter como benefícios:

1. Redução de custos pela redução da complexidade;
2. Aumento da produtividade pela aplicação dos recursos de forma mais eficiente;
3. Aumento do valor de negócio através do aumento do número de clientes;
4. Melhoria da qualidade através da experiência do consumidor.

Para além destes benefícios ainda são apontados por Reichwald e Piller (2006) outros quatro graças à participação dos consumidores no processo de desenvolvimento e produção por partes das organizações: redução do tempo no desenvolvimento de novos produtos ("*time-to-market*"), redução dos custos ligados à inovação ("*cost-to-market*"), uma maior suscetibilidade a aceitar por parte dos consumidores um novo produto e a comprá-lo ("*fit-to-market*"), e um maior conhecimento e perceção por parte do consumidor relativamente a um novo produto quando entra no mercado ("*new-to-market*").

3. METODOLOGIA, MATERIAIS E MÉTODOS

3.1. Tipo de Estudo

Tendo em conta as características desta investigação e, tal como o próprio tema do TIG sugere, o tipo de estudo escolhido foi um estudo de caso. Segundo Yin (2005, p. 32), "*um estudo de caso é uma investigação empírica que investiga um fenómeno contemporâneo dentro do seu contexto de vida real, especialmente quando os limites entre o fenómeno e o contexto não estão claramente definidos*."

Este trabalho assume, portanto, a forma de um estudo de caso descritivo, que "*representa a descrição completa de um fenómeno inserido no seu contexto*" (Yin, 1993 *apud* Meirinhos & Osório, 2010, p. 57).

3.2. Amostra

A amostra *"é um grupo de sujeitos ou objetos selecionados para representar a população inteira de onde a provieram. É um subconjunto da população que terá de a representar, ou seja, refletir os seus traços."* (Coutinho, 2011, p. 89). Não houve lugar a processo de amostragem na nossa investigação.

3.3. Instrumentos

É sabido que, "*todo e qualquer plano de investigação seja ele de cariz quantitativo, qualitativo ou multimetodológico implica uma recolha de dados originais por parte do investigador*" (Coutinho, 2011, p. 105). Tendo em conta a especificidade qualitativa do nosso TIG, a recolha dos dados baseou-se em livros, artigos científicos, publicações e diversos trabalhos de investigação, ou seja, em fontes bibliográficas secundárias e terciárias, recolha de dados por técnicas documentais e pesquisas em bases de dados científicas e estatísticas (Rosado, 2017, p. 124).

3.4. Procedimentos

A realização deste TIG teve início no segundo semestre do ano letivo de 2017/2018, no âmbito da avaliação da Unidade Curricular de Gestão Estratégica. Em primeiro lugar, procedeu-se à escolha do tema do trabalho e, simultaneamente, à construção da PP. Estas etapas só foram possíveis pois foi elaborada, nessa mesma altura, uma revisão de literatura inicial. Em segundo lugar, e depois de se estabelecerem os objetivos gerais e específicos do TIG, ainda foi escolhida uma metodologia, e onde foram definidos o tipo de estudo, as amostras e os instrumentos necessários para conduzir a investigação.

Concluídas estas etapas, e após dedicar um capítulo teórico, com o intuito de facilitar a compreensão e introdução de conceitos essenciais para a investigação, procedeu-se à sua análise para se responder às questões de investigação e à PP.

4. APRESENTAÇÃO E DISCUSSÃO DE RESULTADOS

4.1. Conexão entre as duas teorias: Estratégia Oceano Azul e Inovação Disruptiva

Após a revisão da literatura, podemos verificar que existem características comuns entre as duas estratégias. Primeiramente, a BOS consiste em criar e explorar novos mercados, evitando qualquer competição. Numa metáfora marítima seria nadar e desfrutar livremente num oceano por explorar. Em contrapartida do oceano azul temos o oceano vermelho, que consiste numa competição feroz dentro de um mercado, onde os limites do setor são conhecidos e as empresas tentam superar as suas rivais, resultando em baixas margens de lucro e perspetivas reduzidas de crescimento.

Posteriormente, temos a teoria da ID, que consiste em criar um produto ou um serviço novo que irá permitir expandir novas fronteiras num setor ou mesmo criar um novo mercado. É geralmente algo mais simples e mais barato do que já existia ou algo que passa a abranger uma população que antes não tinha acesso a tal bem ou mercado. Esta estratégia resulta, inicialmente, em margens de lucro reduzidas, contudo, este novo bem ou serviço tem como objetivo a revolução do mercado em questão, deixando assim, obsoleto os anteriores líderes do mercado. Casos práticos desta estratégia são: Wikipédia, Airbnb, Uber, Netflix, companhias aéreas lowcost, entre outros.

Ilustração 6: Relação entre BOS e ID
Fonte: Elaboração própria.

Assim, comparando as duas estratégias, a Inovação Disruptiva pode abranger os dois oceanos. Na conexão ID e RO, temos a criação de um novo bem ou serviço idêntico a algum já existente, mas a um preço mais baixo ou de qualidade mais simples ou reduzida. Sendo assim, a nova inovação vai resultar numa expansão das fronteiras do setor, abrangendo novos clientes que antes não conseguiam ou não podiam desfrutar desse mercado. Como tal, esta expansão terá como consequências uma nova disposição na repartição de rendimentos dentro desse mercado.

Anteriormente, o mercado era dominado por um conjunto de empresas rivais que prestavam o mesmo serviço, com preços semelhantes. Com o surgimento de um novo bem ou serviço disruptivo, a base de clientes deste setor tende a crescer, e a empresa passa a ter capacidade de competir com outras que até então dominavam o mercado. O caso mais explicativo deste exemplo é o setor de aviação com a introdução das companhias *low-cost*. Primeiramente, o mercado era dominado por um conjunto de companhias que praticavam preços elevados, pois os seus serviços podiam ser considerados de qualidade, com oferta de refeições e possibilidade de transporte de bagagem, etc. Recentemente, surgiram novas companhias, como o caso da Ryanair e a EasyJet, que prestam o mesmo serviço primário que a concorrência, no entanto, a um preço mais reduzido em contrapartida de um menor conforto: sem oferta de refeições, pagamento extra pela bagagem e alterações de voo, etc.

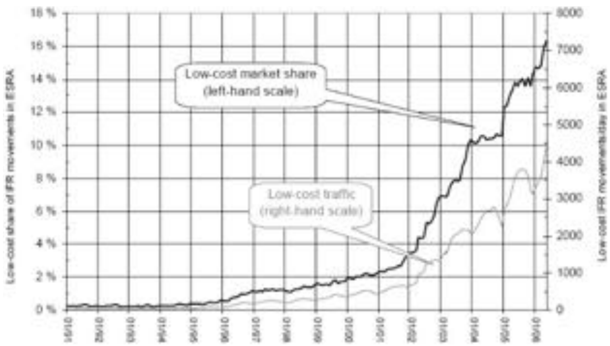

Ilustração 7: Quota de Mercado das Companhias *Low-Cost* no mercado europeu entre 1991 e 2006
Fonte: Adaptado de Steiner & Babic (2006, p. 7)

A título de exemplo, no mercado europeu as companhias low-cost conseguiram ganhar uma influência significativa, atingido uma cota de mercado de 16.5%, na europa, comparando aos 0.4% no início da década de 90, como se pode verificar na Ilustração 6. Ainda hoje se verifica uma crescente influência deste segmento, tendo em 2016 os lugares disponibilizados pelas companhias low-cost atingido os 39% do total de lugares disponíveis na europa, face aos 30% disponíveis em 2007 (MacDonald, 2017, p. 93).

Assim, o surgimento de um bem ou serviço disruptivo, embora tendo como objetivo a satisfação de uma necessidade primária de um bem ou serviço já existente, mas a preço mais reduzido ou de qualidade mais simples, pode levar a fortes alterações no mercado concorrencial, podendo alterar a repartição de rendimentos nesse mesmo setor e alterar o rumo do seu crescimento.

Posteriormente, temos a conexão BO e ID, que consiste numa rutura com o mercado tradicional e na criação de um bem ou serviço totalmente novo, que permitirá assim explorar um oceano azul, ou seja, um mercado completamente novo. Este novo mercado investe em novas necessidades, novos clientes e oferece novas experiências. Ao contrário da ID no RO, neste caso, o preço do bem ou serviço não é um critério primário na estratégia da empresa, pois teoricamente esta explora um oceano azul.

O caso mais concreto referido por Mauborgne & Kim (2005) é o do "*Le Cirque du Soleil*", na criação de um novo tipo de espetáculo numa fusão entre o teatro e o circo. Como resultado nasceu um espetáculo híbrido com uma base de clientes potenciais maior e mais abrangente. Um mercado totalmente novo, inexplorado, com grandes potencialidades de crescimento.

4.2. Conexão entre Benchmarking e Crowdsourcing e a Estratégia Oceano Azul e a Inovação Disruptiva

O *Benchmarking* é um processo, um instrumento de medida da performance de uma empresa em comparação com uma melhor empresa do mesmo ou de um diferente setor. Consiste, basicamente, na obtenção de conhecimento através do que é exterior à empresa, a partir do conhecimento e da experiência das outras empresas, concorrentes ou não, com o objetivo de melhorar a sua organização.

A maior vantagem do *benchmarking* é permitir uma maior capacidade de adaptação e de reação face às mudanças impostas pela constante mutação dos mercados e pela crescente globalização. Durante o processo de *benchmarking*, a empresa pode descobrir e desenvolver novas ideias e novas formas de trabalhar. Assim, o objetivo desta ferramenta, não é apenas aprender, comparar e incorporar estratégias dos seus rivais, como também tentar inovar e reinventar, de forma a manter-se no mercado concorrencial.

Keen & Cummings (2008, p. 51) defendem que *"as empresas que tenham como objetivo aplicar a BOS devem resistir à velha lógica do benchmarking no presente campo de batalha e ter que escolher entre a diferenciação ou a liderança pelo custo."* Seguindo os fundamentos destes autores, podemos concluir que o *benchmarking* é um instrumento que dificilmente, mas não impossível, se enquadra na ótica da BOS. Este instrumento não tem como base a criação de novos bens ou serviços e, consequentemente, novos mercados, os ditos oceanos azuis. Tem como objetivos bater a concorrência e, portanto, o foco está nos concorrentes e nos clientes habituais, totalmente o oposto da BOS, que dá preferência a alternativas em vez da concorrência e aos não-clientes em vez dos clientes habituais.

Sendo assim, o *benchmarking* poderá ser importante para empresas que aplicam a ID numa vertente, como vimos anteriormente, de RO. O foco está na concorrência e no ganho de quotas de mercado e, portanto, este pode ser um processo importante para ganhos de produtividade, melhorias no processo produtivo e na tomada de decisão, melhorias dos próprios bens e serviços e, consequentemente, maior capacidade de adaptação e de fazer frente à concorrência (Elmulti & Kathawala, 1997).

Relativamente ao *crowdsourcing*, este consiste numa contribuição individual ou coletiva, de uma população externa, restrita ou não à empresa, em que as suas ideias ou soluções poderão criar riqueza e dar mais valor a um bem ou serviço, e consequentemente à empresa, fomentar a inovação, e por um preço reduzido ou mesmo gratuitamente.

Num mundo cada vez mais global e com uma rivalidade e competição crescente nos mercados, sobretudo desde a entrada dos mercados asiáticos no mercado global, o *crowdsourcing* tornou-se, para muitas empresas, uma ferramenta importante para a sua sobrevivência. Deste modo, este instrumento pode ser importante tanto para o RO como para os BO, quer pela via da fomentação da inovação, importante para ambas as estratégias, podendo levar ao surgimento de inovações disruptivas, quer pela redução do tempo e dos custos ligados à inovação, ou ainda pela maior suscetibilidade de conhecimento e aceitação por parte dos clientes aos novos produtos, numa ótica de marketing à empresa e aos seus produtos.

Numa estratégia de oceano azul, o *crowdsourcing* pode ser a porta para o surgimento de novos bens ou serviços e, porventura, a construção de novos mercados. Vejamos o caso da Apple com o surgimento do iTunes. Até 2003, o mercado digital de música era inexistente, sendo que a maioria fluía na internet de modo ilegal. Enquanto, as companhias de CDs tentava limitar o crescente fluxo de downloads ilegais, a população queixava-se de não haver uma plataforma que permitisse adquirir música na internet de forma simples, legal e de preferência, barata. Face às opiniões do mercado, a Apple apercebeu-se na oportunidade e lançou em 2003 a plataforma iTunes que faria então a ponte entre o mercado da música e os seus clientes no mundo virtual. A Apple foi assim a primeira grande empresa a dedicar-se a este novo setor, através de uma inovação disruptiva, criando ela própria um novo mercado, um oceano azul, livre de concorrência.

Numa perspetiva de oceano vermelho, o *crowdsourcing* também é uma mais valia para as empresas, que quando bem aplicado pode acrescentar novos clientes e potenciar as vendas, bem como criar novos produtos para o setor. Segue-se o caso da campanha crowdsourcing do McDonald's, em

2011, na Alemanha. Esta campanha consistia em convidar os seus clientes a criar o seu próprio hamgúrguer via online. Posteriormente, as novas receitas seriam sujeitas a uma votação pelo publico, "*the crowd*", e no final, os hambúrgueres com mais clicks seriam vendidos nos restaurantes desta cadeia de fast food. De forma a vencer o concurso, os criadores, através de várias ferramentas, promoveram os seus hambúrgueres, acabando por publicitar gratuitamente a marca McDonald's. Em 5 semanas, o seu site teve mais de 7 milhões de visitas e mais de 116.000 hambúrgueres criados (Reichwarld e Piller, 2006).[3]

CONCLUSÕES

Com o presente trabalho foi possível compreender e analisar as vantagens da implementação das estratégias BO e da Teoria da ID na gestão estratégica empresarial, bem como o uso de ferramentas como o *benchmarking* e o *crowdsourcing*.

No que concerne à PD 1, "**Qual é a relação entre a Inovação Disruptiva e a Estratégia Oceano Azul e a Estratégia Oceano Vermelho**?", importa referir que a Inovação Disruptiva é uma estratégia que pode ser usada em conjunto tanto com a estratégia oceano azul como com a estratégia oceano vermelho.

Relativamente ao relacionamento de uma ID com o RO, em que o objetivo é bater a concorrência, é importante mencionar que o surgimento de um novo bem ou serviço disruptivo no mercado provocará uma expansão das fronteiras do mercado e terá como resultado alterações na repartição de rendimentos nesse setor e poderá alterar o rumo do seu crescimento.

No que diz respeito à relação da ID com um BO, verifica-se uma rutura com o mercado tradicional, com o surgimento de uma nova inovação, permitindo assim criar um novo mercado, livre de concorrência, um oceano azul.

Quanto à PD 2, "**De que forma é o Benchmarking uma mais-valia para a Estratégia Oceano Azul, Estratégia Oceano Vermelho e Inovação Disruptiva?**", constata-se que o *benchmarking* é um instrumento que dificilmente se enquadra na ótica da BOS, já que esta ferramenta tem como objetivos a obtenção de conhecimento de forma a superar a concorrência.

Assim, esta é uma mais-valia para as empresas que aplicam a estratégia da ID, numa vertente de RO, podendo ser uma ferramenta importante para aumentos significativos de produtividade, melhorias dos próprios bens e serviços e uma maior capacidade concorrencial.

Quanto à PD 3, "**De que forma é o Crowdsourcing uma mais-valia para a Estratégia Oceano Azul, Estratégia Oceano Vermelho e Inovação Disruptiva?**", verifica-se que o *crowdsourcing* é uma mais-valia tanto para a estratégia BO como a estratégia RO, podendo esta estar aliada, ou não, a uma ID.

Numa estratégia BO, o *crowdsourcing* pode levar ao surgimento de novos bens ou serviços, já que se tem em conta a opinião e as sugestões dos seus clientes e, por sua a vez, a construção de novos mercados.

Referente ao RO, esta ferramenta pode ser importante para a redução do tempo e dos custos associados à inovação e ao *marketing*, melhorar ou colmatar problemas dos seus bens e serviços. Quando ligado a uma ID, o *crowdsourcing* pode favorecer o surgimento de novos bens ou serviços.

Após toda a análise realizada, resultados demonstrados e respostas dadas, estão criadas as condições necessárias para responder à PP: "**Qual é a relevância da utilização da Estratégia Oceano Azul e Inovação Disruptiva na Gestão Estratégica Empresarial?**". Analisando esta questão, é possível afirmar que a adoção de tais estratégias pode ser importante para o sucesso de uma empresa e para a sua sobrevivência no mercado global. A escolha da estratégia está subordinada aos objetivos da empresa quanto ao tipo de mercado em que está inserida. Quando se encontra perante um mercado concorrencial cabe a esta optar entre continuar no mercado de oceano vermelho, de forte concorrência, ou criar um novo mercado em oceano azul, livre de concorrência, com as devidas consequências. A estratégia da inovação disruptiva pode ainda ser usada paralelamente com as duas estratégias anteriores, podendo ser uma mais-valia aquando a sua adoção conjunta com a estratégia Red/ Blue Ocean, como verificado na PD 1.

As ferramentas de *benchmarking* e de *crowdsourcing* poderão também ser importantes para implementação das estratégias definidas no presente trabalho, como concluído, respetivamente, na PD 2 e PD 3.

DESAFIOS PARA INVESTIGAÇÕES FUTURAS

Durante a elaboração do presente trabalho de investigação de grupo, verificámos a existência de uma limitação que condicionou a realização do mesmo: o número de páginas permitidas para o trabalho. O que levou a que a informação fosse exposta de forma muito resumida dificultando a transmissão das ideias-chave, tanto como o próprio resumo da extensa informação encontrada.

Com base na análise e discussão de resultados e, posteriormente, nas conclusões da investigação, propomos como futuros objetos de estudo os seguintes temas:

1. A aplicação do benchmarking nas Forças Armadas;
2. A importância da Gestão da Mudança nas organizações.

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Referencial de Utilização das Tecnologias de Informação para a Melhoria da Qualidade de Vida nas Smart Cities

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ABSTRACT

Due to the growth of the world population and the strong urbanization of cities, the efficient and sustainable management of resources and spaces has become a priority to improve the quality of life of the population. This is only possible when combined with new technologies. In this context, the concept of Smart City emerged, which refers to cities that, with the help of technology, offer citizens services and opportunities that otherwise would not be possible to guarantee.

The goal of this article is to explore and understand the impact and the numerous improvements that the Smart Cities can bring to our society, as well as analyse which are the technologies that influence the quality of life.

It is also intended to propose a framework that can be adopted by any city, in order to improve the daily lives of its citizens. This framework focuses on technologies that influence the quality of life of citizens, especially in the areas of health, education, environment, security, civic participation, accessibility of services, mobility and culture.

KEYWORDS: Information systems; Framework; Citizens; Sustainability; Cities.

RESUMO

Com o crescimento da população mundial e a forte urbanização das cidades, tornou-se uma prioridade a gestão eficiente e sustentável de recursos e espaços, por forma a melhorar a qualidade de vida da população. Tudo isto só é possível quando aliado às novas tecnologias. Neste contexto, originou-se o conceito de *Smart City*, cidades que, com a ajuda da tecnologia, oferecem aos cidadãos serviços e oportunidades que, de outra forma, não seria possível garantir.

Este artigo tem como objetivo explorar e perceber o impacto e as inúmeras melhorias que as *Smart Cities* podem trazer à nossa sociedade, bem como analisar quais são as tecnologias que influenciam a qualidade de vida.

Propõe-se, ainda, um referencial que poderá ser adotado por qualquer cidade, de forma a melhorar o quotidiano dos seus cidadãos. Este referencial foca-se nas tecnologias que têm influência na qualidade de vida dos cidadãos, designadamente nas áreas da saúde, educação, ambiente, segurança, participação cívica, acessibilidade de serviços, mobilidade e cultura.

PALAVRAS-CHAVE: Sistemas de informação; Framework; Cidadãos; Sustentabilidade; Cidades.

1. INTRODUÇÃO

Atualmente, mais de metade da população reside em zonas urbanas e a tendência é que esta percentagem aumente cada vez mais (ONU, 2012). Com o surgimento das cidades, a vida da população melhorou consideravelmente, através do fornecimento de água e saneamento básico, educação, transportes e habitações. As cidades são, também, responsáveis pelo fomento da economia e pela criação de novos empregos (Yin et al., 2015). Contudo, esta situação origina diversos constrangimentos como, por exemplo, a poluição atmosférica e sonora, o congestionamento rodoviário, as desigualdades económicas e financeiras, a degradação de edifícios, a diminuição dos espaços verdes, falta de espaço, entre outros (Aires & Santos, 2016). Por forma a tentar solucionar estes problemas de uma forma inteligente, começaram a ser utilizadas as tecnologias (Sujata et al., 2016).

No âmbito deste pressuposto, surgiu o conceito de *Smart City* (SC), no qual uma cidade tradicional transforma-se numa cidade inteligente, respondendo a desafios atuais, tais como a sustentabilidade e a qualidade de vida (QV) da população, criando cidades mais habitáveis e convenientes (Marsal Llacuna et al., 2015).

Neste artigo, serão analisados os conceitos de *Smart Cities* e qualidade de vida, bem como as Tecnologias de Informação (TI) associadas a estas noções. O objetivo é compreender qual a importância das TI no funcionamento e construção das cidades inteligentes e, ainda, perceber quais destas tecnologias estão a ser utilizadas, bem como aquelas que futuramente poderão ser implementadas de forma a melhorar a qualidade de vida dos cidadãos.

2. QUALIDADE DE VIDA

2.1. Definição

Um dos maiores objetivos dos investigadores, governo e sociedade é perceber, melhorar e medir a experiência humana. Esta experiência pode ser definida como qualidade de vida e é referida em diversas disciplinas como Medicina, Psicologia, Economia, Sociologia e Ciência Ambiental (Costanza et al., 2007).

O conceito de qualidade de vida é facilmente percebido pelas populações e existe um consenso sobre o seu caráter positivo, mesmo não sabendo do que se está a falar concretamente. É descrito pela maior parte dos autores como estando relacionada com as condições de saúde, enquanto outros têm abordagens mais amplas, em que a saúde é apenas um dos parâmetros a considerar (Pereira et al., 2012).

O termo qualidade de vida surgiu por volta de 1960, nos Estados Unidos, como propaganda política. O presidente Lyndon Johnson fez menção a este conceito durante um discurso em 1964, na Universidade de Michigan, que fazia refletir sobre como as pessoas procuram uma “vida melhor” ou “vida de qualidade”. Muitos outros políticos, desde essa altura, têm utilizado este termo nas suas campanhas políticas, o que incentivou o interesse sobre este tema (Pereira et al., 2012).

O termo qualidade implica por si um grau de excelência de uma determinada característica, não obstante, o conceito de qualidade de vida pode ter significados diferentes para cada pessoa. Para alguns indivíduos, pode exprimir a sua felicidade e a dos outros, ou pode significar o nível económico, de saúde, de segurança ou de educação (Das, 2008).

Existem diversas definições para o que se considera qualidade de vida, mas nenhuma que seja universalmente aceite. Este conceito tem evoluído ao longo dos anos e, atualmente, sabe-se que não está só relacionada com fatores relacionados com a saúde, mas também com o bem-estar físico, emocional, mental e funcional, e, ainda, com outros fatores fundamentais na vida dos seres humanos como, por exemplo, a família, amigos, trabalho e fatores do quotidiano (Pereira et al., 2012).

2.2. Tópicos

Segundo um estudo realizado pela OECD, a qualidade de vida é influenciada por 6 tópicos, e cada um possui 1 ou 2 indicadores (OECD, 2016):

	Tópicos	Indicadores
Qualidade de vida	Saúde	- Expectativa de vida (anos) - Idade ajustada a taxa de mortalidade (por 1000 pessoas)
	Educação	- População com pelo menos o 12º ano de escolaridade (%)
	Ambiente	- Poluição média do ar por PM2.5 (µg/m³)
	Segurança	- Taxa de homicídios (por 100 000 habitantes)
	Participação cívica	- Participação de eleitores (%)
	Acessibilidade de serviços	- Percentagem de habitações com acesso à internet (%)

Ilustração 1: Tópicos selecionados para a qualidade de vida
Fonte: OECD Regional Well-Being

Na nossa opinião, deveria estar incluído na ilustração um tópico de mobilidade, com os indicadores de quantidade de transporte públicos e número de lugares de estacionamento disponíveis. Da mesma forma, deveria ser, ainda, adicionado um outro somente relacionado com a cultura, apoiando-se em indicadores como o número de sessões de espetáculos culturais, número de visitantes aos museus e número de utilizadores de bibliotecas.

Face ao já exposto, serão analisadas as TI que contribuem para a melhoria a qualidade de vida nos seguintes tópicos: saúde, educação, ambiente, segurança, participação cívica, acessibilidade de serviço, mobilidade e cultura.

3. SMART CITIES

O conceito de *Smart City* começou a ser utilizado no início dos anos 90, de forma a transmitir que o desenvolvimento urbano estava cada vez mais inclinado para as tecnologias, inovação e globalização (Yin et al., 2015). Foi devido a projetos suportados pela União Europeia que, desde 2010, existe um grande interesse por esta área e surgiram muitas publicações académicas sobre este tema (Jucevičius et al.,2014).

Ainda não há um consenso universal sobre o que é uma *Smart City*, existindo diversas definições sobre este tópico.

Uma *Smart City* pode ser descrita como um conjunto de serviços que podem ser implementados para melhorar a vida da população, dos visitantes, os negócios e a interação com o governo. São utilizadas TICs com o intuito de melhorar a qualidade de vida dos residentes e desenvolver a economia, tendo em conta a sustentabilidade ambiental (Council, Cisco, & Telstra, 2015).

Uma cidade inteligente permite a integração de dados e informação, antecipando problemas, criando soluções rápidas e eficazes, principalmente no âmbito da gestão de tráfego rodoviário, segurança, saúde, meteorologia, água e energia (Inteli, 2012).

Estas cidades também permitem a participação dos cidadãos no processo de definição de políticas públicas, serviços públicos e na gestão da cidade, tornando-os, desta forma, ativos (Giffinger, 2007).

Existem várias definições e várias perspetivas sobre as SC, contudo, este conceito ainda está por evoluir e antevê-se que serão criadas novas perspetivas. Pode-se concluir que as SC dependem das tecnologias avançadas de processamento de dados, por forma a melhorar a qualidade de vida dos cidadãos, tornando a cidade mais eficiente, melhorando o ambiente e os negócios (Yin et al., 2015).

Assim, as *Smart Cities* são essenciais para que um país possa competir globalmente, permitindo diminuir os efeitos negativos das urbanizações, melhorando as infraestruturas e qualidade de vida, tendo em conta a sustentabilidade ambiental, aumentando a segurança e melhorando a economia (Zhuhadar et al., 2017).

3.1. TECNOLOGIAS NAS SMART CITIES

Um dos temas mais abordados na literatura nesta matéria, é o papel das TIC nas SC que se considera a sua principal característica. As cidades inteligentes estão relacionadas com as aplicações das tecnologias, quer como infraestrutura digital quer com o seu uso a nível das cidades e regiões (Komninos, 2002). Na infraestrutura digital inclui-se os telefones fixos e telemóveis, TVs via satélite e principalmente a Internet (Tranos & Gertner, 2012).

Surgem, de forma acelerada, tecnologias relacionadas com as SC, designadamente a inteligência artificial, engenharia de software, computação em nuvem, rede de computadores, engenharia de sistemas, sistema de informação geográfica, a Internet das coisas (IoT), computação de alto desempenho, tecnologia de segurança da informação, modelagem e simulação, sistema de posicionamento global, etc. (Liu & Peng, 2013).

3.1.1. Tecnologias na Saúde

A tecnologia também pode ajudar a melhorar a qualidade de vida na área da saúde, sendo importante destacar algumas das evoluções tecnológicas que causam um maior impacto na vida dos pacientes.

Hoje em dia já podemos encontrar software destinado a promover alterações comportamentais, de forma a precaver o aparecimento de doenças (Santos, 2015). Estas aplicações estão inseridas no *mHealth*, através do qual a prática da saúde é suportada por telemóveis, dispositivos de monitorização de pacientes e outros dispositivos sem fio. As iniciativas do *mHealth* mais frequentes são as linhas de ajuda de cuidados de saúde, serviços telefónicos gratuitos de emergência e telemedicina (WHO, 2011).

Podemos também salientar os aplicativos móveis, que permitem monitorizar pessoas, incluindo doentes, objetos, a equipa médica e ambulâncias (Bouskela et al., 2016). Em relação aos doentes, pode-se monitorizar o seu estado de saúde *online*, através de dispositivos vestíveis com sensores, possibilitando a uma melhor gestão clínica, do hospital e dos seus trabalhadores (Niyato et. al, 2009).

Todos os hospitais, centros de saúde e clínicas devem possuir conectividade de banda larga e plataformas de videoconferência, por forma a fornecer serviços médicos *online* (telemedicina) ou permitir o ensino *online* de profissionais em zonas remotas (Bouskela et al., 2016).

Os Sistemas de Informação Hospital (*Health Information System*), são essenciais nos serviços de rotina de um hospital. Devem permitir pesquisar e modificar dados sobre os pacientes, nomeadamente os diagnósticos e resultados (Mattoo, Zia-ur-Rehman, & Rashid, 2013).

Outra tecnologia que pode melhorar bastante a qualidade de vida da população mais envelhecida é o sistema de monitorização de idosos, que é constituído por diversos sensores. Também a partir de dispositivos vestíveis, é possível observar os sinais vitais dos idosos (Tsukiyama, 2015).

A impressão 3D é uma tecnologia de fabrico por sobreposição que permite a conceção de objetos tridimensionais de quase todo o tipo de formato, utilizando, para o efeito, um modelo digital. (STOA, 2016).

Outro avanço tecnológico foram os *IBeacons*, que são pequenos aparelhos que fornecem informação através de *Bluetooth* e que comunicam com qualquer *smartphone* ao seu alcance. Cada um tem um número próprio de identificação e, com este, consegue encontrar a informação sobre uma determinada loja. Estes também podem ser utilizados como um sistema de distribuição de informação *indoor* para pessoas invisuais (Ruffa et al., 2015).

A utilização da inteligência artificial na medicina tem crescido gradualmente nos últimos tempos. Esta pode ser descrita como o uso de computadores, com o intuito de analisar grande volumes de dados e, através de algoritmos de decisão, é capaz de encontrar novas soluções para problemas e doenças. Outra utilização da inteligência artificial é a criação de sistemas inteligentes, que conseguem realizar tarefas sem nenhuma interação humana (Lobo, 2017).

3.1.2. Tecnologias na Educação

Atualmente, as TIC encontram-se em todos os setores da atividade humana, e a educação não é exceção. Estas tecnologias aumentam a eficiência e a qualidade do trabalho dos professores e são inseparáveis das crianças (Hlásná et al., 2017). Em seguida, serão apontadas algumas evoluções tecnológicas relevantes no contexto escolar e pedagógico.

A Internet permitiu que grande parte das crianças tivesse acesso a plataformas de ensino e a conteúdos de qualidade. Estas plataformas colaborativas permitem, ainda, o acesso ao material escolar e a comunicação e conhecimento entre instituições escolares. Um exemplo deste tipo de aplicações é a MOOCs (*Massive Open Online Course*), que permite a vários alunos terem acesso a diversos cursos (Ganju, Pavlou, & Banker, 2016). Outra tecnologia relacionada com os dispositivos móveis são os *Ebooks*, livros eletrónicos. Uma vez que todo o material está disponível 24 horas, tem a funcionalidade de pesquisa de texto e a sua portabilidade é uma vantagem (Wells & Sallenbach, 2015).

Na gestão escolar, os dados devem estar informatizados, permitindo consultar as matrículas, vagas *online*, notas e relatórios de desempenho, traduzindo-se numa melhor comunicação entre os encarregados de educação e a escola (Bouskela et al., 2016).

A realidade aumentada é uma tecnologia que permite a sobreposição de informações virtuais sobre a realidade. Esta realidade encoraja a aprendizagem, permite inspecionar objetos 3D, vê-los em determinas perspetivas e, consequentemente, facilita a compreensão dos mesmos (Diaz, Hincapié, & Moreno, 2015).

A realidade virtual permite simular situações que são difíceis de criar no mundo real, possibilitando, assim, o desenvolvimento das habilidades e motivação dos indivíduos (Dávideková, Mjartan, & Greguš, 2017).

Os robôs educacionais são outra tecnologia que permite melhorar a aprendizagem. Estes fornecem um instantâneo *feedback*, fazendo com que os alunos considerem as diversas soluções até encontrarem a correta, captando a atenção dos mesmos durante esse período de reflexão (Damaševičius, et al., 2017).

No que respeita às escolas, estas devem possuir sensores de *bullying* e *vaping* (utilização de cigarros eletrónicos), como é o caso do *Fly Sense*, que pode ser colocado em zonas cuja instalação de câmaras de vigilância é proibida. Este equipamento consegue controlar a qualidade do ar e níveis de som, por exemplo, se os níveis de som aumentam devido a uma luta entre alunos, ou se a qualidade do ar mudar devido ao vapor provocado pelo fumo de cigarros, o *Fly Sense* deteta automaticamente e envia um alerta ao responsável da escola (Digitalfly, 2018).

Os sensores inteligentes podem ser usados de forma educacional, uma vez que permitem, por exemplo, monitorizar a integridade estrutural, temperatura e densidade do tráfego de uma ponte (Cisco, 2018).

3.1.3. Tecnologias no Ambiente

O ambiente é um dos temas essenciais a ser abordado quando se trata de qualidade de vida, uma vez que espaços verdes, áreas recreativas e uma boa qualidade do ar e água são essenciais para ter cidadãos felizes e saudáveis. Entre as diversas tecnologias do ambiente podemos destacar:

Energias renováveis

As energias renováveis são essenciais nas comunidades, uma vez que aumentam a segurança energética, aceleraram o desenvolvimento económico, reduzem a poluição no ar, diminuem a dependência do carvão e de outros combustíveis fósseis, etc.(Noorollahi et al., 2017).

Rede elétrica inteligente

A rede elétrica inteligente (*Smart grid*), tem como objetivo aumentar o desempenho do sistema de rede, utilizando métodos de monitorização e de controlo remoto que fornecem informação em tempo real dos consumos e, ainda permitem, em casos de erro humano ou desastres naturais, minimizar as perdas e prever os problemas (Bressan et al., 2010).

Sistemas meteorológicos e de água

Os sistemas meteorológicos permitem melhorar a eficiência de uma cidade, utilizando vários sensores que fornecem dados sobre a temperatura, velocidade do vento, chuva e radiação solar (Botta et al., 2016).

Os sistemas inteligentes de distribuição de água são mais eficientes do que os convencionais, uma vez que permitem implantar sensores em locais apropriados nos sistemas de distribuição, melhorando a eficiência e deteção de falhas, controlando o nível de água do reservatório e a qualidade da água. Pode-se, ainda, mencionar os sistemas de monitorização de águas residuais, que são constituídos por dispositivos de monitorização que detetam fugas e mudanças na pressão da água, garantindo, assim, um controlo à distância de reservatórios e caudais (Deloitte, 2015).

Sistemas inteligentes de gestão de resíduos

As cidades preocupam-se, cada vez mais, com a eficiência na recolha e tratamento de resíduos urbanos e utilizam as tecnologias como auxílio neste processo. A República Checa utiliza uma solução inovadora de recolha de resíduos urbanos, os contentores de lixo inteligentes chamados "*Bigbells*", da empresa *Bigbelly* - *Smart Solutions*. Estes estão equipados com um sensor (que informa quando o contentor se encontra cheio), painéis solares (que permitem carregar as baterias) e uma prensa elétrica, reduzindo assim o volume de resíduos (Dufek, Chorazy, & Apeltauer, 2017).

Iluminação pública inteligente

As lâmpadas inteligentes são, na sua maioria, compostas por LEDs: são menores, mais resistentes e imitem diversos espectros de luz, conforme as necessidades subjacentes. Têm como objetivo ser mais eficientes, reduzindo, assim, o uso de eletricidade, criando um impacto menor no ambiente (Karlicek, 2012).

Sensores na área do ambiente

Na área do ambiente, pode-se salientar a importância da existência dos seguintes sensores: sensores de ar (detetam os níveis de poluição existente no ar), sensores de energia (monitorizam o uso de energia), sensores de estufa (detetam a temperatura, humidade e nível de CO_2), sensores de iluminação pública (ajustam a iluminação pública ao nível exigido), sensores de gestão de resíduos (detetam quando os caixotes do lixo estão cheios) e sensores de monitorização da água (detetam fugas de água na rede de distribuição) (Deloitte, 2015).

3.1.4. Tecnologias na Segurança Pública

A segurança pública compreende um conjunto de processos que proporcionam a segurança ao cidadão e a integridade do património. Esta pode ser aperfeiçoada utilizando, para este fim, as tecnologias que permitem uma maior eficiência, agilidade e menores custos (ABDI, 2010).

No domínio da segurança pública, é importante o uso de sistemas de vigilância, de forma a monitorizar locais e áreas (Al-muaythir & Hossain, 2016).

Dentro das diversas tecnologias na área da segurança pública, podemos destacar algumas das mais relevantes, como, por exemplo, a iluminação pública, que aumenta bastante a segurança dos cidadãos (Deloitte, 2015).

Os drones também são bastantes importantes, uma vez que possibilitam obter imagens de locais de crimes, pesquisar locais de acidentes e encontrar incêndios, sem colocar em risco vidas humanas.

Os programas de prevenção de crime baseados em dados são igualmente úteis, pois a partir da análise dos mesmos, consegue-se determinar as causas mais prováveis do aumento de crimes numa determinada região (Deloitte, 2015).

Neste contexto, podemos referir os aplicativos de emergência, pois estes podem ser utilizados pelos cidadãos para enviar alertas no caso de uma emergência, médica ou criminal. Estes detetam automaticamente os locais, e notificam os órgãos policiais mais próximos.

A deteção de disparos (Sistema de Deteção de Disparos de Armas de Fogo), também é fundamental, pois uma rede de sensores acústicos em toda a cidade, nomeadamente nos telhados dos edifícios, pode detetar com precisão um tiroteio (Deloitte, 2015).

Os sistemas biométricos capturam determinadas características de uma pessoa em sinais analógicos ou digitais, codificando as mesmas em informação e armazenando-as para análise computacional. Pode-se mencionar, também, os sistemas de monitorização e bloqueio de sinais, que permitem monitorizar e bloquear radiofrequência em zonas prisionais. Os sistemas de deteção e reconhecimento de padrões de vídeo, juntamente com as câmaras de vigilância, conseguem detetar objetos perigosos e ainda reconhecer padrões em imagens (ABDI, 2010).

Ainda podemos falar de realidade aumentada na área da segurança, que melhora a eficiência da reposta à emergência e que, juntamente com sistemas de banda larga sem fios, irão dar origem a aplicativos e serviços de segurança públicas impensáveis até ao momento (Cision, 2018).

Também é importante salientar que, nos EUA, será implementado um novo sistema de apoio via chamadas de emergência ("*Next Generation* 911"). Este sistema permite a partilha de dados digitais, como fotografias, vídeos, texto ou áudios entre o indivíduo que contacta o número de emergência e o *call center*. O NG911 estará, ainda, apto para receber dados e notificações de dispositivos conectados digitalmente, como alarmes domésticos, carros, computadores, etc. (911, 2018).

<u>Sensores na área da segurança</u>

Na área da segurança, podemos salientar a importância dos seguintes sensores: sensores de disparos (detetam o som de um tiro e identificam a sua localização em tempo real), sensores de gases perigosos (detetam níveis de gases explosivos ou tóxicos), sensores de localização (utilizados para localizar objetos), sensores de ruído (monitorizam os níveis de ruído) e sensores perimetrais (detetam pessoas em áreas não autorizadas) (Deloitte, 2015).

3.1.5. Tecnologias na Participação Cívica

A confiança no governo é essencial para que exista uma alta participação da população no processo político. Esta participação é fundamental para a qualidade de vida e bem-estar social (OECD Better Life Index, 2016).

Com o desenvolvimento das TIC e das comunidades digitais, não se pode negar as inúmeras oportunidades que as mesmas fornecem à população, no que diz respeito ao envolvimento e participação cívica, educação, interação e autoexpressão (Jenkins et al., 2009).

Portanto, devido ao crescente uso de plataformas digitais acessíveis na internet ou nos *smartphones*, cada vez mais os cidadãos têm acesso a várias vertentes da administração pública de uma cidade. As cidades podem permitir a participação cívica através de, por exemplo, fóruns de discussão, onde a população pode comentar, discutir e votar nas propostas sugeridas pelas câmaras municipais; através das aplicações móveis, que permite os cidadãos informar a câmara municipal sobre diversos problemas nas infraestrutura da cidade, e solicitar serviços ou reparos, ou até mesmo através das redes sociais da própria cidade, permitindo averiguar a tomada de decisão dos cidadãos nos diversos assuntos vários sobre a cidade (Bouskela et. al, 2016).

É, ainda, relevante salientar a importância do Orçamento Participativo (envolvimento da população nas tomadas de decisão sobre os investimentos públicos), utilizado para ouvir a opinião dos cidadãos. A maioria dos municípios em Portugal já disponibiliza uma qualquer forma de orçamento participativo (Silva, 2016).

3.1.6. Tecnologias na Acessibilidade de Serviços

Dentro das diversas tecnologias na área da acessibilidade de serviços que uma cidade deve oferecer, podemos destacar, por exemplo, o acesso gratuito a redes de *Wi-Fi*, a pontos de informação turísticos espalhados pela cidade (ou podendo ser acedidos a partir de uma aplicação móvel) e a possibilidade de as câmaras municipais comunicarem incidentes/problemas aos seus cidadãos, através de uma aplicação móvel.

A cidade de Nova Iorque é pioneira no que se trata de rede de comunicações, pretendendo substituir mais de 7,500 cabines telefónicas por novas estruturas chamadas *Links*. Cada *link* oferece *Wi-Fi* gratuito, chamadas telefónicas gratuitas para os Estados Unidos, podendo carregar-se dispositivos e observar mapas da cidade (LinkNYC, 2017).

Já a cidade de Amesterdão tem como objetivo instalar vários bancos *Sterora*: este banco fornece conexão à internet, carrega o telemóvel em segundos e tudo a partir da energia solar (Amsterdam Smart City, 2017).

No que se trata a fornecer informação para os seus cidadãos, existem cidades que deram um passo mais além, como é o caso de Telaviv, que faculta serviços e comunicações com o Digi-tel, permitindo personalizar a informação recebida consoante os seus interesses (ambiente, saúde, transportes, etc.), e possibilita escolher como quer receber essa informação (telefone, carta ou *e-mail*). Assim, a câmara municipal consegue enviar informação personalizada para cada indivíduo (Tel-aviv, 2017).

O Projeto Vincles, foi criado pela cidade de Barcelona e tem como principal objetivo diminuir o isolamento dos cidadãos mais idosos, cidadãos com doenças crónicas ou dependentes referenciados pela Segurança Social. Vincles funciona com uma rede de apoio social, onde se pode criar círculos sociais, permitindo que as pessoas comuniquem entre si e que respondam a pedidos e alertas. Esta rede é composta por amigos, família e profissionais da área dos serviços socias de área da saúde (Aires & Santos, 2016).

Não podemos deixar de referir a acessibilidade de serviços para as pessoas com algum tipo de deficiência. Cada vez mais existem ferramentas e aplicações que têm como objetivo melhorar a vida destes cidadãos. A Microsoft, por exemplo, criou um projeto - a Microsoft *Soudscape* -, que tem como objetivo ajudar pessoas com problemas de visão. Esta aplicação fornece informações sobre o ambiente em que o utilizador se encontra (através de áudio), utilizando, para isso, sensores de localização e os *IBeacons* (Microsoft, 2018).

3.1.7. Tecnologias na Mobilidade

A mobilidade inteligente compreende diversas ações por forma a facilitar a mobilidade dos cidadãos, quer seja a pé, de bicicleta, de transportes públicos, ou de carro (Bustamante, 2015). Neste contexto, podemos salientar, a título exemplificativo, as tecnologias que se seguem.

Uma SC deve possuir câmaras de monitorização e fortes infraestruturas de comunicação, bem como os veículos devem possuir GPS e as estradas devem ser alvo de instalação de sensores de ar e acústicos (Li et. al, 2009).

Gestão de tráfego inteligente

A partir de sensores colocados em carros e infraestruturas, consegue-se obter dados em tempo real sobre o tráfego rodoviário, permitindo aos sistemas inteligentes otimizar o tráfego, ajustando os semáforos. Estes sistemas podem, ainda, ajudar os serviços de emergência, permitindo que as ambulâncias se desloquem no caminho mais rápido, alterando os semáforos à sua passagem e controlando pontes (Deloitte, 2015).

Gestão inteligente dos transportes públicos

Hoje em dia, a tecnologia pode ser utilizada para fornecer diversas informações sobre transportes públicos. Os aplicativos desta área permitem, por exemplo, avisar o utilizador da chegada de um determinado transporte público ou fornecer informações de qual o melhor transporte a utilizar, caso o indivíduo não esteja familiarizado com a rota (Deloitte, 2015).

Gestão inteligente de lugares de estacionamento

Este serviço funciona com bases em sensores rodoviários e mostradores inteligentes que levam os condutores à melhor rota para estacionar na localidade pretendida (Lee et al., 2008).

Como este tipo de serviços, é possível encontrar um lugar mais rapidamente, e, consequentemente, reduzir as emissões de dióxido de carbono, diminuindo o tráfego rodoviário e aumentando a satisfação dos cidadãos (Zanella et al., 2014).

Veículos autónomos e elétricos

Os benefícios dos veículos elétricos são óbvios no que toca ao ambiente e ao bem-estar da população, reduzindo o dióxido de carbono e outros gases de estufa no ambiente, aumentado consideravelmente a qualidade do ar (Todorovic & Kumar, 2017).

Os transportes autónomos têm a capacidade de operar de forma independente e abrangem uma grande variedade de tipos de veículos, normalmente os que se deslocam em terra, mas também no ar e no mar (STOA, 2016).

Sensores na área da mobilidade

Podem-se destacar os seguintes sensores na área da mobilidade: sensores de distribuição de veículos (detetam a localização geográfica de veículos), sensores de estacionamento (informação facultada é utilizada para orientar as pessoas que procuram um lugar de estacionamento), sensores de estradas (detetam a temperatura de uma estrada, fornecendo, assim, alertas antecipados aos condutores) e sensores de congestionamento e trânsito (detetam congestionamento de tráfego rodoviário) (Deloitte, 2015).

3.1.8. Tecnologias na Cultura

Ao contrário do que se possa pensar, a arte está relacionada com a ciência, uma vez que esta permite novas formas de representação e suporte. A tecnologia também é influenciada pela arte, o que lhe atribui uma maior componente de humanização (Domingues, 2003).

Existem vários tipos de arte espalhados pela cidade, desde o património arquitetónico até à *Street Art* (p.e *graffitis, stickers*, entre outros). As tecnologias de informação permitiram uma evolução mais sofisticada da arte interativa – é a forma de arte que permite a interação com o espectador. Neste tipo de arte, normalmente utilizam-se sensores e supercomputadores para responder a vários tipos de estímulos como sons, calor, movimentos, etc. Na cidade de Doetinchen, na Holanda, existe uma escultura de 12 metros, que muda de cor consoante a escolha dos internautas, sendo assim uma forma de arte interativa (Santos, 2016). A cidade de Viena também demonstra que as tecnologias e a cultura não são mutualmente exclusivas. Já é possível, através de um computador, *SmartTV* ou da *App Wiener Staatsoper*, ter acesso aos espetáculos da Ópera de Viena. Esta extensão virtual possui imagem em formato HD e oferece legendas em diversos idiomas, no entanto, as transmissões não são em direto, pois têm em consideração o fuso horário de cada país, sendo a emissão sempre em horário nobre, permitindo, assim, com a ajuda da tecnologia, abranger um público de maior dimensão (Wien, 2018).

A tecnologia também é cada vez mais utilizada pelos museus, desde aplicações móveis que permitem pesquisar exposições e áudio guias dos espaços, até aos *websites* (Henriques, 2004).

A tecnologia também permite que pessoas invisuais consigam apreciar obras artes, a partir da reprodução digital e tecnologia em 3D. O museu Louvre foi o primeiro a criar a Tactile Gallery, em 1995 - esta galeria permite que todas as pessoas invisuais toquem nas reproduções de arte da coleção. (Ideiafixa, 2018).

4. REFERENCIAL PARA UTILIZAÇÃO DAS TI NA MELHORIA DA QUALIDADE DE VIDA

4.1. Pressupostos

Considerando a revisão de literatura anteriormente apresentada sobre cidades inteligentes e qualidade de vida, construiu-se um referencial, baseado nos conhecimentos adquiridos. Este referencial apresenta-se numa ilustração constituída por 8 linhas e 4 colunas. Esta escolha teve em consideração o estudo realizado pela OECD sobre a qualidade de vida, e as áreas que este considera relevantes para a qualidade de vida (Ilustração 1) e as áreas acrescentadas para melhorar o mesmo estudo. Portanto, tem 8 linhas, uma linha por cada área e 4 colunas, uma por cada macro grupo tecnológico (Sensores, Sistemas, Aplicações e Outras).

O processo de validação deste referencial consistiu na realização de entrevistas individuais a peritos de diversas áreas. Face ao confronto com a realidade, proveniente das entrevistas realizadas nas áreas da saúde, educação, ambiente, segurança, participação cívica, acessibilidade de serviços, mobilidade e cultura, aperfeiçoou-se o referencial, incorporando as tecnologias mencionadas pelos vários especialistas.

TI / Áreas	Sensores	Sistemas	Aplicações	Outras
Saúde	• Dispositivos vestíveis; • Dispositivos internos; • Dispositivos externos; • Sensores de ruído e monitorização de quedas.	• Sistemas de monitorização; • Sistemas inteligentes (inteligência artificial); • Sistemas de informação hospitalar.	• Aplicações de m-Health; • Aplicações de literacia na saúde.	• Impressão3D; • Infraestrutura digital; • Telemedicina; • Ibeacons; • Drones.
Educação	• Sensores de bullying e vaping; • Sensores inteligentes utilizados de forma educacional.	• Sistema de gestão escolar.	• Aplicações educativas; • Aplicações de auxílio ao estudo.	• Plataformas colaborativas; • Robot educacional; • Realidade Virtual e aumentada.
Ambiente	• Sensores de ar; • Sensores de energia; • Sensores de estufa; • Sensores de iluminação pública; • Sensores de monitorização de água; • Sensores de gestão de resíduos.	• Sistemas de gestão da água, de rega e meteorológicos; • Sistemas de monitorização de águas residuais; • Sistemas de gestão inteligente de resíduos urbanos; • Rede elétrica inteligente.	• Aplicações de gestão de resíduos; • Aplicações de rede elétrica inteligente.	• Painéis Solares/ aerogeradores; • Drones.

TI / Áreas	Sensores	Sistemas	Aplicações	Outras
Segurança	• Sensores de gases perigosos; • Sensores de localização; • Sensores perimetrais; • Sensores de ruído; • Sensores de disparo; • Sensores de infravermelhos.	• Sistema de iluminação pública inteligente; • Sistema de deteção de disparos de armas de fogo; • Novos sistemas de apoio de emergência; • Sistemas biométricos; • Sistemas de monitorização e bloqueio de sinais; • Sistemas de vigilância e de deteção de padrões.	• Aplicativos de emergência;	• Equipamentos de visão noturna; • Câmaras corporais; • Drones; • Programas de prevenção de crime baseados em dados; • Realidade aumentada; • Segurança física (pilaretes semiautomáticos e automático).
Participação Cívica		• Sistema de votação online (orçamento participativo).	• Aplicações móveis de solicitação de serviços ou reparos; • Aplicações de fornecimento de serviços.	• Plataformas digitais; • Fóruns de discussão.
Acessibilidade de serviços	• Sensores de localização.		• Aplicações de informação ao cidadão e aos turistas; • Aplicações de localização para pessoas com deficiências; • Aplicações que permitem a comunicação entre municípios e cidadãos.	• Acesso gratuito a redes de Wi-fi; • Pontos de informação turísticos, espalhados pela cidade; • Redes de apoio social; • IBeacons; • Dados Abertos.
Mobilidade	• Sensores de distribuição de veículos; • Sensores de estacionamento; • Sensores de estradas; • Sensores de congestionamento e trânsito.	• Sistema de gestão inteligente de lugares de estacionamento; • Sistemas de gestão inteligente de tráfego e da sinalização semafórica; • Sistema de gestão inteligente dos transportes públicos.	• Aplicações de estacinamento, que divulguem lugares disponíveis e meios de pagamento; • Aplicações de transportes públicos; • Aplicações de informação atualizada do tráfego automóvel.	• Veículos autónomos e elétricos; • Transportes públicos elétricos e não tripulados; • Locais de carregamento de veículos elétricos.
Cultura	• Sensores de temperatura, fumo e humidade para bibliotecas, museus e outros ambientes sensíveis; • Sensores e supercomputadores que respondam a vários tipos de estímulos como sons, calor e movimentos.	• Sistema inteligente de iluminação e de equipamentos eletrónicos (arte interativa); • Sistemas de vigilância.	• Aplicações que permitam aceder a transmissões de espetáculos; • Aplicações para compra de bilhetes; • Aplicações que permitem a interatividade entre os internautas e a forma de arte.	• Websites que permitam visitas virtuais, em formato HD, em museus; • Áudio guias dos espaços; • Tecnologia que permita o acesso a pessoas invisuais.

Ilustração 2: Referencial Validado

Fonte: Elaboração Própria

5. CONCLUSÕES

Com o aumento da população nas áreas metropolitanas, há interesse em perceber como se pode melhorar a qualidade de vida nas mesmas.

Assim, as cidades fazem cada vez mais investimentos para se tornarem “inteligentes”, de forma a tornarem-se menos poluentes, mais organizadas, utilizando os recursos de uma forma sustentável e criando espaços autossustentáveis – isto, com o auxílio das tecnologias.

As TI têm, sem sombra de dúvida, um grande impacto na nossa sociedade, permitindo, por exemplo, a comunicação entre a população, a educação a pessoas desfavorecidas, melhoram os serviços de saúde, ajudam no combate a problemas ambientais, etc.

Um dos objetivos deste estudo foi compreender as definições de SC e da qualidade vida, bem como o papel das TI na melhoria desta qualidade de vida e como determinadas áreas que a influenciam podem ser transformadas pela adoção e uso das tecnologias de informação.

Conclui-se que não existem definições consensuais sobre estes dois conceitos e verifica-se uma infinidade de TI associadas a cada área que influencia a QV. Contudo, a descrição de algumas das tecnologias mais utilizadas permitiu obter um conhecimento mais vasto, por forma a alcançar o objetivo final deste artigo.

Na nossa opinião, o objetivo foi atingido, uma vez que se propôs um referencial com as tecnologias a serem implementadas nas cidades, por forma a contribuir para melhorar a qualidade de vida dos cidadãos. O referencial poderá ser também utilizado como um guia de confiança para promover projetos de investimento em tecnologia por parte dos mais variados governos locais.

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Da Pirâmide dos Clientes à Gestão de Stakeholders: O Significado Da Análise Risco-Recompensa

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ABSTRACT

Companies work as open systems where there is a clear need to interact with the surrounding environment. For that reason, it is necessary to know which are the parts interested in the company (*stakeholders*). Stakeholder management is directly related to the risk-reward analysis, as it records the potential rewards of strategic operations against the risk associated with them. Often these strategic operations are limited due to the lack of multiple perspectives, which is a danger and pushes the risk analysis into the background.

On the other hand, the recession of the major world economies translates into greater competition between companies and, in turn, a greater diversity of products, shorter cycles of innovation and production, and greater uncertainty in the definition of the strategy to follow. These factors mean that companies are forced to react to changes in the external environment, such as marketing management and customer relations. In this way, it becomes necessary to create a pyramid that allows us to categorize clients according to appropriate management policies.

Thus, the main objective of this investigation aims to assess the contribution that the management of stakeholders and the respective strategic options, related to the pyramid of clients have in the ideal risk-reward analysis.

KEYWORDS: Pyramid, Management, Reward, Risk, Clients, Strategy.

RESUMO

As empresas funcionam como sistemas abertos onde existe uma clara necessidade de interagir com o meio circundante. No fundo, é necessário avaliar quais são as partes interessadas na empresa (*stakeholders*). A gestão de *stakeholders* está diretamente relacionada com a análise risco-recompensa, uma vez que regista as potenciais recompensas das operações estratégicas em confronto com o risco que lhes está associado. Muitas vezes, estas operações estratégicas são limitadas, devido à falta de perspetivas múltiplas, o que se revela um perigo e empurra para segundo plano a análise de risco.

Por outro lado, a recessão das grandes economias mundiais traduz-se numa maior concorrência entre as empresas e, por sua vez, numa maior diversidade de produtos, em ciclos de inovação e produção mais curtos e na maior incerteza na definição da estratégia a seguir. Estes fatores levam a que as empresas sejam obrigadas a reagir às mudanças da envolvente externa, nomeadamente, a gestão do *marketing* e as relações com os clientes. Deste modo, surge a necessidade de criar uma pirâmide que nos permita a categorização dos clientes, de acordo políticas de gestão adequadas.

Assim, o farol desta investigação visa aferir o contributo que a gestão de *stakeholders* e as respetivas opções estratégicas, relacionadas com a pirâmide de clientes têm na análise de risco-recompensa ideal.

PALAVRAS-CHAVE: Pirâmide, Gestão, Recompensa, Risco, Clientes, Estratégia.

LISTA DE ABREVIATURAS, ACRÓNIMOS E SIGLAS

AM – Academia Militar

CS – Ciências Sociais

CS – Ciências Sociais

FA – Forças Armadas

FS – Forças de Segurança

GNR – Guarda Nacional Republicana

ONU – Organização Das Nações Unidas

OTAN – Organização Do Tratado Do Atlântico Norte

SGO – Sociologia da Gestão e das Organizações

TIG – Trabalho de Investigação de Grupo

1. INTRODUÇÃO

1.1. Temática, Problema de Investigação e Delimitação da Abordagem

"Não importa o quão excelente seja a equipa e o quão eficiente seja a sua metodologia, se não estiver a resolver o problema correto, o projeto falhará."

Woody Williams

O tema deste artigo é "Da Pirâmide dos Clientes à Gestão de Stakeholders: O Significado da Análise Risco-Recompensa". Foi proposto no âmbito da unidade curricular H134 - Gestão Estratégica, ministrada aos ciclos de estudo frequentados pela Administração Militar e pela GNR Administração na AM. A elaboração do presente trabalho fomentou nos alunos um acréscimo das capacidades de pesquisa e de análise no âmbito da Gestão Estratégica, com especial incidência nas áreas da Pirâmide dos Clientes, na Gestão de Stakeholders e na Análise Risco-Recompensa.

Tratando-se de um tema bastante amplo, importa mencionar que foi feita uma investigação fundamentalmente teórica, baseada sobretudo em livros, artigos científicos e teorizações, destacando as componentes das vantagens estratégicas adstritas.

1.2. Questão de Investigação

Como é sabido, a questão de investigação é a primeira e mais importante etapa de uma investigação, funcionando como um fio condutor em qualquer estudo. Esta deve ser *"clara, unívoca, concisa, direta, precisa, restritiva, relevante, inovadora, exequível e, finalmente, compreensiva"* (Rosado, 2017, p. 122).

A nossa investigação procurou, então, responder à seguinte questão central: **"Qual é a ligação entre a Pirâmide dos Clientes e a Gestão de Stakeholders, no que concerne à Análise Risco-Recompensa?".**

1.3. Objetivos de Estudo

Esta pesquisa baseou-se, essencialmente, em analisar algumas referências que, sendo pertinentes nesta matéria de estudo, foram por isso sintetizadas e correlacionadas. Pretendeu-se criar uma síntese teórica detalhada que nos permitiu um domínio mais seguro desta matéria bem como a aferência de alguns conceitos a esta associada. Além disso, foram discriminadas as ligações existentes entre as conceptualizações enunciadas, as quais culminaram com o nosso objetivo principal, designadamente, a resposta à questão de investigação. Quer isto dizer que destacámos as ligações existentes entre a Pirâmide dos Clientes e a Gestão de Stakeholders, relativamente à Análise Risco-Recompensa.

2. REVISÃO DE LITERATURA

2.1. Análise da literatura científica sobre a problemática

2.1.1. Gestão de stakeholders

Quer as organizações públicas, quer as empresas privadas (Nutt & Backoff, 1993; Moore, 2000; Rainey, 2009), funcionam como sistemas abertos onde existe uma clara necessidade de interagir com o meio circundante, nomeadamente, lidar com indivíduos, grupos e outras organizações, ou seja, com as partes interessadas – *stakeholders* (Berg & Pietersma, 2015, p. 216). Sem surpresa, surgem, muitas vezes, objetivos ambíguos dentro das instituições (Allison, [1980] 2004; Bozeman, 1987) incentivados pela existência de múltiplos *stakeholders* (Rainey, 2009).

A gestão estratégica dos *stakeholders* funciona como um molde para o eficaz desempenho das organizações (Andrews et al., 2012) constituindo, de acordo com Berg e Pietersma (2015, p. 216) um "*conjunto de ferramentas para avaliar esses stakeholders e analisar os seus interesses e a sua relação com a organização"*. Por exemplo, o controlo da riqueza e dos mercados de um país, através do capitalismo, permitem que o governo (também *stakeholder*) assuma um papel dominante relativamente às empresas do setor público (Bremmer, 2014, p. 104). De tal modo que os stakeholders podem ser agrupados de acordo com a prioridade que assumem no seio da empresa, tendo em consideração o seu poder, a legitimidade da relação e das ações relativamente à empresa e, por fim, a premência das exigências à organização pelo *stakeholder*. Por consequência, os *stakeholders* que primem em apenas uma das caraterísticas são considerados *"stakeholders latentes"* e, em contrapartida, os que perfaçam as três caraterísticas, denominam-se *"parceiros cruciais"* (Berg & Pietersma, 2015, pp. 217-218).

Por outro lado, torna-se fulcral que seja cumprido, impreterivelmente, o mandato e missão da organização (Rosenberg & Ferlie, 2016, p. 12) e, para tal, os *stakeholders* devem trabalhar todos em função de um objetivo comum. Isto, independentemente, das relações entre si, com a organização ou quaisquer outras partes, do seu poder e prioridades, ou até, da sua posição no mercado.

Assim, a gestão de *stakeholders* deve ser utilizada sempre que existam opositores ou resistentes às propostas colocadas pelas organizações, de modo a que sejam descobertos os seus apoiantes, designados por *"movers",* os opositores, denominados como *"blockers"* e, por último, os *"floaters"*, os quais não apresentam uma opinião concreta relativamente ao objetivo (Berg & Pietersma, 2015, pp. 218-219). Para uma organização ou várias, através das relações entre si, culminarem no sucesso, o seu foco principal deverá então basear-se não só nos processos, objetivos e formas estruturais a níveis macro, meso e micro (Felsmann, 2016, p. 7) mas também, na eficaz gestão dos *stakeholders*.

2.1.2. Pirâmide dos Clientes de Jay e Adam Curry

Segundo Jay e Adam Curry, existir um mecanismo que proporcione uma correta avaliação da importância dos diversos clientes de uma empresa, no que toca à geração de receitas, é fulcral para o seu sucesso. Em concordância, também Igor Ansoff afirma que o crescimento de uma empresa depende, essencialmente, dos mercados alvo da mesma. Deste modo, uma forma de gestão estratégica para o desenvolvimento económico duma empresa consiste em tornar os clientes num farol para toda a produção, e não, o produto em si mesmo (Samantha & Garrie, 2015, p. 2).

Sabemos que num mercado competitivo, produzir produtos de alta qualidade não é suficiente para os clientes (Krzakiewicz & Cyfert, 2017, p. 11) e que estes podem assumir posições de maior ou menor relevância numa determinada empresa. Desta forma, a Pirâmide dos Clientes de Curry retrata, por grupos/níveis, os clientes que são imprescindíveis para a organização, os quais se encontram no topo, e os menos valiosos, situados na base da mesma. Vejamos a ilustração 1:

Ilustração 1: Pirâmide de Curry
Fonte: Adaptado de Curry (2000, p. 14)

A pirâmide apresentada segue uma regra de 80/20, ou seja, *"20% dos clientes representam 80% dos lucros e os outros 80% só contribuem os restantes 20%"* (Berg & Pietersma, 2015, p. 199). Os autores H. Hamel e K. Prahalad (2002) apoiam o facto de que uma empresa deve estar obrigada a oferecer benefícios aos seus clientes, pelo que após serem identificados os clientes mais rentáveis para a instituição através da Pirâmide de Curry, então, esta possibilitará:

- Descobrir toda a informação pertinente acerca dos clientes mais relevantes;
- Analisar e, se necessário, redesenhar toda a informação;
- Visar objetivos que definem o modo como queremos ser vistos pelos clientes;
- Utilizar os *media* como forma de propaganda;
- Desenhar regras de relacionamento para cada cliente;
- Fomentar uma cultura na empresa que valorize o cliente;
- Desenvolver os sistemas de gestão de clientes.

Salientemos que Andrews (1980 *apud* Krzakiewicz & Cyfert, 2017, p. 4) utiliza o termo *"competência distintiva"* para se referir a uma capacidade suprema de uma empresa, pois que esta *"é algo mais do que a organização pode fazer, é o que a organização pode fazer particularmente bem"*.

Posto isto, uma empresa não deve concentrar a sua atenção apenas nos clientes existentes, mas, pelo contrário, deve dar primazia aos potenciais clientes, fazendo-o de forma acertada. Assim, o êxito da mesma dependerá, não só, dos preços, do valor do produto, do serviço produzido ou das estratégias de *marketing*, mas, sobretudo, de uma abordagem centrada no cliente e na sua correta avaliação (Berg & Pietersma, 2015, p. 200).

2.1.3. Análise Risco-Recompensa

A análise de risco-recompensa relaciona *"as recompensas potenciais das operações estratégicas em confronto com o risco que lhes está associado"* (Berg & Pietersma, 2015, p. 180), o qual pode variar consoante o seu nível técnico, económico, psicológico e, por fim, sociológico (Vasvári, 2015 *apud* Domokos et al., 2015, p. 8), sendo que os seus efeitos e a sua probabilidade mudam continuamente (Hornai, 2001, p. 43).

Conforme refere Domokos (2015, pp. 13-14), a análise e avaliação dos riscos a que as instituições do setor público se devem sujeitar é fundamental, visto que os sistemas só podem responder aos riscos que conhecerem. Por exemplo, a *"lealdade, a alegria em agir para o público ou aumentar o poder, renda, prestígio, segurança ou conforto"* (Blais & Dion, 1991 *apud* Domokos, 2015, p. 7) podem contribuir para que um líder tenha uma maior perceção dos riscos que corre, bem como das recompensas que pode auferir devido à proximidade com os seus subordinados, desenvolvendo uma atitude de gestão do risco (Gajduschek, 2010 *apud* Domokos, 2015, p. 7).

Ilustração 2: Análise Risco-Recompensa

Fonte: Adaptado de Berg & Pietersma (2015, p. 180) e Weerakkody & Irani (2009, p. 11)

A ilustração anterior representa uma sucinta análise do risco-recompensa, na qual podemos identificar os principais fatores que a condicionam, nomeadamente, o *outsourcing* que é definido por Loh & Venkatraman (1992, p. 9) como sendo *"a contribuição significativa dos fornecedores nos recursos físicos e/ou humanos associados à totalidade ou a componente das infraestruturas na organização"*.

Surge então que o objetivo principal da análise risco-recompensa consiste em encontrar o equilíbrio através de uma lista de estratégias exequíveis, as quais devem ser analisadas, criteriosamente, a par do risco que lhe está associado. Posteriormente, é útil fazer um *"brainstorming",* de forma a reduzir o risco associado às opções com alto potencial de recompensa e, para além disso, descobrir os métodos necessários para aumentar a recompensa das opções relativamente seguras (Berg & Pietersma, 2015, p. 181).

Podemos aferir ainda que, o risco e o retorno relativos a qualquer tipo de investimento são as duas faces da moeda. De um modo geral, quanto maior for o risco associado a um investimento, maior será também, o seu retorno em forma de recompensa[1]. Assim, como está explícito na ilustração, a curva eficiente é uma curva no plano de risco-recompensa que representa graficamente o conjunto de esquemas de transmissão eficientes (Kotelba & Mammela, p. 1757), a qual se aplica, fundamentalmente, na comparação e combinação de diversos projetos, tornando mais simples o ajuste das estratégias no seio da empresa, para proporcionar a obtenção de recursos de forma equilibrada e sustentável (Berg & Pietersma, 2015, p. 181).

Por fim, é de realçar a existência de dois tipos organizações no que concerne à sua perspetiva, relativamente ao risco que a mesma deve correr ou não (Berg & Pietersma, 2015, p. 181):

– Aversão ao risco (decisões seguras/longo prazo, no entanto, menos recompensadoras);

– As mais empreendedoras (alcançam recompensas mais elevadas).

2.2. Quadro de Referência

O quadro de referência "representa as bases teóricas ou conceptuais da investigação, as quais permitem ordenar os conceitos entre si, de maneira a descrever, explicar ou predizer relações entre eles" (Fortin, 2009, p. 89). Os autores de referência no âmbito da metodologia científica foram, sobretudo, Raymound, Quivy e Luc Van, para além de Campenhoudt e, no que diz respeito à formatação e estrutura do trabalho, baseamo-nos nos livros do TCor AdMil (PhD) David Pascoal Rosado.

Para além disso, o conteúdo desta investigação baseou-se, a título de referenciais bibliográficos, salientados na revisão de literatura, entre outros, nos seguintes:

– Berg, G. V., & Pirtersma, P. (2015). Os principais Modelos da Gestão. Coimbra: ACTUAL.

– Curry, J. (1992). Know your customers: How Customer Marketing can Increase Profits. Kogan Page LTD.

– Curry, J., & Curry, A. (2000). The Customer Marketing Method: How to Implement and Profit from Customer Relationship Management. Free Press.

– Quivy, Raymound, Campenhoudt, & Luc Van. (1998). Manual de Investigação em Ciências Sociais. Gradiva.

– Rainey, H. (2009). Understanding and Managing Public Organizations. Jossey-Bass.

– Rosado, D. P. (2015). Sociologia da Gestão e das Organizações. Lisboa: Gradiva.

3. METODOLOGIA, MATERIAIS E MÉTODOS

3.1. Paradigmas, Estratégias, Métodos e Desenho de Investigação

É sabido que *"uma investigação é, por definição, algo que se procura"* (Quivy & Campenhoudt, 1998, p. 31). O paradigma quantitativo, presente em todos os artigos científicos estudados, conforme a nossa interpretação pessoal, desde o início do desenho de investigação até à análise dos dados (Stake *apud* Osório, 2010, p. 51), caraterizando-se por uma metodologia de cariz quantitativo e, como tal, baseada numa estratégia de investigação quantitativa também.

É do nosso conhecimento que *"os paradigmas orientam as metodologias, e que as metodologias enformam e aferem os métodos"* (Rosado, 2015, p. 77). O método de investigação utilizado na elaboração do presente artigo científico, baseado quer nas CS quer na SGO foi, essencialmente, o método dedutivo, fundamentado num raciocínio racional e lógico. Assim, o desenho de investigação do trabalho facilita a sua resolução e torna-se um fio condutor, importantíssimo, do mesmo para o seu planeamento. Salienta-se aqui que John L. Beckley dizia: *"a maioria das pessoas não planeia fracassar, fracassa por não planear"*.

3.2. Instrumentos, Recolha de Dados, Amostra/s e Técnicas de Análise e Tratamento de Dados

Ao longo de toda a investigação, tornou-se imprescindível recorrer a diversas fontes bibliográficas para fundamentar o nosso estudo. Nomeadamente, às fontes primárias que dizem respeito a todos os textos originais, às fontes secundárias, as quais são interpretações de outros autores sobre as fontes primárias e, por fim, às fontes terciárias, ou seja, as compilações, seleções e organizações de informação, baseadas quer em fontes primárias quer em fontes secundárias (Rosado, 2017, p. 124).

Desta forma, a fim de reunir as informações necessárias à investigação, foram utilizadas diversas formas de recolhas de dados, sendo que se optou, preferencialmente, pela realização de uma entrevista, *"um método que exige interação humana e comunicação"* (Quivy e Campenhoudt, 1998, p. 192), bem como pela análise de um conjunto de artigos científicos. É de salientar ainda que, no que remete às técnicas de recolhas de dados, nas CS incluem-se as técnicas documentais e não documentais, sendo que nos baseamos na realização deste artigo, essencialmente, nas documentais.

4. APRESENTAÇÃO DOS RESULTADOS

4.1. Enunciação de Dados e Informações Obtidas

4.1.1. Reposta À Questão de Investigação

A questão central consubstanciou o farol de toda a investigação e após a análise realizada, considera-se estar em condições de proporcionar uma resposta à mesma: **"Qual é a ligação entre a Pirâmide dos Clientes e a Gestão de Stakeholders, no que concerne à Análise Risco-Recompensa?"**, a qual é totalmente respondida pela Revisão de Literatura.

Como é sabido, um dos maiores perigos na gestão estratégica consiste na tomada de decisões com base em informação limitada, não tendo em consideração a perspetiva e vontade dos clientes que queremos alcançar e, por isso, descorando a importância da correta avaliação dos *stakeholders*, o que leva a que a empresa corra riscos descabidos e desnecessários.

Por um lado, as empresas precisam de conhecer os seus apoiantes designados por *movers* (agentes), os quais darão um contributo ativo e procurarão que os outros também o façam. Devem ainda, conhecer os seus opositores – *blockers* (forças de bloqueio) – e, por último, os *floaters* (flutuantes) que não são a favor, mas não se opõem.

Deste modo, podemos considerar que os clientes são *movers* da empresa, pois adquirem e utilizam os bens e serviços produzidos por ela. No entanto, de acordo com a Pirâmide de Clientes, a empresa tem de ter em conta que existem diferentes tipos de clientes e que nem todos são rentáveis. Por esse motivo, é essencial que se proceda à categorização dos mesmos, para perceber quais são os que oferecem às empresas mais potencialidades e benefícios.

Assim, as empresas devem analisar minuciosamente todas as suas opções estratégicas, tendo em conta as recompensas potenciais e os benefícios que as partes interessadas, nomeadamente os clientes, lhes trazem em confronto o risco que lhes está associado. Estas opções serão registadas num gráfico de análise risco-recompensa que se tornará útil para perceber como reduzir o risco associado às opções com maior potencial de recompensa bem como, encontrar formas de aumentar a recompensa das opções mais seguras.

Concluindo, é fundamental proceder à interligação da Pirâmide dos Clientes e a Gestão de Stakeholders, no que concerne à Análise Risco-Recompensa, para que seja atingido o equilíbrio necessário, em termos económicos, das empresas.

4.1.2. Análise Swot

A análise SWOT resulta de quatro vocábulos: Strenghs, Weaknesses, Opportunities e Threats, o que corresponde, em português, respetivamente, a: pontos fortes, pontos fracos, oportunidades e ameaças. Esta análise corresponde à identificação dos principais aspetos que caraterizam a posição estratégica de determinada empresa ou instituição, num determinado momento e é um meio de Gestão e de Planeamento Estratégico desenvolvida por dois professores da Harvard Business School, Kenneth Andrews e Roland Christensen. Foi utilizado o modelo SWOT para ressaltar numa empresa, os seus pontos fortes e pontos fracos e referir as oportunidades e ameaças, relativamente à possível ligação entre a Pirâmide dos Clientes e a Gestão de Stakeholders, no que concerne à Análise Risco-Recompensa. O último propósito é tornar as decisões estratégicas mais eficazes e eficientes nas empresas, a nível interno e externo.

Análise Interna (S/W)	S – Pontos Fortes	W – Pontos Fracos
	- Maior proximidade com o cliente; - Melhor Avaliação dos Stakeholders; - Eficácia e Eficiência.	- Infidelidades por parte dos Stakeholders.
Análise Externa (O/T)	**O – Oportunidades**	**T – Ameaças**
	- Adaptação ao mercado	- Exposição económica da empresa.

Ilustração 3: Análise SWOT relativa à investigação
Fonte: Elaboração própria

5. CONCLUSÕES E IMPLICAÇÕES

5.1. Limitações da Investigação

No decorrer de toda a investigação sentimos a existência de determinados obstáculos e condicionamentos que influenciaram, definitivamente, a sua composição e realização.

Deste modo, a principal limitação remete para o fator tempo, o qual obrigou a que se tornasse essencial uma organização de todas as tarefas a realizar por cada elemento do grupo e que os objetivos fossem cumpridos da forma mais eficiente possível, atempadamente. Por outro lado, a restrição do número de páginas limitou a quantidade de informação a incluir no trabalho, para além de dificultar a recolha e seleção da informação disponível mais importante.

Por fim, é de salientar que esta se tornou na nossa primeira experiência na realização de um TIG, devidamente referenciado, conforme as normas da APA, o que devido à nossa inexperiência também se tornou numa barreira que, impreterivelmente, tivemos de ultrapassar pois, tal como refere Albert Einstein *"no meio da dificuldade encontra-se a oportunidade"*.

5.2. Recomendações e Desafios para Futuras Investigações

Abordada uma perspetiva iminentemente empresarial, seria interessante, no futuro, direcionarmos a nossa investigação ao ambiente militar. Ou seja, proceder a uma análise da gestão de *stakeholders*, tendo como partes interessadas os próprios militares e o Estado, no empenhamento das FA e das FS no teatro de operações em missões no estrangeiro. Também neste contexto, no que concerne à análise risco-recompensa, seria necessário avaliar o risco a que as nossas forças estariam sujeitas em prol dos benefícios para o Estado, por forma a cumprir os pressupostos acordados com a OTAN e a ONU.

RECONHECIMENTOS

Finalizado o presente trabalho de investigação, podemos usufruir da sensação de missão cumprida. Esta, só foi possível de concluir graças ao apoio, disponibilidade e colaboração incansável de todos aqueles que se demonstraram sempre gentis para ajudar no que estivesse ao seu alcance e, desse modo, se tornaram fulcrais para a realização e conclusão da nossa investigação, aos quais queremos expressar a nossa gratidão.

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A todos vós, um sincero muito obrigado!

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(Endnotes)

[1] Cfr https://www.portal-gestao.com/artigos/2148-risco-e-retorno.html em 16/04/2018 às 22h13min.

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Balanced Scorecard e a EFQM Como Ferramentas de Apoio à Tomada de Decisão[1]

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ABSTRACT

The organizational environment and society in general have evolved a lot in time, as we live increasingly in a non-watertight environment undergoing significant changes in all fields. Therefore, it is strictly necessary to find measures or tools that help managers to ascertain the situation of their company and to point out possible gaps that are occurring or aspects to improve. It is in this context that the Balanced Scorecard (BSC) and the European Foundation for Quality Management (EFQM) model of excellence arise. Both models are able to assist the manager in a positive way in his decision making. This research arises exactly so that we can perceive the main gaps of the models, what are the main advantages of both tools and essentially realize how these two models can work simultaneously so that the manager can draw conclusions in the most assertive way possible. In order to structure this research, we have recoursed to several scientific articles that contemplate basic concepts of what these two important management tools are and we observe where these same concepts intersect. From the analysis carried out, we conclude that these two tools, if applied simultaneously, can help the manager to make the decisions in the most appropriate way for the pursuit of the objectives proposed. Therefore, with indicators of action elements observed by the BSC and an evaluation elaborated by the EFQM model of excellence at a given moment, decision-making becomes clear.

KEYWORDS: Balanced Scorecard, European Foundation for Quality Management, decision making, management tool.

RESUMO

O ambiente organizacional e a sociedade em geral têm evoluído muito à medida que o tempo passa, uma vez que vivemos cada vez mais num ambiente que não é estanque sofrendo alterações significativas em todos os campos. Assim sendo, torna-se estritamente necessário que se encontrem medidas ou ferramentas que auxiliem os gestores a averiguar o ponto de situação da sua empresa, apontar possíveis lacunas que estejam a ocorrer ou aspetos a melhorar. É neste contexto que surge o *Balanced Scorecard* (BSC) e o modelo de excelência da *European Foundation for Quality Management (EFQM)*. Ambos os modelos conseguem auxiliar o gestor de forma positiva na sua tomada de decisão. Esta investigação surge exatamente para que consigamos perceber quais as principais lacunas dos modelos, quais as principais vantagens de ambas as ferramentas e essencialmente perceber de que forma é que estes dois modelos conseguem funcionar simultaneamente para que o gestor possa retirar conclusões da forma mais assertiva possível. Para estruturar esta investigação, recorremos a vários artigos científicos que contemplam conceitos basilares daquilo que são estas duas importantes ferramentas de gestão e observamos onde é que estes mesmos conceitos se intercetam. Da análise efetuada, concluímos que estas duas ferramentas se forem aplicadas em simultâneo o gestor consegue num dado momento tomar as decisões da forma mais acertada para a prossecução dos objetivos a que se propõe. Uma vez que, com indicadores de elementos de ação observados pelo *BSC* e de uma avaliação elaborada pelo modelo de excelência da *EFQM* num dado momento, torna-se clara a tomada de decisão.

PALAVRAS-CHAVE: *Balanced Scorecard, European Foundation for Quality Management*, tomada de decisão, ferramenta de gestão.

1. INTRODUÇÃO

É cada vez mais necessário, por parte das organizações, encontrar formas de dinamizar e controlar os seus próprios recursos, este fator acompanhado pelo grande crescimento de concorrência entre organizações, torna-se de necessidade primordial encontrar instrumentos de gestão válidos para fazer face a esta problemática (Manica, Manica, Souza, e Silva, 2017).

Não existe uma forma estanque de obter vantagem competitiva em relação a outra organização, principalmente quando se trata de avaliar os recursos intangíveis, desta forma é importante encontrar métodos de avaliar a componente não-financeira e não só a vertente financeira (Singh, 2015).

É desta forma que surge o *Balanced Scorecard*, como "*um complemento à medida financeira, suprindo sua deficiência em monitorar os ativos intangíveis essenciais para o crescimento futuro.*" (Kaplan e Norton, 1997). Esta importante ferramenta de apoio à gestão permite relacionar as diferentes perspetivas bem como as diferentes partes interessadas, no sentido de tomar as melhores decisões alcançando os objetivos a que se propõe (Kaplan e Norton, 2006).

Para que se tenha a perfeita perceção da correta implementação do *Balanced Scorecard*, é interessante observar que surge uma outra ferramenta de apoio à gestão de verificação da qualidade, o modelo de excelência da *EFQM*[2], que faz a autoavaliação das organizações relacionando os meios ao dispor com os resultados da organização, obtendo um importante *feedback*, que vai servir para concluir a sua sustentabilidade (Andrade, 1999). Embora o *BSC*[3] ajude a definir objetivos e a definir métricas para averiguar a prossecução dos mesmos, o modelo *EFQM*, é utilizado essencialmente para observar o sucesso de uma organização e se esta está no caminho certo para alcançar esses mesmos objetivos (Andjelkovic Pesic e Dahlgaard, 2013).

Posto isto, o que vamos observar com esta investigação, são as vantagens e inconvenientes de cada um destes modelos, bem como averiguar de que forma estes podem influenciar a tomada de decisão, assim sendo recorremos à seguinte pergunta de partida, que serve como fio condutor de toda esta organização. Deste modo, a pergunta de partida que orienta esta investigação é: *"De que forma o Balanced Scorecard e o Modelo de Excelência da EFQM contribuem para a tomada de decisão?"*.

Assim sendo a metodologia adotada assenta na revisão sistemática da literatura, onde serão selecionados artigos científicos alusivos ao *Balanced Scorecard* bem como para o Modelo de excelência da *EFQM*. Este trabalho está organizado por uma introdução onde serão explicados os principais objetivos da investigação, seguida de uma revisão da literatura, para que se possa conhecer melhor os conceitos gerais, passando pelos resultados da investigação bem como discussão dos mesmos e por fim conclusões e propostas de investigações futuras.

2. REVISÃO DA LITERATURA

2.1. Balanced Scorecard

Tal como referem Epstein e Manzoni (1997), ambos perceberam que o conceito de *Balanced Scorecard* era essencial para evidenciar que um único indicador de desempenho não seria suficiente para analisar o desempenho de uma organização. Desenvolvimento este efetuado por David Norton e Robert Kaplan, em 1997, este estudo foi realizado e aprofundado uma vez que os indicadores financeiros eram insuficientes para avaliação do sucesso organizacional, passou-se a entender que os recursos humanos eram uma vertente essencial.

Rodrigues e Sousa (2002), perceberam que existia a necessidade de substituir os modelos tradicionais existentes, que praticamente contemplavam indicadores financeiros, e que estes se mostravam incompletos para se adaptarem a um contexto de rápidas mudanças num ambiente competitivo de empresas.

Tornou-se indispensável a criação de um modelo que não contemplasse apenas os indicadores financeiros. Os tradicionais indicadores financeiros tornavam-se enganosos, uma vez, que temos de ter em conta possíveis inovações e desenvolvimento que ocorre com o passar dos tempos, assim sendo, segundo Epstein e Manzoni (1997), indicadores exclusivamente financeiros apresentam fragilidades na captação do impacto das decisões, representando um desfasamento grande de tempo. Tendem ainda a ser menos pró-ativos do que os indicadores operacionais (não financeiros).

Ilustração 1: Perspetivas *Balanced Scorecard*
Fonte: Kaplan, R., & Norton, D. (1997)

Foram desta forma criadas quatro perspetivas do *BSC* (perspetiva financeira, perspetiva interna, perspetiva do cliente e perspetiva de aprendizagem e crescimento), criadas com o intuito de incluir um conjunto de indicadores de desempenho específico, estas perspetivas conseguem fazer o balanço entre os indicadores internos (inovação, aprendizagem e crescimento) e os indicadores externos (acionistas e clientes).

De acordo com Campos (2001), torna-se essencial vincular objetivos estratégicos concretos, observando os pontos vitais da organização, uma vez que a avaliação de desempenho tem vindo a ser esquecida. Segundo Quesado et al. (2018), o *BSC* é uma ferramenta essencial para a definição de indicadores e objetivos que dão suporte à tomada de decisão.

2.2. European Foundation for Quality Management

Ao longo dos tempos, a par do *Balanced Scorecard* foram sendo elaboradas diversas ferramentas de apoio à decisão, como é o caso do modelo de excelência da *EFQM* no âmbito da definição de planeamentos estratégicos. Deste modo, Andrade (2010, p. 114) define este modelo do seguinte modo: *"Ferramenta de autoavaliação, que possibilita às organizações obterem um panorama abrangente da sua situação global num dado momento, fornecendo um valioso feedback acerca da eficácia das abordagens adotadas por esta em todas as suas atividades, constituindo desta forma uma força motriz para a melhoria."*

Segundo Liviu (2010), o modelo de excelência da *EFQM* apresenta duas premissas que se desdobram em nove critérios. A primeira premissa é relativa aos "meios" e representa as atividades das organizações, o que fazem e como o fazem. A segunda premissa é a dos "resultados", onde se pode plasmar o que fez a organização e o que alcançou.

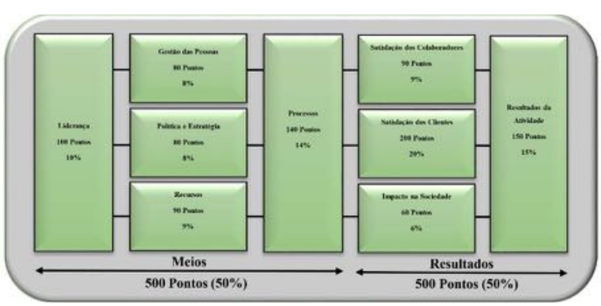

Ilustração 2: Modelo *EFQM*
Fonte: Fundação Europeia para a Gestão da Qualidade (1988)

A primeira premissa possui 5 critérios. São eles: a liderança, a gestão de pessoal, a política e a estratégia, as parcerias e os recursos e processos. Por outro lado, a segunda contempla os restantes quatro: a satisfação do funcionário, a satisfação do cliente, a integração na comunidade e os resultados operacionais (Andrade, 1999).

Segundo Tejedor et al. (2008), o modelo de excelência da *EFQM* torna-se importante por parte de quem implementa, uma vez que constitui um modelo de autoavaliação, que ajudam na avaliação externa e na implementação de *benchmarking*. Por outro lado, é constituído por um elevado número de indicadores, dificultando assim a seu controlo.

Em suma, o modelo *EFQM* é definido como uma ferramenta de apoio à tomada de decisão, materializada por ser um instrumento de autoavaliação organizacional, no sentido de conseguir alcançar os objetivos a que estas mesmas organizações se propõe nos campos de *"orientação para resultados, focalização no cliente, liderança e consistência de objetivos, envolvimento das pessoas, abordagem por processos, melhoria contínua e inovação, abordagem à tomada de decisão baseada em factos, parcerias mutuamente benéficas e responsabilidade pública"* (Louro, 2009, p.9).

3. RESULTADOS

Após uma revisão sistemática da literatura, neste campo iremos observar com mais profundidade vantagens e inconvenientes tanto do *BSC* como do modelo de excelência da *EFQM*, podendo compar**á**-los com outros estudos já efetuados e os que mais contribuem para a tomada de decisão.

Numa primeira abordagem ao *BSC* este consegue estabelecer um modelo para a empresa e transforma este mesmo modelo adaptado a cada empresa, criando indicadores que de certa forma vão uniformizar a forma de trabalhar da organização. De acordo com Quesado, Guzmán e Rodrigues (2014) declarar um modelo que consiga uniformizar todo o processo da empresa e traduzi-lo em indicadores torna-se não só importante do ponto de vista da gestão mas também sobre como alcança-lo.

Uma outra mais valia desta ferramenta será o facto de esta ser composta por indicadores que medem o que está a acontecer no imediato, ao passo que outros instrumentos se concentram no planeamento a longo prazo. O *BSC* consegue mostrar o desempenho da organização com maior rapidez influenciando assim os responsáveis a tomar decisões imediatas. Para

Quesado et al. (2018) esta ferramenta demonstra como as ações diárias condicionam o curto prazo, mas ainda a perspetiva de longo prazo.

O *BSC* para além de controlar todo o processo interno da organização, também consegue arranjar mecanismos para que seja criado um *feedback* não só em torno dos processos internos, mas também do planeamento estratégico. De acordo com Divandri & Yousefi (2011, p.473) *"O BSC incorpora comentários em torno dos resultados do processo comercial interno, como no TQM[4], mas também adiciona em loop um feedback em torno dos resultados dos negócios estratégicos"*.

Uma das principais valências, se não mesmo a principal, será o facto de o *BSC* assentar e medir a organização segundo quatro perspetivas e não só pela perspetiva financeira à semelhança dos modelos tradicionais. Estas quatro perspetivas são a financeira, clientes, processos internos e aprendizagem e crescimento, *"O BSC sugere que vejamos a organização a partir de quatro perspetivas, e para desenvolver métricas, coletar dados e analisá-los em relação a cada uma dessas perspetivas: financeira, clientes, processos internos e aprendizagem e crescimento"* (idem, 2011, pp. 472 e 473).

No entanto, existem possíveis inconvenientes apontados por alguns autores, tais como, as relações de causa e efeito não estão ligadas na realidade, algumas das perspetivas não estão ligadas entre si, tornando-se assim difícil de implementar (Rillo, 2004).

Kaplan e Norton (2006) afirmam que clientes mais leais geram mais receitas, o que pode não corresponder totalmente à verdade. Rillo (2004) refere que, existem clientes leais que por norma preferem produtos de elevada qualidade e fazem compras que não geram tanto lucro para a organização. Por norma, são clientes de maior idade que exigem um serviço de maior qualidade.

Uma das lacunas apontadas para o *BSC* é a deficiente ligação entre os níveis operacionais e os níveis de topo. Este instrumento não consegue funcionar nestas duas vias, descendente e ascendente. Em traços gerais, esta problemática é materializada pelo facto dos níveis inferiores não perceberem a linha de pensamento dos superiores, sendo que *"um dos pontos críticos do BSC é a falta de integração entre os níveis superior e operacional, o que pode levar a problemas estratégicos."* (Malgwi & Dahiru 2014, p.6).

Observou-se que esta ferramenta de gestão tem um grande foco naquilo que concerne aos seus processos internos, olhando muitas vezes para dentro da organização ou invés de adquirir uma perspetiva exterior, de mercado e dos seus concorrentes diretos. De acordo com (Frezatti, Bido, Cruz, & Machado, 2014) estes, referem que o *BSC* é incapaz de observar de forma concreta movimentos da concorrência. Para além disso não avalia da melhor forma movimentações externas. Os Gestores devem observar de que forma as mudanças externas afetam a implementação do *BSC*.

Este último defeito leva a que se consiga retirar uma outra conclusão, pelo facto do BSC observam essencialmente a sua vertente interna naquilo que são a prossecução dos seus objetivos, isto leva a que os interesses prioritários sejam os dos acionistas, *"Na verdade, a conceção do BSC apenas atende aos interesses dos acionistas, ignorando os interesses de outras partes interessadas principais, como fornecedores, governo e meio ambiente."* (Awadallah & Allam, 2015, p.96).

Desta forma, depois da pesquisa efetuada e recolha de dados alusivos a este instrumento estamos em condições de conseguir apresentar um quadro resumo onde congregue as vantagens e inconvenientes que integram esta mesma ferramenta.

BSC	
Vantagens	**Inconvenientes**
- Indicadores que conseguem uniformizar a forma de trabalhar da empresa. - Consegue mostrar o que está a acontecer no momento, o que facilita tomada de decisão mais rápida. - Controla todo o processo interno fornecendo feedback. - Quatro Perspetivas, englobando componentes não financeiras	- Relações de causa e efeito não estão ligadas na realidade - Avaliação dos clientes difícil - Deficiente ligação entre os níveis operacionais e os níveis de topo. - Grande foco naquilo que concerne aos seus processos internos - Interesses prioritários sejam os dos acionistas.

Ilustração 3: Resumo *BSC*
Fonte: Elaboração Própria

Passando agora para o estudo do modelo de excelência da *EFQM* observámos que uma das principais vantagens será o facto de fazer a ligação, de forma clara, entre os vários critérios, (liderança, estratégia, pessoas, parcerias e recursos, processos, produtos e serviços, resultados clientes, resultados pessoas, resultados sociedade e resultados do negócio). De acordo com Dahlgaard et al, *"As relações de causa e efeito estão claramente indicadas em um modelo dinâmico orientado a processos. Além disso, a relação causa-efeito é fundamentada em ideias sobre os mecanismos de geração, processamento e feedback da informação."* (Dahlgaard et al, 2013, p.4).

Por outro lado, uma lacuna observada derivada dos critérios escolhidos para dar forma a este modelo consiste no facto de corresponderem a excessivos critérios e subcritérios o que pode levar a alguma desorientação por parte das organizações, *"O modelo de excelência EFQM, por exemplo, consiste em 9 critérios e 32 subcritérios, que dividem a gestão organizacional numa fragmentação excessiva que pode resultar em autoavaliações que não possuem foco."* (idem, 2013, p.6).

Uma importante vantagem do ponto de vista da compreensão e aplicabilidade será o facto de ostentar um *design* prático e de fácil análise, uma vez que impõe padrões estáticos, *"A EFQM avalia o desempenho em relação a um padrão de atividades contra padrões genéricos de "melhores práticas". Isso pode levar a dizer que o design do BSC é mais complexo do que o design do EFQM"* (Del Río-Rama, Álvarez-García and Coca-Pérez, 2017).

Muitos autores referem que o modelo de excelência está estanque, o que leva a que haja apenas uma avaliação momentânea e que não se pratique nem ponha em prática planeamento a longo prazo, (Del Río-Rama, Álvarez-García and Coca-Pérez, 2017). Enfatiza também *"as limitações do modelo EFQM como um quadro estratégico na medida em que é principalmente a avaliação da saída, em vez de executar a previsão da estratégia futura"* (idem, 2012, p.6).

Alguns autores apontam outro defeito do modelo como sendo crucial para o auxilio à excelência das organizações. Prende-se pelo facto de ser um modelo estanque não sendo muito aberto a possíveis ajustes, *"esses quadros podem ser um obstáculo para aceitar e considerar outras possibilidades alternativas para alcançar a excelência."* (Andjelkovic Pesic & Dahlgaard, 2013, p.13).

Uma das principais virtudes será o facto de se encontrar em comunhão com todos processos organizacionais, ou seja, encontra-se um fim condutor deste o topo da pirâmide à sua base, "*O modelo europeu de excelência pode ser considerado uma abordagem holística e integrante, onde os processos de controlo estratégico, tático e operacional estão integrados no modelo.*" (idem, 2013, p.13). Assim sendo, após análise dos artigos escolhidos para a investigação do modelo de excelência da *EFQM*, conseguimos elaborar um quadro resumo que integra de forma clara as caraterísticas positivas e negativas deste instrumento de gestão de apoio à tomada de decisão.

EFQM	
Vantagens	**Inconvenientes**
- Faz ligação de forma clara entre os vários critérios. - Ostenta um *design* prático e de fácil compreensão. - Comunhão entre os processos organizacionais.	- Excessivos critérios e sub critérios que podem levar a desorientação por parte da organização. - Modelo de excelência estanque, não é fácil ajustar

Ilustração 4. Resumo *EFQM*
Fonte: Elaboração Própria

Posto isto, e depois de evidenciarmos de forma clara possíveis ventagens e inconvenientes destas duas ferramentas de gestão, baseadas numa forte componente de revisão da literatura, constituída essencialmente por artigos científicos, passaremos à elaboração de duas matrizes *SWOT*[5], uma primeira referente ao *BSC* uma segunda alusiva ao modelo de excelência da *EFQM*. Matrizes estas que vão ser analisadas juntamente com a revisão de literatura efetuada na secção seguinte (Discussão dos Resultados).

<table>
<tr><td></td><td></td><th colspan="2">Análise Interna</th></tr>
<tr><td></td><td></td><th>Pontos Fortes</th><th>Pontos Fracos</th></tr>
<tr><th rowspan="2">Análise Externa</th><th>Oportunidades</th><td>Aproveitar:
- Ligação clara entre todos os outros critérios (Dahlgaard et al, 2013, p.4)
- Design simples, de fácil compreensão (Del Río-Rama, Álvarez-García, & Coca-Pérez, 2017)</td><td>Desenvolver:
- Critérios excessivos (Dahlgaard et al, 2013, p.4)
- Avaliação momentânea (Del Río-Rama et al., 2017)</td></tr>
<tr><th>Ameaças</th><td>Combater:
- Fio condutor, da base ao topo (Andjelkovic Pesic & Dahlgaard, 2013, p.13).</td><td>Melhorar:
- Apresenta poucas alternativas (Del Río-Rama et al., 2017)
- Modelo estanque (Andjelkovic Pesic & Dahlgaard, 2013, p.13).</td></tr>
</table>

Ilustração 5: Análise SWOT adstrita ao *Balanced Scorecard*
Fonte: Elaboração própria (Adaptado)

<table>
<tr><td></td><td></td><th colspan="2">Análise Interna</th></tr>
<tr><td></td><td></td><th>Pontos Fortes</th><th>Pontos Fracos</th></tr>
<tr><th rowspan="2">Análise Externa</th><th>Oportunidades</th><td>Aproveitar:
- Uniformizar processos Quesado, Guzmán e Rodrigues (2014)
- Empiricamente aplicável e observável Quesado et al. (2018)</td><td>Desenvolver:
- Relação causa-efeito entre perspetivas (Rillo, 2004)
- Linha de pensamento ascendente e descendente incongruente (Malgwi & Dahiru 2014, p.6)</td></tr>
<tr><th>Ameaças</th><td>Combater:
- Feedback em torno dos resultados Divadri et al (2011)
- Perspetivas amplas (idem, 2011, pp. 472 e 473).</td><td>Melhorar:
- Foca-se maioritariamente em fatores endógenos esquecendo influências exónegas (Frezatti, Bido, Cruz & Machado, 2014)</td></tr>
</table>

Ilustração 6: Análise SWOT adstrita ao *EFQM*
Fonte: Elaboração própria (Adaptado)

4. DISCUSSÃO DOS RESULTADOS

Com base na revisão da literatura e na análise *SWOT* tanto para o *BSC* como para o modelo de excelência da *EFQM*, estamos em condições de observar de forma concreta quais as principais diferenças e semelhanças entre estas duas ferramentas de apoio à tomada de decisão.

Uma das principais valências do *BSC* será o facto de este conseguir estipular a longo prazo um planeamento estratégico, através de indicadores que medem o cumprimento ou não dos objetivos que a organização se propôs a realizar. Kaplan e Norton queriam uniformizar processos dentro de cada organização, para que se conseguisse orientar os princípios do todo da pirâmide para a base. Após analisarmos as consequências de cada modelo, observamos que o modelo da *EFQM* faz isto de forma mais perfeita.

Se por um lado este modelo apresenta uma ligação clara entre todos os critérios, criando uma relação causa-efeito entre estes, o mesmo não se pode afirmar para o BSC, uma vez que este nem sempre contempla uma plena ligação entre as perspetivas. Não obstante, o modelo de excelência contém uma série exagerada de critérios o que pode fazer com que se torne de difícil implementação.

O *BSC* apresenta perspetivas amplas, uma vez que não se concentra apenas nos indicadores financeiros mas também nos fatores não-financeiros. O mesmo não se pode dizer quanto ao modelo *EFQM* que retrata de forma mais estanque as suas valências, apresentando poucas alternativas.

O modelo de excelência da *EFQM* apresenta uma autoavaliação organizacional momentânea, isto faz com que não existe uma avaliação continua dos processos que estão a decorrer durante toda a atividade da empresa, por outro lado o *BSC* aparece com ícones que demostram "*in loco*" o que está a acontecer na organização, bem como estão plasmadas todos as diretivas emanadas pelo planeamento a longo prazo.

Ambos os instrumentos de apoio à tomada de decisão possibilitam um *feedback*, seja ele positivo ou não, a todos os *stakeholders* da organização, possibilitando assim a adoção de medidas imediatas para colmatar possíveis lacunas.

Com o cruzamento de informação recolhida através de uma variedade de artigos científicos conseguimos identificar com clareza onde estas mesmas ferramentas de gestão se podem cruzar. Desta forma, construímos a seguinte ilustração no sentido de facilitar a compreensão das semelhanças dos instrumentos em causa. Posto isto, conseguimos observar onde é que estes dois modelos se podem cruzar, no sentido de averiguar qual deles consegue auxiliar da melhor forma o gestor para a tomada de decisão. Vimos que tanto um como o outro apresentam vantagens e inconvenientes na sua implementação e que ambos têm funcionalidades diferentes, que podem ser revistas e implementadas da forma mais adequada.

BSC	EFQM
- Estipula a longo prazo um planeamento estratégico - Uniformiza parcialmente processos - Relação causa efeito deficitária - Poucos critérios - Avaliação contínua do que esta a decorrer	- Observa o que se deve melhorar para o futuro - Uniformiza processo de forma mais perfeita - Relação causa efeito entre critérios - Elevado número de critérios - Avaliação momentânea

Ilustração 7: Cruzamento de Instrumentos
Fonte: Elaboração própria

5.CONCLUSÕES

Ao longo da investigação conseguimos observar que tanto o *BSC* como o modelo de excelência da *EFQM*, foram elaborados no sentido de dar resposta as constantes mutações da atividade empresarial, procuram dar uma resposta positiva as organizações que sofrem tanto pressões externas quanto internas.

Neste sentido, são elaboradas perspetivas mais amplas e critérios mais adaptados ao mundo em que vivemos, para que de forma mais exequível se possa colmatar possíveis lacunas que existam durante a prossecução dos objetivos propostos pelas organizações, objetivos estes oriundos de um planeamento estratégico a longo prazo.

Consideramos desta forma que estes dois instrumentos favorecem completamente a tomada de decisão dos gestores, uma vez que estes têm de arranjar métricas ou indicadores onde facilmente consigam averiguar o que está a correr bem e o que não está a correr tão bem.

Posto isto, observando e comparando todas as vantagens e inconvenientes destes dois modelos, podemos afirmar que uma organização consegue implementar simultaneamente estas duas ferramentas, adaptando-as ao seu normal funcionamento. Para uma abordagem de longo prazo e de no sentido de uniformizar processos bem como obter feedback de todo este funcionamento, existe o *BSC*. Por outro lado, para a criação de uma relação causa-efeito entre critérios e um fio condutor do topo à base da pirâmide através de mecanismos de autoavaliação, temos o modelo de excelência da *EFQM*.

Por conseguinte, estamos agora em condições de dar uma resposta concreta à pergunta de partida a que nos propusemos responder no início da investigação, *"De que forma o Balanced Scorecard e o Modelo de Excelência da EFQM contribuem para a tomada de decisão?"* Para que o gestor possa dar uma resposta à altura das dificuldades mutáveis que encontra ao longo da sua tarefa de gestão, terá de incluir estes dois modelos simultaneamente nas suas atividades, um para que possa averiguar a ação a longo prazo e um segundo onde poderá observar e realizar uma avaliação da própria organização num dado momento.

Desta forma, torna-se uma necessidade primordial criar um fio condutor entre todas as etapas da estratégia começando no pensamento estratégico, da gestão de topo, para que o pensamento tático, elaborado pelos departamentos seja efetivado, de maneira a que a estratégia operacional, materializada em elementos de ação, seja adequada aos objetivos da empresa. Assim, os indicadores podem ser facilmente medidos com o *BSC*. Até que em determinado momento o modelo de excelência da *EFQM* possa ser introduzido, observando-se desta forma a avaliação de desempenho da organização, através dos seus critérios e premissas semelhantes.

Como possibilidades para investigações futuras propunha a implementação dos dois modelos, onde cada organização conseguiria avaliar as mais-valias tanto do *Balanced Scorecard* como do modelo de excelência da *EFQM*.

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É com toda a justiça que muito agradeço a orientação, do ponto de vista técnico e metodológico, ao Senhor Tenente-Coronel AdMil Paulo Jorge Alves Gomes e ao Senhor Major AdMil Artur Manuel Vieira Saraiva. Todo o apoio destes foi decisivo para o cumprimento dos objetivos que foram apresentados de início, apresentado ainda contributos de elevada qualidade que em muito contribuíram para a credibilidade do presente artigo.

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(Endnotes)

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[2] *European Foundation for Quality Management,* ou em português, Fundação Europeia de Gestão da Qualidade.

[3] Balanced Scorecard.

[4] *Total Quality Management*

[5] *SWOT* é a sigla dos termos ingleses *Strengths* (Forças), *Weaknesses* (Fraquezas), *Opportunities* (Oportunidades) e *Threats* (Ameaças) que consiste em uma ferramenta de análise bastante popular no âmbito empresarial.

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NPD Project as an Impulse for Digital Transformation in Light of Sociotechnical Approach

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ABSTRACT

The relevance of disruptive digital technologies for manufacturing industries is visible, however, there is a debate if organization underlying excessively technology-oriented innovation will be appropriately developing the potentials of digital technology. The paper proposes a Conceptual Framework (CF) to support Digital Transformation (DT) implementation in light of Sociotechnical design, in the perspective of operations management perspective. The CF supports DT implementation through New Product Development (NPD) projects at Discrete Manufacturing Industries (DMI). This is a qualitative research to develop a CF. The research shows that little attention has been devoted to Sociotechnical design principles in the context of DT. The research limitation is that some quality papers may have been left out of because of the research methodology. The paper's theory contributions are: (1) Sociotechnical approach in DT implementation, (2) Agile- Stage-Gate- Design Thinking integrated and (3) Alter's (2013) work system elements adapted for an open innovation environment. As a management contribution, practitioners could use the Conceptual Framework to support DT implementation in light of a Sociotechnical approach.

KEYWORDS: Conceptual Framework, Digital Transformation, Sociotechnical Approach.

1. INTRODUCTION

The relevance of digital technologies for manufacturing industries has grown significantly in the last few years. Evolving from approaches such as Computer Integrated Manufacturing, they have crossed the physical limits of the factory, leading to the emergence of market trends like Mass Customization and Mass Personalization.

The Internet of Services, Internet of Things, Internet of knowledge, and Internet by and for People will transform the Computer Integrated Manufacturing, embracing networks of humans, computers, knowledge, services and things (Yao et al., 2014) in a highly integrated system.

The Internet of Things (IoT) will stimulate mass customization strategies, as its connected devices provide real time information about production systems, client requirements and the environment where the product is being used (Zawadzki and Żywicki, 2016).

Unlike mass customization, mass personalization may integrate technologies, like Cyber-physical system, Cloud Computing and IoT, Real-time big data, and Internet of Service leaving room for Customers to participate in the production process, generating innovative products (Wang et al., 2017).

Wisdom manufacturing proposes a human-computer-thing collaborative manufacturing model that relies on intense use of tacit knowledge or collective intelligence, artificial intelligence and ubiquitous intelligence. It is based on a shared collection of distributed manufacturing resources, rapid product manufacturing, manufacturing real-time optimization processes and supply chain network (Yao et al., 2014).

Reis et al. (2018: 418) define Digital Transformation (DT) as "(…) the use of new digital technologies that enables major business improvements and influences all aspects of customers' life". That new trend can increase product variety and reduce production times, allowing manufacturing to meet individual customer needs. On the other hand, to fully explore that potential, excessively technology-oriented innovation approaches should be avoided (Kopp et al., 2016).

The DT's debate has brought back the issues associated with the radical technology-centered approaches, especially after the resurgence of Industry 4.0. Some studies suggest that factory work, planning and control systems, product development, and leadership demands will change permanently with the progressive application of digital technologies. Those changes may result in risks and opportunities to workers. On the risks side, job loss, disqualification and increased social insecurity. On the opportunities side, new kinds of jobs and increasing qualitative demands on labor (Dregger et al., 2016).

Sociotechnical school offers an alternative to create innovation in changing environment, as the case of present DT challenge, while balancing the responsibilities attributed to humans and machines (Mumford, 2006).

In the operations management perspective, this paper proposes a Conceptual Framework (CF) to support the implementation of DT in Discrete Manufacturing Industries (DMI) in light of Innovative and Sociotechnical values.

2. THEORETICAL BACKGROUND

2.1. Innovative and Sociotechnical Values

Dembek et al. (2016) argues that innovation is an important tool to create values that can be shared among corporation stakeholders and incorporated in the business model. Lichtenthaler (2017) argues that organizations in a DT environment should develop different types of innovations in order to create shared innovation value which integrates social and economic dimensions. Gao and Bernard (2018) affirm that innovative product development is a key competitive issue for modern organizations.

In this sense, New Product Development (NPD) projects should be viewed as an opportunity to generate digital innovations shared among the industry’s stakeholders, in addition to those that will be incorporated directly into the innovative product. As DT may impact the reorganization of the work (shop floor, planning and control systems and product development), it is also a chance to find new ways to integrate sociotechnical principles into future industrial work systems.

The sociotechnical principles (Cherns, 1987; Trist and Murray, 1993) intend to support organizational designers to:

- understand and respect individual workers differences;
- give greater importance to workers’ rights and needs rather than the demands of non-human parts of the system;
- emphasize workers motivation, communication transparency and participation of work teams in the innovation process should be highly emphasized (Brauner and Ziefle, 2015);

NPD projects should be an opportunity to generate digital innovations and sociotechnical principles shared among industry stakeholders. It is necessary to align these desired initiatives with the available technologies, resources and capacities among the industry stakeholders so that DT is effectively shared and implemented.

2.2. Open Innovation Enviroment

Open Innovation occurs when organizations seek to interact with collaborators located beyond their walls, such as makers (Hamalainen; Karjalainen, 2017), suppliers, customers, competitors, and research organizations aiming to create new products, improved distribution, broader product assortment, increased manufacturing flexibility, and compliance with regulation (Najafi-Tavani et al., 2018).

Open innovation practices are usually used for product development (Jaaskelainen et al., 2017; Stanko et al., 2017; Bahemia et al., 2017; Neyer et al., 2009) and be also useful for production process innovation (Krogh et al., 2018). Despite the risk of loss of intellectual property (Caridi et al., 2017), a combination of production process and product innovations often results in productivity improvement and competitive advantage (Krogh et al., 2018).

2.3. Actively Engaged Stakeholders

A classical stakeholder analysis method consists of stakeholder identification and assessments. A better assessments analysis is obtained if a given stakeholder category is broken down into smaller ones, until individual levels are reached. Strategies on how to interact with each stakeholder are based on those assessments (Eskerod et al., 2015). The main outcome of the assessments is knowing how to motivate stakeholders to be engaged and participate actively in the project.

The stakeholder engagement in the innovation projects contribute for better performance, higher productivity and flexibility of the innovation activities (Caridi et al., 2017; Martin et al., 2016; Driessen and Hillebrand, 2013; Elias, 2015). Stakeholders engagement depends on the organization's ability to balance different points of view, competences, cultures, technical skills and localities (Martin et al., 2016), sharing and using stakeholders' information and knowledge.

2.4. Knowledge and Knowledge Absorptive Capacity

Collaborative development requires a continuous flow of information and knowledge sharing between stakeholders (Caridi et al., 2017; Sjoerdsma and Weele, 2015). Information becomes knowledge when it is interpreted by individuals. Knowledge depends on individual values, organizational values and context; without context, information cannot become knowledge (Gao and Bernard, 2018).

At Nonaka's knowledge spiral model, the knowledge is generated from an upward flow of information sharing, where tacit knowledge is transformed into explicit knowledge, starting from one individual, proceeding to a group and then to the organization. That flow enables the creation, dissemination and transference of new knowledge (Gao and Bernard, 2018; Finley and Sathe, 2013). According to Gao and Bernard (2018), it is crucial that failures in the knowledge conversion process be identified and repaired as early as possible in innovation projects.

Dynamic knowledge management is the convergence of people and machines working together to achieve profitable income for the organization (Gao and Bernard, 2018). Some dynamic knowledge systems support organizational learning for better decision-making.

The organization has knowledge absorptive capacity when there is a set of routines and processes related to knowledge acquisition, assimilation, transformation and exploration. The absorptive capacity allows project teams to employ large amounts of information and knowledge and share it among different stakeholders, resulting in higher performance outcomes (Martin et al., 2016).

2.5. Agile-Stage-Gate, Design Thinking and Scrum Integration

According to Ben Mahmoud-Jouini et al. (2016), innovation projects, also called exploration projects, defy traditional project management rationality.

They emerge from learning – trial and error – and are strategically ambiguous. There are no explicit demands and no customers clearly identified, no specifications, nor objectives clearly identified at the beginning. The team must explore and develop new knowledge along the project.

Traditional project management models are based on waterfall methodology, where returns to early phases to correct errors are viewed as exceptions that should be avoided. Those models are not suitable for complex and volatile environments, such as innovation projects within the scope of DT. The authors believe that hybrid models (PMI, 2017) are more flexible, therefore more suitable to deal with DT, innovation intensive. Based on this reasoning, they build an integrated approach, using e Design Thinking (Ben Mahmoud-Jouini, 2016; Davis et al., 2016; Kupp et al., 2017; Luchs et al., 2016), Agile-Stage-Gate (Cooper, 2017; Cooper and Sommer, 2016a - 2016b) and Agile models (Potdar et al., 2017) to drive the implementation of DT.

The integration of “Agile-Stage-Gate-Design Thinking”, named as “Driving Cycle” by the authors, can increase the project management effectiveness: the focus of Design Thinking on prototyping a multitude of product options and developing “empathy” among stakeholder allied with the Scrum, that develops incremental functional outputs as quickly as possible, and Agile-Stage-Gate coordination through the project life cycle, minimize risks and uncertainties.

Summing up, the CF presented in this paper takes the NPD project as a starting point to implement DT in light of innovative and sociotechnical values in an open innovation environment, where actively engaged stakeholders with knowledge and knowledge absorptive capacity act as main agents of the DT implementation guided through the Driving Cycle.

3. RESEARCH METHODOLOGY

DT is being questioned. In order to ensure a balance between human and machine participation, DMI should consider sociotechnical value in DT implementation project from the moment of their conception and share it among their partner organizations, so that actions of all the organizations involved would be aligned. The paper departs from the central question: How manufacturing organizations should create shared value in the context of DT?

The general research objective is to develop a CF that supports DT implementation through NPD in light of sociotechnical approach. CF is a construct, an idea or theory, developed from a qualitative research. It addresses multidisciplinary conceptual elements of the literature in an integrated way (Jabareen, 2009).

The research methodology is based on qualitative systematic review approach (Webster and Watson, 2002), which phases (identification, screening, eligibility and included) are presented using PRISMA flowchart (Moher et al., 2009). While addressing the central question, the authors performed a literature review based on three intermediate objectives:

Objective 1. Identify whether researchers are considering the application of Sociotechnical approach, in line with Cherns (1987), in the context of DT, Industry 4.0, Smart Factory and Advanced Manufacturing.

Objective 2. Investigate the use of the term "Shared value" in the specify literature.

Objective 3. Identify conceptual elements that should constitute the theoretical background of the CF.

First objective: research was carried on the Web of Science (WoS) database with different terms combinations either as a "TITLE" (T) and/or a "TOPIC" (to). Time constraint was applied (10 years) and only publications in English were considered: **7 publications** of interest were selected. The research results are illustrated in Illustration 1.

56 publications-identifiedthroughWoS

Digital Transformation – Sociotechnical and (Socio-technical)		**Industry 4.0 -Sociotechnical and (Socio-technical)**	
TT	0(0)	TT	0(1)
Tto	0(0)	Tto	0(1)
toT	0(1)	ToT	0(2)
to/to	0(0)	ToT	0(2)

Smart Factory -Sociotechnical and (Socio-technical)		**Advanced Manufacturing – Sociotechnical and (Socio-technical)**	
TT	0(0)	TT	4(0)
Tto	0(0)	Tto	5(2)
toT	0(0)	ToT	4(2)
to/to	2(1)	ToT	15(7)

Identification | Screening | Eligibility | Included

56 publications-identified through WoS

31 publications-after duplicates removed

16 publications screened: English publications and 10 years

16 full-text publications assessed for eligibility

7 publications of interest were selected

15 publications excluded

9 full-text publications excluded: not in line with Cherns' (1987)

Illustration 1 – Research results and PRISMA (adapted from Moher et al., 2009)

Second objective: research was carried on WoS database with the keyword “shared value” in the title **- 83 publications** were found. No time constraints were applied, but only publications in English peer-reviewed academic journal papers, conference articles and bibliographic reviews were considered. Some WoS categories were used to the restrictions: Business, Engineering Multidisciplinary, Ethics and Management, resulting in **45 publications**.

The study from Porter and Kramer (2011) summarizes that “Creating shared value (CSV) should supersede corporate social responsibility (CSR) in guiding the investments of companies in their communities. (…) It leverages the unique resources and expertise of the company to create economic value by creating social value” (p.16).

This study received many criticisms (Corazza et al., 2017; Kettner, 2017; Dembek et al., 2016), which are out of the scope of this paper. Authors took those criticisms into account and **discarded 24 publications** from the 45 obtained in the previous investigation, leaving **21 publications,** which were considered eligible and included in the review. The research results are presented in Illustration 2.

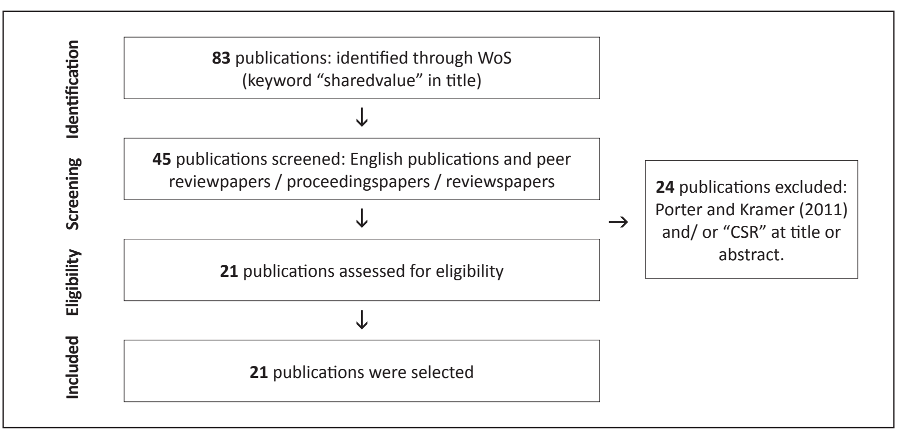

Illustration 2 – PRISMA (adapted from Moher et al., 2009)

Third objective: Among those 21 publications, Dembek et al. (2016) performed an extensive research about Shared Value. They identified some concepts and theories that overlap with Shared Value: CSR and sustainability; Corporate citizenship;

blended value; social innovation and social entrepreneurship; and Bottom of the pyramid. According to the same authors, Stakeholder theory is the only one that do not compete views with "Shared Value". Stakeholder theory claims that "(…) jointness of interests, cooperative posture and rejection of a narrow economic view of the firm. (…) Shared value is a restatement of the tenets of the Stakeholder theory. (…) Provide a precise definition of shared value especially addressing the relative importance of different stakeholder groups" (p. 242).

Lichtenthaler (2017) argues that organizations in a DT environment should seek to develop different types of innovations in order to create shared innovation value which integrate social and economic dimensions.

As a result of the above explanation, authors researched for ideas and concepts related to "stakeholder", "social" and "innov" (innovation/ innovating/ innovator) in the **21 publications selected**. Those ideas and concepts were analyzed by similarity and integrated into four concepts, understood as main facilitators of shared value and, therefore, considered relevant to constitute the theoretical background to develop the CF, as shown in Illustration 3.

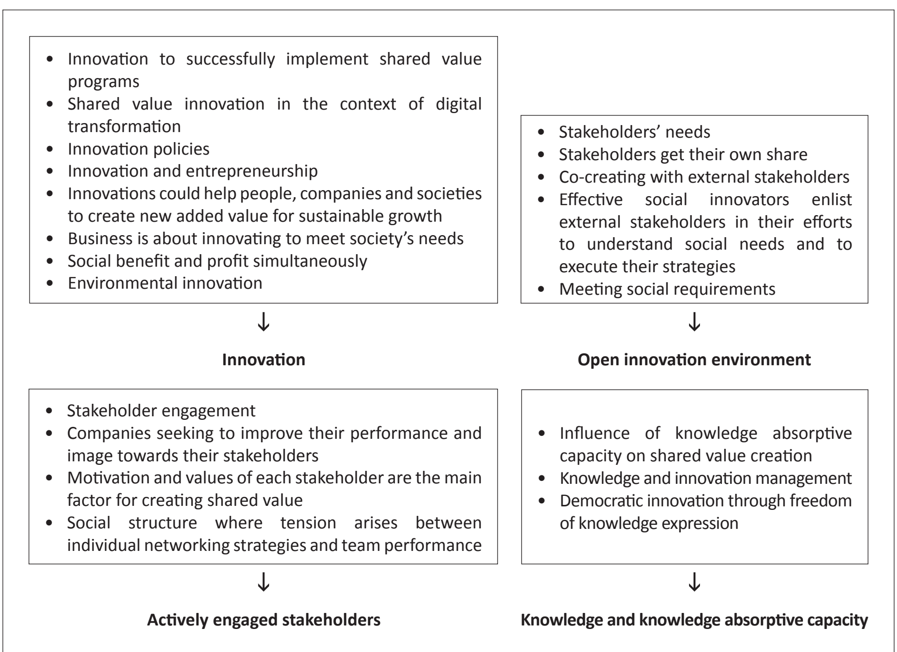

Illustration 3 – Relevant concepts to constitute the Theoretical Background

There is a dispute among researchers about whether shared value is related to singular project, coordinated activities, or an entire organization (Dembek et al., 2016). Authors assumed that shared value is related to a project because, according to Alter (2013), it is sociotechnical by default.

The authors considered the following topics to constitute the Theoretical Background to develop the CF:

- Innovative and sociotechnical values;
- Open innovation environment;
- Actively engaged stakeholders;
- Knowledge and knowledge absorptive capacity;
- Agile-Stage-Gate, Design Thinking and Scrum integration.

The literature review resulted in the following findings: the **first objective** showed that little attention has been devoted to Sociotechnical approach in line with Cherns' (1987) in the context of DT, Industry 4.0, Smart Factory and Advanced Manufacturing, what indicates the necessity to develop a CF to support the DT implementation in light of Sociotechnical approach. The **second objective** was accomplished, considering that "shared value" is related to stakeholders' needs, social's needs and innovation in context of DT. The **third objective** was fulfilled with the identification of the relevant concepts to constitute the Theoretical Background to the CF development.

4. RESULTS

4.1. Fundamental Elements

Alter (2013) states that projects are temporary work systems, therefore the structural elements of the proposed CF are in accordance with Alter (2013)'s work system definition:

(1) **Processes/ activities**, **internal stakeholder** (workers from R&D, Production, Sales, Finances, Marketing, Logistics, Information Technology and Human Resource departments), **information (and knowledge)** and **digital technology** (additive manufacturing, cloud computing and smart technology) are considered insider elements of the work system;

(2) **Product** and **collaborators** (customers, users, makers, suppliers and research organizations, university researchers, consultants) are part inside and part outside of the work system.

(3) **Environment, infrastructure, and strategies** are considered outsider of the work system, even though they have direct effect on it. The proposed CF assumes that DMI's infrastructure and strategy will support its DT implementation: "(…) Strategic planning and innovativeness affect the adoption of technological and NPD-marketing alignment positively, both of which affect NPD performance positively" (Acur et al., 2012:312-313). The **external stakeholder** (competitors, intellectual property organizations, environmental organizations, other regulatory organizations) represents the DMI environment.

4.2. PSD Conceptual Framework

The CF, named PSD (P - PEM, S – Stakeholder-digital technology/ Knowledge Spiral, Dc – Driving cycle), is illustrated in Illustration 4 and detailed as following.

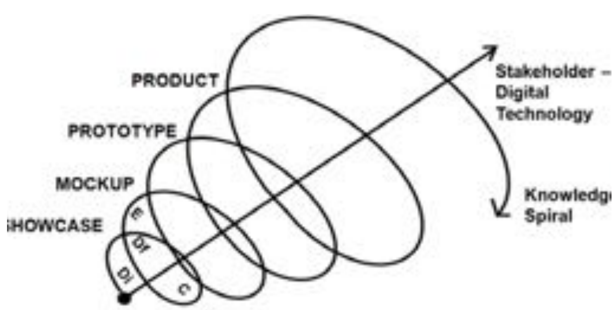

Illustration 4 – PSD conceptual framework

<u>Product Evolution Moment</u>. PEM is arranged in four Evolution Moments (EM): Showcase, Mockup, Prototype and Product evolution, where potential solutions evolve until the desired final product is reached. Each EM aims to generate information and knowledge that will trigger the beginning of the next one.

(1) **Showcase Moment -** aims to create an awareness of the physical, emotional, cognitive and business requirements of the internal

stakeholders, collaborators and external stakeholders. It's also the moment when initial ideas about the product are generated based on those identified requirements. The DMI should investigate the main problems and opportunities to understand the NPD challenges. Sketches, digital or physical mockups with few functions will work as "tasting versions", conceived to create a basic experience and develop an initial understanding of the stakeholder´s requirements. Reactions, opinions, behavior are registered, integrated and analyzed. It is when the DT objectives are identified, partnerships are established, and contracts are formalized.

(2) **Mockup Moment** - aims to develop and present a few concepts already in line with the stakeholders' needs and the DT objectives identified in the Showcase Moment. This set of concepts is developed by internal stakeholders and collaborators, shared among them and among other relevant external stakeholders through mockups to DMI obtain feedback and understand their specific needs. Those mockups should not be detailed versions, nor fully functional, but focused in providing an experience of a whole alternative or a set of main attributes of the product proposal. They may be tridimensional image, 3D printed, scale models, simulated models or virtual and augmented reality models. They should accelerate and encourage the creation of new ideas, allowing DMI observe the stakeholder's reactions while experiencing them.

(3) **Prototype Moment -** detailing of the product and an experiencing with a real tangible solution, which is built based on the results collected from the previous experiments with the mockups.

(4) **Product Moment** – DT goals achieved and new product launch procedures defined.

Each EM is related to a specific managerial context (complexity and broadness of the potential product solutions are distinct, and so its costs, resources, risks and times) that will evolve until the commercialization structure of the product is completed and the DT is implemented. PEM allows a macro view of the development and better coordination between EM and between internal stakeholders, collaborators and external stakeholders.

Stakeholder-Digital Technology/ Knowledge Spiral. Alternative versions of product (potential solutions) or its parts are used as enablers of the creation process by the internal stakeholders and collaborators at an open innovation environment. The current and desired level of digital maturity considering sociotechnical approach should be discussed in a shared way to be transformed into information, which, in turn, will be transformed into knowledge throughout the PEM. Industries in DT transition should be supported by digital maturity models to assess them on taking strategy decisions and action plans to enhance their capabilities and increase digital technology level (Schumacher, 2016).

Observation, discussion, register and integration of new ideas occur simultaneously when stakeholders experience the potential solutions versions. The results of these experiments help to direct the most appropriate lines of action to deal with the problems that arise at each EM.

PEM determines the direction of the product evolution; however, it is the information and new knowledge generated through the Knowledge Spiral that guide the transition to the next Moment. The active engagement of the internal stakeholders and collaborators across the PEM is essential to put the new knowledge into practice and allow the internalization of explicit knowledge.

While knowledge is shared among stakeholders, there is an exchange of explicit knowledge and a transformation of explicit knowledge into tacit in the spiral (combination and internalization respectively). It is an opportunity to reflect on current capabilities and take decision on strategies and plans regarding the DMI digital maturity level considering sociotechnical initiatives according to its needs and the needs of its partners.

The digital technologies should support the stakeholders' dynamic knowledge at PEM, starting at the Showcase Moment. The Showcase Moment's digital maturity level will determine which digital initiatives should support them. It is necessary to align digital initiatives with the available digital technologies, resources, capabilities and current internal stakeholders' and collaborators' knowledge.

The DMI's knowledge absorptive capacity allows internal stakeholders and collaborators to share, expand, internalized and employ large amounts of information and knowledge, what results in higher performance outcomes in each EM. Subsequent EMs require higher levels of digital maturity considering sociotechnical initiatives that DMI should pursue, implement and share with their partners during the NPD project.

Driving Cycle. PSD framework proposes a “Driving Cycle” (Dc) developed in light of integrated Agile-Stage-Gate-Design Thinking models. It provides flexible decision-making mechanisms, agile responses and lean documentation to support DMI’s product innovation and the corresponding DT.

The different contexts of each EM require that the management be carried out in an immersed, flexible and dynamic way and that their particularities be respected. The complexity of the information and of the stakeholders’ knowledge is diverse at each EM. The internal stakeholders and collaborators are mobilized and demobilized according to their distinct knowledge, motivations and responsibilities. The complexity and broadness of the potential product solutions are distinct, consequently, costs, resources, risks, times should be different in each EM.

The distinct context of each EM is managed in a hybrid way by Dc, structured as “Discovery - Definition - Creation - Evaluation”, which ensures the coherence between the EMs.

The coherence is guaranteed, because the Dc is repeated for each EM, ending each time, after stakeholders’ knowledge is transformed in a potential product version. The ideas and knowledge generated in each Dc may lead to new versions of the product or demand corrections in old versions, therefore it should also be able to proceed or retreat.

The active participation of the internal stakeholders and collaborators in every one of the EM allows a gradual progression from each EM to the next on, as new information, ideas, knowledges and opinions are recorded, integrated and analyzed to form potential solutions.

The DC may be planned and executed more than once at each EM, following Agile orientations. The fit between successive EMs is achieved when the outcome of one Moment is a consequence of the potential solution that precedes it. The Dc “Discovery - Definition - Creation - Evaluation” is briefly explained:

(1) **Discovery** - an investigation about which stakeholder would like to participate and should be part of the innovation process is carried out at the beginning of each EM. They are mapped and involved

according to the information, ideas, knowledge, motivations and opinions identified for the EM considered. Their values and behaviors are observed and registered focused on continuous learning and collaboration to integrate different visions.

(2) **Definition** – tangible results, the necessary digital technologies (depending on the digital maturity level required) and the sociotechnical initiatives should be planned with internal stakeholders and collaborators to integrate their knowledge, findings and specifications into the solution corresponding to the EM objectives.

(3) **Creation -** knowledge absorptive capacity and communication must be strengthened so that internal stakeholders and collaborators can accumulate new knowledge accurately to create tangible results in real-time through digital technologies. In this sense, the new knowledge is mobilized, shared, expanded, and internalized to generate innovation and sociotechnical initiatives.

(4) **Evaluation -** decision on whether to proceed to the next EM is taken at this point, which is positioned between every two contiguous EMs. It aims to ensure the continuity and fit between EMs, in other words, depending on the evaluation of the tangible potential solution in relation to the purpose of the respective EM, results in a new Dc sequence in the next EM or in a Dc restart in the current EM.

5. DISCUSSION AND CONCLUDING REMARKS

As a theoretical contribution, authors presented a Conceptual Framework named PSD to support DT implementation in light of sociotechnical approach.

PSD sees the development of new products as an opportunity to generate innovations beyond those that will be directly embedded in the innovative product. It should create not only innovative value but also sociotechnical value that can be shared among engaged stakeholders.

PSD supports a human participative work system in an open innovative environment where internal stakeholders, collaborators and external stakeholders work as a team to develop innovations.

PSD reinforces deep engagement of internal stakeholders and collaborators across the PEM. Internalization of explicit knowledge is achieved through the observation, discussion and experiences with potential solutions versions.

PSD intends to develop a deep understanding of the stakeholders' needs and behaviors. It proposes the implementation and application of digital technologies and sociotechnical initiatives to allow the creation of potential solutions as early as possible, demanding active stakeholder participation throughout the PEM.

PEM allows a macro view of the product development process and a better coordination between internal stakeholders, collaborators and external stakeholders.

Knowledge Spiral is an enabler of liberty and creativity, where the digital technologies will support the creation of stakeholders' dynamic knowledge to solve complex problems, whose interactions and whole system can be visualized and understood (Lanz et al., 2013) throughout the PEM. Digital maturity level is evaluated since the first EM.

The Driving cycle is repeated along the Knowledge Spiral, ensuring the alignment between consecutive EMs: each EM must depart from the solution developed in the previous one. The potential (product) solutions should be aligned with the DT goals and should fit the interfaces and interdependencies with other innovations developed in the process. DT is implemented gradually along the PEM.

The paper also provides an adaptation of Alter's (2013) work system elements for an open innovation environment and an integrated Agile-Stage-Gate-Design Thinking model, named Driving Cycle. PSD was developed in such a way that practitioners could take it as a reference to support DT implementation in light with a Sociotechnical approach.

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A Robust Multi Objective Optimization of a Drug Distribution System: A Case Study

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ABSTRACT

Robust designing of facility location problems (FLPs) can significantly improve the efficiency and performance of several industrial and services systems. Accordingly, the study of facility location problems regarding to several real situations of the system (e.g., stochastic demands, system disruptions, and uncertain operational costs) can propose a more practical image of the real system and subsequently help to enhance the performance and responsiveness of distributions and services system. In this paper, a robust multi objective mixed integer linear programming model is developed for a facility location network design problem (FL/NDP), which takes uncertain parameters (containing demand and transportation costs) into the account. The proposed model simultaneously minimizes the total operating costs and maximizes the total coverage. In addition, opening of facilities and also constructing of transportation links are faced with a predetermined investment budget constraint. Therefore, this model specifies the optimal locations of new facilities, new link roads and also demand nodes covered by these facilities and link roads. Then, the suggested model is robust by suitable approaches. An efficient multi objective approach, based on *Lp*-metrics- is proposed and tested for several test problems. A practical case study, based on an integrated distribution system, is explained in detail to present the utilization of the suggested mathematical formulation.

KEYWORDS: Facility location; Network design; Coverage; Multi-objective optimization; Heuristic method; uncertain environment; robust stochastic programming; Lp-metrics method.

1. MOTIVATION

The robust design of the FLPs is one of the most efficient approaches to improve several industrial and service systems. In recent years, the governments in most of the countries scramble to maximize the populations' fair welfare and comfort, and, at a second level, to control and minimize several investment budget and operational expenditures. On the other side, the reliability of several demands uncertainties and also the designed service system play a critical role and an efficient and also robust service systems can be substantially affected on the quality of the provided services especially in uncertain tension statuses. However, study of this problem regarding to several parameter uncertainties can be very irritating and merits special heed by the several planners.

This paper aims to propose a new multi objective mathematical formulation that can behave as a support instrumentation to help distribution/service systems planners and ameliorate the geographic impartiality of access and reduce transportation costs and also uncertainty costs of distribution/service centers in presence of some uncertain statuses. The proposed formulation can achieve optimum distribution/service centers location and link construction to simultaneously minimize total investment and operational cost and also maximize the total coverage while also taking into account the parameter uncertainty. The goal is to elect facility location, link construction, and demand assignment such that the objective of the formulation is minimizing the onomastic costs, while maximizing the total coverage of several demands. In the other words, the formulation purveys an enough efficient and a confident approach to be handled in distribution/service systems under the uncertain environment (containing demands and transportation expenditures uncertainty).

The rest of the study is arranged as follows: In section 2, a fairly comprehensive review of the relevant background is presented and the explanation of research gap and our contribution are presented in the following. In section 3, the mathematical formulation description for the facility location problems is illustrated. In section 4, some multiple objective solution procedures are proposed. In details, in section 4, at the first, a suitable multi objective solution procedure is described. Then, because of importance of efficiency of the solution procedure, an efficient hybrid heuristic approach, according to the LP relaxation technique, is proposed. In section 5, the efficiency of the hybrid heuristic approach is tested by solving several test problems. At the following, in section 6, a case study that exactly presents the application of the model is indicated and unraveled by the proposed robust multi objective model.

2. BACKGROUND

Concerning the clear description of our contribution, four main streams of the literature can be reviewed that may be interesting for comparison: (1) the FLP with respect to network design, (2) the FLP with parameters uncertainty, (3) the FLP with multi objective functions, (4) the FLP with regards to coverage topic. Clearly these four research areas are strongly related to the propounded topic in this paper.

As it can be derived from the literature, albeit the background on facility location problems is broad, there are a few studies in which facility location problems were studied with respect to one of the subsequent topics; parameter uncertainty, link network design, and coverage topic. Hereupon, as it is evident from the related background, study of facility location problems with such constitution is comparatively scarce. Besides, the existent researches have not studied all aforesaid topics altogether on facility location, while, with bringing up only one of them, they have developed several solving methods such as meta-heuristics, heuristics, and exact methods. As a conclusion, developing a new multi objective formulization, which can achieve optimum facility location and link constructing/improving with considering to different practicable statuses, can cause planners to more robust solutions for the discussed quandary. In other words, the suggested model purveys a confident and an enough effective methodology to be applied by several decision makers, particularly several systems planners in locating of facilities, service/distribution centers in order to improve the efficiency and responsibility of them.

The contributions of this paper can be summarized as following. As a significant point in the formulating of facility location problems is to develop an efficacious mathematical formulation which can present an efficient explanation of the quandary and accordingly obtain a rational practicable solution. Four substantial subjects that can help to attain such goal are parameter uncertainty, network design, coverage topic, and multi objective functions. The significance of these subjects in the formulating of facility location problems was shortly discussed separately.

The principal stimulant of this study is to formulate an integrated robust multi objective mathematical model to RMFLNDP, which has not been investigated until now according to the authors' best cognition.

3. MODEL EXPLANATION

3.1. Quantification

An overall description of the proposed problem is presented in this section. Suppose that there is a distribution system in a broad geographical area. Also, there is a set of demand nodes (e.g., wholesalers, big stores, shops…) exists in this area and a set of roads as transportation links that includes new and existing volunteer links is introduced to open a transportation network in the aforesaid area. There is a set of facilities (e.g., service/distribution centers) in the area and it is obviously desired to place a set of new facilities, and to open new volunteer links, such that, as the first objective function, the total investment budget expenditures (including locating new facilities, and constructing new links) and the total operational expenditures (including transportation expenditures) are minimized (the first objective function). On the other hands, it is desired that, as the second objective, the total coverage of the demands in the considered geographical region is maximized. One point that should be considered is that the amount of demands of each demand node and also the transportation costs at the area has a stochastic behavior and are not specified.

The ultimate goals are to: (1) minimize the total investment budget expenditures (for opening of facilities and building of transportation links) and also the transportation expenditures, (2) maximize the total coverage of demands of nodes, (3) determine (*i*) the optimal locations of new facilities with regards to uncertain circumference (containing demand and transportation cost uncertainty), network design, and coverage topic (*ii*) the transportation links that have to be established in the suggested network, (*iii*) the amount of demands of nodes that have to be transported by the links at each scenario, and, (*iv*) The portion of each demand that have to be supplied/covered at each scenario by exciting and new facilities.

3.2. Suppositions

The suppositions of the considered problem can be explained as following:

1. Every node of network illustrates a demand center as whole seller, big store, or shops in the geographical region.
2. Each node may be facility or demand center; i.e., at every demand center, a facility such as a distribution/service center can be opened.

Therefore, each demand center is covered by itself (as distribution/service center) or by other distribution/service centers.

3. New facilities may only be placed at the nodes of the network and cannot be placed on the transportation links of network.
4. No more than one new facility can be placed at every node.
5. The generic infrastructure of the network is brought forth according to a *server-to-customer* system, i.e., the demands (as goods/products) are transported from facilities to the demand nodes.
6. All network links (transportation roads) and facilities are limited.
7. An investiture budget constraint is predetermined on facility opening and link establishing.
8. Demand of each node has a fortuitous demeanor and are uncertain.
9. The demands of the nodes must be covered completely by the located facilities.

3.3. NOTIFICATIONS

Sets:

D : Set of demand nodes.

T : Set of transportation links in the network.

Parameters:

P_f : Number of new facilities to locate.

f_l : Constant expenditure of placing a facility at node *l*, $l \in D$.

c_{kl} : Cost of establishing link (k,l) $(k,l) \in T$.

t_{kl} : Transportation expenditure of a unit flow on link (k,l) $(k,l) \in T$.

d_l : Demand at node *l*, $l \in D$. α_l : Valence of facility *l*, $l \in D$.

β_{kl} : Valence of link (k,l), $(k,l) \in T$. M : A big number.

BC: Allowable maximum level of investiture budget amount.

δ_{kl} : 1 If demand of facility at node k can be covered by facility at node *l* (from technical aspect), $k,l \in D$, 0 any other way.

Decision variables:

Z_l : 1 If a facility center is placed at node *l*, $l \in D$, 0 any other way.

V_l : 1 If demand of facility at node *l* is covered, $l \in D$, 0 any other way.

X_{kl} : 1 If a link (k,l) is established, 0 any other way.

W_{kl} : 1 If demand of facility at node *k* is covered by facility at node *l* (from economic aspect), $k,l \in D$, 0 any other way.

Y_{kl} : Value of demand on transportation link (k,l), $(k,l) \in T$.

3.4. Model Formulation

3.4.1. The First Objective

At this objective function, the minimizing of fixed expenditures (including facility location expenditures and link construction expenditures) and also transportation expenditures are considered. Therefore, the first objective function is defined as following:

$$Minmize \sum_{l \in D} f_l Z_l + \sum_{(k,l) \in T} c_{kl} X_{kl} + \sum_{(k,l) \in T} t_{kl} Y_{kl} \tag{1}$$

Where the $\sum_{l \in D} f_l Z_l + \sum_{(k,l) \in T} c_{kl} X_{kl}$ illustrates the fixed costs and the $\sum_{(k,l) \in T} t_{kl} Y_{kl}$ illustrates the transportation costs.

3.4.2. The Second Objective

This objective function presents the maximizing of demand covering as follows:

$$Maximize \sum_{l \in D} d_l V_l \tag{2}$$

Where V_l will be equal to 1 if node *l* is covered completely; otherwise equal to 0.

3.4.3. The Multi-Objective Peer Formulation

According to the notations and assumptions, the mixed integer programming formulation of the multi objective FL/NDP (MFL/NDP) can be emblazoned as following:

(MFL/NDP):

$$Min\ Obj_1 = \sum_{l \in D} f_l Z_l + \sum_{(k,l) \in T} c_{kl} X_{kl} + \sum_{(k,l) \in T} t_{kl} Y_{kl}^0 \qquad (3)$$

$$Max\ Obj_2 = \sum_{l \in D} d_l V_l \qquad (4)$$

$$s.t. \sum_{(k,l) \in T} Y_{kl} - \sum_{(k,l) \in T} Y_{kl} + d_l \le \alpha_l + M\left(1 - Z_l\right) \qquad \forall l \in D \qquad (5)$$

$$\sum_{(k,l) \in T} Y_{kl} - \sum_{(k,l) \in T} Y_{kl} \le d_l + M\left(Z_l\right) \qquad \forall l \in D \qquad (6)$$

$$\sum_{(k,l) \in T} Y_{kl} - \sum_{(k,l) \in T} Y_{kl} \ge d_l - M\left(Z_l\right) \qquad \forall l \in D \qquad (7)$$

$$W_{kl} \le \delta_{kl} Z_l \qquad \forall k,l \in D \qquad (8)$$

$$V_l \le \sum_{k \in D} W_{kl} \qquad \forall l \in D \qquad (9)$$

$$\sum_{l \in D} f_l Z_l + \sum_{(k,l) \in T} c_{kl} X_{kl} \le BC \qquad (10)$$

$$X_{kl} + X_{lk} \le 1 \qquad \forall (k,l) \in T \qquad (11)$$

$$\sum_{k \in D} Z_k = P_f \qquad (12)$$

$$Y_{kl} \le \beta_{kl} X_{kl} \qquad \forall \left(k,l\right) \in T \qquad (13)$$

$$Z_l, V_l, W_{kl} \ge 0\ ; X_{kl} \in \left\{0,1\right\};\ \ Y_{kl} \ge 0 \qquad \forall (k,l) \in T \qquad (14\text{-}16)$$

The first objective (3) minimizes the total expenditure, including fixed facility location expenditures, link establishment expenditures, and the transportation expenditures. The second objective (4) maximizes the total covering value. Constraints (5)-(7) illustrate the flow conservation constraints. Figure on that each node (service/distribution center or demand center) may be exploited as a transportation node and it may have a rational flow in and flow out. Constraints (8) insure that a demand point *i* is covered by facility *j* if and only if there is a remaining route shorter than the coverage distance between *i* and *j*. Constraints (9) enforces that a demand point *i* is covered by a located facility in scenario *s* only if at least one facility is accessible as much as possible. Constraint (10) illustrates the investment budget constraint. Constraints (11) accentuate that the transportation link have to be established from (i,j) or (j,i), not both of the directions. Constraint (12) indicates the predestined number facilities that have to be placed. Constraints (13) present the capacity of transportation links. Constraints (14-16) are standard non-negativity and integrality constraints of decision variables.

3.4.4. Robust Optimization Method

Robust optimization (RO) is known as an efficient methodology in order to coping with the risk in the case where there is no adequate epochal information to appraise the contingency distribution of the uncertain parameters. Three of the most favorite RO methodologies have been brought forward by Muley et al. (1995), Ben-Tal and Nemirovski (1998), Ben-Tal and Nemirovski (1999), Ben-Tal and Nemirovski (2000), Bertsimas and Sim (2003) and Bertsimas and Sim (2004). With respect to the scenario based approach of the considered quandary, and also, simple comprehension of the Mulvey methodology for various designers/planners, in this research, this robust methodology is opted conductive to cope of the parameter uncertainty of the quandary. For more detail reading about this robust optimization methodology, the readers are referred to Muley *et al.* (1995), Yu and Li. (2000), Leung *et al*. (2007), BozorgI-Amiri *et al*. (2011), Shishebori and Yousefi-Babadi (2015) and Romero *et al*. (1998).

3.4.5 The Robust Multi-Objective Peer Formulation

The MFL/NDP formulation is an uncertain model which may be converted to robust model due to equations (27) - (29). Accordingly, the robust MFL/

NDP (RMFL/NDP) is instituted as following (some new sets, decision variables, and parameters are required to hold forth the robust formulation):

Sets:

Ω : Set of uncertain scenarios. $\Omega = \{1, 2, ..., \tilde{h}\}$

Parameters:

$t_{kl}^{\tilde{h}}$: Transportation expenditure of a module flow on link (k,l) in presence of uncertain scenario $\tilde{h}$, $(k,l) \in T$, $\tilde{h} \in \Omega$.

$d_l^{\tilde{h}}$: Demand at node *l* under uncertain scenario $\tilde{h}$, $(k,l) \in T$, $\tilde{h} \in \Omega$.

$p^{\tilde{h}}$: Contingency of uncertain scenario $\tilde{h}$, $\tilde{h} \in \Omega$.

λ_1 and λ_2 : Specified weight of the solution variance.

χ : Specified weight of penalty (under-fulfilment) of demand variance.

Variables:

$Y_{kl}^{\tilde{h}}$: Extent of demand on link (k,l) in presence of uncertain scenario $\tilde{h}$, $(k,l) \in T, \tilde{h} \in \Omega$

$W_{kl}^{\tilde{h}}$: 1 If demand of facility at point *k* covered by facility at point *l* under uncertain scenario $\tilde{h}$ $k,l \in D, \tilde{h} \in \Omega$, 0 otherwise

$\theta_1^{\tilde{h}}$: Robust method variable for first objective function under uncertain scenario $\tilde{h}$, $\tilde{h} \in \Omega$

$\theta_2^{\tilde{h}}$: Robust method variable for second objective function under uncertain scenario $\tilde{h}$, $\tilde{h} \in \Omega$

$\partial^{\tilde{h}}$: The penalty (under-fulfilment) of demand under uncertain scenario $\tilde{h}$, $\tilde{h} \in \Omega$

(RMFL/NDP):

$$Min\, obj_1 = \sum_{\tilde{h} \in \Omega} p^{\tilde{h}}.\xi^{\tilde{h}} + \lambda_1 \sum_{\tilde{h} \in \Omega} p^{\tilde{h}}.\left[\left(\xi^{\tilde{h}} - \sum_{\tilde{h}' \in \Omega} p^{\tilde{h}'}.\xi^{\tilde{h}'}\right) + 2\theta_1^{\tilde{h}}\right] + \chi \sum_{\tilde{h}} p^{\tilde{h}}.\partial^{\tilde{h}} + \sum_{l \in D} f_l Z_l + \sum_{(k,l) \in T} c_{kl} X_{kl} \quad (17)$$

$$Max\,obj_2 = \sum_{\tilde{h}\in\Omega} p^{\tilde{h}}.\varphi^{\tilde{h}} + \lambda_2 \sum_{\tilde{h}\in\Omega} p^{\tilde{h}}.\left[\left(\varphi^{\tilde{h}} - \sum_{\tilde{h}'\in\Omega} p^{\tilde{h}'}.\varphi^{\tilde{h}'}\right) + 2\theta_2^{\tilde{h}}\right] \quad (18)$$

$$s.t.\ \xi^{\tilde{h}} - \sum_{\tilde{h}\in\Omega} p^{\tilde{h}}.\xi^{\tilde{h}} + \theta_1^{\tilde{h}} \geq 0 \qquad \forall \tilde{h}\in\Omega \quad (19)$$

$$\varphi^{\tilde{h}} - \sum_{\tilde{h}\in\Omega} p^{\tilde{h}}.\varphi^{\tilde{h}} + \theta_2^{\tilde{h}} \geq 0 \qquad \forall \tilde{h}\in\Omega \quad (20)$$

$$\sum_{(k,l)\in T} Y_{ij}^{s\tilde{h}} - \sum_{(k,l)\in T} Y_{lk}^{s\tilde{h}} + d_l^{\tilde{h}} \leq \alpha_l + M\left(1 - Z_l\right) \qquad \forall l\in D, \forall \tilde{h}\in\Omega \quad (21)$$

$$\sum_{(k,l)\in T} Y_{lk}^{\tilde{h}} - \sum_{(k,l)\in T} Y_{kl}^{\tilde{h}} \leq d_l^{\tilde{h}} + M\left(Z_l\right) \qquad \forall l\in D,\ \forall \tilde{h}\in\Omega \quad (22)$$

$$\sum_{(k,l)\in T} Y_{lk}^{\tilde{h}} - \sum_{(k,l)\in T} Y_{kl}^{\tilde{h}} \geq d_l^{\tilde{h}} - M\left(Z_l\right) \qquad \forall l\in D,\ \forall \tilde{h}\in\Omega \quad (23)$$

$$W_{kl}^{\tilde{h}} \leq \delta_{kl}^{\tilde{h}} Z_l \qquad \forall k,l\in D, \forall \tilde{h}\in\Omega \quad (24)$$

$$V_l^{\tilde{h}} \leq \sum_{k\in D} W_{kl}^{\tilde{h}} \qquad \forall l\in D, \forall \tilde{h}\in\Omega \quad (25)$$

$$\sum_{l\in D} f_l Z_l + \sum_{(k,l)\in T} c_{kl} X_{kl} \leq BC \quad (26)$$

$$X_{kl} + X_{kl} \leq 1 \qquad \forall (k,l)\in T \quad (27)$$

$$\sum_{k\in D} Z_k = P_f \quad (28)$$

$$Y_{kl}^{\tilde{h}} \leq \beta_{kl} X_{kl} \qquad \forall (k,l)\in T, \forall \tilde{h}\in\Omega \quad (29)$$

$$Z_l, V_l^{\tilde{h}}, W_{kl}^{\tilde{h}} \in \{0,1\} \qquad \forall k,l\in D, \forall \tilde{h}\in\Omega \quad (30)$$

$$X_{kl} \in \{0,1\} \qquad \forall (k,l) \in T \qquad (31)$$

$$Y_{kl}^{\tilde{h}} \geq 0 \qquad \forall (k,l) \in T, \forall \tilde{h} \in \Omega \qquad (32)$$

$$\theta_1^{\tilde{h}}, \theta_2^{\tilde{h}} \geq 0 \qquad (33)$$

Where $\xi^{\tilde{h}} = \sum_{(k,l)\in T} t_{kl}^{\tilde{h}} Y_{kl}^{\tilde{h}}$, and $\varphi^{\tilde{h}} = \sum_{l \in D} d_l^{\tilde{h}} V_l$.

The equations (17)-(18) present the robust objective function by Muley *et al.* (1995) methodology. In addition, the equations (19)-(20) indicate the linearization of the objective at RO methodology. The explanation of equations (21)-(32) has been previously aforesaid. The equations (33) represent the standard integrality constraints of decision variables.

4. SOLUTION PROCEDURE

4.1. Multi Objective Solution Procedure

In the literature review, several approaches of multi-objective function optimization have been satisfyingly exerted. Some of the most praiseworthy multi-objective decision-making approaches are compromise programming (CP), goal programming (GP), and the reference point method (RPM) (Romero *et al*, 1998). Because of easy understanding and efficient application compromise programming in several multi-objective optimization problems, this methodology has several suitable aspects for selecting. In this research, the compromise programming is applied to unravel the proposed multi-objective optimization problem.

As a brief description, in compromise programming, a multi-objective problem is unraveled with respect to every objective function independently and afterwards reformulating a single objective that attains to minimize the summation upon the normalized distinction between the corresponding optimum value and each objective function. For the suggested formulation, it is supposed that two objectives are denominated Obj_1 and later Obj_2. According to the LP-metrics procedure, our formulation have to be separately unraveled for each of the two objectives. Supposing that the optimal worthies for these two problems are Obj_1* and Obj_2*, the *Lp*-metrics objective may now be formulized as following:

$$Min\ Obj_3 = \left[wei \times \frac{Obj_1 - Obj_1^*}{Obj_1^*} + \left(1 - wei\right) \times \frac{Obj_2^* - Obj_2}{Obj_2^*} \right] \tag{34}$$

wherever $0 \leq Wei \leq 1$ is the comparative weight of the elements of the objective appointed by the decision maker, scilicet, *Lp*-metrics coefficient. Applying this *Lp*-metrics objective and propounding our formulation constraints, a single-objective, mixed-integer programming (MIP) mathematical model is achieved, which can be unraveled effectually by a linear programming solver.

It is worth mentioning that the Obj_1 and Obj_2 are a minimizing and maximizing objective function respectively. Accordingly, the first and second phrase are established as $\frac{Obj_1 - Obj_1^*}{Obj_1^*}$ and $\frac{Obj_2^* - Obj_2}{Obj_2^*}$ in order to obtain a positive value. Also, this purpose can be achieved by using absolute value of phrases.

4.2. Multi Objective Heuristic - LP Relaxation Based - Solution Procedure

The formulation of the RMFL/NDP, proposed in Section 3.4.3, was codified in GAMS 24.1.2 and solved it using CPLEX 12.0. The results emphasized that the CPLEX can detect an optimum solution for the RMFL/NDP swiftly for pint-sized specimen but that the execution time sharply grows as the problem scale increases. Thereupon, it is admirable to have an efficacious heuristic solution methodology to unravel large-scale specimens of the proposed problem.

The fundamental basis of this procedure is according to the LP relaxation approach. The main steps of this procedure are as follows:

***Step.* 1:** Relax the binary variable *Z* at the model of RMFLNDP and solve the obtained model. Let Z_{LP}^1 denote the 1×n vector of location decision variables, and give clearance $Z_{j\ LP}^1$ be its j th element.

Therefore, $Z_{j\ LP}^{1}$ is a number in [0 , 1]. It is noted that in addition to the LP relaxation of the binary variable Z, the constraint of a number of predetermined facilities (constraints (12) or (29)) is ignored; because this trick can help to find more feasible and also suitable initial solutions.

***Step.* 2:** Relax all the binary variables (i.e., vectors Z, V, and matrix W, X). Let Z_{LP}^{2} denote the 1×n vector of location decision variables, and give clearance $Z_{j\ LP}^{2}$ be its j th element. Therefore, $Z_{j\ LP}^{2}$ is a number in [0 , 1]. It is noted that in addition to the LP relaxation of the binary variable Z, the constraint of a number of predetermined facilities (constraints (12) or (29)) is ignored; because this trick can help to find more feasible and also suitable initial solutions.

***Step.* 3:** Find the summation of the vectors $Z_{j\ LP}^{1}$ and $Z_{j\ LP}^{2}$ and save at a new vector, named Z_{LP}^{Final} (i.e., $Z_{LP}^{Final} = Z_{LP}^{1} + Z_{LP}^{2}$). Therefore, two states are happened as follows:

I) Each element of the Z_{LP}^{Final} is less than 0.5 (i.e., $Z_{LP}^{Final} < 0.5$); in this way, the possibility of facility establishment on the related location will be equal to 0.

II) Each element of the Z_{LP}^{Final} is equal or greater than 0.5 (i.e., $Z_{LP}^{Final} \geq 0.5$); in this way, the possibility of facility establishment on the related location will be equal to 1.

***Step.* 4:** Select the P_f of the largest elements of the vector Z_{LP}^{Final}. Change their values to 1. (Note: if more than one element of the vector Z_{LP}^{Final} have similar values, then the element with smaller index will be selected) At the following, change the value of other elements of the vector Z_{LP}^{Final} to 0.

***Step.* 5:** Set the new Z_{LP}^{Final} as an input vector of the RMFL/NDP. Also, the constraint of number of predetermined facilities (constraints (11) or (28)) is removed; because the number of facilities is equal to P_f and therefore, this constraint is redundant and can be removed.

***Step.* 6:** Solve the obtained model and report the output of solving of the RMFL/NDP as the best final solution of the proposed multi objective solution procedure.

5. THE EFFICIENCY OF HYBRID HEURISTIC PROCEDURE

Conductive to consider the performance of the hybrid heuristic algorithm, the small size test problems were generated and the RMFLNDP was solved by both the CPLEX solver of the GAMS 24.1.2 software and the hybrid heuristic. The obtained results are reflected to Illustration 1 and 2. According to the results, it can be educed that the suggested hybrid heuristic has not the considerable differences with the obtained solution of CPLEX solver; therefore, it can be elicited that the suggested hybrid heuristic has a suitable efficiency. In this way, the proposed algorithm can be generalized to solve the RMFLNDP in large scale (especially about our case study).

No.	Type		Time		Objective value	
	P_f	Node	Cplex	Heuristic	Cplex	Heuristic
SP1	2	5	1.57	2.132	0.0502	0.0501
SP2		6	2.138	2.482	0.0501	0.0500
SP3		7	3.509	2.884	0.0502	0.0502
SP4		8	4.0258	3.618	0.0502	0.0501
SP5		9	4.502	4.704	0.0502	0.0501
SP6		10	6.21	6.167	0.0502	0.0501
SP7		11	6.896	6.568	0.0503	0.0502
SP8		12	14.016	17.461	0.0506	0.0502
SP9		13	9.36	7.462	0.0503	0.0502
SP10		14	16.714	8.268	0.0503	0.0502
SP11		15	15.645	6.559	0.0504	0.0502
SP12		20	74.413	48.059	0.0502	0.0502
SP13		25	71	32.612	0.0533	0.0546
SP14		30	64.576	73.945	0.0549	0.0532
SP15		35	149.356	12.789	0.0551	0.0541
SP16		40	715.147	12.432	0.0545	0.0563
SP17		45	1985.514	78.834	0.0541	0.0567
SP18		50	2519.07	95.947	0.0544	0.0569

SP19		6	2.505	2.453	0.0503	0.0500
SP20		7	5.738	3.095	0.0503	0.0503
SP21		8	6.588	9.025	0.0508	0.0501
SP22		9	7.262	10.8	0.0503	0.0501
SP23		10	17.824	3.339	0.0502	0.05
SP24	3	11	19.86	10.865	0.0504	0.0503
SP25		12	27.537	9.03	0.0505	0.0503
SP26		13	31.781	7.09	0.0504	0.0502
SP27		14	29.323	8.117	0.0505	0.0503
SP28		15	43.388	7.019	0.0503	0.0503
SP29		20	172.074	48.152	0.0504	0.0502

Illustration 1 – Comparison of the hybrid heuristic and CPLEX solver according to the solution time and the objective function value

6. A PRACTICABLE CASE STUDY

The utilization of the RMFL/NDP is presented as a practicable case study, the aim of which is to ameliorate the efficiency of a broad medical service/distribution system with several drug distribution centers as facilities and several wholesalers in different towns in Iran. Hejrat is one of the biggest distribution and seller companies of drugs, medical devices, dietary supplements and health products with high quality in Iran. At the present time, this company has 2 wholesaler centers and some retailer centers. These centers cover a part of the pharmacies, hospitals and medical centers across the country. In order to more growth of the company, the senior managers group wants to locate 10 new wholesaler centers. There are 50 demand centers across the country and these demand centers can be suggested as wholesaler centers; therefore, 10 of them should be selected for locating the new provincial centers. Iran consists of 50 towns (nodes).

Regarding to the epochal information, some varying statuses (e.g. mutability in stock market expenditures, climate change, etc.) can stimulate to uncertainty at some of the input parameters of the RMFL/NDP. In this research, the demands of the nodes as well as the transportation unit costs are stochastic as some scenarios. Hereupon, the value of transportation will be stochastic. These uncertain statuses are classified as following: supreme, good, medium, bad which their contingencies are 0.25, 0.28, 0.32, and 0.2 respectively. The transportation expenditure for every customer in kilometer is emblazoned as a proportionality of distance for four forenamed scenarios as following, 0.0040, 0.0035, 0.0025, and 0.0015 respectively.

The establishment expenditure of new roads is propounded twice as many as the distance between two relevant demand centers. Each demand center is a customer node with a demand that is equivalent its patients. The constant expenditure of opening a service/distribution center hinges on diverse urban condition of demand centers and uniformly mutates between [90000 - 180000] (Monetary Unit) MU.

It is worth mentioning that, in this practical case study, the link construction cost is interpreted as initial fixed cost of establishing of transportation vehicles in a road link. In other words, if Hejrat decides to transporting products between two nodes, this company must pay an initial fixed establishment cost in order to buy or long time rent of necessary transportation vehicles. This cost is considered/interpreted as link construction cost. In order to opening of new facilities and construction of new roads, the Hejrat has investment constraint and the investment constraint is regulated 350000 MU. The primary aims in the mentioned case study are to specify:

- ✓ The optimal locations of new service/distribution centers regarding to the foresaid objective functions;
- ✓ The transportation links that have be established in the suggested network;
- ✓ The extent of demands of towns that have to be transported via links;
- ✓ The portion of each demand that have to be supplied/covered by new service/distribution centers;
- ✓ Each of the 50 nodes should be covered by which of facilities.

It is noted that the central drug stores of the 50 nodes are considered as customers. Also, each distribution center is known as a medical service emporium and services to the retailers and local customers. Moreover, each of the service distribution centers and the demand nodes can be connected together.

Conforming to the forenamed statuses, it is obvious that the case study may be literally perused as a RMFL/NDP. As a consequence, regarding to the aforesaid explanation, the RMFL/NDP formulation is an appropriate model for the case study. Hence, as a predicative choice to detract transportation expenditures, the mathematical RMFL/NDP can hold forth that new drug distribution centers may be constituted in the demand centers in which no medical service distribution center has placed. Besides, establishing new roads may be brought forward as the other predicative choices to meliorate the forenamed objective function of the case study.

Illustration 2 shows the locating of new facilities by red squares. The optimum amount of the first objective is 338676.539 MU and the optimal amount of the second objective function is 2705.321 MU, also the optimal value of Obj_3, presented as equation (48), is 0.0521. Also, regarding to the Illustration 2, it can be concluded that the nodes 1, 4, 10, 16, 21, 22, 25, 28, 42, and 46 are nodes that have the maximum coverage and also simultaneously minimum location costs. Therefore, these nodes are selected for establishing of 10 new urban centers.

7. CONCLUSION

Regarding to the incisive impress of the efficacious designing of facility location problems in ameliorating the efficiency and performance of service/distribution systems; in this study, a robust MIP model was proposed for the FL/NDP conductive to minimize the total expenditure of the entire system of service/distribution centers under unforeseen situations. The Mulvey et al. robust optimization methodology was exerted to formulation demands' uncertainty. The suggested robust formulation specifies the optimum locations of new service/distribution centers, optimum establishing of link roads as well as optimum allocating of demand centers to service/distribution centers for every scenario with respect to improved/constructed transportation links. In the following, a general multi objective solution procedure was presented and because of obtaining the more suitable efficiency, especially in the solution time, an efficient heuristic –LP relaxation based- solution procedure was proposed. Then, a practicable case study on the Hejrat medical service/distribution company presents the noteworthy proficiency of the proposed model in ameliorating the proficiency of service/distribution systems.

Our detections promote some expedient inquiries for ulterior study. We are exclusively interested in summoning efficient and apposite multi objective meta-heuristics and heuristics such as non-dominated sorting genetic algorithm (NSGA II) and multi objective particle swarm optimization (MOPSO) for compering with the proposed multi objective procedure in this paper.

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Absorptive Capacity of Positive Externalities in the Added Value of Rio de Janeiro State

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ABSTRACT

The present work has the objective of understanding the influence of spatial externalities on the creation of value in the state of Rio de Janeiro. An exploratory analysis of spatial data and a multiple regression complemented by a spatial autocorrelation model are used as methodological support; both are fed with official data from the Ministry of Labor, the Ministry of Finance (RJ), IBGE, FIRJAN and the DataViva platform. The results indicate the capacity of absorption of spatial concentration externalities and economic diversity externalities, and a negative influence of education externality on the composition of added value of the municipalities of Rio de Janeiro. This contradiction, where richer regions present a low predominance of education while poorer regions present a higher predominance of education in the Rio de Janeiro state, is an important research finding inverse to the debate in the literature that considers education as a relevant foundation of both wealth creation and consequent insertion of the regional environment in the context of digital transformation.

KEYWORDS: Positive Externalities, Absorptive Capacity, Rio de Janeiro, Spatial Autocorrelation.

1. INTRODUCTION

Brazil is, historically, one of the countries with the largest economies in the world. Only the state of Rio de Janeiro, one of the twenty-seven

Brazilian states, contributes to more than 10% of the country's gross domestic product, thus occupying the second largest economy among the Brazilian states. To achieve this result, the state has a strong service sector and a representative industrial park.

Industry in the state of Rio de Janeiro, which is the second largest sector responsible for state GDP, is heavily linked to metallurgy and oil production, activities that are highly extractive and are not heavily associated with a manufacturing industry (Silva, 2012). Still regarding about the extractive industry, the state is also strong in limestone, dolomite and salt production. Oil activity in turn is one of the great foundations of the state economy, having a very strong impact on several indicators.

It is natural that for a state with strong industrial character to have the occurrence of productive agglomerations, even those with a high degree of specialization. This is due to the creation and exploitation of synergies between companies when they share a defined geographical area. These cooperative relationships occur through diverse connections, whether horizontal or vertical, creating a series of peculiarities that make these companies more productive and competitive. These agglomeration of companies, sometimes with similar characteristics and unique relationships within the same location, generate benefits called positive externalities.

Considering particularly the state of Rio de Janeiro, it is important to note the existence of an unequal spatial distribution of productive agglomerations throughout its territory and regions[1] (CEPERJ). The Northern Region of the state of Rio de Janeiro is known for hosting companies that are heavily involved in the petroleum sector, and large projects such as the Açu Port Complex. The Metropolitan Region of the state, although linked to petroleum, also has an extensive diversified industrial sector and is home to many national and international-level companies. The Mountainous Region and North Region of Rio de Janeiro, in turn, are known for their clothing and textile industries. The Region of the Middle Paraíba, strategic for being a link of connection with other states, is home to the second largest agglomeration of industries of the federation of Rio de Janeiro. And the Northwest Region, although having a minor representativeness, has industries of the agricultural sector.

It is extremely important, therefore, to determine how the distribution of these agglomerations occurs in the state of Rio de Janeiro, and the capacity to absorb positive externalities within this context. The present article is divided in six sections counting the introduction, being the next five respectively: bibliographical revision, with information of diverse studies on the subject; methods, where the analysis model will be described; results, where the relevant information will be extracted from the analysis model; discussion, with a comparison and reflection of the important information; and lastly the final considerations.

2. BIBLIOGRAPHIC REVIEW

Research on the capacity to absorb positive externalities in specific territories is an object of investigation already seen by relevant studies and authors. The existence of the need to understand the theme combined with the unique interests of each location regarding its capacity for absorption essentially fosters studies in the area (Caragliu and Nijkamp 2016).

Still in the context of studies about this subject, Vale and Castro (2010) propose the existence of three large integrated blocks of reflection. The first, the "typology of regional analysis and neoclassical inspiration" is linked to aspects attached to the perceptions of neoclassical economics, related to the presuppositions of strict rationality and successors of the "regional economy". The second is the "typology of regional analyzes of industrial organization". This is a direct heir of Marshall, with emphasis on literature on industrial districts (emphasis on the role of agglomerations in the generation of externalities and regional assets) and clusters (emphasis on competition and cooperation territorial dynamics). Finally, the third, the "typology of regional analyzes of institutional inspiration", with two lines of reflection: transaction costs theory, represented by Williamson; evolutionary institutional economy, represented by Schumpter.

A more specific cluster definition, made by Albuquerque and Brito (2002), is linked to the high need of a concentration of both sectoral and geographical companies, which generates externalities and consequently greater efficiency. A cluster has as its main characteristics the territorial proximity of economic agents, political, social, and interorganizational networks formed between them (Hoffman *et. al.*, 2006 and Latres and Cassolato 2009).

Porter (1990) defines a cluster as a group of companies concentrated in the same geographical space delimited and in an interrelated way, with the presence of related institutions, which may be a district, city, state or country. He also points out that different agglomerations have disparities in their degrees of sophistication, but that most of them include suppliers, companies and related financial institutions.

Similarly, the same region may have different agglomerations. In this case, each company in the cluster can participate, as it wishes, in different forms of interaction. The resurgence of this approach, which centrally places a specific locality or region as the focus of innovative and competitive advantages since 1970, is exemplified by regional economies and industrial districts such as Silicon Valley in California, Third Italy, Baden-Wurttemberg, *et al*. whose success was driven by the dynamism of local assets (Melo *et al*., 2012).

Regardless of the nomenclature used to designate different types of industrial agglomerations, Pugas et al. (2015) argue that in all of them there is a certain use of the synergies that are generated by the interactions between the companies of a cluster, which makes this environment more prone to the survival and growth of these companies. These synergies, also called positive externalities, can be productive or technological, and induce a higher level of competitiveness and efficiency. These externalities may also be classified into four types: Marshallians (productive dimension), schumpterians (innovative), Transactionals (information and knowledge exchange) and Jacobians (urban dimension).

Jorge and Dantas (2009) in his study about the phenomenon of the absorption of externalities highlight the importance of a qualified labor in the process of positive overflow of productivity from the foreign companies to nationals. This process can occur when a firm has an expressive number of skilled workers, since this makes higher the chances of absorbing external technological knowledge, and thus self-benefiting from productivity overflows.

Other studies also show the importance of the training of the workforce for this absorption of externalities occurs. In the field of innovation, Foster-McGregor *et al.* (2017) investigated the key role of knowledge diffusion through R&D investments and concluded that absorption capacity is commonly greater when both the industry in the country is more backward allied and the human capital is more educated. Mancusi (2008) argues that the positive externalities generated through international knowledge flows will depend on the country’s ability to absorb this external knowledge, as it is possibly easier for those who invest in research and development.

The spatial concentration of these firms is extremely important in determining the capacity to absorb externalities. When companies, whether national or multinational, share the same geographic space, they allow the occurrence of positive externalities since this transfer occurs through channels of demonstration and imitation, labor volatility and interconnections between companies (Jordaan 2005). It is important to mention that productivity spillovers between firms, especially in agglomerations, can take place vertically (relationship between buyer and supplier firms and their advantages generated) or horizontally (relationship between competing firms, which stimulates innovative capacity and stimulates development) (Gonçalves 2005).

Crespo and Fountoura (2007) conducted a survey in which they analyzed a vast literature investigating the existence of foreign direct investment externalities on national companies that could be translated into productivity gains. They evaluated that the most common procedure used to make this evaluation consists of a regression where productivity is assumed as a dependent variable of the relevance of the foreign presence. They concluded that despite the expectation of positive effects from externalities on domestic firms, more recent studies using newer econometric techniques have challenged this consensus, and some of them have also shown the evidence of a negative influence on domestic firms.

3. METHODS

The methodology formulated with the purpose of analyzing the absorption capacity of positive externalities in the creation of value in the municipalities of Rio de Janeiro was based on a spatial analysis composed of two parts: an exploratory analysis and an econometric model. This model of analysis is similar to the one proposed by Rezende *et al*. (2016) and has the modification of some variables to improve and adapt the model to the state of Rio de Janeiro.

The first, the exploratory spatial data analysis (ESDA), identifies patterns of spatial associations using the global statistical indicator of spatial autocorrelation Moran's I. Since this indicator is generated globally, that is, a single value as a measure of spatial association for each observation, it may obscure certain local patterns. For this reason, this indicator is decomposed with the purpose of grouping similar values around a single observation, that is, spatial clusters that are statistically significant.

The clusters identified by ESDA present autocorrelation that can be positive or negative. When it is positive, there is a statistically significant similarity in the value of the attribute studied between certain localities, and it may be that ratio between "high/high" values (a cluster of high values of a certain variable) or "low/low" values (a cluster of low values of a certain variable). When it is negative, there is a statistically significant difference in the value of the attribute studied between nearby localities, and it may be that ratio between "high/low" values (a cluster of high values surrounded by one of low values) or "low/high "(a cluster of low values surrounded by one of high values).

The second part of the spatial analysis is based on an econometric model that captures the capacity of absorption of the externalities generated by the variables of economic diversity, education and market structure on the creation of value in the municipalities of Rio de Janeiro. Initially a multiple regression is performed, and a statistical technique used to analyze the relationship between a dependent variable (criterion) and independent (predictor) variables. The proposed regression model is given by:

$$\mathrm{Ln(VA)} = \alpha + \beta 1 \text{ IFDM-edu} + \beta 2 \text{ DivOcup} + \beta 3 \text{ NumEmp} \qquad (1)$$

Where:

- **Ln(VA):** Added Value, measures the additional value created when purchases goods and services are transformed by a productive process in each one of the municipalities of Rio de Janeiro. To reduce the heterogeneity of the data and to smooth its numerical scale with others, the natural logarithm was applied.
- **IFDM-edu:** FIRJAN index of municipal development (education), is a social indicator that captures the quality of education provided until elementary school. It is an indicator of human capital.
- **DivOcup:** Effective Diversity of Occupations, is an indicator of the economic diversity of a locality as it accounts the number of unique occupations (4 CBO digits) that are present being corrected by the participation that each unit represents. This index captures both the diversity of the labor market and the complexity of the economy, thus the economic diversity.
- **NumEmp:** Number of operating companies, measures the market structure of a locality through the number of companies operating in

it. It indicates the concentration of companies and the competitive advantages generated.

The data above was collected, respectively, on the website of the Ministry of Finance-RJ 17. (Ministério da Fazenda, 2018), FIRJAN website (FIRJAN, 2018), DataViva platform (Plataforma DataViva, 2018) and IBGE website 11. IBGE (2018); all data analyzed refer to the year 2013, due to the unavailability of all data for a most recent period. The latest version of the IFDM refers to the year 2013. The software used for the application of statistical tools is GeoDA, a free and open source with focus on the introduction of spatial data analysis, exploring and modeling certain spatial patterns (Anselin *et al*., 2006).

4. RESULTS

Based on ESDA, the local spatial autocorrelation patterns are identified through the local indicators of spatial association (LISA) for the variables: Added Value, IFDM-edu, Effective Diversity of Occupations, and the Number of Operating Companies. The Moran's I value is also given for each of them.

Illustration 1 below shows the local spatial autocorrection patterns of Added Value variable.

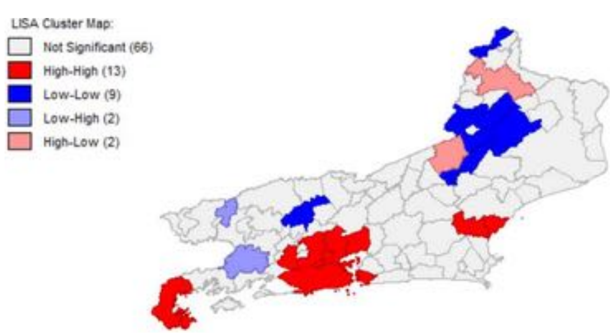

Illustration 1 - Added Value Clusters

For the Added Value variable, Moran's I is 0.319. As can be seen in figure 1, there is a cluster of high values in the Metropolitan Region formed by the municipalities of Belford Roxo, Duque de Caxias, Magé, Mesquita, Niteroi, Niterói, Nova Iguaçu, Rio de Janeiro, São João de Meriti and Seropédica. Another cluster of high values of the Added Value variable is seen in the north of the Coastal Region composed of the municipalities of Casimiro de Abreu and Rio das Ostras. In contrast, there is also a cluster of low values between the Northwest Fluminense and Serrana Regions formed by the municipalities Cambuci, Cordeiro, Itaocara, Macuco, Miracema, Santo Antônio de Pádua, São José de Ubá and São Sebastião do Alto; there is a "low/high" relation on the part of this grouping with the municipalities of Cantagalo and Itaperuna.

Illustration 2 below shows the local spatial autocorrection patterns of the occupancy Diversity variable.

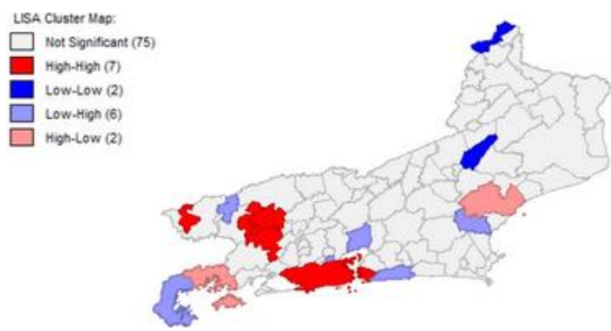

Illustration 2 – Effective Diversity of Occupations Clusters

For the variable Effective Diversity of Occupations, Moran's I index was only 0.011. As shown in Illustration 2, there is a small cluster of high values in the Metropolitan Region formed by the municipalities of Niterói and Rio de Janeiro. There is also another cluster of high values in the Region of the Middle of Paraíba formed by the municipalities of Barra do Piraí, Pinheiral, Piraí and Volta Redonda. Other clusters reveal a "high/low" relationship, such as Angra dos Reis (high) and Paraty (low), and Macaé (high) and Casimiro de Abreu (low).

Illustration 3 below shows the local spatial autocorrection patterns of the IFDM-edu variable.

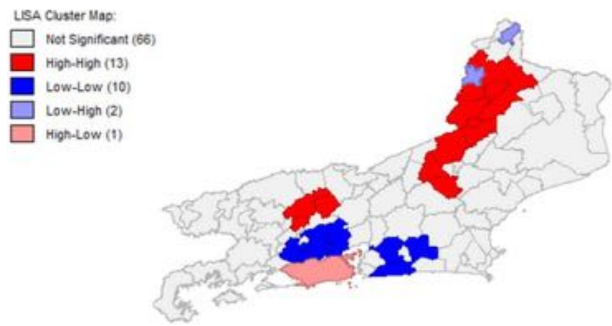

Illustration 3 – IFDM-edu Clusters

For the IFDM-edu variable, Moran's is 0.323. Illustration 3 illustrates the existence of a cluster of high values in the Northwest and Serrana Regions formed by the municipalities of Aperibé, Bom Jardim, Cambuci, Cantagalo, Dois Barras, Itaperuna, Laje do Muriaé, Miracema, Santo Antônio de Pádua and São José of Ubá. Another cluster of high values is located in the Center-South Fluminense Region formed by the municipalities of Engenheiro Paulo de Frontin, Paty do Alferes and Vassouras. In the Metropolitan Region there is a "low/high" cluster formed by the municipalities of Belford Roxo, Duque de Caxias, Mesquita, Nova Iguaçu, Queimados, São João de Meriti, Seropédica and Rio de Janeiro (high). In this same region there is another cluster of low values formed by the municipalities of Itaboraí, Maricá and Rio Bonito.

Illustration 4 below shows the local spatial autocorrection patterns of the Number of Companies variable.

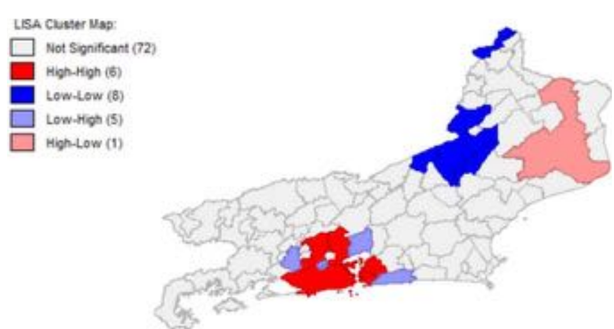

Illustration 4 – Number of Operating Companies Clusters

For the variable Number of Operating Companies, Moran's I is 0.047. Figure 4 shows a cluster of high values in the Metropolitan Region formed by the municipalities of Niterói, Nova Iguaçu, Rio de Janeiro, São Gonçalo and São João de Meriti. Some municipalities showed a "low/high" relationship with this group, being Magé, Maricá, Mesquita, Nilópolis and Seropédica. A cluster of low values can be seen between the Regions Northwest Fluminense and Serrana composed by the municipalities of Cantagalo, Carmo, Cordeiro, Itaocara, Macuco, Santo Antônio de Pádua and São Sebastião do Alto. The municipality of Campos dos Goytacazes shows a relationship of "high/low" with others around.

The second part of the spatial analysis consisted in the application in a spatial regression model that uses as base the equation (1) with the purpose of explaining the spatial effects of externality variables on the construction of Added Value in the municipalities of Rio de Janeiro.

$$\text{Ln (VA)} = \alpha + \beta 1\ \text{IFDMedu} + \beta 2\ \text{DivOcup} + \beta 3\ \text{NumEmp} \qquad (1)$$

The multiple regression showed an adjusted r-squared of 0.64. The number of multicollinearity condition was lower than 30 (29,61), indicating the non-presence of multicollinearity. The Jarque Bera test of non-collinearity was not significant (significance of 0.1), accepting the null hypothesis of a normal distribution. All the tests of heteroskedasticity accepted the null hypothesis that the variance is constant, not showing significance for the rejection of the null hypothesis, being them Breusch-Pagan test (significance of 0.23), Koender-Bassett test (significance of 0.25) and White Test (significance of 0.32). Moran's I index was significant (significance of 0.01) to reject the null hypothesis of non-spatial dependence.

Thus, the only test to choose the best spatial regression model that proved to be significant was the Spatial Lag Model, having a Robust LM (lag) with a significance of 0.00337. For the Spatial Lag Model, the values of the constant and the independent variables are shown in Illustration 5 bellow. All the variables were significant in the composition of the model.

Variable	Coefficient	Probability
Constant	12.4674	0.00000
DivOcu	0.060148	0.00000
IFDM-edu	-4.135	0.01673
NumEmp	1.59457e-005	0.00239
W_lnVA	0.352396	0.00002

Illustration 5 – Coefficients and Probabilities of Variables from Spatial Lag Model

For this final model, the r-squared is 0.71, a value higher than the adjusted r-squared of 0.64 from the common multiple regression, which indicates the improvement of the model.

5. DISCUSSION

The results obtained by the explanatory models show certain local and global patterns for each of the presented variables. Firstly, the local and later global standards were discussed through the spatial regression model.

The high Added Value cluster in the Metropolitan Region, shown in Illustration 1, demonstrates not only the concentration of Added Value in the capital Rio de Janeiro, which alone holds almost 40% of the total value, but also in the cluster, reaching a value of almost 59% of all Added Value of the state. This shows a very strong Added Value concentration in only 9 of all 92 counties, in the capital and some adjacent cities. In contrast, the cluster of low values between the Noroeste Fluminense and Serrana Regions is not responsible for making up 0.3% of the state Added Value. This shows a completely unequal creation of Added Value in the state of Rio de Janeiro, super concentrated in the capital and surrounding cities, and with small values in the northwest of the state.

Illustration 2 shows only two groups of high values for the Effective Diversity of Occupations index: one in the Metropolitan Region and another in the Middle Paraíba Region. Although the Added Value is concentrated in several cities of the Metropolitan Region, only the cities of Rio de Janeiro and Niterói have a significantly higher index of effective diversity of occupations in this area, with an average value of 94.25, a value much higher than the average state of 57.90. This shows that these two cities benefit from better economic dynamics than their neighboring cities. There is another cluster of high values in the Middle of Paraíba Region, with a mean value of 76.21. Macaé is isolated as a value far superior to those who are around (113,84), because there is a complex economy in the petroleum sector.

There is a large cluster of high values for the index of IFDM-edu, as seen in Illustration 3, in the Northwest and Serrana Regions, with a value of 0.836, considered high, while the general mean of the state is 0.775, considered moderate. Another cluster of high values is in the Central South Region with a value of 0.801. The cluster of values of the Metropolitan Region of the river is considered moderate, with 0.666, well below the state average. Also in the Metropolitan Region, the other cluster has a value of 0.748, considered moderate, and although not as low as the value of the other cluster in the same region, is also below the state average. These two clusters in the Metropolitan Region indicate the weakness of the region in education.

As for the variable Number of Operating Companies, there are two groupings of values as illustrated in Illustration 4: One of high values in the Metropolitan Region that alone holds 61% of state companies; and another between the Serrana and Northwest Regions, composed of 7 cities, with only 1% of the state companies. One way to materialize as the distribution of companies in the state occurs irregularly, only the city of Campos dos Goytacazes holds 2.45% of the number of state companies, a value two and a half times higher than the group previously presented.

According to the clusters generated through the LISA analysis, it can be noticed that the clusters of high values of the Added Value variable are related to clusters of high values of the variables Effective Diversity of Occupations and Number of Companies Operating. Surprisingly, the opposite occurs with the IFDM-edu variable: The relationship between Added Value Creation and Education is inversely proportional. High value clusters of the Added Value variable tend to have low values of the variable IFDM-edu; and high value clusters of the IFDM-edu variable tend to have low values of the variable Added Value.

This reading of the clusters revealed by the LISA analysis is also stated in the econometric model: the constants' value of the spatial lag regression shown in Table 1 reveals that all the independent variables have positive values except the IFDM-edu variable, with negative coefficient. The creation of Added Value in the municipalities of Rio de Janeiro can be explained, mostly, by the econometric model proposed. However it also reveals that if there is the capacity of absorption of the externalities of economic diversity and concentration of companies, the opposite can be said of the variable education, since even if its influence on the regression model is significant, it shows an inconsistency in the state of Rio de Janeiro where clusters of cities with lower levels of education tend to have a greater creation of Added Value.

6. FINAL CONSIDERATIONS

The model proposed to investigate the existence of the capacity to absorb positive externalities proved to be very effective both in terms of a detailed analysis of certain groups in the territory of Rio de Janeiro and in terms of a comprehensive analysis for the whole state.

According to the results obtained, it was proved the existence of capacity to absorb the externalities of economic diversity and market structure in the creation of Added Value in the municipalities of Rio de Janeiro, while the absorption of the externality of education was inversely proportional to the creation of Added Value. The method of evaluating the absorption capacity was also efficient in terms of its statistical validation and the results obtained.

It was also verified the existence of spatial dependence in the creation of Added Value with the use of spatial lag model, where the autocorrelation is attributed to the own variable response in the search for a model more appropriate to the studied territory. The application of the spatial lag model further improved the regression results, also revealing the unequal form in which the variables studied are distributed throughout the state, that is, Added Value clusters in the state of Rio de Janeiro have a strong pattern of heterogeneity. Regions which receive a large amount of investments have demonstrated ability to concentrate wealth, while regions of low investment the pattern of wealth generation is much lower, as its concentration.

It is important to mention the contrast between indicators of education and creation of Added Value, a comparison that resulted a different response than expected. Municipalities with a high education rate and, consequently, high human capital, should excel in the construction of added value. In contrast, municipalities with high levels of education had, for the most part, minimal contributions to the creation of value.

Paradoxically, the richer regions had a lower predominance of education. This contradiction is an important finding of the research that shows a profile of the peripheral region inverse to the debate in the literature on the subject, that is, education constitutes a relevant foundation of wealth generation and the consequent insertion of the regional environment in the context of digital transformation. This logic may not be generalized. Other elements act in the formation and distribution of wealth regionally.

Given the results obtained, it is verified the importance of this study to understand the creation of value in the state of Rio de Janeiro and the variables that contribute to its design. Indeed, further studies to improve the current model and to seek a deeper understanding between the variables education and added value and their inversely proportional values are recommended.

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APPENDIX

Notas Finais

[1] The map showing different government Regions and municipalities of Rio de Janeiro state may be seen on Appendix.

Agile Regulations Management Method: An Approach Based on Excelence Models

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ABSTRACT

Although management systems are of paramount importance to organizations, they are complex to implement, and maintain. Moreover, in the current competitive environment, due to fast access to information and fierce competition, there is a need for greater control over how organizations handle and execute parameters stipulated by regulatory bodies, be they environmental, health, security, social responsibility, financial or other. However, this management process must be carried out constantly in order to avoid possible penalties and to ensure that companies are complying with the appropriate regulations, which adaptations should not generate large negative impacts when performed. The purpose of this paper is to propose a method for the management of regulations, based on relevant management excellence models (MEG, Malcolm Baldrige, EFQM and Deming). This method seeks to provide a flexible and adaptive management approach with the intention of assisting organizations in the bureaucratic activity of handling regulations. It presents an integrative map of such models, modeled with ArchiMate, which provides guidelines on how to build a consistent management system, as well as applying other elements such as VUCA concepts (volatility, uncertainty, complexity and ambiguity), agile methodology, the integrative map and constructs of agile companies. Therefore, the map structures the method, which provides a form of robust management for this process.

KEYWORDS: Excellence Management Models, Agile, Integrative Map.

1. INTRODUCTION

Managerial approaches were modified as organizational needs evolved, as Industrial Revolutions occurred, since “changes in manufacturing processes, design, product, operations, and production-related systems, increasing value in the organizational chain, and the entire product life cycle” (FIRJAN, 2016) happened. Therefore, management processes were being highlighted and considered essential for the proper functioning of organizations, although these organizations require a set of activities that mostly become complex to be executed, due to the resources and knowledge required.

These evidences, at the beginning of the twentieth century, were exclusively product-oriented, due to the Taylorist system focusing on productivity. As production advanced, it became impracticable to carry out 100% inspection, spread by Taylor. Thus, in 1924, Walter Shewhart proposed statistical concepts in quality control, focusing on the management process (Cequeira, 2006).

In 1956, Armand Van Feigenbaum spread the principles of total quality control, giving a systemic vision to the quality management process. Through organizations seeking to adapt to market changes and satisfaction of their customers, management started to play a more strategic role, in which it should observe aspects related to the entire business (Cequeira, 2006).

Given such complexity and relevance, management standards have emerged to support these processes. They advise decision-making and are constituted of requirements that guide the development and the continuity of managerial processes. In the same sense, regulations have been stipulated with the intention of standardizing and supervising organizational aspects and actions. These standards are defined, in particular, by the International Standardization System (ISO). This system is represented in Brazil by the Brazilian Association of Technical Standards (ABNT) (Neto *et al.*, 2008).

However, with the increase and diversification of management standards and other bureaucracies, since there are regulations and specifications according to each managerial scope, such as environment, quality and safety, among others, it is difficult for companies to implement and adapt regulatory changes in an effective and constant manner, in order to have a robust management system that is continuously updated in bureaucratic matters without negatively interfering in its operation.

Parallel to this, management excellence models were created with the aim of making management processes more solid, more sustainable and cooperative (Gill, 2015). These are recommended by the respective Management Excellence Awards, such as: the Deming Prize, Malcolm Baldridge Award, EFQM Excellence Award and the National Quality Award (PNQ) in Brazil, which are references in this area. In this view, such models "present a methodology that, using a self-evaluation tool, helps organizations to measure their degree of adherence with respect to the model in question" (Zanca and Costa, 2009).

Considering this and that organizations are living systems in an integrated ecosystem, in which they need to understand and exercise the principles of interdependence, systemic thinking and sustainability in management (FNQ, 2017) in search for efficiency and effectiveness, together with the complexity of the current business environment, it is necessary to implement adaptive models that help in this matter as well as causing bureaucratic changes to be planned and implemented in a consistent manner so that they are included in management issues, in order to generate the least organizational impact. It must be also recalled that any change in the business environment reflects on social, bureaucratic, cultural, structural, procedural and managerial issues (Dietz *et al.*, 2013).

So, the purpose of this paper is to propose a flexible management approach to take regulations and their changes into account based on such models of excellence. The method used to achieve this purpose includes a literature review about management systems, main models of excellence, enterprise engineering and agile methodology, and content analysis of the references for the construction of the conceptual model, pondering the aspects raised in the literature. Through this, it is possible to define how regulations, standards and organizational bureaucracies need to be implemented in order to become an adaptive, agile, effective and systematic process based on the main models of management excellence.

In the next session the main aspects raised through the literature review will be presented. Session 3 will explain the conceptual model of flexible management of bureaucratic processes. Finally, in session 4 the results obtained will be discussed, and session 5 presents the final conclusion of the work and suggestions for future work.

2. SCIENTIFIC BASIS OF THE RESEACH

This section presents the foundations of the work, based on management systems, management excellence models, enterprise engineering and agile methods.

2.1. MANAGEMENT SYSTEMS

Management systems are conceptualized as "a structured set of processes and procedures necessary to reach certain objectives" (Oliveira, 2013). Such systems are structured based on the PDCA cycle model with a focus on continuous improvement. Therefore, the National Quality Foundation of Brazil defines it as "a set of standardized practices, logically interrelated with the purpose of managing an organization and producing results". Furthermore, they are structured with operational and managerial processes, which are based on the PDCL cycle, and transform information into managerial decisions that are based on the PDCA cycle, turning inputs into products and services.

The PDCL cycle consists of 4 steps: planning, executing, checking and learning. In the first phase, the processes are standardized to be possible for the correct repetition. In the second phase the operational process is carried out, and in the third phase it is verified if the standard is being fulfilled. Finally, the concept of learning is introduced in the managerial questions (FNQ, 2017).

The PDCA cycle is constituted by the phases of planning, in which the objectives are planned; executing, the phase in which the plan is implemented; checking, in which the results obtained in the previous phase are measured, analyzed and compared with their expected results and; acting, in which corrective actions are taken on significant disagreements, analyzing their causes and applying, thus, continuous improvement techniques (FNQ, 2017).

Well-structured management systems also take into account specific standards, which are defined, in particular, by the International Standardization Organization (ISO). For sample, there are standards related to quality (ISO 9001), environment (ISO 14001), safety and occupational health (OHSAS 18001 by British Standard Institution) and social responsibility (ISO 16001) (Cequeira, 2006). However, such standards engage a host of others bureaucracies under federal, state and municipal laws, as well as aligned to the type and branch of the company and, the niche which it is inserted.

Quality management refers, based on ISO 9001, to the set of actions of planning, control and improvement of quality through policies and objectives stipulated by top management to ensure and improve the customer and the regulatory bodies requirements. Furthermore, including social responsibility issues, environmental and, health and safety concerns drives the achievement of sustainable development, where environmental, social and economic resources are viewed in a balanced way so as not to compromise access to such resources by the next generations (Cequeira, 2006).

2.2. Excellence Management Models

The historical evolution of managerial processes has led to the need for management models capable of dealing with such changes, as new organizational aspects and needs have arisen, which need to be controlled and monitored, such as the difficulty in carrying out the inspection of quality of products without the aid of statistical process control. That is why management models began to emerge, not only with focus on organizational performance in relation to the product, but on the whole business, that is product, process and system. Hence, to guide the entire business strategy and, excellence management models are based on documents provided by governmental and non-governmental institutions which aims to document best practices and disseminate them in order to leverage the quality of organizational processes and provide prizes for those who meet certain criteria, constantly evolving their results (Blauth, 2011).

Some of the most prominent excellence management models are discussed next, since they are the most present in the literature and for being the most related in integrated management systems, mainly the European Foundation for Quality Management (EFQM) and Malcolm Baldrige (Garengo and Biazzo, 2013). In addition, when focus on this type of management systems, it is common to relate to aspects of Total Quality Management, which makes reference, more explicitly, to the Deming model (Garengo and Biazzo, 2013). Also, referring to the PDCA cycle, characterized in MEG model, which was also selected for being the Brazilian Excellence Model, that is, the starting point of the study.

MEG. The management excellence model (MEG – Modelo de Excelência em Gestão) is the flagship of the National Quality Foundation (FNQ), which since 1991 has been stimulating and supporting Brazilian organizations in the development and advancement of management to generate value for all stakeholders and have the ability to learn and adapt to new unforeseen and uncontrollable scenarios. Therefore, MEG can be considered a reference model for companies that wish to improve their management processes worldwide, with an integrative and holistic vision, and be adaptable to the needs of organizations. Its conceptual diagram is represented by the. It should be pointed out that it is MEG that must be adapted to the companies, not the other way around, because the model is represented according to the characteristics of the organization (FNQ, 2017).

The self-assessment is based on the 8 fundamentals of Management for Excellence. These, according to FNQ, are tangible, measurable, quantitative or qualitative characteristics that are realized through processes and their respective results. These fundamentals are: systemic thinking, commitment to stakeholders, organizational learning and innovation, adaptability, transformative leadership, sustainable development, process orientation and value creation. And, this model has as its conceptual base the PDCL cycle and presents the following logic: the fundamentals are subdivided into themes, which are realized through processes, which in turn are detailed and explained through tools and methodologies (FNQ, 2017).

Deming. The purpose of the Deming Prize is to leverage the importance of quality management for organizational business success and to contribute to the advancement of useful quality methodologies and business improvement activities. It was created in 1951 by the Union of Japanese Scientists and Engineers (JUSE), in honor of Dr. William Edwards Deming, considered the quality movement's father, who helped to create the quality management system in Japan after World War II (JUSE, 2017).

The evaluation process does not require organizations to comply with the baseline model, widespread by the Deming Prize's Committee; however, it requires them to develop their own themes and approaches, provided they are focused on total quality management, thereby improving organizations as a whole, and making a mutual development, not only an evaluation, since quality methodologies are developed (JUSE, 2017).

Therefore, total quality management can be defined as, a set of systematic activities carried out by the whole organization to efficiently and effectively achieve the organization's goals, in order to provide products and services with a level of quality that satisfies customers, at the appropriate time and price (JUSE, 2017).

For this reason, the Deming Award is an annual award presented to an organization that has properly implemented full quality management in its management philosophy, business scope and management environment (JUSE, 2017). And in view of these aspects, it is essential to remember that, in order to assess an organization for an award, the crucial factor is the constant internal development of methodologies, as well as the experience, practice and excellence in performance (Blauth, 2011).

Malcolm Baldrige. The Malcolm Baldrige Award is provided by the president of the United States to enterprises and non-profit organizations that apply and are judged as excellent in seven areas of performance excellence that assist them in strategic development, governance and, sustainability and competitiveness organizational, as they address comprehensive management, learning, and knowledge sharing. These criteria are: leadership; strategy; customers; measuring, analyzing and managing knowledge; workforce; operations and results (NIST, 2017a; NIST, 2017b).

Moreover, in order to guide and prioritize the information that constitutes these criteria, it is essential to consider the profile of the organization, in which the main organizational factors that comprise it will be identified, providing a critical view on the contextual aspects, which describe their main characteristics in the environment in which they are inserted, and aspects about the current situation of the organization are, thus analyzing their respective challenges and opportunities. And also, the basis of this framework is composed of concepts and values, which become necessary to achieve excellence. These are: systems perspective, leadership vision, focus on customer excellence, appreciation of people, learning and organizational agility, focus on success, management for innovation, management by facts, social responsibility, ethics and transparency, and delivery of results and value (NIST, 2017a; NIST, 2017b).

European Foundation for Quality Management (EFQM). The first EFQM award was granted in 1992, then in 2017 it completed 25 years of existence and the models was applied to more than 30,000 organizations in Europe. Its model provides a holistic view to assess how well strategy development is focused on the organization's stakeholders. In this way, the four result areas focus on the four main groups of stakeholders: business, customers, people and society (EFQM, 2017).

As a result, the important thing is to enhance the creation of value for stakeholders, through creativity and innovation, since today's level of excellence will be considered the right one tomorrow, thus making a cycle of continuous improvement. In addition, the criteria used in the evaluation of the award are formed by the fundamental concepts, such as: value creation for clients, creation of a sustainable future, development of organizational capacity, use of creativity and innovation, leadership with mission, integrity and inspiration, managing with agility, success through people's talent, and sustaining results (EFQM, 2017).

For that reason, the model is constituted by 5 enabling criteria that focus on what the organization does and how it is done: leadership, people, strategy, partnerships and resources, and processes, products and services, plus, 4 results criteria, oriented to what organizations reach in relation to the people, clients, society and businesses, representing the 4 main groups of stakeholders. Accordingly, it can be considered dynamic, since it is creativity, learning and innovation that help the development of the enabling criteria, which are characterized as the things that organizations need to execute to optimize and implement its strategy, leading to improved and aligned results in accordance with the strategic goals (EFQM, 2017).

2.3. Enterprise Engineering

In the current business environment, the smaller the size of the company, the less resources it will have to address the range of regulations to which it must adhere. This is particularly problematic for small and medium-sized companies in a highly competitive market, with easy access and rapid processing of information, in which they have difficulty of implementing internal changes based on changes in the environment, adapting to the environment and becoming more robust. In this way, the discipline of enterprise engineering encompasses these aspects, addressing both social and technological issues, providing techniques for systematic redesigning of firms (Dietz *et al.*, 2013).

Thereby, enterprise engineering is defined as "an integrated set of disciplines for the construction or change of an organization, its processes and systems" (Martin, 1995), focusing on the integration between people, business and information technology. This discipline is focused on studies of socio-technical systems in two perspectives, that is, in terms of information systems (infrastructure, management and strategy) and organizational sciences (culture, human behavior and philosophy), taking into account organizational, process, informational and resource visions (Molnar and Korhonen, 2014).

Due to the wide scope of the discipline, it has several tools and methods to assist in the process of modeling, integration and organizational transformation, thus generating diversity in its application. As for example, the framework of Zachman, CIMOSA, GERAM and TOGAF, among others. However, this work will focus on ArchiMate since it is the most suitable for the purpose to be achieved (Vernadat, 2014).

Therefore, ArchiMate is an open and independent language used for the modeling of organizational architecture, developed by the Open Group, since it allows the description, analysis and visualization of the relations between organizational domains, through a common language that describes the construction and operation of business processes, organizational structures, information flows, IT systems and infrastructure techniques (Open Group, 2017).

2.4. Agile Methodology

Considering that agile organizations can operate in a complex and dynamic environment such as today's business environment, the need to address issues related to this type of scenario is identified. To do so, it is necessary that the operations and architecture of an organization have the capacity for continuous adaptation, needing to be modeled "end-to-end", that is, from the strategic level to the most operational level, contemplating technology, business and application aspects. This need for modeling is made possible by the wide range of existing tools, each of which addresses a level of detail, such as: ArchiMate, BPMN and UML (Gill, 2015). According to the Agile Alliance, agile means the ability to create and respond to change to succeed in an uncertain and turbulent environment, and its first use was in software development, before 2011 (Agile Alliance, 2017).

However, it is not enough to just apply tools, because one runs the risk of getting too much information and consequently, can be difficult to achieve adequate results and the correct integration between the business levels. With this in mind, it is necessary to understand the principles of agile methodology, which are defined by the agile manifesto as being: focus on individuals and interactions, collaboration with clients and quick answers when following a plan, and simplicity (Agile Alliance, 2017).

One of the most used approaches of agile methodology is SCRUM. This framework focuses on what has already been developed to obtain sequential increments, generating precuts and services from the items of higher priority to the ones with minor priority. It requires constant communication between participants (Paschek *et al.*, 2016). SCRUM's main idea is to make systems flexible enough to adapt to changes in requirements, resources and technologies to achieve value-added results. In this way, it allows the development of several processes and techniques, consisting of the stages of planning of the iterative cycles (SPRINTs), execution of these cycles, daily meetings for follow-up, meetings for SPRINTs review and retrospective meetings. Therefore, SPRINTs represent the set of activities that are executed sequentially in each iteration (Raj *et al.*, 2015).

3. CONCEPTUAL MODEL

The conceptual model of flexible bureaucracy/regulations management is composed of two frameworks: the first one, in Illustration 1, is called the generic model, and was constructed using ArchiMate, which presents the integration between management excellence models, identifying and correlating their aspects with the management of bureaucracies/regulations. The second, Illustration 2, presents the way in which agile management of the bureaucracy/regulations should be done, that is, the method itself, in which it is possible to extract the adequate management stages, based on the management guidelines extracted from the first model.

3.1. Generic Model

In order to obtain an agile and effective management of bureaucracies, based on the four main excellence models already presented, it is important to identify how these models relate to the main objective of this work. For this, an integrative map was elaborated using the ArchiMate modeling language and the Archi software, presented in Illustration 1, which correlates the main models of management excellence; MEG, Malcolm Baldrige, EFQM and Deming, with the way bureaucracies interfere in the managerial process.

The objective of mitigating the impacts of regulatory changes on organizations and keeping them up to date and in compliance with such regulations demands that organizations are able to adapt to new regulatory rules during the implementation of such changes, as new regulations are emerging and constantly changing. Thus, in order to have adequate control and adaptive capacity, it is essential to have an integrated management system, that is both agile and process-based, so that the organizational aspects are fully known to the organization, and knowledge and their systemic understanding are embedded in the management process.

However, for such conditions to be guaranteed, it is indispensable that the organizational capacities of process orientation, sustainable development, management system, systemic thinking, transformative and participatory leadership, adaptability and Total Quality Management (TQM) exist and are considered in all organizational processes and environments. Also, for such capacities to be boosted, there must be technical and managerial human resources that master the techniques specific to each capacity.

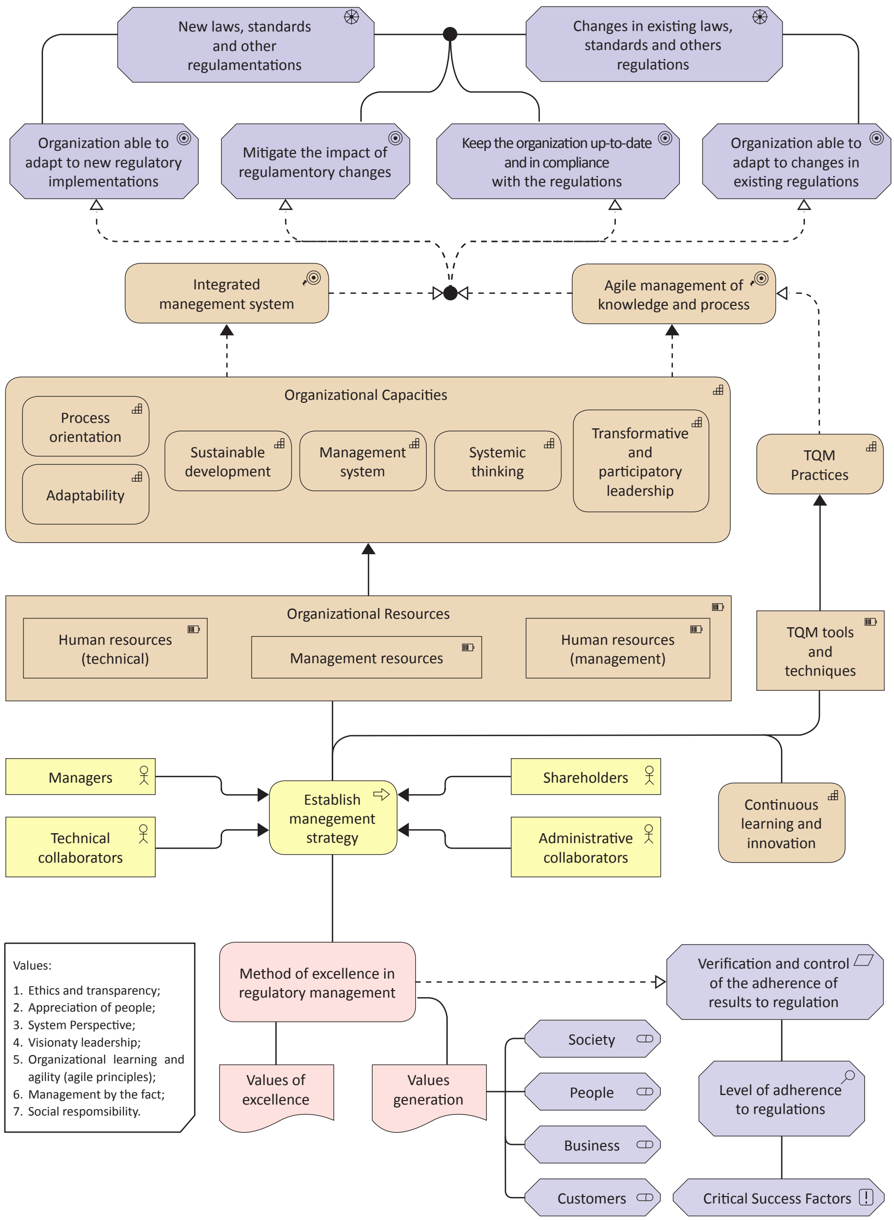

Illustration 1. Integrative Map of Excellence Models for Bureaucracies

Therefore, these resources will be able to elaborate a management strategy focused on continuous learning and innovation, contemplating the visions of its stakeholders and, thus, developing the method in regulations management, sustained by the values of excellence and directed to the generation of value for the four groups of stakeholders (society, people, business and customers), given that such a method will also include verification and control over the level of adherence to regulations through critical success factors.

3.2. Method of Excellence in Regulations Management

Based on the integrative map, it is possible to identify the relationship between the main elements of excellence models and how they can be used in the management of regulations. In this way, it is perceived that there is a need to have a method of excellence in regulations management, following the guidelines described and correlated in the map.

Furthermore, the method, shown in Illustration 2, uses the VUCA concept, which is a term used to explain the dynamics of the world, widespread by the United States Army. VUCA stands for volatility, uncertainty, complexity and ambiguity. Because it is a concept for the rapid change of organizational environments, in which it assumes that leaders and managers must act in agile change management, that is, they require that the organizations do different things through different moments quickly and for this there is a need for constant learning. Moreover, the agile leader concept has been increasingly emphasized since it has come to be seen as a prerequisite for success in today's global marketplace, because of the increasing technological and communication complexity (Hall *et al.*, 2016).

Another point observed is that agile organizations are constituted by 3 main constructs: agility strategy, which represents the different practices, techniques and ideas developed in flexible organizations, so that they are able to adapt, according to each situation of their environment, composed of the aspects of agility focused on products, people and organization; agility of the workforce, which is concerned with the agile behavior of its employees, such as proactivity; and organizational work, in which the main aspects that impact organizations are considered, for example, the demand (Sherehiy and Karwowski, 2014).

The excellence model proposed in this paper builds upon these concepts and is composed of 4 phases; planning and strategy, modeling, verification and optimization. In the first stage, the analysis of the organization is performed, relating the concepts of VUCA and agile constructs to identify and define which scope will be verified in the process, due to the fact that regulations cover several areas; security, health, environment, social responsibility, and technical responsibilities, according to financial, municipal, state and governmental demands. So, the process of adaptation to new rules or changes in current rules becomes very complex and infeasible if all scopes are considered at the same time. This point can be pointed as the initial strategy of the whole process, because a schedule is made about these verifications and, after this definition, the necessary workforce is planned for that activity, as well as the other agility and organization aspects, based on agile constructs already presented.

In the second step, modelling is executed in accordance with the SCRUM approach, where a sequence of iterations is performed. Each cycle, named SPRINT, consists of four stages; definition, development, review and test, and update. In the first phase of this cycle, actions are planned, regardless of whether it is a change or a new regulation, with the intention that each SPRINT will conclude one of the stipulated actions. In the development phase, the planned actions are executed so that, in the third stage, the revision and test, results are aligned and verified according to the implementation topic under study. Finally, in the update step, a general meeting is held to plan the next iteration, i.e. the next SPRINT.

After the second phase of the method is concluded, it is possible to continue with its application. For that, in the third step, the verification of the adherence of the results to the regulations analyzed according to the previously defined area will be carried out through the critical success factors, such as: adherence level and impact level. Finally, in the optimization stage, improvement actions are established according to the results obtained in the verification step and then implemented. Due to the nature of the actions identified, they can be placed in steps 1 or 2, which characterizes the PDCA cycle.

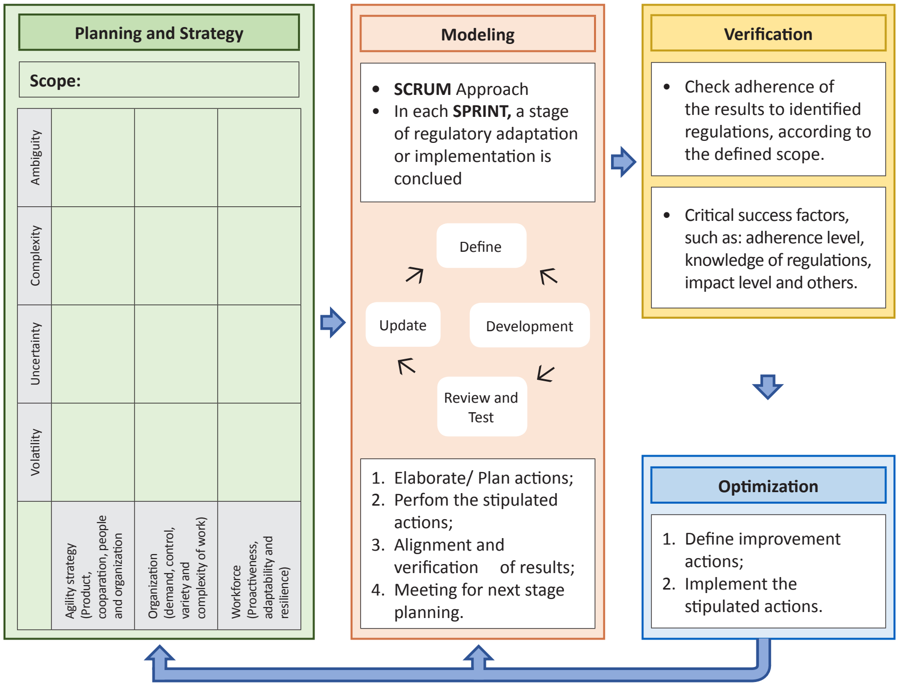

Illustration 2 – Method of Excellence in Regulations Management

4. DISCUSSION

Knowing that regulations are inevitable for organizations, even more so in an environment of extreme competition and access to information, in which organizations require more effective forms of control, and understanding the integrative map and the proposed method, it is possible to verify that such models can help in this process, given that they take into account the regulatory complexity and the main aspects of the worldwide models of excellence.

In conclusion, the integrative map provides guidelines by which the regulatory management process must occur, or at least, what should be considered when iterating through an evolving process that continuously improves. The entire method is based on management excellence models and is proposed in a way that is robust, easy-to-understand and with an applied approach. Such map provides the path by which the agile management of regulations might be carried out, based on the four main models of management excellence chosen. Also, because it is modeled through the ArchiMate language, it is possible to generate a holistic view about all the necessary structure for a good management of the bureaucracy, facilitating its understanding and use, since it emphasizes organizational architecture, generating a discernment about the whole organization, contemplating both social and technical aspects, which characterizes organizational engineering.

Furthermore, the method can be considered easy to understand and adaptable to any type and size of organization, provided that changes are made regarding to the structure and size of the required workforce. It also provides an adequate way to effectively manage bureaucracy, which is able to smooth the impacts related to the respective changes constantly, because it encompasses cycles of implementation in a continuous and sequential manner, respecting the workloads of the responsible group, since it is the own group that plans and executes the respective activities. However, in order to better understand how they may be applied, at least one practical application must be carried out, which is already being planned.

5. CONCLUSION AND FUTURE WORK

Considering the context of this paper and its purpose, the method applied was appropriate, since through the literature review it was possible to identify the main models of excellence in management, as well as the aspects of agile methodology. Consequently, it was possible to obtain a good basis for its development. Although this literature review was directed to the four main models, it was first necessary to make a selection by means of this review.

In addition, through the use of the main models of excellence in management (MEG, Malcolm Baldrige, Deming and EFQM), it was possible to construct an interactive map, relating the respective aspects of management excellence with the process of administration of bureaucracies. This map provided the identification of guidelines for more effective management of regulations, seeking to mitigate the impacts arising from the implementation of the respective changes.

Therefore, such a map and guidelines structured the development of the proposed method, generating the way in which bureaucratic changes must be introduced in the organizations in order to become more effective. The intention was to make this process more constant, making the organization always up to date with the latest standards, with less risk of penalties and no debts with regard to regulations, since it has become an adaptable and flexible process.

As a continuity of the work, a practical study will be carried out on this method and, consequently, on the map, in order to intensify the previous analyzes and obtain a greater detail of its practical operation and the final observations of its users. And also, it is important to update the concepts and approaches used on it, in order to have the method, always consistent with the organizational reality, following the respective academic and practical evolutions.

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An Integrated Approach to Thermal Hotel Selection

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ABSTRACT

Many thermal hotels of various quantities and qualities are available in today's tourism sector. There are more options for customers than ever. One of the basic problems of a tourism agent is to suggest the best hotel for its customers that can best meet their needs. Such problems are referred to as multi-criteria decision making (MCDM) problems in the literature and various methods are used for this purpose. In this study, thermal hotel selection problem is examined for an Istanbul based tourism agency. Five thermal hotels located in western Anatolia (*Bursa, Kütahya, Afyon, Denizli,* **İzmir**) are compared according to five different criteria *(water quality, SPA facilities, cost, accessibility, reputation*), and the most suitable hotel is chosen among them. An integrated approach of fuzzy AHP and fuzzy TOPSIS is used for solving the problem. The proposed approach has yielded satisfactory results in the study.

KEYWORDS: Thermal hotel, MCDM, fuzziness, AHP, TOPSIS

1. INTRODUCTION

As a branch of service sector, tourism is considered to be a significant contributor of economic and social assets in the globe. In recent years, as other sectors, there is an increasing trend of competition in the thermal hotel sector as well. A variety of thermal hotels with various service facilities operate in the sector.

In today's tourism sector, there is an increasing consensus that tourism movements stemming from health and health related issues are increasing

(Hudson and Li, 2012). Therefore, as in other countries, thermal tourism sector is also attracting the attention of many people in Turkey. Aslan (1992) describes thermal facilities as those tourism establishments that are located around thermal water resources and have their own treatment centers and cure parks in addition to accommodation services. The purpose of these enterprises is to provide thermal facilities as well as supplementary and complementary treatments to their customers along with services provided by other tourism facilities such as accommodation, eating and drinking, rest and entertainment (Kozak, 1992). Healthcare services in thermal hotels may include medical examinations of specialist doctors and nurses, special diets, acupuncture, herbal medicines, and specific medical treatments for various diseases such as arthritis (Hudson and Li, 2012).

According to PKF's trend reports on hotel / Spa industry, thermal enterprises get most of their revenue from various Spa / wellness / health related products and services. Revenue-generating activities cover treatments such as massages, face and body wraps, hair and nail services, fitness programs and retail products like exercise equipment, skin care products and herbal supplements (PKF Consulting and PKF Hospitality Research, 2009). Thermal tourism is not only seen as a cure for people with physical disabilities, but also as a means for good health, rejuvenation and physiological nutrition (Emir and Pasaoglu, 2013).

The most important difference between thermal hotels and other normal hotels is that they have the opportunity to have thermal water and mud. Thermal water is a type of mineral water that is found underground and has healing properties, and is free from bacteria and pollution. It is naturally pure and rich in mineral salts, iodine and CO2. Thermal water has been used for thousands of years in the treatment of rheumatism / arthritis, joint pain and burns, and especially in the treatment of skin disorders. It is substantially known for its therapeutic properties of interest to the skin. As volcanic activity has created thermal springs and boiling and pools, thermal streams or baths contain water which is naturally hot or warm.

In addition to customary hotel services, thermal hotels offer also healthcare services to their customers. The healthcare services are the prominant outcome of the thermal hotels, and it is the most important concern for customers who need therapy. Therefore, making a hotel choice by considering the priorities of customers is of great significance. The selection process to be carried out by considering the customer needs among thermal hotels with particular healthcare features is an important decision matter. In this regard, it is the duty of the tourism agency to make suggestions to its customers.

Thermal hotel selection problem can be perceived as a typical multi-criteria decision making (MCDM) problem. Until now, there has been a number of MCDM methods used in standard hotel selection problems ((Kim and Perdue, 2013; Wibowo, 2013; Yu et al., 2016, 2017; Peng et al., 2018), but with limited use for thermal hotel selections. Işık and Adalı (2016) used Stepwise Weight Assessment Ratio Analysis (SWARA) and Operational Competitiveness Ratings Analysis (OCRA) methods together in selecting thermal hotel while Roy et al. (2018) preferred to use Analytic Hierarchy Process (AHP) method in selecting medical tourism site. Research is mostly focused on the choice of hotel locations (Emir and Saraçlı, 2014; Aksoy and ***Özbük***, 2017; Güneri et al., 2015; Kundakçı et al., 2015). This study, however, attempts to use two different MCDM methods together with fuzzy logic approach in this limited line of work, and contributes to the literature in this direction.

2. LITERATURE REVIEW

Current research on hotel selection can be roughly divided into three categories (Peng et al., 2018). The first category includes studies based on online comment information, the second category of research focuses on constructing models to assist tourists in selecting a hotel, and the third category of research discusses multi-criteria methods.

Various studies related to touristic hotels have been made in the literature. Some of the works dealt with hotel service quality evaluation from web data sources (Carrasco et al., 20121) and weight of criteria in hotel selection (Zaman et al., 2016). Some others researched on evaluating hotel websites (Akincilar and Dagdeviren, 2014) and selection of medical tourism sites (Roy et al., 2018). A number of researchers discussed hotel booking intentions (Sparks and Browning, 2011; Zhao et al., 2015; Ladhari and Michaud, 2015; Casaló et al., 2015; Agag and Al-Masry, 2016). Most of the work have been carried on hotel location selection problem in general (Kundakçı et al., 2015; Guneri et al., 2015; Aksoy and Ozbuk, 2017), where Emir and Saracli (2014) specifically analysed thermal hotel location selection problem.

Regarding the hotel selection problem, which is our concern in the study, there are a few works to be mentioned (Kim and Perdue, 2013; Wibowo, 2013; Yu et al., 2016, 2017; Peng et al., 2018). Only one single study we have encountered in the literature about thermal hotel selection problem which was accomplished by Işık and Adalı (2016). The authors used an integrated decision making approach based on SWARA and OCRA methods for the thermal hotel selection problem,

As you can see, work on thermal hotel selection is limited. Fuzzy logic applications are seen, but there are not many studies that take integrated MCDM methods into consideration. This work, which is based on fuzzy logic and integrates the two methods of MCDM, namely AHP and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS), is unique and contributes to the literature.

3. METHODOLOGY

A hybrid MCDM approach is used to assist in evaluating a set of thermal hotel alternatives. The approach includes a combined fuzzy AHP (Saaty, 1980) and fuzzy TOPSIS (Hwang and Yoon, 1981) methods to rank thermal hotels with respect to several criteria. Fuzzy set theory helps to quantify the uncertainty of concepts related to human subjective judgment (Zadeh, 1965). Since rankings are made with the preferences of decision makers, it is necessary to evaluate them in an uncertain, fuzzy environment. Also, by applying AHP in obtaining criteria weights and TOPSIS in ranking, the comprehensiveness and reasonableness of the evaluation and ranking is strengthened.

The integrated method used in the study includes the following phases:

1. The evaluation criteria are selected by a group of five experts and weighted according to the fuzzy AHP method.
2. The criterial weights determined by the fuzzy AHP method are used as input data in the fuzzy TOPSIS application.
3. A separate group of three experts is established for the fuzzy TOPSIS application, which compares the alternatives with linguistic expressions according to the criteria set out in phase 1.
4. As a result of the comparison using the fuzzy TOPSIS method, the alternative hotels are subjected to priority order and the first ranked hotel is presented to the customer.

Applying AHP to a complex problem usually requires a four-step process (Cheng et al., 1999): 1. Divide the complex problem into a set of small constituent elements and then construct the elements in a hierarchical format. 2. Perform a series of pair-wise comparisons between elements according to a ratio scale (Illustration 1). 3. Estimate the relative weights of the elements by use of the eigenvalue method. 4. Gather all the relative weights and synthesize them for the final measurement of decision alternatives concerned.

Intensity of importance	Linguistic variables	Triangular fuzzy numbers (TFNs)	Reciprocal of TFNs
1	Equally Important	(1,1,1)	(1/1,1/1,1/1)
3	Weekly important	(1,3,5)	(1/5,1/3,1/1)
5	Strongly important	(3,5,7)	(1/7,1/5,1/3)
7	Very strongly important	(5,7,9)	(1/9,1/7,1/5)
9	Extremely more important	(7,9,9)	(1/9,1/9,1/7)

Illustration 1 – Linguistic scale used in fuzzy AHP for pairwise comparison of criteria.
Source: Chang, D-Y. (1996). "Applications of the Extent Analysis Method on Fuzzy AHP", European Journal of Operational Research, 95(3), pp. 649-655.

The technique of TOPSIS is another method of MCDM and can be used to evaluate multiple alternatives against the selected criteria (Illustration 2). In TOPSIS method, an alternative that is nearest to the Fuzzy Positive Ideal Solution (FPIS) and farthest from the Fuzzy Negative Ideal Solution (FNIS) is selected as optimal. While FPIS consists of the best performance values for each alternative, FNIS is composed of the worst performance values.

After the alternatives are evaluated according to the criteria and the fuzzy decision matrix is obtained, the distance of each alternative to the positive ideal solution (D^+) and to the negative ideal solution (D^-) is calculated. Then, for each alternative closeness coefficients (CC) are determined. The CC represents D^+ and D^- simultaneously and calculated as $CC = D^- / (D^- + D^+)$.

Finally, the different alternatives are ranked according to the maximum CC values in decreasing order.

Here, the details of the methods have not been entered, assuming that the reader is familiar with the concept of fuzziness and the methods of AHP and TOPSIS.

Linguistic variables	Very low	Low	Medium low	Medium	Medium high	High	Very high
TFNs	(0,0,1)	(0,1,3)	(1,3,5)	(3,5,7)	(5,7,9)	(7,9,10)	(9,10,10)

Illustration 2 – Linguistic scale used in fuzzy TOPSIS for alternatives' evaluation.
Source: Chen, G. and Pham, T.T. (2001). Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems, CRC Press, Florida.

4. APPLICATION

The practice was based on the request of a tourism agency (Prontis) located in Istanbul, which is mainly interested in health tourism. Prontis wanted to choose one of the 5-star thermal hotels in western Anatolia region of Turkey to offer its institutional customer (Association of Health and Social Services) in line with the demand. The study was conducted in collaboration with Prontis.

There were five candidate hotels to work with and these were located in the cities of Bursa, Kütahya, Afyon, Denizli, and İzmir. The names of the hotels were kept secret throughout the study and they were identified by the city names they were in.

The criteria to be used in the evaluation of the hotels were determined and weighted by an expert group of five persons. The distribution of the experts is as follows: 1 expert from Tuzla Thermal Resort, 1 expert from Prontis, 3 experts from Istanbul 5-star hotels. All of the experts were serving as marketing managers in their organizations. The expert group gave its decisions by unanimity and selected the following criteria and weighted those using linguistic expressions.

Thermal water quality: This criterion is about the purity and richness of the thermal water in mineral salts, iodine and CO2. It also considers the proximity of the hotel to the thermal water source.

SPA facilities: This criterion includes healthcare oriented services; basically the presence of a thermal treatment center, and a cure park. Due to their purpose of existence, these facilities involve thermal facilities as well as supplementary and complementary treatments. A variety of Spa/wellness/health-related products and services are concerned; which are massages, facial masks and body wraps, hair and nail care services, fitness programs, exercise tools, skin-care products, and herbal supplements and mud baths.

Cost: This criterion includes the hotel accommodation price plus the expenditures for extra eating, drinking and snacks, along with benefitting from Spa facilities,

Accessibility: It expresses the ease of access to the hotel which takes into account all the modes of transportation and transfers (airway, highway, railway, seaway.)

Reputation: This criterion explains the identity and image of the hotel in the market. The hotel's reputation for its past performance in the tourism sector determines its reliability and consistency.

The fuzzy AHP approach was applied in weighting the determined criteria and the results are given in the following Illustrations (Illustrations 3-5). Geometric averages were used to calculate the fuzzy weights of the criteria.

	Water Quality	SPA Facilities	Cost	Accessibility	Reputation
Water Quality	1,00 1,00 1,00	3,00 5,00 7,00	1,00 3,00 5,00	3,00 5,00 7,00	1,00 3,00 5,00
SPA Facilities	0,14 0,20 0,33	1,00 1,00 1,00	3,00 5,00 7,00	5,00 7,00 9,00	1,00 3,00 5,00
Cost	0,20 0,33 1,00	0,14 0,20 0,33	1,00 1,00 1,00	0,20 0,33 1,00	0,11 0,11 0,14
Accessibility	0,14 0,20 0,33	0,11 0,14 0,20	1,00 3,00 5,00	1,00 1,00 1,00	0,11 0,14 0,20
Reputation	0,20 0,33 1,00	0,20 0,33 1,00	7,00 9,00 9,00	5,00 7,00 9,00	1,00 1,00 1,00

Illustration 3 – Pairwise comparison matrix of the criteria.

Water Quality	1,55	2,95	4,15
SPA Facilities	1,16	1,84	2,53
Cost	0,23	0,30	0,54
Accessibility	0,28	0,41	0,58
Reputation	1,07	1,47	2,41
Total	4,29	6,97	10,21

Illustration 4 – Fuzzy geometric means of the criteria.

Water Quality	0,36	0,42	0,40
SPA Facilities	0,27	0,26	0,25
Cost	0,05	0,05	0,05
Accessibility	0,/7	0,06	0,06
Reputation	0,25	0,21	0,24

Illustration 5 – Normalized fuzzy geometric means of the criteria.

When we look at Illustration 5, we see that the *water quality* has the highest weight (around 0.42). This criterion is followed by the *Spa facilities* with a weight about 0,26. The high scores on these two criteria may be an expected result for the thermal hotels. On the other hand, the *reputation* criterion takes the third row with a weight (around 0,21) slightly lower than the weight of the *Spa facilities* criterion. The weights of the *cost* and a*ccessibility* criteria are found to be very low with respect to the other criteria, and they are almost the same (around 0,05 – 0,06). Hence, it is clear that the *water quality*, *Spa facilities* and *reputation* are very important criteria for thermal hotels, while the *cost* and *reputation* are evaluated at the second level. This is also true of the claim that human health is more important than everything.

The evaluation of the hotels according to the selected criteria was again carried out by a specialist group. This time a group of three people made this assessment. Here too, linguistic expressions were used. The group members were selected from Prontis, Assocıatıon of Turkısh Travel Agencıes, and Istanbul Provincial Culture and Truism Directorate as one person from each. The selected persons were in managerial positions.

Using the criterial weights obtained from the fuzzy AHP application, the hotel alternatives were ordered by the fuzzy TOPSIS method. The results are given in the following Illustrations (Illustrations 6-10).

	Water Quality	SPA Facilities	Cost	Accessibility	Reputation
Bursa	0,5 0,7 0,9	0,63, 0,8 0,93	0,7 0,9 1,0	0,7 0,9 1,0	0,7 0,9 1,0
Kütahya	0,7 0,9 1,0	0,9 1,0 1,0	0,9 1,0 1,0	0,83 0,97 1,0	0,9 1,0 1,0
Afyon	0,83 0,97 1,0	0,83 0,97 1,0	0,83 0,97 1,0	0,9 1,0 1,0	0,77 0,93 1,0
Denizli	0,7 0,9 1,0	0,63 0,83 0,97	0,57 0,77 0,93	0,7 0,9 1,0	0,77 0,93 1,0
İzmir	0,52 0,72 0,93	0,65 0,86 1,0	0,52 0,72 0,93	0,59 0,79 0,96	0,52 0,72 0,93

Illustration 6 – Normalized fuzzy decision matrix for the alternatives.

	Water Quality	SPA Facilities	Cost	Accessibility	Reputation
Bursa	0,18 0,29 0,36	0,17 0,21 0,23	0,04 0,05 0,05	0,05 0,05 0,06	0,18 0,19 0,24
Kütahya	0,25 0,38 0,40	0,24 0,26 0,25	0,05 0,05 0,05	0,06 0,06 0,06	0,23 0,21 0,24
Afyon	0,30 0,41 0,40	0,22 0,25 0,25	0,04 0,05 0,05	0,06 0,06 0,06	0,19 0,20 0,24
Denizli	0,25 0,38 0,40	0,17 0,22 0,24	0,03 0,04 0,05	0,05 0,05 0,06	0,19 0,20 0,24
İzmir	0,19 0,30 0,37	0,18 0,22 0,25	0,03 0,04 0,05	0,04 0,05 0,06	0,13 0,15 0,22

Illustration 7 – Weighted normalized fuzzy decision matrix for the alternatives.

	Water Quality	SPA Facilities	Cost	Accessibility	Reputation	Total
Bursa	0,73	0,80	0,95	0,95	0,80	4,23
Kütahya	0,66	0,75	0,95	0,94	0,77	4,07
Afyon	0,63	0,76	0,95	0,94	0,79	4,07
Denizli	0,66	0,79	0,96	0,95	0,79	4,15
İzmir	0,72	0,78	0,96	0,95	0,83	4,24

Illustration 8 – Distances to fuzzy positive ideal solution.

	Water Quality	SPA Facilities	Cost	Accessibility	Reputation	Total
Bursa	0,29	0,20	0,05	0,05	0,21	0,80
Kütahya	0,35	0,25	0,05	0,06	0,23	0,94
Afyon	0,37	0,24	0,05	0,06	0,21	0,93
Denizli	0,35	0,21	0,04	0,05	0,21	0,86
İzmir	0,30	0,22	0,04	0,05	0,17	0,78

Illustration 9 – Distances to fuzzy negative ideal solution.

	Bursa	Kütahya	Afyon	Denizli	İzmir
D^+	4,23	4,07	4,07	4,15	4,24
D^-	0,80	0,94	0,93	0,86	0,78
CC	0,159	0,188	0,186	0,172	0,155
Ranking	*4*	*1*	*2*	*3*	*5*

Illustration 10 – Aggregate results.

Illustration 10 indicates that the CC values of the hotels are quite close to each other. However, if a discrimination is to be made, Kütahya thermal hotel takes the first place with its CC value of 0,188, followed by Afyon Hotel with a slight difference in CC value (0,186). In the third place, Denizli thermal hotel receives a CC value of 0.172. Bursa and İzmir thermal hotel CC values are very close to each other and these hotels are in the fourth and fifth row (0,159 and 0,155, respectively). It can be said that these five hotels subject to research can be classified into three groups according to their CC values. Kütahya and Afyon thermal hotels are in the first group, Denizli thermal hotel is in the second group, and Bursa and Izmir thermal hotels are in the last group.

5. CONCLUSION

Health is indispensable to life, and for this reason people are increasingly interested in thermal hotels around the world. Beyond routine hotel services (accommodation, eating-drinking, entertainment, recreation, etc.), thermal hotels deliver health-related services to their clients. The most important factor that distinguishes them from others is their focus on human health. With their thermal facilities, they provide treatment services to protect and maintain human health. That's why thermal hotels have an important place in health tourism.

As thermal tourism facilities have features that distinguish them from other establishments, it is essential that these facilities take this privilege into full consideration and be very careful and sensitive to meet the needs of healthcare customers.

Since the health-related services of thermal Spa facilities are very diverse and comprehensive in nature, the choice of the appropriate thermal hotel is an important issue for the customers. Tourism agents can help customers in this matter. In the study, the selection of the most appropriate thermal hotel of a tourism agency was dealt with using an integrated approach on a certain set of criteria. Findings revealed that there is no big difference between the hotel alternatives.

It appears that the service standards of the 5-star thermal hotels, which have been ranked in this study, are very close to each other. The differences between them are quite low. This also indicates a high level of performance reached by the thermal tourism sector in Turkey.

On the other hand, a constraint of the study may be that comparisons are made based on only five criteria. A more detailed examination of the thermal water quality and Spa facilities will significantly increase the reliability of the work if they are split into more than one criterion. Likewise, the other criteria can be divided, even sub-criteria can be defined under the main criteria.

The study, which combines two different MCDM methods with fuzzy logic, provides an original contribution to the literature. Similarly, the use of different methods in the ranking of thermal hotels will be a considerable research area in the future.

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Application of Systems Evaluation Methods to Support the Scope of Digital Transformation Projects

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ABSTRACT

Great corporations work with legacy systems to standardize an execution of activities, support, data formatting and communication between different sites around the world. However, some companies in certain countries are unable to integrate these systems because of a number of factors involving cultural resources, local legislation and deficit infrastructure. With the Forth Industrial Revolution, also known as Industry 4.0, there is a need to deploy digital projects that have a relationship of dependency with systems in acquisition and information management making it more accessible to the user. In addition, the integration has to be well-synchronized with other countries so that they do not generate maturity unevenness between the organizations, causing difficulties in the adoption of I4.0 in different plants around the world. In this paper, we apply two multi-criteria decision-making methods (PROMETHEE and TOPSIS) in order to expand and assist in the corroboration of the results in the evaluation of legacy systems and local systems, verifying if both serve the specifications of the organization's digital transformation projects. A case of an automotive industry located in Brazil for more than 20 years that has one of its units in South America (Colombia) with local systems that are bringing numerous difficulties in the implementation of projects involving I4.0 was used to evaluate the model proposed. As a result, both methods pointed out that by customizing some points, certain local systems managed to reach the projects scope.

KEYWORDS: Industry 4.0, PROMETHEE, TOPSIS, MCDM/A.

1. INTRODUCTION

With advances in science and technology, the manufacturing industry has undergone constant changes to meet the needs of the market throughout the world (Liao *et al*., 2017). This is due to the demand of different types of customers who have requested higher quality products produced in a short time and affordable to all levels of society (Gosewehr *et al*., 2016). In this way, companies have realized the need to increase their competitiveness by transforming their productive process so that it becomes more adaptive, digital, integrated and with a solid conceptual foundation. Thus, the term Advanced Manufacturing or Industry 4.0 has been constantly mentioned in Brazilian industries as a way to achieve this goal.

To make processes more flexible and productive, it is necessary to make specific customizations to the systems that are currently in operation in organizations, usually called legacy systems or standards. Normally such systems (software's) have been operating with a standalone architecture for approximately 50 years (ChainOne, 2015). Legacy systems are already existing enterprise systems that present challenges to upgrade or integrate with new functions, demanded from I4.0, and also with local systems present on distinct sites of the organization (Romero and Vernadat, 2016). The existence of local systems in corporations is due to unique characteristics of each internal process that is not mapped by standard systems and is used to meet specific needs.

The I4.0 era has called for the adoption of agile decision-making methods based on consistent data from manufacturing systems, allowing process reconfiguration to be rapidly changed in an automated way. Current legacy systems do not have these characteristics. They have low autonomy in disruptive events where the response time needs to be immediate (Rosas *et al*., 2017). In addition, there is a marked difficulty in integrating them with local systems. Local applications are designed to meet a timely need that does not follow the company's global standard. This is due to several factors such as usability, costs and infrastructure.

Therefore, the objective of this research is to develop a methodology that allows the evaluation of local and legacy systems for the implementation of projects related to Industry 4.0, through the application of PROMETHEE and TOPSIS methods, both multi-criteria decision-making methods. Some projects require information from legacy/local systems to make its operationalization feasible. With a model that provides more assertive decision making through closer analysis, it is possible to judge whether or not the project can be adopted in a given organization. In order to contextualize the research, section 1 highlights the concepts of Industry 4.0 and Multicriteria Decision Making/Analysis (MCMD / A). Section 2 presents the methodology used in the research. In section 3 the results obtained are discussed. Finally, section 4 mentions the final conclusions.

2. BACKGROUND

2.1. Industry 4.0

The term Industry 4.0 (I4.0) was first mentioned at the Hannover fair in 2011. It is a denomination for the integration of several technological concepts that will have an impact in the company´s organizational management and in society. The communication between devices is one of the most critical aspects of I4.0 due to the different interfaces and communication protocols that exist between them. New technologies are emerging to facilitate communication between various types of software and hardware, such as the Internet of Things (IoT) (Vermesan and Friess, 2014), Machine-to-Machine (Gyrard *et al*., 2014) and Cyber-Physical Systems (CPS) (Araine *et al*., 2011) among others.

From the point of view of manufacturing, recent research emphasizes the idea that the frequent control of the production process, traditionally carried out by PLCs and numerical computers, will be integrated with the CPS and IoT devices to meet the specifications predefined by the organization (Babiceanu and Seker, 2016). In one of these studies, Thramboulidis and Christoulakis (2015) states that IoT will modify the way manufacturing systems operate, especially when it involves the adaptation of REST (Representational State Transfer) architecture. This way, there will be a decentralization of the legacy systems currently used to allow the flexibilization of the production of the factory floor through the use of I4.0 technologies.

2.2. MCDM/A METHODS

In MCDM, many alternatives must be evaluated and compared using several criteria. The aim of MCDM is to provide support to the decision-maker in the process of making the choice between alternatives. In this way, practical problems are often characterized by several conflicting criteria's, and there may be no solution which satisfies all criteria simultaneously (García-Cascales and Lamata, 2012).

A characteristic of the multi-criteria methods is the attribute comparison analysis. Among the available methods, the most appropriate for the evaluation space involved are the PROMETHEE and TOPSIS methods. Due to the modeling characteristics of the evaluation space involved both methods will be used to rank and determine which systems meet the most defined criteria based on the functional requirements raised by I4.0 manufacturing projects. Both methods were applied to broaden the evaluation space and help corroborate the diagnostic results. The PROMETHEE method was chosen because it has been successfully applied in the literature in the field of evaluation of projects, it also presents an accessible interface (Visual PROMETHEE) by providing tools that aid in evaluation. Also, some of the advantages that lead to the choice of applying the TOPSIS method was that: it has a simple, rational, comprehensible concept; it is intuitive and has a clear logic that represents the rationale of human choice, it has an ease of computation and good computational efficiency and has the possibility for visualization.

PROMETHEE (Method of organizing preferences for the evaluation of enrichment) is a decision-making process developed by Brans et al. in the early 1980s (Brans *et al*., 1986). It is a MCDM/A classification method adapted to problems where a finite number of alternatives should be ranked according to the criteria. The PROMETHEE evaluation table allows the alternatives to be evaluated by different criteria. The modeling of the evaluation problem in PROMETHEE requires two types of information: (i) Information about the relative relevance (weights) of the considered criteria and; (ii) Information related to the preference function used to optimize the comparison between criteria and alternatives (Dağdeviren, 2008). There are six preference functions in the method that allow you to adjust the parameters to find the best answer. They are: Usual, U-Shape, V-Shape, Level, V-Shape with Indifference and Gaussian.

The TOPSIS method was developed by Hwang and Yoon in 1981. It is a technique to evaluate the performance of alternatives through similarity with the ideal solution (Hwang and Yoon, 1981). According to this technique, the best alternative would be the one that is the closest to the ideal positive solution and the farthest from the ideal negative solution (Ertuğrul and

Karakaşoğlu, 2009). The procedure for applying TOPSIS consists of 7 steps. First a performance matrix is established, then the decision-matrix is normalized. In the third step, the weighted normalized decision matrix is calculated. Thus, the ideal positive and negative solution is determined. In the fifth step the separation measure is calculated, then the calculation of the relative closeness to the ideal solution is made. Finally, the preference order is classified (García-Cascales and Lamata, 2012).

3. METHODOLOGY

The research consists of 10 steps, as shown in Illustration 1. The first step is to choose which projects have the highest priority following the criteria defined by the company. The criterion that defines this is the time and the budget that determined sectors of the organization have to dispense with the proposed demand.

The second step is the definition of the processes that need to be analyzed based on the predefined projects. The third step is the definition of the local systems that are used in Colombia. The fourth step refers to the survey of which legacy systems are used to operationalize the processes involved in the projects. The fifth step brings a simple comparison, using the weighted average, to determine which system is most relevant in relation to the other.

The sixth stage encompasses the use of PROMETHEE, a multicriteria decision-making method. The seventh stage applies the TOPSIS method in order to enrich the analysis and the results. The eighth step compares the results of the practices of the PROMETHEE and TOPSIS methods. The ninth and tenth steps cover the decision-making of those involved in the project with their stakeholders where they determine which will be prioritized taking into account the data obtained in the analysis and other criteria with equal relevance as costs and human resources.

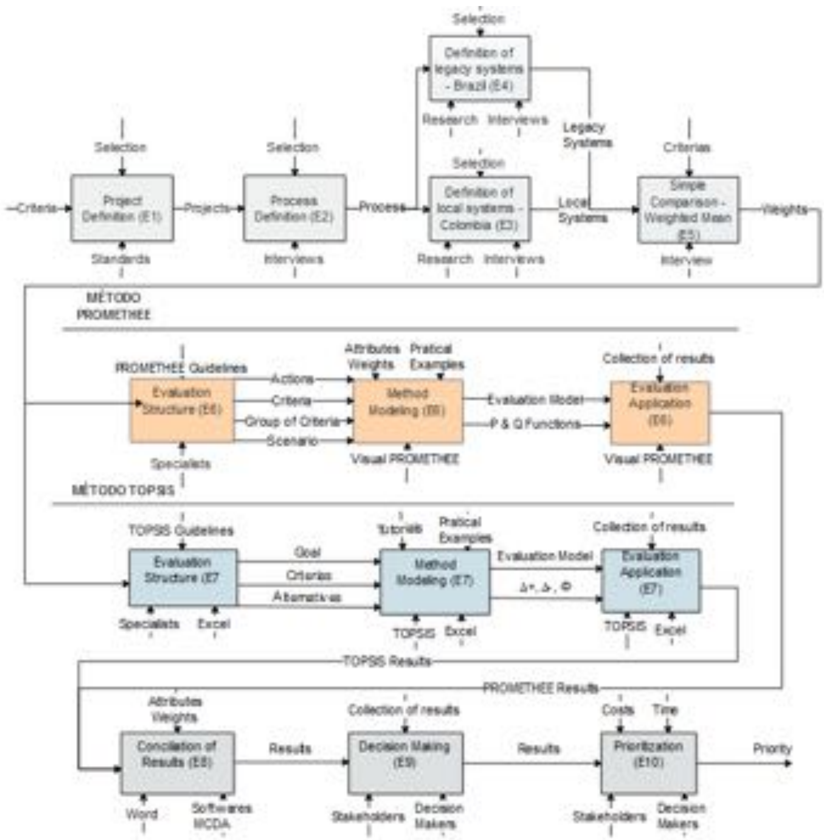

Illustration 1 – Research's IDEF0.

The demand for the implementation of systems and tools containing the concepts of Industry 4.0 is growing. Many companies have built their own methodology to try to correlate the interface between systems and technologies that have more autonomous characteristics. The study carried out in the French multinational indicates the procedure shown in Illustration 2. It was developed based on studies from consultancies and also from the experience of professionals who have worked for years in the design and implementation of systems in different sectors of the organization. There are two types of digital projects: (1) It has integration with legacy systems; and (2) It has its own characteristics that can be adopted in any sector of the company without the need for interaction with legacy or local systems already present.

The representation of the area where "Digital Project" is described represents the steps of executing a project following the procedures adopted by the organization. The "Flow Implementation" arrow, located next to the triangle, indicates the direction in which the procedural flow should be directed. Both projects require the infrastructure layer to make it possible to deploy to the enterprise. In the case of projects involving legacy systems, there are situations where they do not apply due to the unique characteristics of the plant. One of the factories that was pointed out this fact is located in Colombia. Originally the plant belonged to a Japanese multinational and all its architecture was imported along with some systems of the logistics and manufacturing area. To meet the company's physical and technical demands, not all legacy systems have been adopted. Thus, a space was left for possible inefficiencies in the exchange of critical information with the headquarters located in France and with other factories in South America.

The evaluation proposed in the research can therefore support the understanding of the main gaps that the company has in relation to the manipulation of its local systems. In infrastructure there is a need to integrate leadoff / local systems with the existing architecture. When new projects are involved without reliance on information from the standard systems, it is a new concept that needs elements that guarantee the technical interoperability between the infrastructure and the devices that it is desired to standardize in the organization, as described in Illustration 2.

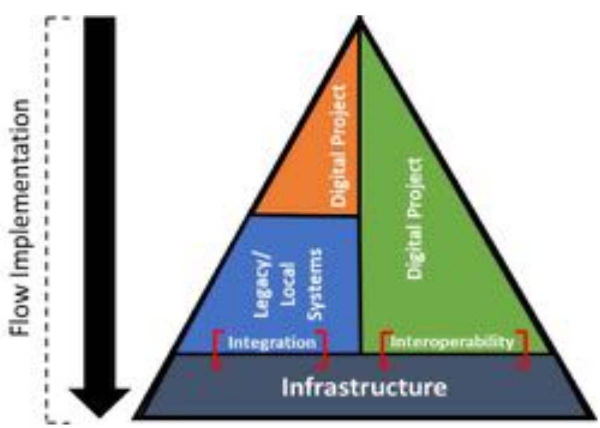

Illustration 2 – Methodology of Implementation of Industry 4.0 Projects.

Illustration 3 presents the list of the main demands that have arisen in the case study company that need integration with existing manufacturing and logistics systems. Four projects stand out, depending on information from legacy systems to assist users in specific tasks. The first one focuses on parts traceability. The second, third and fourth relate production line needs so the process can improve its performance. All of these projects rely on information from legacy systems for their functionality to be met (as highlighted in the Demanded Systems column of Illustration 3).

Project Name	Functionalities	Demanded Systems
Project #01	Enable traceability of parts in the stamping industry through an RFID tag in the rack.	Legacy inventory management system information (LS#01).
Project #02	Allow the operator to answer calls from the production line using mobile devices.	Information coming from the maintenance alert message system (LS#02), product failure management (LS#03) and product quality assessment (LS#04)
Project #03	Allow the service technician to view equipment alert messages from the mobile phone by SMS.	Information coming from the maintenance alert message system (LS#02).
Project #04	Allow the head of the production line work unit to view different information on different systems through a mobile platform.	Information from Maintenance Alert Message Systems (LS # 02), MES (Manufacturing Execution Systems) (LS#05), product failure management (LS#03) and document management and sequencing processes (LS#06).

Illustration 3 – Recurring Digital Transformation Projects.

To compose the evaluation, eight criteria were adopted that allow a more effective comparison between the different systems to be evaluated. They were obtained based on the experience of the professionals of the area who pointed out a greater relevance in these aspects for a more assertive decision making. Illustration 4 presents the defined elements, their description and also the weight of each one. The criterion "External Accessibility and Integration with Systems" received the highest value due to the growing demand for integration between the systems of different company sites. Another relevant point is the "Infrastructure Needs" that impacts directly on the viability of the project due to the cost of implementation surpassing the possible gains that will be obtained.

Criteria Name	Description	Weight
Support	Assistance to solve specific system problems	10
Infrastructure Needs	Infrastructure that guarantees the correct execution of the system in different layers of the organization	20
Possibility of Substitution	Flexibility to introduce new tools with superior quality to existing	10
Autonomy for System/ Process Evolutions	Need for possible intervention to ensure that the process does not stop suddenly	15
Capacity/Processing Speed	Speed in exchange of information and commands given by the user	5
Ease of Use of End User	User Usability	10
Training Need	Costs related to user training that will handle the systems	5
External Accessibility and Integration with Systems	Integration of the systems in different sites allowing a more adequate control of plant production indicators	25

Illustration 4 – Criteria Used for the Evaluation of Systems.

4. RESULTS

The data presented refer to the study of Project#03, described in Illustration 3, which has the maintenance alert system (LS#02). Illustration 5 presents the data related to the maintenance application domain, which evaluated maintenance process where the main functionalities of the local systems (LO#02) and legacy (LS#02) were collected, as well as the most relevant outputs.

Systems	Functionalities	Outputs
LO#02	Record events, alarms and faults at different stages of the process	Data recording performed successfully.
	Detect and alert, appropriate personnel, of possible scheduled maintenance shutdowns to occur in a given shift	Reports to support maintenance management.
	Composition of a history that includes information from daily production, non-scheduled stops and operating cycle time	History successfully stored.
	Provide the Paretto and Histograms graphs that allow the prioritization of failures during the execution of the productive process	Fault prioritization graphs reported by the software.
LS#02	Ensure the presentation of the current status of process variables, production indicators and alarms on real-time displays	Indicators, alarms and current status of process variables displayed correctly.
	Present the quantified values of the production, pending and line stops	Reports issued with the information requested.
	Measure current status and possible equipment failures	Current production status provided by the tool.
	Measuring the times and delays of the production cycle	Time and delays reported successfully.
	Generate data that fosters the management of preventive maintenance of machines	Well-managed preventive maintenance management.

Illustration 5 – Characteristics of the systems.

Based on the data presented in Illustration 5, it can be seen that the functionalities between the local and legacy systems are similar. This demonstrates that, a priori, Project#03 has no implementation barriers from the point of view of system characteristics, since it is being designed for legacy system adoption (LS#02). Illustration 6 highlights the evaluation made, considering the criteria mentioned in Illustration 4, where the local and legacy systems are compared through a 5-point scale. The analysis was carried out by experts from the area and with the main stakeholders of the project.

Criteria Name	Local System (LO#02)	Legacy System (LS#02)
Support	5	5
Infrastructure Needs	5	1
Possibility of Substitution	5	5
Autonomy for System/Process Evolution	5	5
Capacity/Processing Speed	5	5
Ease of Use of End User	5	4
Training Need	5	1
External Accessibility and Integration with Systems	2	5

Illustration 6 – Systems Evaluations.

The weighted average obtained in LO#02 and LS#02 was 4.25 and 3.90, respectively, indicating that the local system has conditions to meet the demands required in the project. However, only these numerical data make the evaluation fragile because the values were close and the individual performance of each alternative in its different criteria that allow a more accentuated search for the best system does not exist. Therefore, to support the evaluation requirements, the PROMETHEE method was used, characterizing an evaluation matrix that considers the criteria defined, under weights (from Illustration 4) and alternatives (local/local systems). Thus, Illustration 7 shows the values of Φ found after the application of the method using Visual PROMETHEE software V1.4.0.0, using a 10-point scale in the performance of the alternatives to each criterion, increasing the discrimination of supported comparison by the method.

Criteria Name	Phi -	Phi +	Phi
LO#02	0,5000	0,2500	0,2500
LS#02	0,2500	0,5000	-0,2500

Illustration 7 – Evaluation of systems by Promethee method.

It is identified that the positive flow with respect to the LO#02 system is 0.25 and the negative flow is -0.25. The extremes of Φ are 1 and -1, that is, the closer the result (Phi) is to the positive value, the alternative (system) has adherence to the analyzed criteria. The opposite also applies, when the alternative is close to -1, it tends to suffer more influence from the criteria. It is concluded by means of this result that the LO#02 system is more adherent to the analyzed criteria. Illustration 8 graphically shows the result obtained by the software.

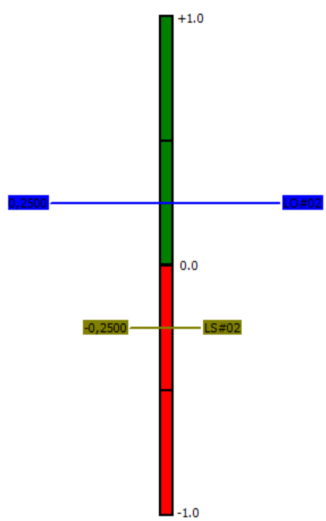

Illustration 8 – Result obtained by the software Visual Promethee.

Illustration 9 and 10 display the graphs showing which criteria prevail most in relation to the alternatives.

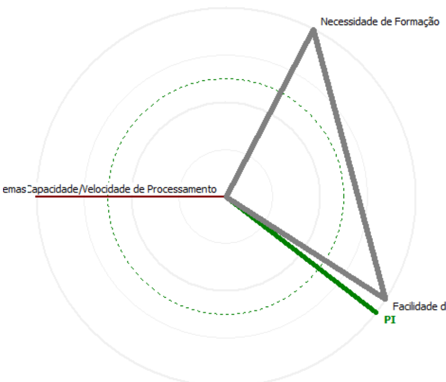

Illustration 9 – Local System (LO#02) Decision Axis Chart.

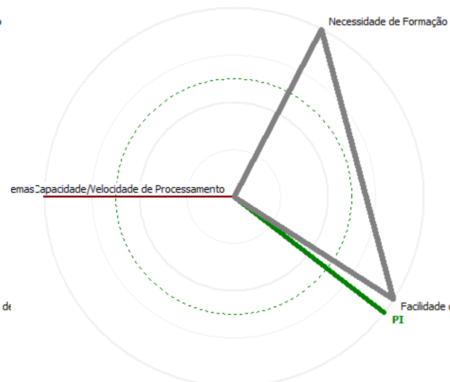

Illustration 10 – Legacy System (LS#02) Decision Axis Chart.

The criteria are represented by "Cn" following the same sequence as in column 1 of Illustration 7. LO#02 holds a larger area where the most relevant criteria are inserted in relation to LS#02. It is also possible to observe that the dotted circumference at the center of the image is larger for the local system than for the legacy. This means that this alternative meets a higher number of criteria with higher weights. In this way, it is diagnosed, in the light of the mathematical base PROMETHEE, that the local system (LO#02) has the most expressive elements for the implementation of Project#03.

In order to broaden the evaluation space and help corroborate the diagnostic results obtained, we opted to apply the TOPSIS method. For the application of this, the same inputs used in the PROMETHEE model were used, considering the established criteria, under weights (from Illustration 4) and alternatives (legacy / local systems). Illustration 11 presents the results obtained using the TOPSIS method.

Systems	Δ +	Δ -	Φ
Local System (LO#02)	0,14	0,16	0,54
Legacy System (LS#02)	0,16	0,14	0,46

Illustration 11 – Evaluation of systems by TOPSIS method.

When compared to PROMETHEE, the TOPSIS method is more sensitive to variations between the values of the evaluation matrix (for more dissipating values among the values of the alternatives in the criteria), since it has no preference functions that model p, q (between 0 and 1). With that said, LO#02 has a Φ greater than LS#02, so it is concluded through the TOPSIS method that the LO#02 system is better prepared for the deployment of Project#03. It is confirmed that both methods point to LO#2 as the most suitable system for the application of Project#03, in this way we can conclude that the two methods are consistent and convergent in their results.

5. CONCLUSION

Through the proposed evaluation methodology, it was possible to provide a more detailed diagnostic basis of analysis that assists in the decision-making spheres that guide the planning of activities throughout the life cycle of projects involving industry 4.0. In addition, it is possible to identify possible barriers that prevent Digital Age expansion in organizations because most existing systems have been developed on closed platforms with little flexibility. A methodological evaluation including MCDM/A methods assists in verifying the viability of the application as well as in the knowledge on the maturity level of the company for the introduction of Digital Transformation. In this research, the PROMETHEE and TOPSIS methods were used, both obtaining the outranking of alternatives by means of comparison and similarity (or relative proximity) to the ideal positive solution and the withdrawal of the ideal negative solution. Although TOPSIS is more sensitive to variations between the values of the evaluation matrix than PROMETHEE, it is noted that the two techniques are appropriate to the evaluation space (modeling and analysis). The application of these assist in the confirmation of the result, leaving it enriched and consistent. The research did not include other aspects considered fundamental in the implementation of I4.0 projects, such as a better detailing in relation to the costs of implementing new systems or even maintaining them as they are. Another essential topic considered is the possibility of adapting the project that is intended to be adopted in other sites with different systems and infrastructure. It is understood that a systems-only analysis can give a superficial view of the company’s real needs. In such cases, a better evaluation of all the elements that are part of the project design is required.

This article presented the applied methodology for a project with only a direct dependence relation of legacy/local systems. There are cases, as pointed out in Illustration 3, where there is a need to interact with two or more systems to obtain the information needed to meet the project requirements. There are also projects that are not dependent on standard systems that can be simplified. However, a more granular and accurate diagnostic analysis methodology is needed for these assessment dimensions, since technical elements involving infrastructure and interoperability must be mapped.

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Human Factor Influence on Eddy Current Non-Destructive Testings

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ABSTRACT

The damage detection in structural components is of extreme importance, because damages that begin in microscopic scale can propagate, causing a structure exposure. The non-destructive testings are used to detect in time this kind of damage. One of the most used methods is one that detects damages through an eddy current. This work evaluates the human factors influence in this kind of testing in aeronautical structures maintenance, because the result of an eddy current inspection has a high dependence of inspector's conditions. This research used Design of Experiments and followed the steps: problem characterization, influence factors and levels, selection of answer variables, determination of a design of experiments model, experiment run, data analysis and final conclusions and recommendations. The problem of this research was identified and evaluate the factors present in human action of the inspection by eddy current method, to contribute to the reliability of the structural damage detection. The influence factors and levels chose are: inspection difficulty (classified as easy or difficult), presence of conditions that causes stress in the inspector (classified as yes or no) and inspector's experience (classified as young or expert). The answer variables are: inspection time and result (the variable result indicates if there was or not a correct diagnosis related to presence of damages in the structural item). The data analysis al-lowed conclude that, to the studied cases, the most influential factor in both inspection time and result has been the inspector's experience. This confirms the Norm NAS 410, that is based upon the time of an inspector's experience as a preponderant factor in the reliability of the eddy current non-destructive testing.

KEYWORDS: First Keyword, Second Keyword, Third Keyword.

1. INTRODUCTION

Non-destructive examination is a means of testing a specimen or component without damaging or destroying it. This plays a vital role in ensuring the safety of products (Ronneteg, 2014).

It is used to obtain information about flaws and deficiencies in critical components, by means of ultrasonic, eddy current, radiographic, liquid penetrant, magnetic particle, and visual testing (Enkvist *et al*., 1999).

The aeronautical industry has its own characteristics. Flights, crews and maintenance have to be scheduled. Fuel, spare parts, tools, training and publications have to be pro-vided. With all these factors, it is necessary to consider the costs of operation and maintenance, which are time and money (Knotts, 1999).

In the view of Salamanca and Quiroz (2005), the costs of maintaining aeronautical structures, taking into account non-destructive inspections, repairs and replacements of dam-aged components, have a high priority in the management of the fleet.

Research has been carried out in the evaluation of the influence of the human factor in non-destructive tests, such as: Moré *et al*. (2003), Stefhens (2000), Wassink and Dijkstra (2007).

Crocker (1999) cites that it is often assumed that inspectors are infallible, that they will always see a crack if they are present and that they would never reject a component unless it was in an unsatisfactory condition. If inspections were always one hundred percent effective, then the inspector would always find a crack, corrode or external damage if present, and would never reject a component unless a fault was present. Although the consequences may be different, false positives (reporting a crack when it does not exist) and false negatives (failing to detect a crack that is present) are both bad for the operational effectiveness of a system. A false positive can lead to removal of the item, leaving the system unnecessarily unnecessary, and exposing it to the possibility of damage induced during maintenance. A false negative can put human lives at risk and also result in the loss of the aircraft.

The research described presupposes the growing complexity of systems and seeks to study human behavior, which results in decisions about product conformity. With emphasis on inspections, common in the food, mechanical and aeronautical industries, where the inspector has a preponderant role in approving or failing the inspected product, the human factor becomes fundamental to the reliability of the inspection processes. Thus, the training of an inspector begins with the job description and is complemented by on-the-job training based on standardizations such as NAS 410 which establishes minimum standards for qualification and certification of personnel involved in non-destructive testing.

In this context, given the importance of the theme, the present work aims to evaluate the influence of the human factor in non-destructive tests by parasitic currents in the maintenance of aeronautical structures.

2. RESULTS AND CONCLUSIONS

Illustration 1 summarizes the observations after data analysis.

In the case studied, through a more quantitative approach, it was verified that the time of experience of the inspector, which is related to the nature of the individual, was a factor that had great influence. These findings confirm NAS 410, which addresses the requirements for the qualification and certification of personnel involved in the application of non-destructive testing. The standard says that there should be a minimum training load for the inspector to obtain his certification.

Selected Factors	DOE Results	General comments
Person	Regarding the inspection time, it was the most statistically significant factor. With regard to the correct answers and errors, 100% of the inspectors considered experienced correct the result.	The researcher observed that actually the experience time was what most influenced the time of the inspection and the correctness and errors. Experienced inspectors demonstrated great safety during inspections.
Difficulty	With regard to the inspection time, the difficulty of the inspection had an influence not as great as the experience and not as small as the stress. Regarding the correctness and errors, considering the inspections per-formed on structural items considered difficult to inspect, there was a 62.5% hit and an error in 37.5% of the inspections. And considering the inspections performed on items considered easy to inspect, there was a 75% hit and an error in 25% of the inspections.	The researcher noted that the inspection of difficult parts did not cause reactions of insecurity, especially with respect to the inspectors considered experienced. The existence of a system-based procedure based on NAS 410 provides a peace of mind to inspectors with less experience, as they know that their inspection will be checked by a more experienced inspector.
Stress	Regarding the time of inspection, it was the variable that had the least influence. Regarding the correctness and errors, considering the inspections that were not performed under conditions that caused stress, there was a 62.5% hit and an error in 37.5% of the inspections. Considering the inspections carried out when the conditions causing stress were present, 75% of the inspections and 25% of the inspections were correct.	Although not considered statistically significant, the researcher observed that the inspectors appeared to be much calmer during inspections performed in the morning and in an environment without parallel conversation. Under stressful conditions, it was observed that young inspectors were more focused on carrying out the inspection.

Illustration 1 – Evaluation of the factors present in human inspection by non-destructive testing.

The DOE statistical tool proved to be efficient and allowed to conclude that the results obtained in the case studied are consistent with the NAS 410 standard. This standard gives more security to the process and to the inspectors, since it guarantees that the results of the inspections done by inspectors with little experience will pass by the approval of more experienced inspectors.

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A Conceptual Model to Investigate the Relationship Among Antecedents and Consequents of Custumer Satisfaction

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ABSTRACT

The services sector has gained prominence in the Brazilian and world economies, promoting that organizations strive for excellence in their service. In this context, there is a challenge in understanding the relationships among the factors that can influence the evaluation of services and the behavior of the clients, in order to improve the management of these organizations. Thus, it was verified the importance of an investigation that can examine the literature on the relations between the factors antecedent to the loyalty of the clients. Thus, the purpose of this study is to specify a model of the multiple relationships among service quality, perceived value, corporate image, customer satisfaction and loyalty. For this, a literature review was carried out seeking to specify the main hypotheses and the development of a conceptual model. From this, it was evidenced that there is no a uniform approach and a generic perception about the factors analyzed. Moreover, the proposal of indicator items was developed, which are operational variables of the latent concepts of the model. This allowed the translation of the theoretical domain into measurable variables so that the empirical domain can be evaluated and compared in future research.

KEYWORDS: Service Management, Customer Behavior, Service Assessment.

1. INTRODUCTION

The services sector has achieved a prominent role in society, as well as important indices in the participation of the world economy.

In this context, it is important that service providers seek excellence by creating a differentiated service, high levels of quality and customer retention. These aspects can become a more effective positioning strategy in the market and a means of sustaining an ongoing relationship with customers (Parasuraman, *et al.*, 1991 and Cronin and Taylor, 1992).

The literature on services evidences service quality as a determinant of success in the competition among the companies, and several researchers have tried to measure it. The first models of service quality evaluation emerged in the 1980s, with Grönroos, (1984) being one of the pioneers. According to this author, perceived quality is a function of expected service, perceived service and corporate image. Then, Parasuraman, *et al.*, (1985) proposed measuring service quality based on Oliver, (1980) satisfaction model, which was based on ten quality-specific dimensions. Parasuraman, *et al.*, (1988) have perfected it by developing an instrument called the SERVQUAL scale, based on five dimensions: tangibility, reliability, responsiveness, assurance and empathy, generically operationalized in two groups, one of expectation and the other of perception, with 22 Likert type questions for each group.

Since then, research has been devoted to this theme, either suggesting adaptations of the model (Parasuraman, *et al.*, 1991, Parasuraman, *et al.*, 1994, Boulding *et al.*, 1993, Teas, 1993, and Parasuraman, *et al.*, 2005), or by comparing the models (Cronin and Taylor, 1994, Lee, *et al.*, 2000 and Landrum, *et al.*, 2007). Other current researches also highlight the relevance of this theme in different service sectors, such as public transportation (Celik *et al.*, 2014), air transportation (Hussain *et al.*, 2015 and Basfirinci and Mitra, 2015) and health (Papanikolaou and Zygiaris, 2014).

A review of the literature has evidenced other factors, as well as quality in services, that can influence the evaluation of services and customer behavior, such as satisfaction, corporate image, perceived value and customer loyalty (Oliver, 1980, Fornell *et al.*, 1996, Andreassen and Lindestad, 1998, Cronin *et al.*, 2000, Choi *et al.*, 2004, Lai, *et al.*, 2009, Wu, 2011, Yu *et al.*, 2014, Jiang, *et al.*, 2015 and Annamdevula and Bellamkonda, 2016).

The, Oliver (1980) was one of the pioneers to develop a model that expresses consumer satisfaction based on two factors, the disconfirmation of expectation and actual performance, applying the study in the US health sector. Subsequently, Fornell *et al*., (1996) proposed an index for the main US economic sectors, the American Customer Satisfaction Index (ACSI), relating three antecedents of satisfaction and two consequent ones. The tourism industry in Norway, corporate image and satisfaction as ways of customer loyalty (Andreassen and Lindestad, 1998). Lai, *et al*. (2009) analyzed the relationship among five factors, service quality, perceived value, corporate image, customer satisfaction and loyalty in a Chinese telecommunication company. More recently in India, (Annamdevula and Bellamkonda, 2016) have tested the direct and indirect effects of service quality on the loyalty of university students to the mediating role of satisfaction.

From the analysis of these studies, it has been found that many factors can influence the reasons why clients evaluate services and choose to remain faithful to them. Thus, from the considerations already presented, it was verified the importance of an investigation that can examine the state of the art on the relations among factors antecedent to the loyalty of the client. Thus, the main objective of this article is to specify the multiple relationships among quality of service, perceived value, corporate image, customer satisfaction and loyalty.

2. METHODOLOGY

The literature review was elaborated through a bibliometric analysis, which allowed to identify important works related to antecedent factors and consequent factors of customer satisfaction.

The bibliometric analysis was performed on the references of complete articles obtained from the main collection of the Web of Science (WOS). A priori the search term was “quality service”, justifying the line of research of the theme. However, after an exploratory reading of the title and summary of the most cited articles, we noticed the use of the keyword “service quality”. By using the expression “OR” for a combination of terms a total of 7,515 articles were generated. This result was refined by Web of Science categories that encompassed areas within the context of Operations Management, in this case, Management, Business, and Operations Research Management Science. In order to obtain a more recent sample it was also refined the publication year for 2013, 2014 and 2015, complete, and 2016, incomplete. As a result, a sample of 803 articles was obtained, of which the metadata was exported to CiteSpace IV software.

The Citespace results pointed to a main network with six clusters, comprising 109 references with 78 authors, concentrating 82% of the authors cited by the articles in the sample. The relevance of this cluster is confirmed by Chen (2006) and Chen (2010), they affirm that the references belonging to a cluster have similarity of subject because they were cited together by the articles of the sample, thus pointing to which should be considered. Therefore, they were the focus of this diagnosis.

Once the sample was determined, an exploratory reading was conducted that included the title and summary of the 109 references, excluding those that were not directly related to the topic of quality in services, 82 valid references were obtained. They are distributed between 1980 and 2009, received 2,317 citations until April 2016 and are mainly concentrated between 1991 and 1995, and can be explained by the emergence of alternative models to SERVQUAL or a comparative study of this model.

Finally, a reading of the work that the bibliometric analysis pointed out as important was done. The subjects of these were categorized according to the sections presented below.

3. LITERATURE REVIEW

The proposed conceptual model, presented in Illustration 1, was based on the model of Lai, *et al*., (2009), adding the measurement of the construct quality services individually, by the five dimensions of SERVQUAL. The purpose of using the dimensions is to capture the customer's perception of service performance rather than the gaps approach proposed by (Parasuraman, *et al*., 1988).

Customer satisfaction has antecedents that determine it and the most frequent in literature of service are quality service and perceived value, both belong to ACSI model proposed by Fornell *et al*. (1996). Many researchers suggest that customer satisfaction is a result of the expectations reached by the service quality (Fornell *et al*., 1996, Cronin and Taylor, 1992, Zeithaml *et al*., 1996, Brady *et al*., 2002), Hu *et al*., 2009 and Clemes *et* *al*., 2010). In this sense, Oliver (1999) states that this causal relationship derives from the paradigm theory of expectancy disconfirmation, once the attribute performance was achieved through quality, the level of satisfaction of the individual rises, so a positive association of factors. Customer satisfaction is a post-consumer experience, which compares perceived quality with expected quality, while service quality refers to an overall assessment of the service delivery system (Anderson and Fornell, 1994). The perceptions of quality in services affect the feelings of satisfaction that, in turn, influence future buying behavior (Hurley and Estelami, 1998). The quality service as a driver of customer satisfaction is supported by empirical validation of several studies (Bolton and Drew, 1991, Cronin *et al*., 2000, Brady and Cronin, 2001, Choi *et al*., 2004, Wu, 2011 and Yu *et al*., 2014). For Wu (2011) service quality was positively associated with satisfaction, showing the highest value among all other coefficients. This discovery implies that the path among them is a critical path. However, other researches such as Lai, *et al*. (2009), did not show any direct link among quality service and satisfaction. This divergence makes it necessary to investigate the quality-satisfaction relation, so the first hypothesis is: H1a: Tangibility has a significant and positive effect on customer satisfaction; H1b: Reliability has a significant and positive effect on customer satisfaction; H1c: Responsiveness has a significant and positive effect on customer satisfaction; H1d: Assurance has a significant and positive effect on customer satisfaction; and H1e: Empathy has a significant and positive effect on customer satisfaction.

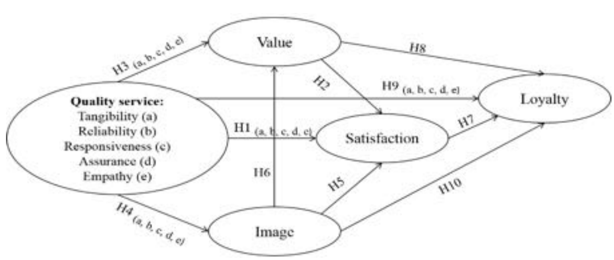

Illustration 1 - Proposed conceptual model. Source: Adapted from Lai, *et al*. (2009).

Perceived value is another important determinant of satisfaction (Andreassen and Lindestad, 1998). For Choi *et al*. (2004), while perceived value is the consequence of a mental weighing of perceived benefits versus sacrifices, satisfaction is an effective response to service evaluation. The direction of causality among these constructs has generated discussion in the academic world. The value has a direct impact on customer satisfaction, and satisfaction depends on value (Ravald and Grönroos, 1996). The clients are more satisfied when they perceive receiving "value for money" than when they do not realize it (Zeithaml, 1988). The perceived value can indirectly change the direction and intensity of satisfaction or dissatisfaction experienced, because deficiencies that occur in service performance can be compensated for by reductions in sacrifices and clients receiving lower performance than expected can still be satisfied (Patterson and Spreng, 1997). In other service providers, perceived value is fundamental to determining customer satisfaction (Fornell *et al*., 1996, Cronin *et al*., 2000, Zins, 2001, Ball *et al*., 2004, Choi *et al*., 2004, Whittaker *et al*., 2007, Lai, *et al*., 2009 and Yu *et al*., 2014). Although the perceived value is related to customer satisfaction in most purchases, it is not necessarily a precedent or consequence of satisfaction because the value is not always considered by the consumer in his product/service choice when the customer expectations affect the value estimation and satisfaction/dissatisfaction is linked to perceptions of value in many, but not all, purchases (Day, 2002). Based on the above discussions, the following hypothesis is proposed: H2: Perceived value has a significant and positive effect on customer satisfaction.

The perceived value is the proportion of what is achieved on what is paid (Parasuraman and Grewal, 2000). Thus, perceived quality will positively influence value, while price will influence it negatively, so high quality is not a prerequisite for value, since a reduction in quality can be offset by lower overall costs (Lai, *et al*., 2009). However, empirical research (Andreassen and Lindestad, 1998), Cronin *et al*., 2000, Zins, 2001, Choi *et al*., 2004, Lai, *et al*., 2009, Ishaq, *et al*., 2014, Yu *et al*., 2014 and Jiang, *et al*., 2015) support a positive relationship among quality service and perceived value, believing that the higher the quality in services the greater the benefit that the consumer will receive for the value that is available, that is, quality would tend to improve the cost-benefit ratio. In the financial sector, Nguyen and Leblanc, (2001) concluded that customer satisfaction and service quality are positively related to value and in their research it was concluded that quality service exerts a greater influence than that exerted by satisfaction on perceived value. Therefore, the third hypothesis is: H3a: Tangibility has a significant and positive effect on perceived value; H3b: Reliability has a significant and positive effect on perceived value; H3c: Responsiveness has a significant and positive effect on perceived value; H3d: Assurance has a significant and positive effect on perceived value; and H3e: Empathy has a significant and positive effect on perceived value.

There is a great importance of corporate image for service companies (Grönroos, 1984), being built mainly by the technical quality (experience with the service) and the functional quality (how the service is delivered). Thus, the image is largely determined by the perception of the services received by the clients. According to Zeithaml and Bitner (2003), the suggestions of the physical environment are fundamental for the company's image. Similarly, Crosby (1990) note that the performance of front line employees is indicative of the level of quality offered by service providers. Considering that these dimensions, physical environment and front-line employees are determinants of service quality identified by Parasuraman, *et al*. (1988), so is it possible to consider the existence of a relationship among service quality and corporate image. Nguyen and Leblanc (2001) tested this relationship in the financial sector and reported a positive effect of perceived quality on the corporate image. In this direction, Ostrowski (1993) examined the air service and argue that after several good experiences, the client perceives a positive image of the company. Lai, *et al*. (2009) concluded in their study that the corporate image is the result of all experiences of consumer consumption, considering service quality. The image can determine the quality perceived by the consumer if the consumers do not have previous experience with the service or the product (Ladhari, *et al*., 2011). But they believe that perceived quality of service determines the image if consumers have any experience with the company's products or services. Therefore, the perception of customers about the quality of services during use affects the perception of the corporate image. Therefore, the fourth hypothesis is: H4a: Tangibility has a significant and positive effect on corporate image; H4b: Reliability has a significant and positive effect on corporate image; H4c: Responsiveness has a significant and positive effect on the corporate image; H4d: Assurance has a significant and positive effect on the corporate image; and H4e: Empathy has a significant and positive effect on the corporate image.

The attitudes are directly related to the behavioral intentions (Johnson, *et al*., 2001), thus, knowing that the image is formed from the perspective of the client's attitudes with the company, this affects the level of satisfaction due to its functional components. To corroborate this view, Lai, *et al*. (2009) believe that consumers who develop a positive mentality of a brand tend to have high satisfaction, where all aspects associated with the brand are similarly valued. Others empirical evidence indicate this causality (Andreassen and Lindestad, 1998, Bloemer *et al*., 1998, Zins, 2001, Lai *et al*., 2009 and Ishaq, *et al*., 2014), and for the banking context, according Ball *et al*. (2004), the corporate image had an impact on customer satisfaction. For Juga, *et al*. (2012) the associations were weaker but statistically significant in logistics service providers. However, in the study by Wu (2011) the hospital image did not have a positive effect on patient satisfaction. Thus, the following hypothesis is derived: H5: Corporate image has a significant and positive effect on customer satisfaction.

Another relationship, but less researched, is the positive and significant effect of the corporate image on the value perceived by the client. The corporate image is conceptualized as the client's emotional stereotypes, suggested this relation to the European air context and corroborated it (Zins, 2001). According to Lai *et al*. (2009), the concept of perceived value may be associated, in addition to the functional aspects, to hedonic, social, emotional and experimental components; thus, a positive image makes the consumer experience more rewarding socially and emotionally. In this way, the following hypothesis emerges: H6: Corporate image has a significant and positive effect on perceived value.

In the proposal of Lai *et al*., (2009), loyalty is the most exogenous dependent variable, being the result of the company's relationship with the customer, as well as the company's subsequent profitability (Fornell *et al*., 1996 and Johnson *et al*., 2001). In this perspective, consumer satisfaction positively affects customer loyalty (Bloemer *et al*., 1998, Amin *et al*., 2011 and Yu *et al*., 2014). As also cited by Andreassen and Lindestad, (1998), this effect ensuring that when service satisfaction exceeds the critical threshold, customer loyalty increases. Thus, Gee *et al*. (2008) suggest that loyalty is reinforced by various experiences over time, and satisfaction becomes important because these experiences must be satisfactory to lead to the positive pre-disposition of loyalty. The literature, however, presents other positions on the influence of satisfaction on loyalty, evidencing that satisfied clients are not necessarily loyal (Reichheld, 1994, and Reichheld, 2000). The misconception is to use satisfaction that is an attitude, resulting from the interaction among expectations and perceptions of performance, to predict loyalty, which is behavior (Neal, 1999). However, other research points out that loyalty when established needs satisfaction to be maintained and developed (Fornell, 1992 and Oliver, 1999). In the study by Yu *et al*. (2014) the role of consumer satisfaction was more salient and had a stronger influence on loyalty compared to other antecedents such as quality of service and perceived value. In this context, many investigations indicate that satisfaction predicts customer loyalty (Fornell, 1992, Johnson, *et al*., 2001, Zins, 2001, Lai, *et al*., 2009, Wu, 2011), Pan, *et al*., 2012, Juga, *et al*., 2012 and Yu *et al*., 2014), including the banking industry (Bloemer *et al*., 1998, Nguyen and Leblanc, 2001, Ball *et al*., 2004 and Brunner *et al*., 2008). Consequently, customer satisfaction is considered a precedent for service loyalty, promoting the hypothesis: H7: Customer satisfaction has a significant and positive effect on loyalty.

Perceived value is another important factor and is recognized as being linked to loyalty by researches such as Lai, *et al*. (2009), Chen and Hu, (2010), Ishaq *et al*. (2014) and Jiang, *et al*. (2015). The perceived value drives loyalty (Neal, 1999). Considering that perceived value has a significant impact on customer loyalty, (Chen and Hu, 2010) found that perceived value is essential in the relational process that leads to customer loyalty, behaving as a mediator variable by linking the relational benefits to customer loyalty. In the studies by (Jiang, *et al*., 2015), it was noted that obtaining more valuable services is one of the main reasons for attracting customers. The leading loyalty companies recognize that consistent supply of relationships that result in superior value is the only way to keep customers longer (Reichheld, 1994). In the literature it is possible to high-light value models, where they present the perceived value, instead of satisfaction, as the main and only direct determinant of behavioral intentions (Chang and Wildt, 1994, and Shamdasani *et al*., 2008). In the study by Lai, *et al*., (2009), the value had the greatest overall effect on customer loyalty. However, other research suggests that perceived value only indirectly influences loyalty through satisfaction (Patterson and Spreng, 1997 and Zins, 2001). Considering this divergence, it is expected to verify the following hypothesis for the banking context: H8: Perceived value has a significant and positive effect on customer loyalty.

According to Hu *et al*. (2009), one of the major interests of service quality for academics and practitioners has been due to their positive relation-ship on the behavioral intentions of consumers. A high level of service quality will lead to service loyalty (Bitner, 1990). Fornell (1992) and Zeithaml *et al*. (1996) found that high quality leads to customer retention levels, which in turn are strongly related to profitability. In this sense, Parasuraman, *et al*. (1991) found a positive and significant relationship among customer perceptions about service quality and their willingness to recommend the company. For Dick and Basu (994), organizations that emphasize customer beliefs about the quality dimensions of services identified by Parasuraman *et al*. (1988) should lead to a repetition of purchasing behavior. There is an association among service quality and the likelihood of the consumer remaining loyal to the company (Boulding *et al*., 1993). Others empirical results supported this relationship, where customer perceptions about quality affect the intentions of purchase (Cronin and Taylor, 1992, Zeithaml *et al*., 1996, Ladhari, *et al*., 2011 and Juga, *et al*., 2012). However, Lai *et al*. (2009), Wu, (2011) and Yu *et al*., (2014) and others cited by them, Gotlieb *et al*. (1994) and Patterson and Spreng (1997), argue that the effect of the service quality on loyalty is indirect because it is influenced by the value perceived. Thus, to investigate this question the following hypothesis was proposed: H9a: Tangibility has a significant and positive effect on loyalty; H9b: Reliability has a significant and positive effect on loyalty; H9c: The promptness has a significant and positive effect on loyalty; H9d: Assurance has a significant and positive effect on loyalty; and H9e: Empathy has a significant and positive effect on loyalty.

The corporate image is also considered as influencing customer loyalty. The idea that a company's favorable image over time positively affects repeat buying and customer relationship with it, was proposed by Dick and Basu (1994) and Ryu *et al*., (2012) assert that the most important factor in the development and maintenance of loyalty is the corporate image of the organization, since it refers to the accumulation of consumer experiences on multiple occasions with emotional and functional principles, making it a relevant aspect also for profit maximization and survival in the market (Bravo *et al*., 2009). According to Andreassen and Lindestad (1998) the less experienced consumers in service consumption suffer more influence from the corporate image while the more experienced consumer suffers less influence. Ostrowski (1993) have analyzed that the relationship among positive image and customer loyalty is strongly elevated to the point that, in the face of a negative experience, it can be considered an exception to the positive global image in customer perception with the company, not influencing their loyalty.

The corporate image is regarded as an attitude that is directly associated with customer satisfaction and loyalty because of its functional components (Johnson, *et al*., 2001). Several empirical researches confirm the significant direct impact of the corporate image on customer loyalty (Nguyen and Leblanc, 2001, Bloemer *et al*., 1998, Zins, 2001, Wu, 2011 and Ishaq, 2012). However, in Lai *et al*., 2009 and Juga, *et al*., 2012) the corporate image has only a significant mediating effect on loyalty when it plays a critical role in increasing customer value and satisfaction. According to these authors, this was also verified in the researches of Aydin and Özer (2005) and Bloemer and Ruyter, (1998). This result may be related to the existence of the so-called “halo effect” that distorts individual quality or measures of satisfaction in relation to an overall impression. In this situation, a strong brand can have indirect effects on all services under the same brand, so the halo effect is seen as a positive impact of the service provider’s image on buyer satisfaction, which strongly affects loyalty (Ladhari *et al*., 2011). Thus, we intend to investigate the following hypothesis: H10: Corporate image has a significant and positive effect on customer loyalty.

3. NEXT STEPS

With the construction of the theoretical base from qualitative research arranged in the correlative literature in the Web of Science base and the development of the main hypotheses existent, the construction of the proposed conceptual model was performed. According to Forza (2002), this phase aims to translate the theoretical domain into measurable variables so that the empirical domain can be evaluated and compared. For Hair *et al*. (1998), the concepts of theorized and unobservable nature can be represented by measurable variables, understood by the operationalization of the construct by examining consistency among multiple measured variables (indicator items).

Thus, the operationalization of the nine constructs of this research occurred through twenty-seven measured variables, as presented in Illustration 2.

The references obtained in the literature review provided the theoretical basis for selection and planning of the indicator items. Thus, it is possible to affirm that the scales have the validity of expression, since, the content of the items is consistent with the definition of the construct. This was confirmed by sending the operation to two specialists in the area.

Variable	Item	Reference
REL1	When you have a problem, your service provider shows an honest interest in resolving it.	(Parasuraman, *et al*., 1988)
REL2	Your service provider performs the right service right the first time.	
REL3	Your service provider provides the services at the time you promise to do so.	
EMP1	You receive individual attention from your service provider.	
EMP2	Employees show an interest in solving their problems.	
EMP3	Employees understand your specific needs.	
TAN1	Your service provider has modern equipment.	
TAN2	The physical facilities are suitable for your needs.	
TAN3	Communication channels (internet, telephone, message, etc.) are suitable for your needs.	
RES1	Requests made to employees are answered promptly.	
RES2	Staffs are willing to help.	
RES3	Staffs are available to assist you.	
ASS1	Employee behaviour conveys confidence.	
ASS2	You feel secure in your transactions with the service provider.	
ASS3	Staffs are knowledgeable about answering your questions.	

IMA1	You consider the reputation of your service provider to be high.	(Nguyen and Leblanc, 2001 and Lai *et al.*, 2009)
IMA2	You consider the reputation of your service provider to be superior to that of the best competitor.	
IMA3	You have admiration for your service provider.	
VAL1	The services you receive are useful to meet your needs.	(Zeithaml, 1988, Zeithaml and Bitner, 2003, Choi *et al.*, 2004, Lai *et al.*, 2009 and Jiang, *et al.*, 2015)
VAL2	The services you receive are worth your time, energy and efforts.	
VAL3	In general, the fees charged for your service provider's service are fair value.	
SAT1	You are satisfied with the services you receive.	(Anderson and Sullivan, 1993, Zeithaml *et al.*, 1996 and Lai *et al.*, 2009)
SAT2	The services met your expectations.	
SAT3	You are satisfied with your service provider.	
LOY1	You will likely remain as a client of your service provider in the future.	(Fornell, 1992, Reichheld, 2000, Lai *et al.*, 2009, Amin *et al.*, 2011, and Ladhari *et al.*, 2011)
LOY2	You will probably recommend your service provider to someone.	
LOY3	You will probably get more services from your service provider in the future.	

Illustration 2 – Operational concepts

4. FINAL REMARKS

Following globalization, the operating environment for the service sector has become more dynamic and competitive, as businesses are struggling to maintain a market advantage. This reality coupled with service providers seeking a mutually beneficial relationship has made customer loyalty and its critical track record crucial to this industry. Thus, this article sought to specify the multiple relationships among service quality, perceived value, corporate image, customer satisfaction and loyalty.

In the academic context, by specifying the multiple relationships among factors, it was possible to raise the main hypotheses for the proposed model and to construct a theoretical discussion for them. The results confirmed that the articles reported in this paper use structural equation modeling as a statistical tool for data interpretation, demonstrating the potential of studies that estimate multiple interrelated dependency relationships in a single model. However, they differ on the importance and impact of the factors, in addition to finding varied and even contradictory results, depending on the sector and country where the models were applied and the focus of the research. It is concluded that because of the complexity of the subject, there is no a uniform approach and generic perception about the evaluation of services and client behavior.

It was also possible with the literature review to operationalize the constructs of the model by translating the theoretical domain into measurable variables so that the empirical domain can be evaluated and compared in future research. Another contribution is in the proposal of analysis of the construct quality in services plus measurement of individual form, by the five dimensions of SERVQUAL. The purpose of using the dimensions is to capture customer perception of service performance, rather than the gaps approach proposed by Parasuraman, *et al*. (1988), making the analysis more specific.

Finally, this work was used a bibliometric analysis to identify the most relevant research to compose the literature review. However, it is suggested that future studies use a systematic review of the literature to evaluate the quality of research resulting from the bibliometric analysis and thus, a deeper discussion of the antecedents and consequent of customer satisfaction can be performed.

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Improvement of Efficiency by Redesigning: The Plant Layout

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ABSTRACT

Production and operations management has undergone several changes over time that have had a profound influence on how companies build their survival and competitiveness strategies in the marketplace. An adequate study of the physical arrangement of a company is important to know the internal processes as flow of people, information and materials. Layout optimization reduces costs and adds value to the end product. The objective of this work is to design a new layout for a shoe factory in order to reduce losses and optimize the production process. In the identification of critical points and analysis of possible improvements, classic concepts and production tools were used to guide the decisions. After the deployment of the layout, it was possible to reduce the path travelled by workers by 53.4%, to eliminate not only the crossed paths, but also the intermediate stock and the need for workers to perform unnecessary tasks, reallocating them in activities that add value to the product. It can be concluded that the study of the layout is capable of optimizing the production process of the factory, reducing losses and, consequently, increasing its competitiveness in the market.

KEYWORDS: Layout Analysis, Product Process, Optimization.

1. INTRODUÇÃO

Over time, management of production and operations underwent several changes that have had a profound influence on the way companies build their strategies for survival and competitiveness in the market (Souza *et al*., 2011). In this scenario, management tools and techniques were created and applied more comprehensively (Silva *et al*., 2011). Logistics has evolved a lot since then, and today it is recognized in companies as a tool linked to growth, profitability and business competitiveness, as it adds value by optimizing resources and, consequently, increases the efficiency and quality of the service provided (De Carlo *et al*., 2013, Wictor and Steff, 2016).

One of the ways to minimize problems is to design an optimal layout for the production chain (Fiedler *et al*., 2009). The physical arrangement (or layout) is a productive operation that is concerned with the adequate physical distribution of the processing resources, determining the location of the facilities, machines, equipment and production personnel (Silva *et al*., 2011).

This is one of the final stages of planning and it is necessary to consider the flow and interrelations between sectors, from receiving the raw material to the output of the product, so that the flow of production is clear and effective (Boa *et al*., 2012). Layout optimization reduces costs and adds value to the end product. The distances travelled between sectors must be reduced, so that the flow of production takes place in the most linear way possible, without large and unnecessary displacements (Auler *et al*., 2016).

The objective of this work is to optimize the productive process of a footwear industry, in light of the knowledge pertinent to the planning of the facilities. This case study was conducted an industry in Juazeiro do Norte, Ceará, Brazil, allowing the identification of good practices and improvement opportunities that can serve as a roadmap for other industries.

2. METHOD

The method adopted was research-action, which consists of a type of research that interprets and encompasses a methodological process based on active observation and interference in the studied object in a cooperative way, aiming to solve problems (Mello *et al*., 2012).

The Systematic Layout Planning (SLP), process-by-process method was developed by Mutter in the 1950s (Muther and Planning, 1961) and became quite popular. Although it is not modern to the point of not contemplating the cellular physical arrangement, it is useful in several situations when designing the layout of the processes. SLP is developed in steps that guided the conduction of this study using some recommended tools (Corrêa and Corrêa, 2012). The following steps are detailed below:

Step 1: To know the productive process with flow and resource analysis through Flow Chart and DE - PARA Letters;

Step 2: To develop a relationship diagram of activities to identify qualitative factors needed for the study;

Step 3: To evaluate work area arrangement data with activity arrangement diagrams (Map flow charts) identifying opportunities for improvement and good practice;

Step 4: To organize a space layout plan using the studies and templates (plan and model) made;

Step 5: To implement the chosen model in the available space and observe

Step 6: To make adjustments according to the observations made.

2.1. THE PRODUCTION PROCESS OF THE CASE STUDY

The plant is made up of 180 employees, which 15 are from management and 165 are from production and is located in the city of Juazeiro do Norte, Ceará, Brazil. The productive process is divided into several sectors: manufacturing, stock, screen printing, preassembly, painting, assembly, packaging, dispatch, maintenance, administration, planning and production control, injection sector. The production process described below refers to the *Chinelão* sandal which has the highest sales volume.

The process begins with the withdrawal of the raw material, PVC and pigment from the stock. Once the required quantities are separated, the two materials are brought to the binder to be mixed, becoming a single material that will be taken to the injectors.

In parallel with this operation, the screen printed insole is also separated from its stock and taken directly to the injectors, where the operator previously inserts the insole in the matrix and then injects the material formed by the PVC and the pigment in the same matrix. Once the injection is made, the operator removes the resulting material from the injection of the matrix, so-called shoe sole, stacking them in a shelf next to him. Then he performs the removal of the shavings and burrs, while inspecting and storing the soles in crates. After that he transports the crates to the intermediate stock.

In this stock, the material awaits the separation of the handles and the ornaments and their transport to treadmill number 3, where they will be assembled together becoming the final product. Prior to the assembly procedure, the handles and ornaments are separated in their stocks and taken to treadmill number 2, where they will go through the process of gluing ornaments on the handles and, only then, they will be transported to treadmill number 3 to finish the assembly process. During the assembly process, the operator carries out a new inspection of the footwear for defects.

After assembly, the shoes are labelled, packed and placed in crates that are next to treadmill number 3, where it will remain until transportation for shipment. In the shipment stage, the footwear is separated by numbering and placed in boxes of 12 units, being finally taken to the stock of finished products, waiting for the transport to the buyers (Illustration 1).

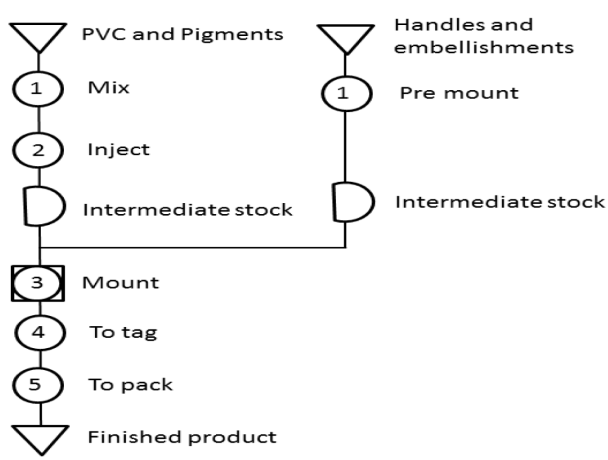

Illustration 1 – Summary flowchart of the productive process.

3. LAYOUT ANALYSIS

During its time of operation, the company did not carry out an adequate study of layout that allowed the optimization of the flow of people, raw material and products inside the factory. Firstly, the layout was analyzed as a whole, noting that there are no demarcated work or storage areas, in the same way that there is no signalling of corridors for circulation, leaving the flow confusing and damaging the process.

In the sequence, the space requirements for each activity and its flow with an DE-PARA diagram were determined. Following the recommendations of (Corrêa and Corrêa, 2012), an activity relationship diagram was elaborated to establish the priorities for proximity between sectors (Illustration 2).

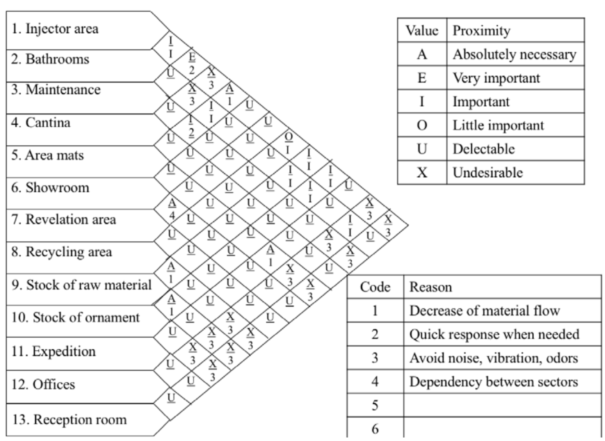

Illustration 2 – Letter of Preferred Interconnections of the plant.

With this tool, some considerations have been established. It was noticed that the area of the injectors should be near the toilets, so that the displacement of the workers diminishes. The canteen and the toilets should be separated, as sanitary surveillance calls for. Offices and noise-producing areas must be removed, as office work demands silence for better concentration. Such considerations were respected in the preparation of the new layout. In addition to other considerations relevant to the proposed layout.

For analysis of the production flow, the company's current layout was elaborated, where it was observed that there are areas without use, as well as spaces with excess of materials. It is possible to visualize the flows of the productive process for the manufacture of sandals, being represented by the highlighted lines and showing the distances travelled between sectors (Illustration 3).

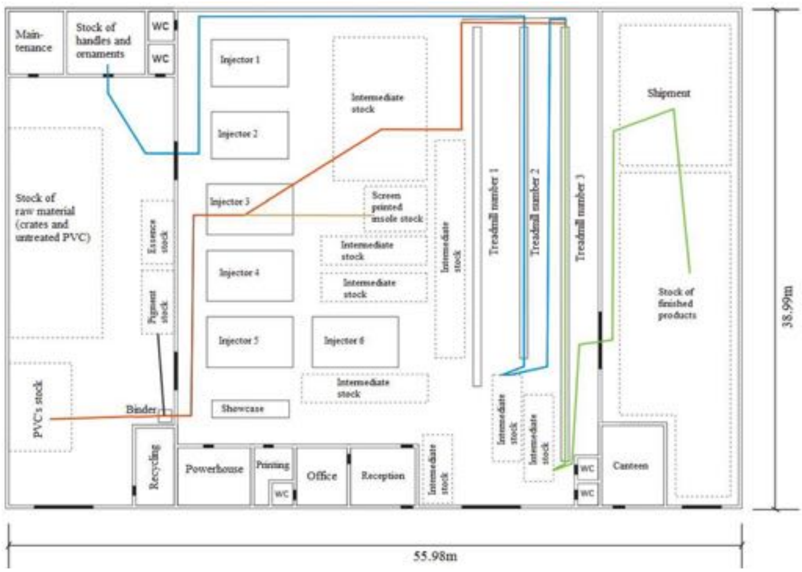

Illustration 3 – Current layout of the company with process flow

Legend:

- Path traveled by the pigment to the agglutinator.
- Path traveled to transport the PVC to the binder, from the injector to the intermediate stock and then to the conveyor 3.
- Path covered by the serigraph insole to the injector.
- Path traveled to carry the handles and trimmings up to the treadmill 2.
- Path traveled by the footwear mounted on the treadmill 3 to the intermediate stock and the intermediate stock to the shipment and, finally, to the stock of finished products.

Still considering Illustration 3, it can be seen that the beginning of sandal manufacturing is in the area of raw material storage, going to the agglutination sector, passing to the injection sector, then to the assembly sector. Soon after assembly, the items are packed and stored. The route covered by a lot of this product totals approximately 207 meters.

4. PROPOSAL FOR IMPROVING LAYOUT

It is necessary to point out that there was no increase of the area of the company, not entailing in extra costs to expand the physical area. The importance of Production Engineering in the ideal planning within the individual reality of each plant stands out.

The positions of the injectors and the mats were rotated by 90º, causing the crossed paths to decrease, being almost annulled. Concurrently with this change, the stock of screen-printed insole was divided and distributed among the six injectors, so that each one had its own stock. In this way, the flow of operations became more linear, thus reducing the unnecessary movement of people and raw materials After an analysis of the current layout of the plant and using the correct tools, it was possible to elaborate an optimized layout for the physical space of the company shown below in Illustration 4.

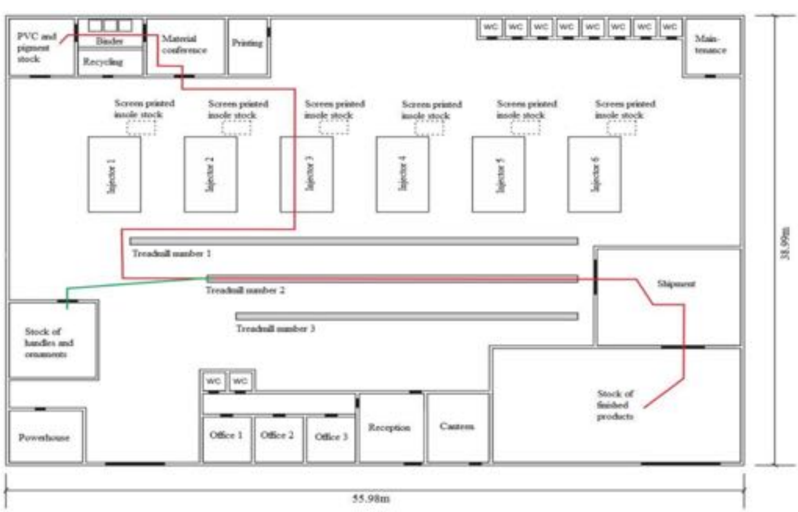

Illustration 4 – Layout optimized for company physical space

Legend:

Path traveled to carry the handles and trimmings up to the treadmill 2.

Path traveled by the footwear mounted on the treadmill 3 to the intermediate stock and the intermediate stock to the shipment and, finally, to the stock of finished products.

It is necessary to point out that there was no increase on the company physical area, not entailing in extra costs to expand the physical area. The importance of Production Engineering in the ideal planning within the individual reality of each company is highlighted here.

The positions of the injectors and the treadmills were rotated by 90º, causing the crossed paths to decrease, being almost annulled. Concurrently with this change, the stock of screen-printed insole was divided and distributed among the six injectors, so that each one had its own stock. In this way, the flow of operations has become more linear, thus reducing the unnecessary movement of people and raw materials.

Previously, there was no physically demarcated area to contain the stock of PVC and pigments, which were assembled in a disorganized manner damaging the flow of production. The current layout proposes the creation of two spaces: one that bears both PVC and pigment stock, and another that is located next to it, to receive the binder, avoiding unnecessary displacements and freeing space for the creation of stock of handles and ornaments.

In the old layout, the handles and ornaments were collected separately and were taken first to a treadmill for assembly and then to a second treadmill for the fitting of the sole. After an analysis of the layout, it was observed that it was not necessary to use two treadmills, since these pieces could be assembled in the stock of handles and ornaments, avoiding additional transport, in addition to being closer to the first treadmill used.

The intermediate stocks were discontinued, freeing up space for a more fluid transit of people and materials. The shipping sector and the stock of finished products that were previously located in the same place without physical delimitation, were reallocated to two different spaces in the new layout, improving organization by separating each operation.

With the changes proposed so far, the travelled route, which was previously 207 meters, has been reduced to 96 meters, corresponding to a reduction of approximately 53% of the way travelled by the workers. This reduction demonstrates the impact that the planning of the installations can have on the productive process.

However, even without direct influence on the production, other changes in the layout were proposed, considering their potential of interfering in the displacement of personnel and in the time of action for solving problems. One of these changes is the relocation of the maintenance sector to an area that allows better observation of the manufacturing process as well as faster access to the machines.

Offices were laid out side by side and away from noise sources as much as possible, contributing to the health of the workers and improving the environment needed for bureaucratic services.

The number of toilets was changed from five to ten with an area of $2.7m^2$ each, in compliance with the Regulatory Standard 24 from the Ministry of Labor, which is related to the sanitary conditions for workers and also to comfort areas. According to the current legislation in Brazil, there should be a sanitary cabin for every 20 employees, with a minimum area of $1m^2$ each (ABNT, 1993).

In the old layout, there were two sanitary cabins on opposite sides and two sanitary cabins in the treadmill sector, where the number of employees is much higher.

Taking into account that each injection is operated by only one employee, it is possible to see the disproportion between the number of users and the number of available toilets. There was also another bathroom used by the sectors of maintenance and stock of PVC, pigment and essences. In the new layout, six sanitary cabins were arranged side by side near the maintenance sector, and two more cabins were arranged near the offices, improving accessibility to employees in all cited sectors. In addition, the new toilets are now far from the canteen, reducing the possibility of direct contamination and cross-contamination in the food handling environment.

Finally, with the proposed layout, maximization of profits is expected, since reallocation of the workers in charge of the transportation of materials to other sectors or to other shifts may increase production without the need of hiring new personal. As a result, it will be possible to produce sandals with higher quality meeting the market demand.

5. CONCLUSION

The current context of intense competition forces companies to seek new ways to improve their processes and to eliminate waste in order to offer increasingly innovative products that win the customer's trust and make them willing to pay for them.

The footwear industries of the Northeast region of Brazil are constantly evolving and consequently are often expanding their facilities to accommodate a larger number of machines and people while supplying a growing market demand. This constant need for optimization means that the correct management of production processes is highly desired in organizations. The analysis of the layout and planning of the installations are important stages in the manufacturing process, as they provide improvements in production, generating greater profit and reducing the waste of time, space and material. It is in this scenario that the Production Engineer acts as a strategist when defining the correct sequencing of the product and the jobs, relating them to their respective activities.

It should be noted that after the implementation of the improved layout, it was possible to reduce the path travelled by the workers by 53.4%, eliminating not only crossed paths, but also the intermediate stock and unnecessary tasks, relocating the workers in activities that add value to the product. Therefore, the main objective of this research was reached: the optimization of the productive process.

Thus, it can be stated that the layout change proposed by this study meets the need of the researched organization to optimize its production process, eliminating losses and, consequently, increasing its competitiveness in the market. It is indicated as future work, to deepen the analysis of the results by means of the replication of this study in other sectors, to analyze differences in the optimization of the layout between different sectors.

For future research we suggest that this study, using SLP, be replicated to industries in other sectors, and also an analysis of productivity improvement after the implementation of the new layout.

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Maintenance Management with Focus on Hospital Equipment: A Case Study in a Medium-Sized Hospital

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ABSTRACT

The Maintenance Management in companies has been shown a primordial factor for the reach of quality and reliability of processes, in face to constant digital transformation. In the current economic scenario of Brazilian hospitals, there is an increasing concern on the part of managers, with a quality of services that are performed every day in hospitals, which has just passed the good state of operation of the hospital equipment that is used in the procedure (consultations, exams and surgeries). Therefore, this paper aims to investigate the main causes of high frequency failure of hospital equipment and to demonstrate possible ways to treat them. For the analysis and study, quality tools and the observatory method were used in order to quantify the problems faced with high frequency of equipment failure and the costs generated by repairs and, from them, to elaborate proposals that could reduce them. With this, it was possible to notice the points with greater failures and the elaboration of a plan of action with the purpose of to provide a significant improvement in the management process of hospital maintenance.

KEYWORDS: Maintenance Management; Improvement; Analyze.

1. INTRODUCTION

In a market that is constantly changing and new goals are constantly being reached, it is necessary for companies to invest in tools that allow a better maintenance management control, achieving more quality and an increase in equipment life, besides improving the capacity to produce or provide an efficient service, Kardec and Nascif (2004). Managers must always be attentive to new demands of a competitive market, seeking the best solution to face the many difficulties that the companies face.

The several transformations that occur in companies caused by globalization and to the digital transformation, make the administration of technological, financial and management resources carry out in an effective way and with a constant processes control, which is related to an efficient maintenance management, in order to stand out against the threats of the market. Following this context, Slack, Chambers and Johnston (2002) affirm that the reliability in the process of an equipment, helps in achieving quality and determination of the maintenance time. Therefore, the maintenance needs to be integrated into all processes, often serving as a decisive factor for decision making of managers, seeking a better performance in order to achieve the desired results, to satisfy the customers needs and expectations.

Digital transformation aligned with hospital maintenance management is a reality in everyday life in healthcare, and many digital strategies are already well known in this field. The impacts of this change can be seen in areas such as customer service / patient relationship, sales and service delivery, operational processes, decision making and maintenance of equipment. Thus, digital transformation brings extremely significant improvements to the day-to-day lives of individuals and companies.

Considering the relevance of the topic addressed by this study, this paper has as a research problem: How does maintenance management contribute to the decrease in high frequency of hospital equipment failures? This questioning will require both a bibliographical review and the use of quality tools for the analysis of information capable of allowing the research topic to reach the general aim of the research: to verify how maintenance management contributes to the decrease the high frequency of hospital equipment failures.

2. MAINTENANCE MANAGEMENT

Nepomuceno (1999) affirms that maintenance management has emerged with the objective of constantly improving of processes of companies, as a way of always being competitive in the current economic scenario. Maintenance has stopped to be only an area of emergency repairs in equipment and has become significant important in the strategy for decision making and the achievement of objectives. One of the pillars for systematizing the maintenance management process is a well-structured maintenance plan, which should contain all the information and goals of the company in relation to the scope of its process.

Viana (2009) reiterates that for the development of a well-structured maintenance plan, some items should be analyzed in order to provide a more comprehensive view of the process. Following this context, the author states that the management plan classification of maintenance is divided into five groups: 1. Apparent research plan; 2. Equipment lubrication route; 3. Monitoring of equipment traces; 4. Maintenance for repairs of worn parts; 5. Preventive action plan.

According to Tavares, Calixto and Poydo (2005), many factors directly influence the non-achievement of maintenance management and control objectives, and it is necessary to analyze these causes and improve the process flow. Some of these factors are: the lack of adequate tools for the work, a short time for the planning of preparation and execution of processes, maintenance plan not aligned to procedures guidelines, lack of technical qualification of the planner, misuse of availability of machines in preventive maintenance, overloaded employees of functions.

Xenos (2004) reiterates that SO (Service Order) is one of the documents that provides information that assists in maintenance control, enabling data that is very important in outlining maintenance improvement guidelines. The author also states that through the SO it is possible to generate statistical reports, providing a better management of the equipment, increasing the reliability and the availability for operation.

In the view of Moro and Auras (2007), corrective maintenance has as main characteristic a methodology that presents immediate short-term actions, aiming at returning the full operation of a machine that is out of its normal operation. This type of maintenance is very common in repair of machines where it is not allowed to use other types, such as preventive or predictive, because the cost generated is in thesis, higher with these maintenance procedures.

In the view of Pereira (2009), preventive maintenance can be defined as the first step of a scheduled maintenance plan, determining the inspections that must be performed in defined periods, in order to avoid corrective maintenance. Its definition describes it as a set of procedures that are performed on the equipment in order to avoid possible failures. Usually, it is accompanied by a pre-established schedule, which includes information about the processes that must be followed, the time that must be obeyed between one maintenance and another, besides the parts that need to be changed.

According to Pereira (2009) predictive maintenance is characterized by monitoring of equipment performance, through methods with data analysis that are provided in the monitoring and inspection performed in predetermined periods. This type of maintenance allows the guarantee of a service with quality, as its main basis is the systemic application with analyzes that are carried out through supervisions, aiming at the reduction of preventive and corrective maintenance.

Kardec and Nascif (2009) affirm that the detective maintenance has appeared with the objective of increasing the availability of equipment for operation, helping in a more effective control of the maintenance process. This method began to be widely used in the 1990s, having as a definition, to be a type of maintenance capable of detecting possible failures that are not perceived during the occurrence of the operation.

3. TPM (TOTAL PRODUCTIVE MAINTENANCE)

According to Fogliatto and Ribeiro (2011), total productive maintenance (TPM) is defined as a maintenance control method capable of providing the company a place where the continuous improvement of its entire production process can be achieved, avoiding the occurrence of possible equipment failures. The total productive maintenance is characterized by the use of the modern Japanese method, since its origin occurred in 1951, when preventive maintenance was implemented in Japan by a company of Toyota grou:

According to Corrêa and Corrêa (2007), the implementation of the TPM concept within companies must occur gradually, analyzing the real use of the equipment and people involved in the process, as well as the need to restructure the entire organization, aiming that everyone participates in this transformation, achieving the established goals.

According to Corrêa and Corrêa (2007), the advantages of the use of total productive maintenance are numerous and can be obtained in a medium period of time, depending on the acceptance and level of commitment of each one in carrying out their activities. According to the authors, the advantages of TPM are related to the reduction of costs with maintenance, a better level of technical qualification of its employees and a constant improvement of their processes, causing the frequency of equipment damage to be reduced.

According to Takahashi and Osada (1993), the TPM concept is implemented in four stages: Organization, introduction of the philosophy, execution of the system and consolidation. From the data generated after the implementation of the total productive maintenance, it is necessary to define which are the activities that must be carried out in order to reach the established objectives.

4. QUALITY TOOLS

For Chase, Jacobs and Aquilano (2006), the cause and effect diagram (Ishikawa) is a tool that helps to diagnose root causes of a given problem by providing information for management decision making. The authors reiterate that the performance of this tool demonstrates in an objective way the direct relations between the problem in question and the causes that lead to this occurrence. The diagram is composed of six Ms (method, mother nature, material, machine, man/mindpower, measurement).

Ritzman and Krajewski (2004: 110) say that one of the major strengths of this tool is the ability to link each aspect of quality from customer value to inputs, methods, and process steps that specifically contribute to a product. The cause and effect diagram is often referred to as a “fishbone diagram”. An analyst, using the cause and effect diagram, is able to identify all the major layers of potential causes of quality problems, and may be related to machinery, personnel, processes, and materials.

Chase et.al (2006) states that the Pareto diagram is characterized as a tool that makes it possible to measure the causes that happen most frequently of a given problem, showing through columns the disposition of factors decreasingly, so that it becomes possible to prioritize the most relevant ones. This managerial method of support is based on the survey and the discovery that the highest percentages of a problem is linked to the small number of causes.

Marshall *et al.* (2012: 76) describes that the Pareto diagram is a tool that deals with problems concerning the quality of products and processes, which are classified as little vital and very trivial. Pareto assists in clarification of fundamental issues within the uncountable problems that may occur in business sectors, this is used in cases where it is necessary to find or demonstrate the significant value of information or data obtained in organizational environments.

According to Carpinetti (2012) 5W1H is one of the management tools that helps in elaboration of actions that must be performed for the causes of the problem to be solved, through the diagnosis of Pareto and Ishikawa diagrams. This methodology allows a better management of actions that will be executed, implementing an optimal level of responsibilities and organization of the proposed activities. The 5W1H is divided as: a) What - what will be done? b) Why - why will it be done? c) Where - where will it be done? d) Who - who will be responsible? e) When - when will it be done? f) How - how will it be done?

César (2011: 122) points out that when using the tool, it must: a) refer the decisions of each step in the development of activities; b) identify what should be done and who should be performing the tasks. The author also states that, as simple as they are, the essential prerequisites for building a 5W1H are the formation of a group of people; and a leader who can guide the various activities for each individual.

5. ADMINISTRATION OF PRODUCTION AND HOSPITAL ENGINEERING

The administration or management of production is the act of managing resources to be allocated to production and availability of goods and services, aiming to satisfy the needs of potential customers. The production function is responsible for this activity in the company. Each and every company has a sector or production function, simply because they all produce some type of product and/or service. However, not all types of firms necessarily call the production function by this name (other expressions such as “operations”, or “production” instead of “production function” can be used) (Slack, Chambers and Johnston, 2009: 4).

Maximiano (2015: 44) states that in 1903, with the intention of proposing his administration philosophy, Taylor propagates the study of Factory Operations Administration, which covered four principles: a) The purpose of good administration is in to pay high wages and have low production costs; b) From the first principle, the administration should apply research methods, determining the best way to perform tasks; c) Employees should be scientifically selected and trained in order that the tasks and people to be compatible; d) There would have to be an intimate and cooperative environment between administration and employees, so they could guarantee a psychological atmosphere in favor of the application of these principles.

Ritzman and Krajewski (2004: 5) show that the administration of operations refers to the direction and control of processes that work to transform inputs into products and services. In an extended way, the administration of operations is placed at the base of the functional sectors of an organization, because the processes are present in all the organizational services. It is fundamentally important to manage operations with a broad and limited vision for each sector of an organization, because it is only through administration or successful management of people, capital, information, and materials that it can finally achieve its goals.

Within any organization, the system of productive processes must be present, so that they can employ and transform resources, to provide goods and services to customers or target audience. In this supply of products, inputs are transformed through the activities of people and the use of machinery, for example: bread and automobile production. During the service, clients can be processed and transformed, according to the branch of the company, as an example of this we have: patients who are treated in hospitals or students who obtains education in certain schools. Therefore, the main models of production processes are divided into three categories: mass production, production by continuous process and unit production and/or in small lots (Maximiano, 2015: 7).

According to Salu (2013: 187), hospital engineering is defined as a set of human and technological resources, with responsibility for planning, operation and maintenance of the infrastructure. Clinical engineering is a characteristic of hospital engineering, responsible for equipment used in surgical procedures and diagnostics in medical equipment.

According to Moura and Viriato (2008: 39), the technological advance promoted the development of equipment that was able to improve the quality of health services, however, it is important to note that the increase of new technologies causes a strong economic impact in the provision of health services, due to the costs of operation and maintenance. With this, it becomes important to maintain a good management in the useful life of these equipments. And in order to maintain this good management, many health facilities adopt the implementation of Clinical Engineering, seeking to maintain a good standard of quality. The main procedures that involve this management are acquisition, installation, training of users, preventive and corrective maintenance.

For Moura and Viriato (2008: 42) Quality control in the management of hospital equipment is a fundamental step and consists in the use of standards to measure their development. The technicians have an indispensable function in the maintenance, keeping the care and zeal of the state of equipment conservation, with the accomplishment of cleanings, decontamination etc.

6. METHODOLOGY

This paper is about a case study carried out in a medium-sized private hospital, where data were collected regarding the hospital equipment maintenance process. The study has a quantitative character, using the observatory method of research, which allowed to enumerate the causes of the problem in question. In the view of Gil (2008) the observatory method of research assists in a high level of accuracy of the most relevant problems within a process. Regarding the objective of the study, the research has as characteristic the descriptive-explanatory method, since it is used techniques and tools of the area of maintenance management, so that the determination of which factors can be obtained the high occurrence of a certain phenomenon.

The research is divided into four stages, being the first one the bibliographic study on the subjects relevant to the paper, the second stage is composed of the data collection, obtained through the observation of internal documents of the hospital, in order to measure, from the diagram of Pareto, the most frequent causes of hospital equipment failure. The third stage is composed of the investigation of roots that take the most common causes, through the Ishikawa diagram. In the last stage an action plan (5W1H) was developed to improve the causes found.

7. THE HOSPITAL CASE

The hospital covered in the study is from the private sector, located in the city of São Luís - MA and has an advanced surgical center and modern equipment, plus 50 beds for hospitalization. The maintenance sector has 5 employees, responsible for the services that are performed in hospital equipment. The high frequency of machine failure has caused a great amount of corrective maintenance, with an average of 11 per month and an approximate cost of R $ 5,000.00 reais, which directly influences the quality of the procedures (exams, consultations, surgeries) that are daily performed in the hospital.

The following figure demonstrates the steps that are followed to perform hospital maintenance activities.

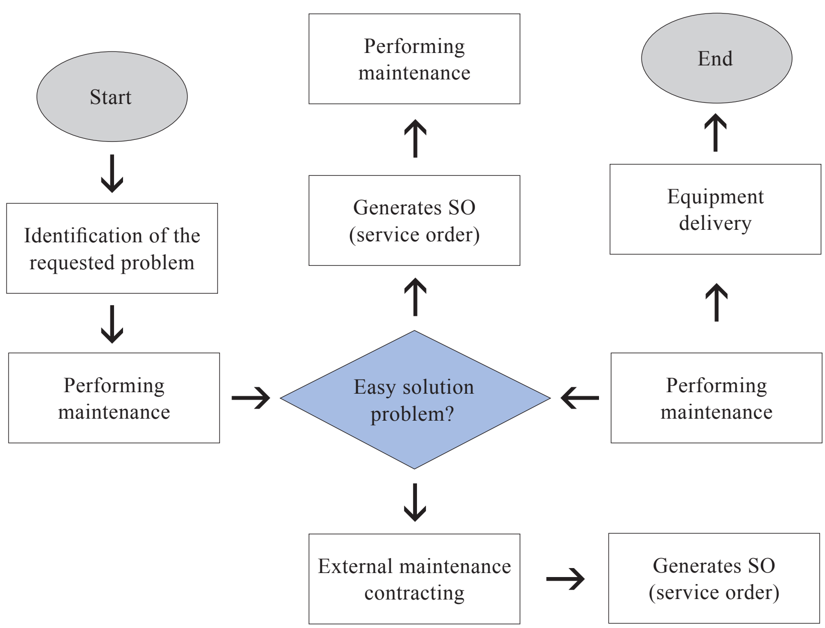

Illustration 1 – Flow of hospital maintenance process

For the investigation of the causes that lead to the problem, it was used the SO (service orders) of the maintenance area of the hospital where the study was developed. Based on the collected data, it was made an investigation of the main causes that lead to high frequency of hospital equipment failure. The research took into account 45 services orders, made available by the maintenance industry for the analysis of the study, due to demonstrate a high frequency of damage according to the survey made by the responsible sector, and the service orders refer to the first four months of the year 2016. Among the most relevant causes are:

a) Equipment Failure: Refers to failures resulting from nonfulfillment of preventive maintenance, which end up leading to equipment failure;
b) Wear of part: Refers to wear beyond the intended wear of a part or component of the equipment;
c) Abuse in use: Refers to the use beyond the capacity of the equipment, generating an overload, which causes failures;
d) Operating errors: Refers to the incorrect use of the equipment, generated by lack of knowledge in the operation carried out, causing failures or lack of control of the equipment;
e) Bad contact: This refers often to installation problems, due to the space where the equipment is not suitable for its full performance;
f) Other causes: Refers to causes that occur with almost no frequency, for example: leaks, lack of calibrations, among others;

To measure the causes of equipment failure, the Pareto diagram was used, according to the check sheet (Illustration 2).

REASON	NUMBER OF OCCURRENCES	ACCUMULATED CASES	UNITARY PERCENTUAL	ACCUMULATED PERCENTUAL
EQUIPMENT FAILURES	15	15	33,33	33,33
PEACE WEAR	10	25	22,22	55,55
OPERATION ERRORS	7	32	15,15	71,10
ABUSE IN USE	5	37	11,11	82,21
BAD CONTACT	5	42	11,11	93,32
OTHER CAUSES	3	45	6,68	100
TOTAL	45		100	

Illustration 2 – Problem Causes Check Sheet

Illustration 2 represents the causes diagnosed and their respective number of occurrences, and the order of the factors is in decreasing form.

The Pareto chart was drawn from the check sheet (Illustration 3) where it was possible to find the two causes with the highest frequency, resulting in a high rate of hospital equipment breaks, being the sum of both 55.55% of all the causes that directly influence this high index.

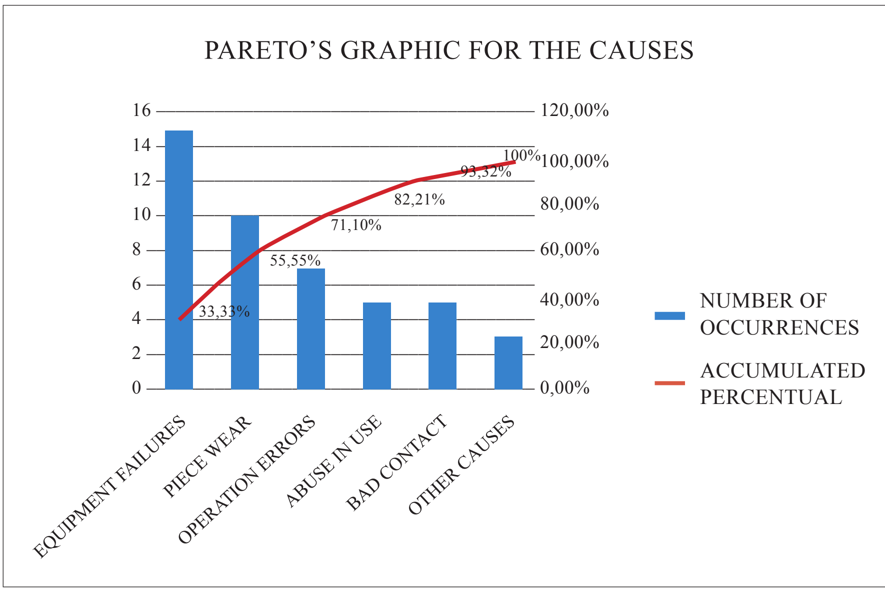

Illustration 3 – Pareto of the causes of problem

Graphic shows that the two main causes were: equipment failure and wear of the part. To find the roots that lead to the high rates of these causes, it was elaborated an Ishikawa diagram obtained through the information collected in the previous stage.

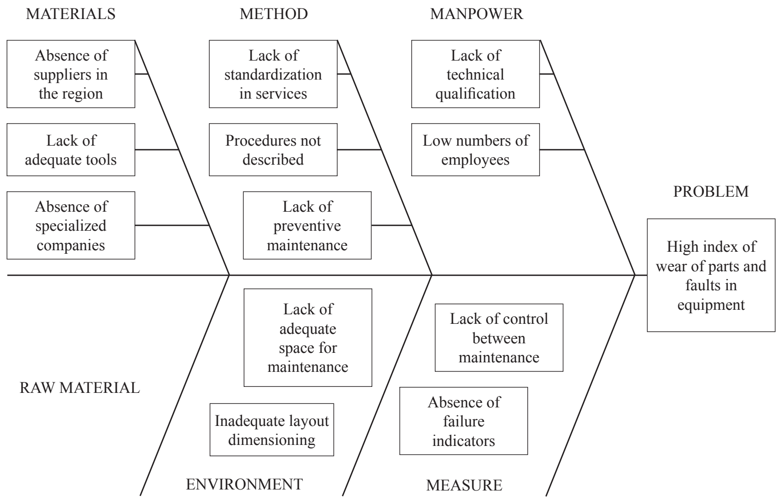

Illustration 4 – (Ishikawa diagram) demonstrates the root causes of the two most frequent problems.

After analyzing the causes found in the previous step, a plan of action for each one of the six Ms (method, mother nature, material, machine, man/mindpower, measurement) diagram was drawn up through the Ishikawa, from the 5W1H matrix with the objective of improving the management of hospital equipment maintenance. The matrix table 5W1H (APPENDIX A) represents the six actions that will be performed in the maintenance area. Indicating what will be done in each proposed action and the objectives of each one of them, also the responsible, in which place will be carried out and how it will be implemented and the status of the actions.

8. FINAL CONSIDERATIONS

From the studies discussed in this paper, it was possible to observe that with the implementation of the 6 proposed actions, it is possible to reduce the frequency of hospital equipment breaks and to increase the reliability and quality of the processes, and to cause future improvements in the management of activities which are performed in the maintenance area, thus attending the general aim defined for the study.

However, it worth to highlight that the culture and philosophy of organizations have been changing over the years and digital transformation has been contributing to this. It is notable the concern from part of the top management with the problems generated by an inefficient maintenance, so the search for the continuous improvement of the processes became fundamental part in the expected objectives, always seeking to analyze quality indicators and propose new work techniques, as a way to optimize operations and eliminate the bottlenecks of poor management.

This research aimed to show clearly and objectively that the maintenance in the current day in the middle of the constant digital transformation is an area of great relevance within any organization, often serving as a decisive factor for the decision making by the managers, so managing these activities is essential to achieve the goals set by the company.

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APPENDIX A - 5W1H Matrix Table

Action Status: 🔴 **Pending** 🟡 **In Progress** 🟢 **Realized**

What?	Why	Where?	Who?	When?	How?	Action Status
Qualification of manpower and increase of employees.	Improvement in the quality and reliability of maintenance processes and services.	Hospital	Hospital direction	January/2017 to October/2017	Courses and lectures in the area of hospital maintenance	🔴
Elaboration of maintenance procedures	Improvement of standardization and execution of maintenance activities	Hospital	Hospital direction	August/2016 to March/2017	Describing the steps that must be followed to perform the maintenance of each hospital equipment	🟡
Development of a preventive maintenance plan	Reduction of occurences of failures and use of corrective maintenance	Hospital	Hospital direction	August/2016 to March/2017	Establishing the preventive maintenance period for each equipment	🟡
Construction of an area for maintenance.	Improvement of maintenance services, providing an area for realization the procedures	Hospital	Hospital direction	July/2017 to December/2017	Hiring an engineering company	🔴
Implementation of a maintenance control system	Increase of reliability and control of maintenance processes	Hospital	Hospital direction	August/2016 to July/2017	Acquisition of a hospital maintenance software	🟡
Partner with parts and equipment suppliers.	Decrease spare time of damaged parts	Hospital	Hospital direction	January 2017	Developing loyalty to suppliers	🔴

Mapping Ergonomic Risks: An Application in an Electronics Manufacturer

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ABSTRACT

Various types of risks can be encountered in manufacturing companies. Before these risks arise, it is very important to identify them, to prevent them if possible, or to form a strategy to mitigate them. Managers are increasingly more interested in improving their risk management activities. A major category of industrial risks is the ergonomic risks such as inappropriate working posture, heavy lifting, repetitive motion and environmental ergonomic risks. In this study, we proposed a systematic procedure to map ergonomic risks and developed a visual tool for managers to be used as part of their ergonomic risk management system. The proposed systematic procedure starts with creating a work group and then identifying ergonomic risk factors. Next, appropriate methods are chosen to assess ergonomic risks and assessment is performed. Finally, the findings of the assessment are visualized. We exemplified the use of this procedure and development of the visual tool by conducting an application in an electronics manufacturer. The visual tool developed in this study enables managers to more easily and effectively review and control ergonomic risks and take necessary actions promptly. Implications for practice are discussed.

KEYWORDS: Risk mapping, Ergonomics, Manufacturing sector.

1. INTRODUCTION

Today, organizations that want to improve their position in the market are moving towards globalization. In addition to this shift, rapid technological developments also affect the industry. The increasing use of technologically intensive industrial operations provides a competitive advantage in the market and also intensify the human-machine interaction significantly. This interaction has begun to be examined in more detail and new regulation studies have emerged (Pincus *et al*., 2018). In this context, ergonomics is the most relevant discipline for investigating human-machine and human-environment relations. Ergonomics is a discipline that aims to protect the anatomical, physiological and psychological health of the employee while optimizing the workload that the employee can carry out and the work power that the employee can show performing this work, thereby increasing productivity (Zare *et al*., 2016). The ever more competitive environment and increasing need for efficiency have stressed the importance and necessity of ergonomic assessment in work.

In today's competitive working environment, organizations need to cultivate and develop themselves in every way. Although the primary goal of the enterprises is to make profits, studies should be carried out to increase the productivity by protecting the anatomic, physiological and psychological health of employees. At this point, ergonomic risk management activities become increasingly important for managers. The science of ergonomics can provide managers effective tools to help them manage ergonomic risks (MacLeod, 2006).

In this study, a visual tool is developed for managers to be used as part of their ergonomic risk management system. When used together with the traditional ergonomic risk assessment activities, this visual tool enables managers to easily see the areas with the greatest risk in the work environment and take actions more quickly. The development process of this tool is explained in detail by conducting an application in an electronics manufacturer. The structure of the paper is as follows. In the next section, information on ergonomics, risk mapping and ergonomic risk mapping are given. Following this conceptual background, the development process of the visual tool is explained with an application in an electronics manufacturer. Finally, the paper is concluded including a discussion on the implications for practice.

2. CONCEPTUAL BACKGROUND

2.1. Ergonomics

The science of ergonomics develops necessary methods by using information from anatomy, physiology, psychology, sociology and engineering to design, assess, improve work systems in which feasibility and convenience of work done by employees are secured and the limits that employees can work in an effective and healthy way are considered (Waterson, 2016). People spend an average of eight to ten hours a day at work. This time slot corresponds to one third of the day and is quite a long time. In this time period, the worker's physical discomfort may cause psychological stresses as well as serious health problems (Choobineh *et al*., 2009).

In order to work at high efficiency rates without sacrificing health, the physiological capacities of the employees must be protected ensuring compliance of the working environment or working tools with the human body (Kroemer, 2017). Therefore, ergonomic design of layout, work conditions, tool and equipment arrangements are necessary to provide optimum efficiency. Only by this way, employees can avoid health problems caused by their job, in both the short and the long term. Working in accordance with the physical capabilities of the employees will make them happier and more motivated as they will not get tired and suffer from health problems.

Ergonomic considerations increase workers' morale, takes safety and productivity-enhancing measures, and do so by taking human behavior and work environment into account considering psychosocial factors (Zare *et al*., 2016). The employee wants to feel himself as an important and necessary person for the organization. Monotonous work is not a work preferred by employees. If the workers job does not satisfy him, he may lose motivation and not do the job properly by thinking that the job is not necessary at all. Managers should be cautious to show all the employees the unique contribution of the work they do within the entire work so as to make them give meaning to their job (Dirkse van Schalkwyk and Steenkamp, 2017). If necessary, the work description should even be expanded or enriched to make the worker feel necessary and sufficient.

2.2. Risk Mapping

The basic definition of risk can be considered as the possibility of danger. These possibilities may arise in the future as a result of internal and external factors and affect the fulfillment of the purposes and objectives of management (Rausand, 2013). Therefore, they should be managed.

The scope of risks can be very wide (i.e. individual, company, country) and the risk level is different for every situation. For this reason, studies on risk analysis should consider probabilities of realization of risks and their possible effects.

Risk mapping is the visualization of the risks that are identified according to their priority values compared to each other. This visual tool can be graphical, tabular, colored map and so on. Risks are scored and visualized accordingly. The main goal of risk mapping is to reduce danger and uncertainty. Information on the size of risks are obtained through systematic identification and evaluation of risks. Risk mapping is used to determine which risks are significant in which regions. It helps to prioritize improvement and development work to be done. It also helps to reduce possible losses.

Each sector has its own risks. The concept of risk mapping can be adapted in a manufacturing plant, construction company, bank, hospital, a new enterprise etc. Risk mapping can be used in various areas, for example obtaining information about earthquake zones (Cografyaharita, 2015) and forest fire regions (Cografyaharita, 2015), landslide regions (Lee *et al*., 2016) in a country.

2.3. Mapping Ergonomic Risks

Risk maps can also be used to better understand the working environment in terms of ergonomic risks. An ergonomic risk map is a graphical representation of the location of various ergonomic workplace hazards that can cause injury, damage, or musculoskeletal disorders to employees in the workplace. Ergonomic risk mapping is a useful technique because it allows identifying potential hazards and prioritizing them. It is easier to see where the focus should be to make improvement (Bolis *et al*., 2014). In several studies, risk maps of working environment for individual risks are drawn, for example for noise (Akçın *et al*., 2015; Lázaro *et al*., 2012; Soundplan, 2015), heat insulation, dust and electromagnetic pollution (Akçın *et al*., 2015).

Mapping ergonomic risks is a method that can be applied in all areas in industry. The riskiest areas where improvement actions should be taken are made directly visible and this information provides guidance to managers. In sections where priority is high, urgent improvements can be achieved without losing time. This, in turn, prevents problems that may arise and prevent worker or factory damage.

3. APPLICATION

3.1. Aim of the Study

The aim of this study is to develop a visual tool for managers to be used as part of their ergonomic risk management system. The systematic procedure followed in this study to develop a map of ergonomic risks is given in Illustration 1. The development process of this visual tool is explained in detail by conducting an application in an electronics manufacturer.

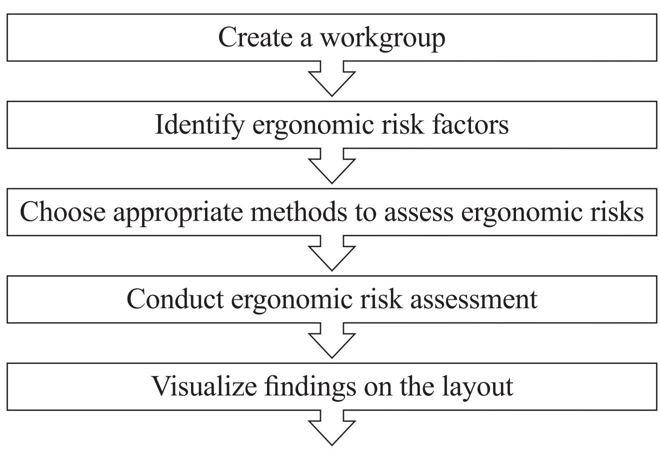

Illustration 1 - Systematic Procedure to Mapping Ergonomic Risks

3.2. Company Profile and Information on the Department

The case company was an electronics manufacturer based in Turkey at an industrial zone, established in 1984. Case company is one of the leading companies in electronics sector in Europe. Its product categories include television, smart phone and computer. Approximately, one million televisions are produced each month as the highest selling product of the company.

This study is therefore performed in the television manufacturing section of the company where production continues three shifts a day. Television manufacturing section has seven departments. These are metal press, plastic injection, styrofoam, chassis, final assembly, dyehouse and storage. After examining the company's infirmary records of accidents and inconveniences for each department for the last five years, it is decided to focus on the metal press department for this study.

In the metal press department, the back cover of the television is produced. There are four identical production lines in this area. Each production line begins with a roll driver. Metal sheet rolls are attached to the roll driver. Immediately after that six machines give different shapes to metal sheet. Metal sheet comes to its last shape in the metal washing machine. The washed metal sheet is checked and packed after various parts are assembled on it. Machines and stations in the production lines are respectively; metal sheet roller, sheet cutting machine, first press operation, second press operation, third press operation, fourth press operation, fifth press operation, sixth press operation, tapping, conveyor, metal sheet washing operation, conveyor, thermal foam assembly, tape assembly, card assembly, bar assembly, testing, bracket assembly, support assembly, screw assembly, final control, prepackaging and packaging. The production area is cleaned by the employees on a weekly and daily basis. The production area has a main gate opening to the hall. This door is used to control the personnel entering the production area. The hall connects other production, assembly and raw material stock areas.

3.3 Mapping Ergonomic Risks

In metal press department, a visual map of ergonomic risks was developed by following the systematic procedure given in Illustration1 above. First a workgroup was created. Then the risks were identified and assessed with suitable methods and the findings of this assessment were visualized on the department layout.

Creating a workgroup. As the first step in this study, a team of two occupational health and safety specialists, workplace physician, an operator, TPM specialist, production specialist and two ergonomics experts were formed.

Identifying ergonomic risk factors. Ergonomic risk factors in the metal press department were grouped under two headings, environmental and work related risk factors. Environmental risk factors included noise, illumination, vibration, and thermal comfort. Work related risk factors included inappropriate working posture (neck, trunk, leg, upper arm, lower arm, and wrist), overload lifting, and repetitive motion.

Ergonomic risk assessment. The following methods were used to evaluate *environmental egonomic risks*.

Noise. Noise factors in the production lines were press machines which perform 6 operations, tapping machine, washing machine, drilling machine used in assembly and conveying equipments. But the main factor is the press machine. In order to assess this risk, data on the amount of noise generated in the production area is obtained from OHS specialists and evaluated (See Illustration 2). A reference value of 80 dB was used for this evaluation.

Illumination. Daylight was not utilized in the metal press department where ergonomic examination was performed, artificial lighting was used. In order to assess the risk related to lighting, data on the amount of illumination in the production area is obtained from OHS specialists and evaluated (See Illustration 2). The following reference values are used for this evaluation, fully automated operations 50 lux, operations 200 lux, assembly 500 lux, quality control 750 lux.

Vibration. In the metal press production line there was vibration in the press machines, but the operator was working without any contact to the machine. For this reason, he was not affected by vibration. There was a belt conveyor in the section where manual assembly operations were done on metal sheet. Operators were not exposed to vibration during these operations. Vibration is therefore not considered as a risk factor in this investigation.

Sub-sections	**Noise value (dB)**	**Illumination value (lux)**
Metal sheet roller	88	50
Sheet cutting machine	89	180
First press operation	90	180

Second press operation	90	180
Third press operation	90	180
Fourth press operation	90	180
Fifth press operation	91	180
Sixth press operation	90	180
Tapping	90	190
Metal sheet washing operation	88	50
Thermal foam assembly	85	460
Tape assembly	83	480
Card assembly	80	470
Bar assembly	78	470
Testing	76	690
Bracket assembly	75	470
Support assembly	74	490
Screw assembly	74	480
Final control	73	700
Prepackaging	73	200
Packaging	72	190

Illustration 2 - Noise and Illumination measurement values of the sub-sections of the metal press department

Thermal comfort. The concept of thermal comfort includes air temperature, air humidity, air velocity and radiant heat. In the section where press machines operate, temperature value was observed an average of 21 ºC. In the assembly section average temperature value was observed to be 20 ºC. The moisture level in the geographical region where the company is located was not high, so the amount of moisture in the air was not adversely affecting the workers. Due to generous space between the production lines in the metal press section, proper conditions were established in order to provide sufficient air flow. When the production line was examined in terms of radiant heat, there was no direct contact with the machine and the semi-finished product in the section where the metal press machines were located. In terms of OHS, the machines were surrounded by iron bars. For this reason, the employees do not get close to the machines. This caution significantly reduced the influence of the heat generated by the machine on the operators. In fact, radiant heat from the metal press machine was rather low when compared to the production lines where casting, heat treatment, hot forming operations are carried out. Considering these evaluations, it has been determined that the thermal comfort is also suitable in this department.

Radiation. As a result of the measurements made by the OHS, it has been determined that the metal press department does not carry the risk of radiation to adversely affect human life.

In this study, one of the systematic observational ergonomic risk assessment methods, namely Rapid Entire Body Assessment (REBA) method was used in order to evaluate musculoskeletal system discomfort risk that may be caused by *work related risk factors* such as inappropriate working posture, overload lifting, and repetitive motion (Hignett and McAtamney, 2000). All the operations performed in the metal press department are listed and for each operation operators were observed while doing their work, ergonomic risk assessment was conducted using REBA method and risk scores were calculated. The operations and respective risk scores are given in Illustration 3. The meanings of risk score colors used in Illustration 3 are given in Illustration 4.

Sub-sections	**Evaluated Operations**	**REBA Risk Scores**
Metal sheet roller	Machine control	3
Sheet cutting machine	Machine control	3
First press operation	Machine control	3
	Collecting burrs	6

Second press operation	Machine control	3
	Collecting burrs	6
Third press operation	Machine control	3
	Collecting burrs	6
Fourth press operation	Machine control	3
	Collecting burrs	6
Fifth press operation	Machine control	3
Sixth press operation	Machine control	3
Tapping	Machine control	3
Metal sheet washing operation	Machine control	3
	Salt spilling	11
Thermal foam assembly	Taking thermal foam	5
	Lifting tape	2
	Bonding	5
Tape assembly	Taking tape	5
	Lifting tape	2
	Bonding	5
Card assembly	Taking card	5
	Mounting card	4
Bar assembly	Taking bar	4
	Mounting bar	4
Testing	Surface control	5
	Reversing metal cover	5

Bracket assembly	Take bracket	5
	Put bracket	4
Support assembly	Take support	4
	Put support	4
Screwing	Take screw	4
	Screwing	4
Final control	Surface control	5
	Reversing metal cover	5
Prepackaging	Take a package	5
	Packaging	4
Packaging	Putting packed products in large boxes	5
	Packaging large boxes	4

Illustration 3 - Operations for which ergonomic risk assessment was performed

Very high risk	
High risk	
Medium risk	
Low risk	
No risk	

Illustration 4 - Ranking of risk scores according to colors

It is seen from Illustration 3 that the burr collecting operations in the metal press production line carry a moderate risk. The salt spilling operation in the metal sheet washing section was identified as the region with the highest risk score. All other work done in the assembly section, except for tape lifting, has received a medium risk score. Machine control operations fall into the low risk group.

In Illustration 5, a summary of the environmental and work related risk assessment values are given.

Sub-sections	**Noise (dB)**	**Illumination (Lux)**	**REBA Analysis**							
			Evaluated Operations	**Body Part Assessment**						**REBA Risk Scores**
				Neck	**Trunk**	**Leg**	**Upper Arm**	**Lower Arm**	**Wrist**	
Metal sheet roller	88	50	Machine control	1	2	1	2	1	2	3
Sheet cutting machine	89	180	Machine control	1	2	1	2	1	2	3
First press operation	90	180	Machine control	1	2	1	2	1	2	3
			Collecting burrs	2	3	2	3	2	1	6
Second press operation	90	180	Machine control	1	2	1	2	1	2	3
			Collecting burrs	2	3	2	3	2	1	6
Third press operation	90	180	Machine control	1	2	1	2	1	2	3
			Collecting burrs	2	3	2	3	2	1	6
Fourth press operation	90	180	Machine control	1	2	1	2	1	2	3
			Collecting burrs	2	3	2	3	2	1	6
Fifth press operation	91	180	Machine control	1	2	1	2	1	2	3
Sixth press operation	90	180	Machine control	1	2	1	2	1	2	3
Tapping	90	190	Machine control	1	2	1	2	1	2	3
Metal sheet washing operation	88	50	Machine control	1	2	1	2	1	2	3
			Salt spilling	2	3	4	3	2	2	11

Thermal foam assembly	85	460	Taking thermal foam	2	3	1	2	1	2	5
			Lifting tape	1	1	1	1	2	2	2
			Bonding	2	2	2	2	1	2	5
Tape assembly	83	480	Taking tape	2	3	1	2	1	2	5
			Lifting tape	1	1	1	1	2	2	2
			Bonding	2	2	2	2	1	2	5
Card assembly	80	470	Taking card	2	3	1	3	1	2	5
			Mounting card	2	2	1	2	2	1	4
Bar assembly	78	470	Taking bar	2	2	1	2	2	1	4
			Mounting bar	2	2	1	2	2	1	4
Testing	76	690	Surface control	2	3	2	2	2	2	5
			Reversing metal cover	1	2	1	4	2	2	5
Bracket assembly	75	470	Take bracket	2	3	1	3	1	2	5
			Put bracket	2	2	1	2	2	1	4
Support assembly	74	490	Take support	2	2	1	2	2	1	4
			Put support	2	2	1	2	2	1	4
Screwing	74	480	Take screw	2	2	1	3	1	1	4
			Screwing	2	2	1	3	2	1	4
Final control	73	700	Surface control	2	3	2	2	2	2	5
			Reversing metal cover	1	2	1	4	2	2	5
Prepackaging	73	200	Take a package	2	3	1	2	1	2	5
			Packaging	1	2	2	2	1	2	4
Packaging	72	190	Putting packed products in large boxes	1	3	1	3	2	2	5
			Packaging large boxes	1	2	1	3	2	2	4

Illustration 5 - Summary of ergonomic risk assessment

Visualizing findings on the layout. After assessing all the ergonomic risks in the metal press department, a map of ergonomic risks was drawn to visualize the risk scores. First of all, layout of the metal press department was obtained. Then for each operation, environmental and work related risk scores were shown using figures and colors. AutoCAD 2016 program was used for the drawings. Illustration 6 shows the overall ergonomic risk map of the metal press department. For the purpose of readability, the dotted section of the map is enlarged in Illustration 7 as an example. The legend used in this map is also given in Illustration 8 As seen from these figures environmental risk factors were depicted with different shapes and color codes were used for risk score levels; work related risk assessment was visualized according to body parts and again color codes were used.

The ergonomic risk map developed in this study, visualizes all the risks and their levels on the layout and provide managers a very efficient way to observe, control and trace ergonomic risks and also take necessary actions on time. When we look at Illustration 7 we can immediately notice that there are problems with high level of noise in the section where press machines are located, also there are problems with the illumination in some parts of the assembly section. Additionally, we can easily see which body parts of the operations are also under risk for each operation.

4. CONCLUSION

In this study, the process of designing a visual tool for ergonomic risks was explained. The way and the method to be followed to carry out this work are explained in detailed. First, the concepts of ergonomics, risk mapping and ergonomic risk mapping were examined. A systematic procedure to mapping ergonomic risks was developed. Following the steps in this procedure, the ergonomic risk mapping study has been described.

Firstly, the company and the department, where this study was conducted, was introduced. Risk factors related to this department were identified. Noise, lighting, vibration, thermal comfort, and radiation values were evaluated according to environmental ergonomic criteria. These values were compared with the values that should be in line with ergonomic conditions. This assessment has been visualized on the layout of the production line.

REBA, which is a systematic and observational ergonomic risk assessment method, was used to evaluate work-related risk factors. The risk scores of all operations were determined using this method.

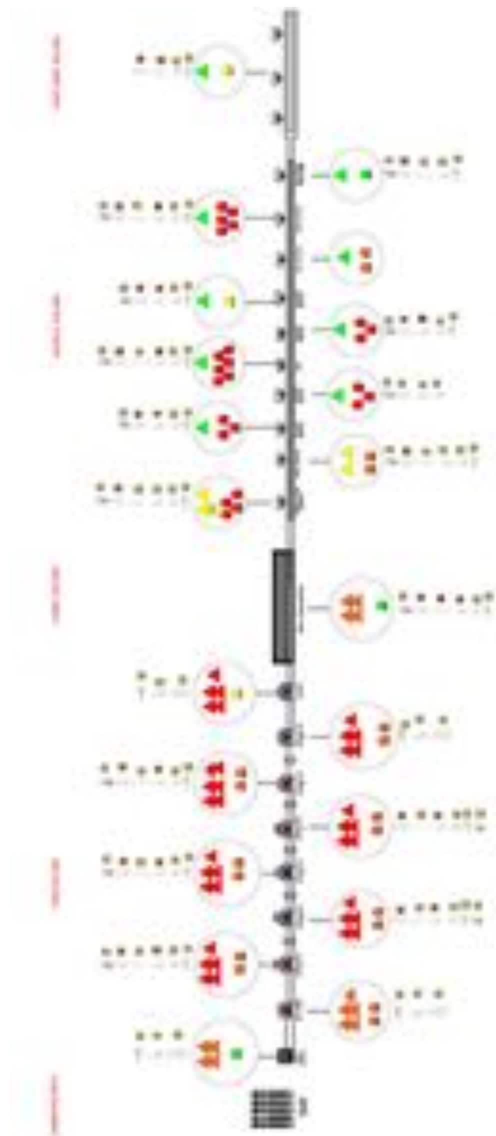

Illustration 6 - Ergonomic risk map of the metal press department

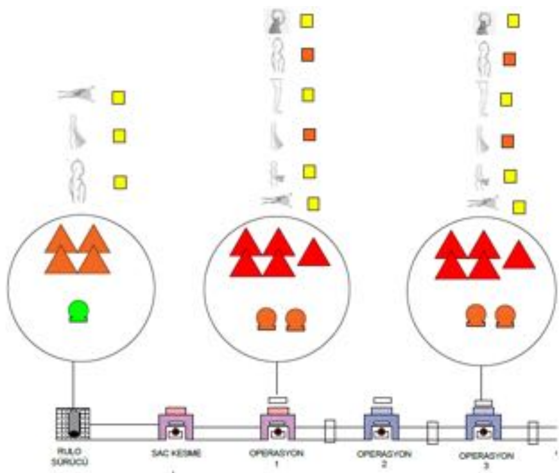

Illustration 7 - An example section of ergonomic risk map of the metal press department

Symbol			Color scale	
Figure Shape	Meaning	Explanation	Color	Explanation
	Noise	Each symbol represents 2dB of surplus value over 80dB		More than 90dB
				Between 89dB and 85dB
				Between 85dB and 80dB
				Less than 80dB
	Illumination	Each symbol represents 10lx of lacking value from the necessary illumination		20lx-50lx less than required
				10lx-20lx less than required
				0lx-10lx less than required
				Same as required
	Neck			
	Trunk	+ 4 risk score		
	Leg	+ 3 risk score		
	Upper arm	+ 2 risk score		
	Lower arm			
	Wrist			

Illustration 8 - Legend used in the ergonomic risk map

Hereby, ergonomic risks were assessed using appropriate methods and findings were visualized on the layout of the production line in addition to environmental ergonomic assessment. The ergonomic risk map, in which all inspections, evaluations and results were visualized according to the level of risks, has been completed.

This study has important implications for practice. Managers are increasingly more interested in improving their risk management activities. A major category of industrial risks is the ergonomic risks. The visual tool developed in this study can be used by managers as part of their ergonomic risk management system. This tool enables managers to more easily and effectively review and control ergonomic risks and take necessary actions promptly. Managing ergonomic risks is not only important at company level but also important at national level. Efforts to examine working conditions, improving them, increasing work efficiency while protecting workers' health, safety and wellbeing, reducing occupational discomforts and work accidents would have a significant contribution to the development of national economies.

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Online Quality: Analysis of Retail Websites Based on Non-Functional Usability Requirements

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ABSTRACT

This study aimed at analyzing two retail websites based on non-functional usability requirements. Information and communication technologies (ICTs) have increased transactions, despite problems involving their interface with users. The theoretical framework discusses aspects of information system quality and usability, with a focus on non-functional requirements. Two websites were selected (Website 1 and Website 2) with negative and positive assessments on the Reclame Aqui (Complain Here) website, respectively. This is a descriptive study using a qualitative approach. Although the results show a slight difference in non-functional usability requirements between the two websites, precluding a direct association with Reclame Aqui assessments, it is important to underscore aspects related to customer-perceived values. In addition to a synthesis of the study, final considerations present a number of suggestions for future research.

KEYWORDS: Online retail, Non-functional requirements, Usability.

1. INTRODUCTION

Information and communication technologies (ICTs) are increasingly permeating and changing the daily lives of individuals. An example of this is electronic commerce (e-commerce), which has revolutionized the retail market through the use of devices such as computers and smartphones connected to the internet to make long-distance purchases. Using e-commerce, customers can simply access the supplier's or retailer's website to visualize the products available, select items of interest, payment method and specify where they want to receive them. As such, in terms of purchasing, individuals use ICTs to increase efficiency and reduce effort.

This basic script for an online purchase seems to be simple, and can theoretically be done by anyone with a minimum of knowledge in using a device connected to the internet and accessing the respective website. However, in practice this process has proven to be less straightforward, with several aspects hindering these types of transactions, some of them related to the user's interface with the site.

In this respect, perceived website quality is associated with user satisfaction, not only with technical elements, such as privacy, security and accurate information, but also non-technical aspects that enhance the navigation and purchase experience. These two categories, technical (or utilitarian) and non-technical (or hedonic), improve website characteristics such as ease of use and usability (Bauer *et al*., 2006 and Gorla *et al*., 2010). Thus, the perceived quality of a website influences perception of the online services provided, thereby impacting the performance of e-commerce companies (Ferreira and Leite, 2003).

This study conducts a thorough and more specific investigation, requiring a more qualitative approach for analysis (Assis and Moura, 2011). A number of literature studies used surveys, which did not conduct an in-depth analysis (Ghasemaghaei and Hassanein, 2015). According to Arazy and Kopak (2011), the subjective nature and differences in individual perceptions make information quality difficult to measure.

Developers sometimes do not consider aspects related to usability from a website user's perspective, which could impact not only on the perception of information quality, but also quality of the system itself, and may influence perception of the service provided (e-service). As such, this study aimed at analyzing the usability of retail websites using the taxonomy proposed by Ferreira and Leite (2003) and Ferreira *et al*. (2008).

The following sections discuss the concepts and perspectives associated with the quality of website information systems and the functional and non-functional requirements of usability, as well as the methodology applied. The results will assess the two retail websites selected. Final considerations will highlight the main findings, limitations and proposals for future research.

2. BACKGROUND REVIEW

2.1. Quality of Information Systems

According to Yang *et al*. (2005) and Bauer *et al*. (2006)these scales do not fully cover all aspects of consumer's quality evaluation. In order to integrate both utilitarian and hedonic e-service quality elements, we apply a transaction process model to electronic service encounters. Based on this general framework capturing all stages of the electronic service delivery process, we develop a transaction process-based scale for measuring service quality (eTransQual, in light of the new perspectives of quality on the web and the multidimensionality of its concepts (whose hedonic elements have increased based on the subjective perceptions of customers), quality on the web, defined as system quality (SQ), information quality (IQ) and service quality (SQ) (Ahn *et al*., 2007), is influenced not only by utilitarian factors of quality but also hedonic aspects (Seo *et al*., 2017).

Given that a website is essentially an information system, its overall quality is influenced by the quality of its information, e-service quality and of the system itself (Negash *et al*., 2003). Furthermore, customers consider both functional (technical or utilitarian) and relational (or hedonic) aspects. Thus, the two quality constructs (system and information) can provide e-service quality (Ferreira *et al*., 2008 and Gorla *et al*., 2010). As such, the concept of system quality on the web should also be discussed from the utilitarian and hedonic standpoint.

From the utilitarian perspective, system quality is related to meeting the objectives of developers and users (Delone and McLean, 2003). It refers to a subjective belief in objects, which are expected to display certain attributes (Seo *et al*., 2017). In this respect, the authors underscore the contribution of marketing, which shows the need to consider the customers' viewpoint in relation to the functionality aspects of these systems.

Likewise, Yang *et al*. (2005) consider the perception of customers regarding delivery performance and information. According to the authors, this perception was analyzed using a number of instruments that measure the quality of a web system and the factors that identify quality were categorized into usability, accessibility, privacy/security and interaction.

With respect to the hedonic perspective, the quality of a web system is related to feelings of pleasure and enjoyment, promoted by the emergence of entertainment on the web and aimed at providing sensory stimuli. A system can be considered purely hedonic provided it displays a personal and/or social aspect that provides leisure and has no specific goals or objectives (Seo *et al*., 2017).

It is important to underscore that the two aforementioned approaches to quality on the web (hedonic or utilitarian) are relevant for any type of website, but will exert different influences depending on the purpose of the site (Lowry *et al*., 2013).

For sites aimed at communication and information availability, hedonic quality is more relevant (Yang *et al*., 2005). In relation to e-retail, the author emphasizes that because this system involves online transactions, the dimensions of perceived quality are related to functional aspects. However, hedonic aspects also influence perception (Lowry *et al*., 2013), since e-retail sites also provide information and communication (despite not being characterized as the primary utility), making elements such as usability (ease of use or design) and security are relevant for website quality (Yang *et al*., 2005).

In light of the concept of web system quality and considering the functional nature of online retail, the relevance of hedonic aspects in the perceived quality of a system, and the terminology of functional and non-functional usability requirements proposed by Pressman (2015), it is important to analyze website quality in the context of e-commerce.

2.2. Usability Rrequirements

Usability is defined as the quality of a system in requiring minimal user effort to understand its characteristics, allowing them to focus their attention on the task at hand (Ferreira and Leite, 2003, Norman, 1986 and Dias, 2003).

In other words, a system developed for usability must provide users with a "friendly interface" (Pressman, 2015 and Costa and Ramalho 2010), which is the ability of a system to not negatively interfere in achieving their goal of using the site (Dias, 2003 and Costa and Ramalho 2010).

Considering a website as a system, usability in this environment is associated with creating easy-to-navigate webpages, a characteristic that has proven to be increasingly relevant to users who, due to the wide range of options on the web, seek those that are the least complex (Parasuraman *et al*., 2005 and Nielsen, 2007).

Website development should adhere to certain user requirements, denominated functional and non-functional (Ferreira and Leite, 2003; Arazy and Kopak, 2011), which are closely linked to quality, or the lack thereof, in producing a final product, since they are part of planning strategies and software design (Pressman, 2015).

The functional requirements "describe what the system does, that is, the functions needed to achieve the objectives of the system" (Ferreira *et al*., 2008), while their non-functional counterparts involve the attributes of human interaction with the system, such as those associated with ease of use, which are often neglected by developers (Ferreira *et al*., 2008) and (Pressman, 2015).

Failure to adhere to non-functional usability requirements has a significant negative impact on user satisfaction because aspects associated with the interface between individuals and the system are some of the main indications of user perceived quality (Ferreira *et al*., 2008; Pressman, 2015).

Ferreira and Leite (2002) and Ferreira *et al*. (2008) report two sets of non-functional usability requirements for websites related to information display (consistency, feedback, skill levels, human behavior, human perception, metaphors, minimized memory load, functional classification of commands and design, regardless of monitor resolution) and data entry (help, error prevention and error analysis mechanisms). Illustration 1, in the methodological aspects section, presents a more detailed discussion of these requirements.

Functional and non-functional usability requirements and their relevance for perceived system quality are associated with literature studies involving online quality. In this respect, functional requirements, defined as what the system needs to function correctly and achieve the proposed objective, may be linked to with a more utilitarian perspective of perceived quality. As such, the perceived quality of a particular website would be associated with the system's achieving or not these requirements.

On the other hand, non-functional requirements, that is, those involving human interaction and easy use (or usability) of the system, may be related to a more hedonic perspective of quality, which provides users with a pleasurable navigation experience, contributing significantly to the perception of a user-friendly system.

Based on the concepts presented, this study aimed at assessing the quality of retail websites in terms of non-functional usability requirements. The stages and characterization of the study will be discussed in the next section, which describes the methodology used.

3. METHODOLOGICAL ASPECTS

This is a descriptive study that describes the characteristics of retail websites and assesses them in terms of their non-functional usability requirements. Data were analyzed qualitatively to provide an in-depth assessment of the specific situations of the sites evaluated.

The retail sites were selected by reading the general assessments on the **Reclame Aqui** (Complain Here) website (Reclame Aqui, 2017), which classifies companies according to complaints received from Brazilian consumers. The two retail websites were selected based on the criterion of which obtained the worst (Website 1) and best (Website 2) assessments and belong to different retail markets. In addition, the websites analyzed are linked to large companies that are highly representative in terms of E-commerce billing in Brazil (Sociedade Brasileira de Varejo e Consumo, 2018).

However, this difference did not compromise analysis since, despite recognizing that after-sales service is important for perceived quality (Parasuraman *et al*., 2005), the present study proposed to assess website usability without considering the details related to the service provided. As such, the websites selected did not necessarily sell the same products.

It is believed that the selection criterion used is relevant since it is based on the view that proposes the mutual influence of the system, information and service on perceived quality in the online environment (Ahn *et al*., 2007; Negash et al., 2003). It is important to underscore that most of the comments were related to the quality of the product itself and/or the after-sales service provided.

The criteria used to analyze the non-functional usability requirements of the two websites were those proposed by Ferreira and Leite (2002) and Ferreira *et al*. (2008), summarized in Illustration 1. It is important to note that, according to literature review there are few academic papers on the subject available and this framework has been proposed based on other authors (Foley, 1990, Laurel, 1990, Pressman, 1992, Tognazzini, 1995, Shneiderman, 1997; Nielsen, 2000), as well as their own experiences in consulting, which made these requirements considered as good references for the analysis of the present study.

Comparative analysis of the two websites was carried out in order to observe the similarities and differences in these requirements. The aim of this analysis was to observe the impacts of non-functional usability requirements of retail websites on user assessments. In other words, analysis of the websites sought to identify the similarities and differences between the non-functional usability requirements of the two sites analyzed and determine whether these requirements are related to website classification on Reclame Aqui.

Sets	Requirements	Description
Related to displaying information	Consistency	To be consistent, the menus, entry commands, information display and all the functions of an interface must have the same visual presentation and behavior.
	Feedback	Information provided during interaction between users and the machine must be planned and well programmed.
	Skill levels and human behavior	It is advisable that the website interface be accessible to by both experienced and new users.
	Human perception	To create an interface that can be used by different people, it must be able to present its content in different ways in order to accommodate a range of perceptions.
	Metaphors	User knowledge of the world should be exploited through metaphors involving familiar ideas, which makes interaction more intuitive and user-friendly.
	Memory load minimization	Interfaces should be designed to require the least possible user effort to memorize its features.
	Functional classification of commands	The presence of menus provides easier access to little used functions.
	Design independent of monitor resolution	One of the basic principles for good planning of sites independent of resolution consists of defining the appearance of components using percentages of available space, instead of designing elements with a fixed size.

Related to data entry	Help mechanisms	Help should be provided for every entry action, as well as tips when the mouse passes over an item so that users know the function of each item without resorting to the textual help system.
	Error prevention	A well designed interface must provide error prevention mechanisms, so that users do not select an invalid option and receive an error message.
	Error Correction	A good interface must allow the fastest possible error correction. This makes people more productive and encouraged to explore the system, which is an efficient way of learning the program features.

Illustration 1 - Non-functional usability requirements.
Source: Prepared by authors based on Ferreira and Leite (2002) and Ferreira *et al*. (2008).

After explaining the website selection criterion and pertinent aspects of the non-functional requirements considered, the next section describes and interprets the results of the study.

4. RESULTS AND DISCUSSION

4.1. Comparative Analysis of the Websites

Illustration 2 presents the results of the two websites using the taxonomy of (Ferreira and Leite, 2003; Ferreira *et al*., 2008), summarizing the main aspects of each item in relation to Website 1 and Website 2.

Sets	Requirements	Website 1	Website 2
Related to displaying information	Consistency	Variation in the number of items. Emergence of an unexpected horizontal bar	Inconsistencies related to hyperlinks and position of the bar displaying product categories
	Feedback	User help options dispersed and duplicated	Grouped help options, but with no online chat

Related to displaying information	Skill levels and human behavior	Too many textual resources, small icons and a number of difficult to understand figures	Simple interface. Presence of visual resources
	Human perception	No possibility of customization	Absence of customized elements
	Metaphors	Dissociated terms and images (ex.: print cart)	Clearly associated terms and images
	Memory load minimization	Too many textual commands	Good use of images
	Functional classification of commands	Confusion related to the horizontal and vertical arrangement of menus	Coherent and organized menu arrangement
	Design independent of monitor resolution	No variation in resolution or internet speed	No variation in resolution. Internet speed influences the exhibition of some images
Related to data entry	Help mechanisms	Existence of resources that help users enter information	Existence of resources that help users enter information
	Error prevention	Error message exhibition	Error message exhibition
	Error correction	Instruction on how to correctly use the search tool	No instructions on how to correctly use the search tool

Illustration 2 - Comparative summary between Website 1 and Website 2.
Source: The authors (2017).

With respect to the consistency requirement, Illustration 2 shows that both sites exhibited a number of inconsistencies regarding the arrangement of items in menus. In relation to feedback, Website 2 has better organized help options, but does not offer online chatting. According to RECLAME AQUI, Website 2 showed good customer responses, which may be related to the efficiency of its current channels, despite not having online chatting.

In regard to skill levels and human behavior, Website 2 has a simpler interface with consistent visual resources, while Website 1 contains many textual elements with difficult to associate images.

With respect to human perception, neither site offered customized resources and, according to Ferreira and Nunes (2008), the absence of these resources compromises accessibility, preventing disabled individuals from navigating the websites in question in an enjoyable manner.

In relation to metaphors, Website 1 does not put them to good use, in contrast to Website 2, which showed clear associations between images and texts. The same occurred with memory load minimization, since Website 2 makes good use of images.

As expected, the functional classification of commands was better perceived on Website 2, given that the superior menu arrangement and use of images enhances the functional perception of commands.

In terms of design being independent of the monitor, no changes in resolution were observed on either website; however, some of the images were incorrectly loaded on Website 2 when the internet speed oscillated. This may be because Website 2 uses more images, thereby increasing the amount of information loaded on its department and product pages.

With respect to data entry requirements, both Website 1 and 2 contained help and error prevention mechanisms; however, Website 2 gave no instructions on how to search correctly, in contrast to Website 1.

In general, Website 2 showed better assessment of non-functional requirements, where disregarding these factors is one of the primary causes of user dissatisfaction (Reclame Aqui, 2017), corroborating the RECLAME AQUI classification, which rated Website 2 as better than Website 1. Nevertheless, since no significant discrepancies were found between requirements for the two websites and the fact that that many of the comments are based on assessments of the quality of the purchased products and after-sales service, no correlation could be established between non-functional usability requirements and classification of the websites evaluated.

However, the study is relevant since the online retail purchasing process is not purely rational, where identifying aspects related to the esthetics of the website and searching for information are important in perceiving value (Gorla *et al*., 2010). In this respect, user acceptance has a direct influence on the purchase and intention to purchase (Ahn *et al*., 2007).

Although price may be the decisive factor in online purchases (Ghasemaghaei and Hassanein, 2015), communication and information delivery influenced the perceived quality of web systems, since they provide better perception of website usability (Yang *et al*., 2005).

5. FINAL CONSIDERATIONS

This study aimed at analyzing two retail websites in terms of non-functional usability requirements, as proposed by Ferreira and Leite (2003). To that end, concepts associated with the quality of information systems and usability were discussed, with an emphasis on their non-functional requirements.

The choice of websites considered customer opinions on the **Reclame Aqui** site, selecting one with predominantly negative assessments (Website 1) and one with positive comments (Website 2). The study concluded that Website 2 was slightly better than Website 1 in terms of non-functional requirements, precluding the possibility of determining any direct relationship between customer evaluations on Reclame Aqui and the usability of these websites.

However, as reported in the literature, the mutual influence of the components of quality in an online setting (Ahn *et al*., 2007; Negash *et al*., 2003), along with aspects such as esthetics, communication and information delivery on the websites may influence usability and the value perceived by customers (Yang *et al*., 2005; Gorla *et al*., 2010).

As such, the practical contribution of the present study is the comparative analysis between the non-functional requirements of two online retail websites. Managers of e-commerce websites can use this analysis method to compare their websites with those of their main competitors, thereby gaining a competitive advantage, provided they charge comparable prices.

We consider that the findings of the present study are important since they underscore a number of points that can improve the usability of websites, providing their customers with a more efficient interface in terms of navigability.

It is suggested that future studies conduct comparative analyses between perceived website quality from the standpoint of customers and specialists, thereby demonstrating better ways to effectively reconcile perceived and achieved non-functional usability requirements.

Other research opportunities could be related to analyses that, in addition to observing questions such as usability, encompass after-sales aspects of e-commerce companies.

Moreover, as proposed for future studies, usability analyses can also be conducted in other types of information systems, such as management systems or other of service-related websites.

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Ranking to Prioritize Maintenance of Electric Engines by Topsis Method

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ABSTRACT

This paper presents a proposal of using of the multi-criteria method TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) to aid the maintenance management of electric engines. The information from the operation of electric engines, such as criticality process, operating time, repair time and complexity of exchange were used as criteria to generate a ranking of engines to perform preventive maintenance. The weights determination for each criterion was also carried out by TOPSIS method, and all the stages of the method application were performed. The results presented, demonstrate the application feasibility by using a tool with a new approach for maintenance management on electric engines.

KEYWORDS: Ranking of electric engines; Maintenance management, TOPSIS method.

1. INTRODUCTION

Maintenance has been prominent in organizations and an opportunity to increase profits by changing standards. Thus, with this approach, it is studied for the purpose of optimizing the operating ways and the appropriate time to perform maintenance.

Unexpected failures may result in increasing on repair costs, but an appropriate maintenance strategy not only mitigates the likelihood of equipment failure but also improves the working condition of assets, resulting in lower maintenance costs, and/or higher product quality (Shafiee, 2015).

The evolution of electronics, mechanics, and automation technologies raises the complexity of industrial machinery considerably, and it also demands more complex and specialized maintenance, especially when the manufacturing has an advanced level of automation and technology. In this context, maintenance is becoming relevant for production process, because it provides opportunities to improve technically and economically process in organizations. However, historically it has not been considered with a positive effect on competitiveness (Carneiro, 2014). But actually, in some cases, maintenance has similar importance with production in industries (Trojan and Morais, 2012).

Thus, maintenance becomes essential to ensure good performance of industrial processes, since it affects profitability and safety. Therefore, to perform maintenance properly depends on the ability to answer the questions: What is the work do we need perform? When do we need to perform it? and in how many steps? Do the maintenance efficiently means scheduling the required volume of work at the right time and only to the planned location (Narayan, 2012).

The development of electronic devices and sensors, as well as the new communication techniques, allows the acquisition and sharing of machine performance data, available almost instantaneously from anywhere, contributing to process automation and helping to characterize the current concept for INDUSTRY 4.0.

Electric engines in the production process are often the main driving force for industrial applications. They are robust machines used not only for general purposes but also for tasks in harsh environments. General purpose applications of electric engines include pumps, conveyors, machine tools, centrifugal machines, pressing, elevators, packaging equipment among other applications (Lamim *et al*., 2013).

This machines are built by different manufacturers and not all of them have useful information for managing repairs throughout their lifecycle. Proper management of these repairs is an opportunity to improve industrial operation, increasing reliability, and reducing overall cost by unwanted outages (Whelan *et al*., 2006).

Predictive maintenance for these cases is considered an adequate and effective maintenance type and aims to identify unsatisfactory operating conditions in advance, predicting failure before that results in a critical equipment damage. Unplanned failures due to the monitoring lack result in high wastes from downtime and are more difficult to repair. In addition, replacing an engine requires availability from the vendor or storage equipment, and this is often not planned (Soergel and Rastgoufard, 2006). In this way, the search for maintenance processes improvement for electric engines is an opportunity to reduce operating stops, which in their majority depends on this mechanical force.

This paper presents a methodology for decision making process based on the TOPSIS multi-criteria method, which considers in its construction as criteria: the engine importance into the process, repair time, operating time, criticality, among others. The goal it is making the maintenance decision process broader through the proposed methodology. All steps of the methodology are described in detail in this paper.

1.1. Maintenance Management

Although during the last years there have been some efforts toward increasing the proactivity in maintenance decision making, existing approaches are still under development and the decisions are narrowed to recommendations about the maintenance schedule and more rarely, the optimal time of applying a predefined action (Bousdekis *et al*., 2015).

Maintenance assigns a value to the productive process when it is performed properly, and when its objectives are defined in accordance to the organization's business, leading companies to exploit a structured maintenance plan through the application of the reliability concepts (Fuentes, 2006).

According to Haroun and Duffuaa (2009) in an organization where there is a structured maintenance management, it is strongly impacted by:

- Type of business: high technology, intensive labour, production or service;
- Organization objectives: maximizing profit, increasing market share, and other social or environmental objectives;
- Organization size and structure;
- Organization culture; and
- The importance degree of maintenance, assigned by the organization.

Even if the equipment is designed in the most efficient way possible, its reliability and lifecycle performance are associated with the operation quality and maintenance efficiency. Thus, optimized maintenance leads to lower operating costs (Floyd, 1998). Equipment maintenance has become a significant fraction of the total cost of the industry sectors and effective maintenance management requires a multidisciplinary approach when maintenance is viewed strategically into the organization's business.

The most important features of this approach include technical integration and commercial problems, the involvement of mathematical models, use of all relevant information, and continuous improvement in maintenance management (Murthy *et al.*, 2002). The main maintenance responsibility is to provide a service that allows an organization to achieve its objectives. And then, these responsibilities varying from one organization to another; however, they generally include:

- Keeping equipment in good condition, well configured and safe to carry out their intended functions;
- Perform all maintenance activities including preventive, predictive, corrective, re-visions, project modification and emergency maintenance in an efficient and effective manner;
- Conservation and control of the use of spare parts and materials;
- Organization of new plants and expansions; and
- Tool operation and energy conservation.

Maintenance is presented as an iterative process, where the improvement must be constant as the machines evolve and the maintenance strategies must be adapted. It is important that the decision system is integrated with a data collection system for the redefinition of reference profiles and machine assignments for future maintenance strategies (Ishizaka and Nemery, 2014).

2. TOPSIS METHOD

The TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) multi-criteria method requires only a minimum number of user inputs and its outputs are easily understood. The only subjective parameters are the weights associated with the criteria. The main idea of TOPSIS is that the best solution is the one that has the shortest distance to the ideal solution and the farthest distance of the ideal solution, according to Illustration 1, for two criteria and alternatives A and B (Ishizaka and Nemery, 2013).

The standard TOPSIS method attempts to choose alternatives that simultaneously have the shortest distance from the ideal positive solution and the farthest distance from the ideal negative solution.

The ideal solution maximizes benefit criteria and minimizes cost criteria while the ideal negative solution maximizes cost criteria and minimizes benefit criteria. TOPSIS makes use of all attribute information, provides a cardinal ranking of alternatives, and does not require attribute preferences to be independent. To apply this technique, the values of the attributes must be numerical, increasing or decreasing monotonically, and must have measurable units (Behzadian *et al.*, 2012).

In Illustration 1, where both criteria are to be maximized, alternative A is closer to the ideal solution than B and further away from the anti-ideal solution and if the criteria weights are equivalent, then, as a result, TOPSIS presents the alternative A as a better solution than Alternative B.

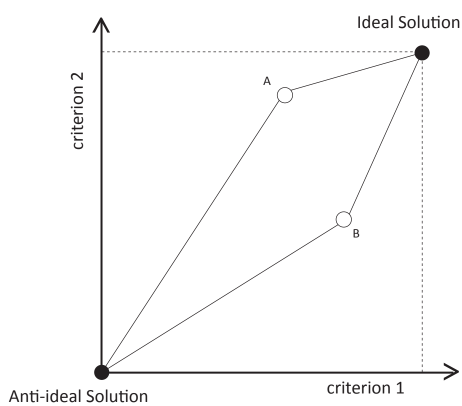

Illustration 1 – TOPSIS method representation

The TOPSIS method is based on five steps of mathematical procedures. The first step is to gather the performances of the alternatives in the different criteria. These performances need to be normalized in the second step.

In the following steps, the normalized scores are then weighted and the distances to an ideal and anti-ideal point are calculated. Finally, in the fifth and last step, proximity is given by the proportion of these distances (Ishizaka and Nemery, 2013).

The descriptions in the sequence present in detail these 5 steps and the mathematical procedures performed in each of them (Behzadian *et al.*, 2012).

Step 1: Construction of the standard decision matrix following equation (1):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum x^2{}_{ij}}} \qquad i = 1, \cdots, m; \cdots\cdots j = 1, \cdots, n \tag{1}$$

Where x_{ij} and r_{ij} are respectively the original and normalized decision matrices.

Step 2: Construction of the normalized weights in the decision matrix, following equation (2).

$$v_{ij} = w_{ij} * r_{ij} \tag{2}$$

Where w_j is the weight of criterion j

Step 3: Determine ideal and anti-ideal solutions. following equations (3), (4), (5) and (6).

$A^* = \{v_i{}^*, \cdots, v_n{}^*\}$ Optimum positive solution (3)

Where $v_i{}^* = \max\ v_{ij}$ if $j \in J$; $v_i{}^* = \min\ v_{ij}$ if $j \in J'$ (4)

$A' = \{v_i{}', \cdots, v_n{}^*\}$ Anti-ideal solution (5)

Where $v_i{}' = \min\ v_{ij}$ if $j \in J$; $v_i{}^* = \max\ v_{ij}$ if $j \in J'$ (6)

<u>Step 4</u>: Determine the distance of each alternative from the ideal and anti-ideal solution, following equations (7) and (8).

The distance of the ideal solution is given by:

$$S_i{}^* = \left[\sum(v_i{}^* - v_{ij})^{2}\right]^{\frac{1}{2}} \quad \text{for} \quad i = 1, \cdots, m \text{ for} \tag{7}$$

Similarly, for the anti-ideal matrix:

$$S_i{}' = \left[\sum(v_j{}' - v_{ij})^{2}\right]^{\frac{1}{2}} \quad \text{for} \quad i = 1, \cdots, m \text{ for} \tag{8}$$

<u>Step 5</u>: Calculation of the relative proximity to the ideal solution C_i *, following equation (9).

$$C_i{}^* = \frac{S_i}{(S_i{}^* + S_i{}')} \quad \text{where} \quad 0 < C_i{}^* < 1 \tag{9}$$

The nearest alternative to 1 is selected.

There is a wide range of real-world applications for the TOPSIS method in different fields, including: Supply Chain Management and Logistics, Design Systems, Engineering and Manufacturing, Business and Marketing Management, Health, Safety and Environment, Management of Human Resources, Energy Management, Chemical Engineering, Water Resources Management among others.

The use of multi-criteria methods in the area of supply chain management and logistics TOPSIS is the most used, while in business and marketing management is the third most used in academic work (Behzadian *et al.*, 2012).

3. PROCEEDINGS

In order to apply the TOPSIS multicriteria method in several sectors, in this work the proposal is to apply the method to assist in the decision making for an ordering of electric engines to perform preventive maintenance.

For this, the criteria that were considered for performing preventive maintenance with weight assignment, that is, the importance for each of these criteria were listed.

The criteria used in this work to apply the method were:

- (**CR**) Process criticality that the engine is involved in
- (**RT**) Engine repair time
- (**OT**) Time the engine is running (operation time)
- (**SC**) Difficulty of replacing the engine

Once the criteria have been defined, the weights must be defined for each criterion used, as well as the evaluation scale. In this case, the established weights were as follows:

3.1. Process Criticality that the Engine is Involved in:

Weight: 0.4;

Scale: 1 to 5 (1 less critical and 5 more critical)

3.2. Engine Repair Time:

Weight: 0.3;

Scale: hours

3.3. Engine Operating Time:

Weight: 0.1;

Scale: months

3.4. The Complexity of Exchange or Replacement:

Weight: 0.2;

Scale: 1 to 5 (1 - low difficulty and 5 - high difficulty).

The method was applied to a sample of 10 engines in an industry process, with the purpose of obtaining an order of which engine should go before for preventive maintenance.

The information on the engines was obtained from the maintenance manager, in such a way that the following matrix, from Illustration 2, was obtained.

Engines	CR	RT	OT	SC
M_1	1	2	15	1
M_2	4	4	2	4
M_3	2	3	36	5
M_4	3	1	50	3
M_5	5	15	60	4
M_6	3	9	32	5
M_7	2	12	17	3
M_8	4	1	12	3
M_9	2	4	25	2
M_{10}	3	6	32	5
Weights	**0.4**	**0.3**	**0.1**	**0.2**

Illustration 2 - Data from engines (Application): Criticality (CR), Repair Time (RT), Operating Time (OT), Substitution Complexity (SC) and the weights used.

With the data obtained on each of the engines, the first step of the TOPSIS was performed, normalizing the values. Illustration 3 shows the normalized values.

Engines	CR	RT	OT	SC
M_1	0.10	0.09	0.14	0.08
M_2	0.41	0.17	0.02	0.34
M_3	0.20	0.13	0.35	0.42
M_4	0.30	0.04	0.48	0.25

M_5	0.51	0.65	0.58	0.34
M_6	0.30	0.39	0.31	0.42
M_7	0.20	0.52	0.16	0.25
M_8	0.41	0.04	0.12	0.25
M_9	0.20	0.17	0.24	0.17
M_{10}	0.30	0.26	0.31	0.42

Illustration 3 – Normalization of data

After normalization of values, the next step and the construction of the normalized weights and the result obtained are presented in Illustration 4.

Engines	CR	RT	OT	SC
M_1	0.041	0.026	0.014	0.017
M_2	0.162	0.052	0.002	0.068
M_3	0.081	0.039	0.035	0.085
M_4	0.122	0.013	0.048	0.051
M_5	0.203	0.195	0.058	0.068
M_6	0.122	0.117	0.031	0.085
M_7	0.081	0.156	0.016	0.051
M_8	0.162	0.013	0.012	0.051
M_9	0.081	0.052	0.024	0.034
M_{10}	0.122	0.078	0.031	0.085

Illustration 4 – Weighted normalized values

The next step was to determine the distance of each alternative to the ideal and anti-ideal solution, with the results presented in Illustration 5 and 6.

Engines	CR	RT	OT	SC
M_1	0.026	0.029	0.002	0.005
M_2	0.002	0.020	0.003	0.000

M_3	0.015	0.024	0.001	0.000
M_4	0.007	0.033	0.000	0.001
M_5	0.000	0.000	0.000	0.000
M_6	0.007	0.006	0.001	0.000
M_7	0.015	0.002	0.002	0.001
M_8	0.002	0.033	0.002	0.001
M_9	0.015	0.020	0.001	0.003
M_{10}	0.007	0.014	0.001	0.000

Illustration 5 – Ideal matrix values

Likewise, for the anti-ideal.

Engines	CR	RT	OT	SC
M_1	0.000	0.000	0.000	0.000
M_2	0.015	0.002	0.000	0.003
M_3	0.002	0.001	0.001	0.005
M_4	0.007	0.000	0.002	0.001
M_5	0.026	0.033	0.003	0.003
M_6	0.007	0.011	0.001	0.005
M_7	0.002	0.020	0.000	0.001
M_8	0.015	0.000	0.000	0.001
M_9	0.002	0.002	0.000	0.000
M_{10}	0.007	0.004	0.001	0.005

Illustration 6 – Anti-ideal matrix values

With the ideal and anti-ideal matrices, the proximity of each alternative to the ideal solution is calculated and the result obtained is presented in Illustration 7.

Engines	C_i*
M_1	0.068
M_2	0.463
M_3	0.310
M_4	0.330
M_5	0.938
M_6	0.566
M_7	0.525
M_8	0.394
M_9	0.241
M_{10}	0.468

Illustration 7 – Final calculated values

After determining C_i *, we have the ordering of the engine with the highest priority (C_i * closest to 1) for maintenance for the engine with the lowest priority (C_i * furthest from 1). Thus, we have the following priority order of preventive maintenance of electric engines based on the multicriteria analysis. according to Illustration 8.

Ranking	**Engines**	C_i*
1º.	M_5	0.938
2º.	M_6	0.566
3º.	M_7	0.525’
4º.	M_{10}	0.468
5º.	M_2	0.463
6º.	M_8	0.394
7º.	M_4	0.330
8º.	M_3	0.310
9º.	M_9	0.241
10º.	M_1	0.068

Illustration 8 – Engines Ordination

Thus, the TOPSIS multicriteria method allows decision making to be done under a broader view of criteria and at the same time facilitating maintenance management.

In addition, in the multicriteria analysis, other criteria can be included for decision making, as well as the change in weights established for each criterion. Thus, the analysis can be performed according to the preferences of the maintenance manager or of the organization.

4. FINAL REMARKS

The method presented in this study proved to be efficient in pointing engines where preventive maintenance should occur as a priority, taking into account several criteria about its functioning for decision making. The use of TOPSIS can be done through a spreadsheet, not requiring a specific program, which makes its application relatively simple.

In the context of INDUSTRY 4.0, where a large amount of information about the productive environment, usually available in the cloud predominates, and the use of multicriteria methods for decision making certainly is a relevant contribution. Other multicriteria methods can be applied within this huge amount of data coming in this context.

Another important factor is that the weights can be modified according to the need of the decision maker, as well as the inclusion of other criteria in the analysis in question. Besides the use of the method for the preventive maintenance of electric engines as the one carried out in this work, this one can be applied to other scenarios. where a multicriteria analysis was desired.

This proposed scheme not only will be useful to researchers, but also assists maintenance professionals to find their specific needs.

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Reduction of Steel Waste in a Forgery Line Thru the Application of the DMAIC Method

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ABSTRACT

In a mechanical components factory located in Manaus industrial hub, profits were increased through the utilization of the DMAIC methodology, one of the Six sigma principles. The article discusses a case study in the metallurgical operations field with improvement in the crankshafts hot forming process. The respective part is an axis which receives force from the piston while the connecting rod reversal direction movement, is responsible for generating and sending torque, force and rotation to the motorcycle's mechanical and transmission system. They are subjected to several manufacturing stages and can generate too much raw material consumption, since forged parts lose a lot of material in the machining process. The DMAIC (Define, Measure, Analyze, Improve and Control) methodology was adopted to identify the problem and decrease the amount of over mold lost in the machining, while maintaining product quality. The large scale of production boosted the factory's profit after improvements. For this study tools such as Pareto diagram, control chart, cause and effect diagram and logical analysis were used. A reduction of over 80% in the highest region of the parts over metal was achieved. This research presents a lean growth in the boundaries of the six sigma philosophy.

KEYWORDS: Method DMAIC, Crankshaft Forging, Waste Elimination.

1. INTRODUCTION

Due to the current high market competitiveness among companies, and high consumer expectations for newer products, making the current ones quickly obsolete, demands that production processes' direct and indirect costs needs be reduced, and requires a constant search for improvements and cost reduction in the productive processes through analysis techniques and problem improvement solutions to achieve the expected reduction goals that can make the production systems leaner, more flexible and faster (Button and Lima, 1995).

2. LITERARY REVIEW

While globalization offers great opportunities, such as increased world demand, better procurement and production conditions, it also creates some challenges for the industry as a whole. For example, companies should constantly increase their productivity and flexibility, market new products, and even increase performance and efficiency levels in ever-shorter cycles to support the increase in global competition (Russwurm, 2014). There is also a need to integrate the whole production chain, in view of this movement, is the increasing expansion of German manufacturing towards Industry 4.0, with machines, processes and products in the network, which enable the connectivity between the factors involved in the automated processes (Schröder *et al*., 2015). The present work deals with lowering the part's cost by reducing the raw material consumption, presenting simultaneously the DMAIC routine (Define; Measure; Improve; Control), which consists of an ordered set of steps, that aims to execute the Six Sigma Project (Addrietta, 2007). Approximately half of the cost of forging is related to the raw material's value. In the precision forging process, a 15% cost reduction in raw material can be obtained, and up to 7.5% in the slab cost can be achieved. A forged part with a 3.6 kg approximate mass can generate a machining cost reduction of US $ 1.00 when compared to the same product when using conventional forgery process (Douglas and Kuhlmann, 2000). Hence, the DMAIC methodology will be used as a form of analysis, for cost reduction in the motorcycles crankshafts forging process. Forging processes can be classified according to the temperature that the work is carried out (Douglas and Kuhlmann, 2005), and can be classified in: cold, warm and hot forging. In this work, however, the conventional forging will be dealt with, that being, the hot forging process. The hot forming process is characterized by being carried out above the material's recrystallization temperature (temperature between 1100°C and 1220°C) and is the most widely used since it facilitates material flow and reduces the risks of cracks and fissures originated thru deformation thru out the process (Lima, 2008). This work explores the reduction of raw materials usage, using the DMAIC methodology to analyze the wastes that can lead to higher operating costs, and by reducing them, lower the parts forged costs which will improve the product's competitiveness.

3. METHOD

The study was carried out in an industrial environment located in the industrial center of Manaus / AM. The forging of crankshafts was observed for 6 weeks. The production begins with the distribution of standard JIS S48C steel bars of Ø52mm and 5m in length. The process configuration takes place according to Illustration 1.

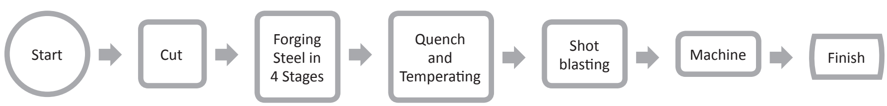

Illustration 1 – Crankshaft manufacturing flow.

Cutting: A process performed by a steel slitting machine (NCH-70N, Nishijimax) in billets weighing the part to be shaped, approximately 1550g ± 5g and bars with Ø52 by 91mm length dimensions.

Forging in four stages: Hot forming of steel occurs with billet to plastic transformation phase through heat induction (IPM-TR, temperatures vary from 1200°C to 1270°C. Crankshaft formation follows thru a 1600-ton vertical impact press (CF 1600, Kurimoto). The stages are laid out in the following method: 1st stage: preforming, responsible for lateral rounding creation to facilitate the flow within the second stage die and breaking of the induction spatter. 2nd stage: crankshaft shaft development.

3rd stage: preform the base of the part, important step for the next production stage.

4th stage: crankshaft final production with measures shown in Illustration 2.

Quench and Tempering: After forging the parts fall into a tank of quenching oil (125N, Daido Química) for 15min. at 60°C with agitators set at 100rpm, then are transported by a conveyor to a continuous gas furnace using GLP (VF 1193-C, Combustol) with 1470 kg/ha capacity at 670 ° C at a speed of 157mm/min for the tempering process.

Shot blasting: The process performs surface cleaning and scrub removal through the blast machine (SNB 50, Sinto) using spherical granules (S390, Sinto).

Machine: The machining of the parts takes place in a Lathe (762, Okuma) in which the over metal is removed with final measurements depicted on Illustration 3.

The DMAIC methodology was applied in order to identify the problem and to reduce it, and after holding several meetings with the employees, the first element of the methodology **Define** was used to explore the possible causes. Improvement factors were raised using the Ishikawa and Pareto diagram, but in a different format than the 6M model, since we noticed a better performance thru brainstorming when using the elements: Quality, Cost, Delivery, Safety, Environment and Labor, as shown in Illustration 3.

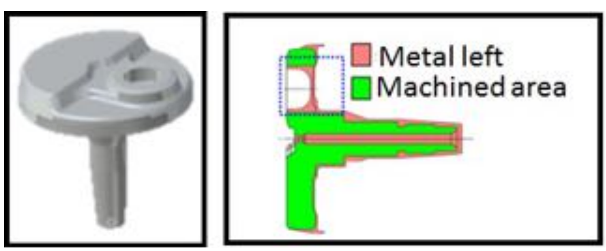

Illustration 2 – Sketch of the crankshaft main measurements by process and over metal definition. Highlighted in red dashed lines is the area of the trunnion hole.

For the item Measure, the pareto graph was used to analyze the steel costs and the machined metal lost in process was applied. The Analysis phase consisted in further detailing the processes for problem solving. The Inventor software (Professional 2016, Auto-desk) was used to simulate the best condition, among them a change in the fourth stage of the crankshaft forging process (Illustration 4). A tempered AISI H13 steel pin was used, aged and nitrided by a Sao Paulo state supplier.

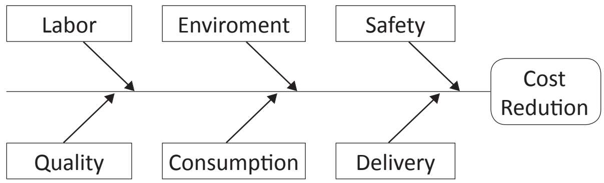

Illustration 3 – Ishikawa diagram model adopted to collect process data.

The measurements considered according to Illustration 4. The Improvement phase occurred from testing and deployment rollout. The studies carried out were converted into the process. Expected results were obtained. The Control phase approved a plan to maintain the improvements achieved and placate reverting back to the previous condition.

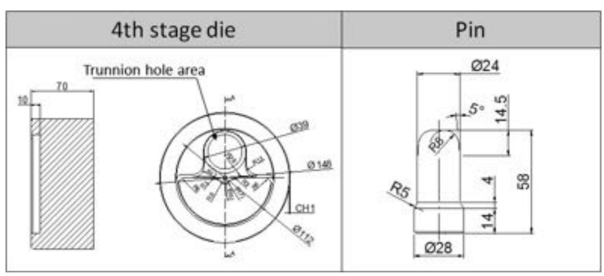

Illustration 4 – Die forge sketch of the fourth stage of the forging line and pin of the trunnion hole.

4. RESULT

4.1. Phase Define

The research conducted to **Define** the main causes, derived from the results raised by the Ishikawa diagram.

Quality: The investigation occurred in 2016, and there were no customer complaints. With regards to the scrap of parts, the department did not meet the months of January until April targets due to the sporadic energy drops in the region.

Consumption: It was verified that the raw material corresponded to the largest department spent, about 79% of the cost was forging and 22% of this value was wasted in the metal machining process. The Pareto graph shown on Illustration 5 demonstrates these numbers.

Delivery: In every month of the year, customer's goal was achieved, leading to no problems, as the same being true related to **Safety**, **Labor** and **Environment** factors where divergency was not experienced.

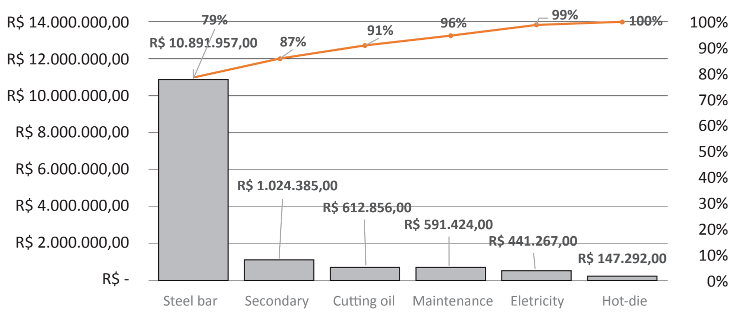

Illustration 5 – Cost of forging in the forging industry during the year 2016 (Pareto).

4.2. Measure

After cost investigation, it was understood that the high consumption of raw material is responsible for raising the department's expenses. As a result, it is necessary to evaluate a new working methodology with steel bars usage reductions. The machining process removes a large amount of metals in order to fit the part to the motor assembly. After measuring the remaining areas of machined steel, it was observed that the region of the trunnion hole consumes about 63g of steel. Equivalent to 18mm that turns into chip or 52% steel cost scrap. Therefore, actions were taken.

4.3. Analyse

Eliminating waste in the largest area of over metal would result in large positive process profit gains, but could lead to catastrophic accidents in the forgery resulting from unsuccessful drainage flow, cracks or die breaking, since the crankshaft design has a stud at its end that prevents a complete conformation according to the Inventor simulation shown in Illustration 6.

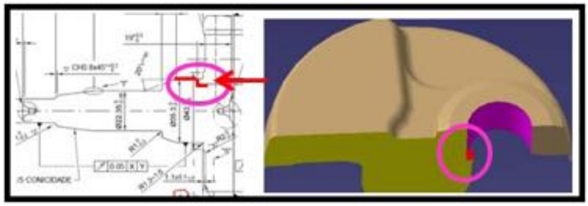

Illustration 6 – Crankshaft cut design. Axle shoulder area blocking complete trunnion hole conformation.

Thus, the operation of the fourth pressing stage was analyzed and it was concluded that the part could finish with a pre-bore of the trunnion, since the recess of the top of the larger diameter is formed at that stage. Thus, a pin was included in that area of the hole in order to remove 15mm of over metal according to the simulation Illustration 7. This is the lowest limit measure to prevent dies breakage or premature wear. And as such, the previous measurement billets that had 52x91mm and 1550g ± 5g became 52x81mm and 1370g ± 5g.

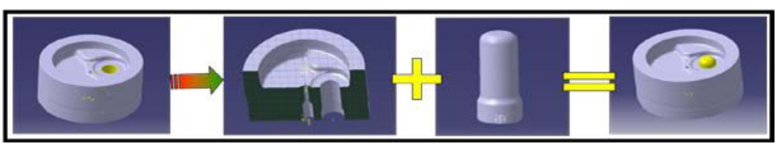

Illustration 7 – Inclusion of steel pin in the trunnion hole die area during the fourth stage.

4.4. Improve

After analyzes, process tests were performed. It took at least three to get the expected result. The first experiment was not successful because the radius of the pin was far below desired, about 2mm beyond the position, as well as the crankshaft larger diameter thickness. This caused a failure in the steel flow and bore displaced in the trunnion area, therefore the radius measurement was raised to 5mm and the measurements of the third stage die forge of Ø80mm and 30mm in height was changed to Ø85mm and 26mm in order to relieve the tension of the steel flow, and shortly the second test was performed. However, the effect was not effective. The hole continued to be dislocated and the pin not only eroded as it acquired cracks in its radius (Illustration 8).

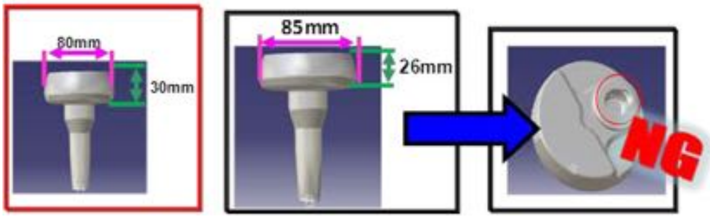

Illustration 8 – Changes in the measurements of third test stage that resulted in the bore displacement in the trunnion region. The NG refers to the acronym No Good in industrial language.

The shear stress for the conformation of the diameter was contributing to the catastrophic event. Thus, in the third test, the measurements of the die of the third stage were adjusted again, the internal diameter was modified to Ø90mm and 23mm deep. The result was satisfactory, the steel maintained the measurements in the region of the trunnion hole and 52 g of over metal was reduced, as well as 15 mm of the length of the hole. The final wall of the hole remained with 3mm.

4.5. Control

At this stage a plan was drawn up against retrocession. A detailed step by step work instruction of the pre-drill was made available to the operators involved in the activities. An hourly control chart was developed to monitor the quality of the parts produced, as well as to check the gains of every crankshaft, a total of more than R $ 300,000.00 per year.

5. CONCLUSION

The hot-forming process promotes formats of parts with inaccurate measurements, so the need for machining arises in many circumstances and this continues to be a major capital investment for companies, whether raw material or resources used in the process. An efficient study allows you to reduce waste and balance costs. Therefore, the DMAIC methodology and tools used here are very relevant for complete elaboration of continuous improvement and cost reduction. The prospect of eliminating waste in a process, especially where there is difficulty in identifying the cause, becomes an overcome challenge. The structural change of dies forges as demonstrated in the research confirms this success, as well as the importance of continuous improvement.

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NORMAS GERAIS E NORMAS DE REDAÇÃO DA REVISTA CIENTÍFICA PROELIUM (SÉRIE VIII)

1. NORMAS GERAIS

1.1. A *PROELIUM* é uma revista de divulgação científica para todos os investigadores nacionais e internacionais submeterem artigos, comunicações e trabalhos de investigação originais.

1.2. A *PROELIUM* caracteriza-se por ser uma revista científica que aceita artigos, comunicações e trabalhos de investigação originais nas diferentes áreas científicas que possam contribuir para a Defesa e Segurança, de uma forma geral.

1.3. Os artigos, as comunicações e os trabalhos de investigação originais são submetidos, obrigatoriamente, por via eletrónica para proelium.editor@academiamilitar.pt. Confirmar-se-á a respetiva receção (que materializa a formalização do início do processo), indicando-se o respeito, ou não, das normas gerais e das normas de redação.

1.4. Os artigos, as comunicações e os trabalhos de investigação são revistos, no mínimo, por dois revisores, em processo de *double-blind review*.

1.5. A notificação do resultado é efetuada por correio eletrónico pelo editor para o autor principal (primeiro autor) do artigo, comunicação ou trabalho de investigação.

1.6. Os artigos, as comunicações e os trabalhos de investigação não devem exceder as 30 páginas A4 ou 15.000 palavras, incluindo *abstract*, resumo, notas de fim, ilustrações e referências bibliográficas. Margens a 2cm, seja na superior, inferior, esquerda ou direita.

1.8. Os autores devem enviar as ilustrações devidamente inseridas no texto e elaborar uma "pasta" em anexo com as mesmas, devidamente identificadas e em formato JPEG ou TIF.

1.9. Os artigos, as comunicações e os trabalhos de investigação devem ser acompanhados de um resumo e *abstract* (aproximadamente 300 palavras) e indicação das palavras-chave e *keywords* (aproximadamente 5 palavras).

1.10. O envio dos artigos, comunicações e trabalhos de investigação, deve ser sempre acompanhado de uma síntese biográfica do(s) autor(es), que não deve exceder meia página A4. A identificação do(s) autor(es) nos artigos comunicações e trabalhos de investigação, deve respeitar o que está estipulado nas Normas de Redação.

2. NORMAS DE REDACÇÃO

2.1. Devem ser consideradas como referência para a elaboração dos artigos, comunicações e trabalhos de investigação, as seguintes indicações: texto em formato Microsoft Word 2007 e justificado; tipo de letra em Times New Roman tamanho 12, com espaçamento 1.5 entre linhas, e com espaçamento antes e depois a 0; notas de fim em Times New Roman tamanho 10, com espaçamento simples entre linhas, e com espaçamento antes e depois a 0.

2.2. O primeiro parágrafo inclui o título do artigo: em letra Times New Roman tamanho 12, a maiúsculas, negrito, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto alinhado à direita.

2.3. Inserir depois um espaço (uma linha em branco): em letra Times New Roman tamanho 12, normal, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto justificado.

2.4. Depois de inserir esse espaço supra referido (linha em branco), aparecerá a identificação do(s) autor(es): em letra Times New Roman tamanho 12, normal, com espaçamento 1.5 entre linhas e com espaçamento antes e depois a 0, sendo o texto alinhado à esquerda. A identificação do(s) autor(es) respeita a seguinte esquematização:

Nome primeiro autor, afiliação, endereço eletrónico
Nome do segundo autor, afiliação, endereço eletrónico
(os restantes autores devem ser colocados no mesmo formato)

2.5. Depois de um espaço em branco (uma linha em branco), inicia-se o terceiro parágrafo com a palavra "ABSTRACT": em letra Times New Roman tamanho 12, a maiúsculas, negrito, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto alinhado ao centro. Na linha seguinte começa-se o texto do abstract: em letra Times

New Roman tamanho 12, normal, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto justificado. O abstract não deve ultrapassar as 300 palavras.

2.6. Depois de um espaço em branco (uma linha em branco), inicia-se o quarto parágrafo com as "KEYWORDS": em letra Times New Roman tamanho 12, a maiúsculas, negrito, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto alinhado à esquerda. Depois de dois pontos, colocam-se aproximadamente cinco keywords separadas por ponto e vírgula: em letra Times New Roman tamanho 12, normal, com espaçamento 1.5 entre linhas, e com espaçamento antes e depois a 0.

2.7. Depois de um espaço em branco (uma linha em branco), inicia-se o quinto parágrafo com a palavra "RESUMO": em letra Times New Roman tamanho 12, a maiúsculas, negrito, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto alinhado ao centro. Na linha seguinte começa-se o texto do resumo: em letra Times New Roman tamanho 12, normal, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto justificado. O resumo não deve ultrapassar as 300 palavras.

2.8. Depois de um espaço em branco (uma linha em branco), inicia-se o sexto parágrafo com as "PALAVRAS-CHAVE": em letra Times New Roman tamanho 12, a maiúsculas, negrito, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto alinhado à esquerda. Depois de dois pontos, colocam-se aproximadamente cinco palavras–chave separadas por ponto e vírgula: em letra Times New Roman tamanho 12, normal, com espaçamento 1.5 entre linhas, e com espaçamento antes e depois a 0.

2.9. Após um espaço em branco (uma linha em branco), coloca-se a primeira secção e, em continuação, o respetivo texto, no parágrafo seguinte, que não tem nenhum espaço em branco (uma linha em branco) entre o título da secção e o respetivo texto.

2.10. Cada secção é identificada em numeração árabe e é separada do texto da anterior secção por um espaço em branco (uma linha em branco) sendo o seu título escrito em letra Times New Roman tamanho 12 e com espaçamento

1.5 entre linhas, a maiúsculas, negrito, com espaçamento antes e depois a 0, sendo o texto alinhado à esquerda.

2.11. O texto de cada secção é redigido em letra Times New Roman tamanho 12, normal, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto justificado.

2.12. As notas de rodapé, quando necessárias, devem ser todas convertidas em notas de fim, sendo redigidas em letra Times New Roman tamanho 10, normal, com espaçamento simples entre linhas, e com espaçamento antes e depois a 0, sendo o texto justificado.

2.13. As palavras "REFERÊNCIAS BIBLIOGRÁFICAS" figuram no final dos artigos, das comunicações e dos trabalhos de investigação, separadas do texto da anterior secção por um espaço em branco (uma linha em branco) e sendo o seu título escrito em letra Times New Roman tamanho 12, a maiúsculas, negrito, com espaçamento 1.5 entre linhas, com espaçamento antes e depois a 0, sendo o texto alinhado à esquerda. As referências bibliográficas aparecem depois, sem haver nenhum espaço em branco (uma linha em branco) entre o título "REFERÊNCIAS BIBLIOGRÁFICAS" e as respetivas referências.

2.14. Todas as referências bibliográficas incluídas nos artigos, nas comunicações e nos trabalhos de investigação, devem seguir o estilo bibliográfico APA (*American Psychological Association*) na sua última edição.

2.15. Todas as ilustrações colocadas ao longo do artigo, comunicação ou trabalho de investigação, devem ser aplicadas ao centro, em letra Times New Roman tamanho 10, com espaçamento 1.5 entre linhas, e com espaçamento antes e depois a 0. A designação de cada ilustração e respetiva fonte, com redação a negrito apenas nos títulos, devem respeitar a seguinte esquematização:

Ilustração 1: Designação da ilustração.
Fonte: Conforme estilo bibliográfico APA (*American Psychological Association*) na sua última edição.

GENERAL RULES AND DRAFTING RULES FOR THE SCIENTIFIC MAGAZINE PROELIUM (VIII EDITION)

1. GENERAL RULES

1.1. PROELIUM is a scientific magazine that includes original articles, reports and research papers of national and international researchers.

1.2. PROELIUM accepts original articles, reports and research papers in the different scientific areas that may contribute to Defence and Security, in general.

1.3. Original articles, reports and research papers must be submitted by e-mail to proelium.editor@academiamilitar.pt. Reception will be confirmed (which initiates the process), stating if general rules and drafting rules have been followed.

1.4. Original articles, reports and research papers are reviewed, at least, by two reviewers, in double-blind review process.

1.5. Result is transmitted by e-mail, by the editor to the main author (first author) of original articles, reports and research papers.

1.6. Original articles, reports and research papers must not exceed 30 A4 paper size pages or 15.000 words, including abstract, footnotes, illustrations and bibliography. Margins at 2cm, whether at the top, bottom, left or right.

1.7. Authors must send the illustrations with the respective text inserted in an annex, duly identified, in JPEG or TIF format.

1.8. An abstract must be made (approximately 300 words), with keywords (approximately 5 words).

1.10. A biographic summary of the author(s) must be made, not exceeding half A4 paper size page. Identification of the author(s) in original articles, reports and research papers must comply with the Drafting Rules.

2. DRAFTING RULES

2.1. To create original articles, reports and research papers, the following rules must be followed: text in Microsoft Word 2007, justified, Times New Roman font, size 12, line-spacing 1.5, letter-spacing 0, notes in Time New Roman, size 10, single-spaced, letter-spacing 0.

2.2. First paragraph includes the title of the article: Times New Roman, size 12, capital letters bold, line-spacing 1.5, letter-spacing 0, right-justified.

2.3. Insert space (blank line), Times New Roman, size 12, normal, 1.5 line-spacing, letter-spacing 0, justified text. Identification of the author(s) must respect the following:

Name of the first author, affiliation, e-mail address
Name of the second author, affiliation, e-mail address
(The names of the remaining authors must appear in the same format).

2.5. After a blank space (blank line), the third paragraph is initiated with the word "ABSTRACT": Times New Roman, size 12, capital letters, bold, line-spacing 1.5, letter-spacing 0, centre-justified text. In the following line, the text of the abstract is initiated: Times New Roman, size 12, normal, line-spacing 1.5, letter-spacing 0, justified text. The abstract must not exceed 300 words.

2.6. After a blank space (blank line), the fourth paragraph is initiated with "KEYWORDS": Times New Roman, size 12, capital letters, bold, line spacing 1.5, letter spacing 0, left-justified text. After the colon, five key words are indicated, separated by semicolon: Times New Roman, size 12, normal, line-spacing 1.5, letter-spacing 0.

2.7. After a blank space (blank line), the fifth paragraph is initiated with the word "RESUMO": Times New Roman size 12, capital letters, bold, line-spacing 1.5, letter-spacing 0, centre-justified text. In the following line, the text of the summary is initiated: Times New Roman, size 12, normal, line-spacing 1.5, letter-spacing 0, justified text. The summary must not exceed 300 words.

2.8. After a blank space (blank line), the sixth paragraph is initiated with "PALAVRAS-CHAVE": Times New Roman, size 12, capital letters, bold, line-spacing 1.5, letter-spacing 0, left-justified text. After de colon, five key words are indicated, separated by semicolon: Times New Roman, size 12, normal, line-spacing 1.5, letter-spacing 0.

2.9. After a blank space (blank line), the first section appears, followed by the respective text, in the following paragraph, without any blank space (blank line) between the title and the respective text.

2.10. Each section is identified in Arabic numeration, separated by the previous text by a blank space (blank line). Title written in Times New Roman, size 12, line-spacing 1.5, capital letters, bold, letter-spacing 0, left-justified text.

2.11. The text of each section is written in Times New Roman, size 12, normal, line-spacing 1.5, letter-spacing 0, justified text.

2.12. Footnotes, when necessary, must be converted into footnotes, in Times New Roman, size 10, normal, single spaced, letter-spacing 0, justified text.

2.13. "BIBLIOGRAPHY" appears in the end of the articles, reports and research papers, separated from the text of the previous section by a blank space (blank line). The title is written is written in Times New Roman, size 12, capital letters, bold, line-spacing 1.5, letter-spacing 0, left-justified text. Bibliography appears in the end, without any blank space (blank line) between the title "BIBLIOGRAPHY" and respective references.

2.14. Bibliographic references included in the articles, reports and research papers, must follow the APA bibliographic style (*American Psychological Association*), last edition.

2.1.5. Illustrations included in the article, report or research paper must appear in the centre, in Times New Roman, size 10, line spacing 1.5, letter spacing 0. Each illustration designation and respective font (only he titles in bold) must respect the following:

Illustration 1: Illustration designation.
Source: Bibliographic style APA (*American Psychological Association*), last edition.

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