Toward an agile adaptation of supply chain planning : a situational use case

Sanaa Tiss, Caroline Thierry, Jacques Lamothe, Christophe Rousse

► To cite this version:

Sanaa Tiss, Caroline Thierry, Jacques Lamothe, Christophe Rousse. Toward an agile adaptation of supply chain planning : a situational use case. 20th Working Conference on Virtual Enterprises (PRO-VE), Sep 2019, Turin, Italy. pp.344-354, 10.1007/978-3-030-28464-0_30 . hal-02290428

HAL Id: hal-02290428

<https://imt-mines-albi.hal.science/hal-02290428>

Submitted on 14 Feb 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution| 4.0 International License

Toward an Agile Adaptation of Supply Chain Planning: A Situational Use Case

Sanaa Tiss¹, Caroline Thierry², Jacques Lamothe¹ and Christophe Rousse³

¹Universite de Toulouse, Centre Génie Industriel, IMT Mines Albi, France

²Universite de Toulouse, IRIT, Université Toulouse Jean Jaurès, France

³Supply Chain Direction Pierre Fabre Dermo-Cosmetics Laval, France
sanaa.tiss@mines-albi.fr

Abstract: The project CAASC “Cloud Adaptation for an Agile Supply Chain” (French ANR project) aims to develop monitoring services in multi actors supply chain, by integrating uncertainties in supply chain planning and developing adaptation functions to environment changes.

In this paper we present a use case in the form of a serious game that aim to emerge and validate the required functionalities for the project. The game simulates a collaborative rolling horizon mid-term planning process. By analyzing its processes and results, we identify the central role of deviations analysis of plans to qualify uncertainties, assess robustness and propose response strategies.

Keywords: Collaborative supply chain planning, uncertainties and robustness, Serious game.

1 Toward an Agile Supply Chain

The CAASC “Cloud Adaptation for an Agile Supply Chain” project considers a supply chain composed of a set of entities that collaborate in the planning of flows of products, services, and finance. Each entity organizes manufacturing and distribution activities using plans managed by several decision-making centers (multi-actors). CAASC is focusing on coordination problems related to mid-term rolling horizon planning decisions across an internal supply chain.

CAASC takes advantage of three main services developed in a monitoring perspective of supply chain mid-term plans during the H2020-FoF project called C2NET “Cloud Collaborative Manufacturing Networks” [1] : i) the modeling service which uses collected data (current plans for demand, production, supply, distribution and inventories) to maintain a model of a supply chain according to a reference meta-model. ii) the detection of deviations service which compares the supply chain status model to the model expressed from the originally validated plans, and therefore detects deviations that are changing the validated plans. iii) the adaptation service which is a rule-based system that proposes adaptation processes according to some business rules and deviations characteristics.

Still focusing on the monitoring services, CAASC aims at developing new features in order to develop robustness as well as agility of the solution while taking advantage of some results of C2NET. Moreover, we are interested in deviation measurement and the interpretation of these movements to quantify and qualify uncertainties.

From a decision maker point of view, uncertainty in the uncontrollable variables of supply chain planning can induce deviations; therefore, increase the nervousness of the plans [2] [3, 4] .

Different approaches in planning uncertainty modelling are proposed in the literature. Uncertainty in the considered uncontrollable variables can be described mainly by intervals [5], probability distribution [6], [7] or fuzzy sets [8], [9], [10],[11].

Using uncertainty modeling, we aim to assess the robustness of plans, enhance anticipation and create a tradeoff between robustness [12] and agility of supply chain planning. However, the project partners belong to different domains (industrial, software developers, supply chain or artificial intelligence researchers) and they do not necessarily know totally interpret the consequences of rolling horizon planning and its related constraints. Thus, before even considering the complexity of integrating uncertainties in collaborative rolling horizon planning, an As-Is emulation was used in a deterministic context to share a user experience. We chose the serious game method for this emulation.

Serious games are known for their use in higher education [13, 14]. Furthermore, many famous serious games are used in trainings. For instance, serious games such as “Beer Game” [15] or “The Fresh Connection” [16] are a supply chain simulation game where the main functions of the company are represented. Serious game has also been used to analyze the dynamic decision-making process in supply [17].

In our case, we chose the serious game method for other reasons, mainly to:

- enable industrial partners to validate a use representative case situation,
- frame the research topic and identify the problems related to the collaborative planning within a rolling horizon process,
- share competences and points of view of the different users,
- allow partners to project themselves into decision-making and validate needs and specifications in terms of agility and robustness evaluation,
- formalize a use case that can be retested to assess the proposed functionalities.

A collaborative approach with the partners of the project (end user, software company, research laboratories) has been adopted to design the serious game. Starting by an industrial interview and a survey on APICS as a reference of planning processes modeling, the collaborative mid-term planning processes was modelled. Then, were defined the components of the game simulating the dynamic of those processes and the physical flow related to the game. After that, in a prepared environment the game was run, and results were collected. Finally, the results issued from the game were analyzed and the main problems and requirement were identified in terms of agility and CAASC functionalities development.

2 Process Under Study

2.1 Industrial Case and APICS Process

The project will provide use cases that come from an analysis of Pierre Fabre Dermo Cosmetics (PFDC) company processes. A series of interviews took place in order to understand the actual process of planning and collaboration between different partners in the supply chain (Fig. 1).

Fig. 1. PFDC Supply Chain (tactical level).

PFDC supply chain is composed of the following stakeholders: suppliers, manufacturing plants (in France), Central Distribution Centre (in France), local subsidiaries or partners and final customers (drugstores) all over the world [18].

Within CAASC, PFDC supply chain supported by a cloud platform links its various actors. The supply chain is a collaborative network of actors that use the platform in order to perform their collaborative planning process.

Production is stored in a central warehouse in France before being distributed to subsidiaries and partners. PFDC is always trying to improve its performances in terms of service. Aligning the plans of the supply chain partners, agile deployment of stocks and the optimization of the distribution of inventories among the subsidiaries are the primary objectives.

In the context of this industrial case, APICS[19] is our reference to model a generic collaborative planning process.

Considering the supply chain described in the figure 1, subsidiaries planners, a supply planner and a production planner are the partners collaborating in the supply chain planning. The master plans exchanged between partners are mainly: Sales and Operations plans, Distribution Requirement planning, Master Production Scheduling [19].

Planning changes are limited by the time fences and delivery time. "Changes that are far off on the planning horizon can be made with little or no cost or disruption to

manufacturing, but the nearer to delivery date, the more disruptive and costly changes will be.” [19]

In the frozen zone, planning changes are not allowed and required the approval of the decision maker in case of emergency. The slushy zone is a tradeoffs zone, downward demand (conv. Upward production) request is automatically accepted while the upward demand (conv. Downward production) must be confirmed by decision makers. Finally, in the liquid zone the changes are automatically accepted and usually done by the computer within the defined limits of the plans.

2.2 Collaborative Planning Process

The figures 2 below details the inputs and outputs (decisions) of every planning related to each partner in the supply chain and for each level of planning. Four steps are identified in the planning process and three different decision makers are concerned:

Fig. 2. Collaborative supply chain planning process

Each subsidiary elaborates its sales forecast and define its supply requirements. The confirmed requirements present the desired supply plan from the Central Distribution Center. Each subsidiary order on its own without regard for the available inventory of the distribution center neither the requirements of other subsidiaries nor the production schedule. However, the supply planner in the CDC has the richest view on all the independent supply chain system (SAP, world DRP) due to his position as coordinator and CDC resource manager in the supply chain.

We make the difference between two levels of planning process. The monthly planning process and the weekly one.

Monthly, in the first week of the month, the requirements of the different subsidiaries are consolidated to become the base of supply chain resources dimensioning for the current month. The resulted plans of this process are the reference of the rest of the month.

Every week, the DRP and MPS master plans are reviewed and can be changed in case of perturbations. We consider perturbations related to the occurrence of a set of events mainly: Demand variation (real sales); Subsidiaries exceptional requests (promotion, shortage...); Quality control problem (rejection of products, high control

time...); Operational production problem (breakdowns, closure, schedule changes, order splitting or aggregation, ...); Transportation problems (lost products, customs delay).

Regarding time fences, it was identified a planning horizon of 24 weeks including a frozen horizon of 2 weeks plus delivery time, slushy horizon of 6 weeks and liquid horizon of 16 weeks.

2.3 Supply Chain Planning Process Analysis

A deterministic supply chain planning is considered. The variables of supply chain planning such as lead time, costs and other system parameters, are considered known with certainty. In a decision process (weekly or monthly), depending on his role, each decision maker receives, decides and sends plans (forecast, requirement, supply, capacity). The received plans are uncontrollable variables on which uncertainty could be modelled. Conversely, the sent plans become uncontrollable variables for other deciders.

In a rolling horizon planning context, deviations are a set of differences between the weekly and the monthly reference for a same plan. In the operational level, deviations present the difference between the planned and the realized quantities. On received plans deviations enable to qualify uncertainty. On decided and sent plans, deviations enable to qualify robustness of service rate and nervousness.

3 A serious Game as a Proof of Concept

3.1 Game Description

Fig. 3. Plant game board

Fig. 4. CDC game board

Fig. 5. Subsidiaries Game board

To best simulate the modelled supply chain planning process while having consistent results, the serious game was sized as follow:

- 4 subsidiaries (France, Australia, Spain, Chile); 1 CDC; 1 factory.
- 5 Products: P1 (English), P2 (Spanish), P3 (Spanish), P3 (English), P4 (English). Products are different according to the packaging language. French is a default language in packaging. In order to avoid a shortage, P3 (Spanish) can be sent to Australia and conversely P3 (English) to Spain or Chile.

The game board is designed as shown in Fig. 5, Fig. 6, Fig. 7.

In addition to the board game, Excel sheets have been designed as a planning decision support enabling to keep a written record of the game. These sheets are shared on a platform allowing the simultaneous modification of the data. Each decision view is a worksheet [17].

R	Product code	Process type	Scenario		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16	W17	W18	W19	W20	W21	W22	W23	W24	W25	W26	W27	W28	W29	W30	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40	W41	W42	W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W53	W54	W55	W56	W57	W58	W59	W60	W61	W62	W63	W64	W65	W66	W67	W68	W69	W70	W71	W72	W73	W74	W75	W76	W77	W78	W79	W80	W81	W82	W83	W84	W85	W86	W87	W88	W89	W90	W91	W92	W93	W94	W95	W96	W97	W98	W99	W100	W101	W102	W103	W104	W105	W106	W107	W108	W109	W110	W111	W112	W113	W114	W115	W116	W117	W118	W119	W120	W121	W122	W123	W124	W125	W126	W127	W128	W129	W130	W131	W132	W133	W134	W135	W136	W137	W138	W139	W140	W141	W142	W143	W144	W145	W146	W147	W148	W149	W150	W151	W152	W153	W154	W155	W156	W157	W158	W159	W160	W161	W162	W163	W164	W165	W166	W167	W168	W169	W170	W171	W172	W173	W174	W175	W176	W177	W178	W179	W180	W181	W182	W183	W184	W185	W186	W187	W188	W189	W190	W191	W192	W193	W194	W195	W196	W197	W198	W199	W200	W201	W202	W203	W204	W205	W206	W207	W208	W209	W210	W211	W212	W213	W214	W215	W216	W217	W218	W219	W220	W221	W222	W223	W224	W225	W226	W227	W228	W229	W230	W231	W232	W233	W234	W235	W236	W237	W238	W239	W240																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
	1134	Monthly/Computer Decision 2: W1	France Supply Requirements(W1)		30	70	60	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Fig. 7. Decisions flow: monthly supply chain process

Fig. 8. Decisions flow: weekly supply chain process

3.2 Game Analysis

The game was played once for one supply chain. Authors played the role of the game master and informed subsidiary players about real demand, market changes and production perturbations.

By the end of the game session, two types of analysis of plans on the rolling horizon are performed: (i) The plan deviation measures the difference two successive plans; (ii) the planning error measure the difference between the planned and real (demanded or delivered) quantities.

In the following, the analysis focuses on the relation between one subsidiary (France) and the Central Distribution Center (CDC) and product P1.

Table 1. Scenario of the game for product P1

Week	Network echelon	Scenario (perturbations)
1	No one	Everything is normal and in line with the forecast.
2	Subsidiary	Sales vary from ± 10 compared to forecasts.
3	Subsidiary	Registered sales compared to forecasts: Australia (-10 P1), France (+20 P1).
4	Subsidiary	Registered sales compared to forecasts: Australia (+10 P1), France (-40 P1).
5	Subsidiary	In France: promotion on product P1 on weeks 10 to 14. A doubling of sales is planned on the period. 80% of the sales increase are an anticipation of sales originally forecasted on weeks 15 to 20.

Table 2. Deviations of Supply Requirements (France;P1) = $SR[w](t) - SR[w-1](t)$.

Week	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18
w2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
w3		10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
w4			20	20	0	0	10	0	0	0	0	0	0	0	0	0	0
w5				-10	30	100	40	50	50	-30	-30	-20	-10	-10	0	0	0
w6					-30	0	40	0	0	0	0	0	0	0	0	0	0

Table 3. Deviations of Supply Plans (France;P1) = $SP[w](t) - SP[w-1](t)$.

Week	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	t19
w2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
w3		0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
w4			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
w5				0	0	100	40	50	50	-30	-30	-20	-10	-10	0	0	0	0
w6					0	0	40	0	0	0	0	0	0	0	0	0	0	0

Table 4. Supply Requirements Error = $SR[w](t) - SRt$.

Week	t2	t3	t4	t5	t6
w1	0	-10	-20	-10	0
w2	0	-10	-20	-10	0
w3		0	-20	-10	0
w4			0	10	0
w5				0	30
w6					0

Fig.9. Production capacity/workload analysis

In table 2 and table 3, the deviation on Supply Requirements (request from subsidiary) and on Supply plan (answer of CDC) make easier the analysis of the propagation of information within the supply chain. In yellow, appear the Supply Requirement deviations that are requested by the subsidiary within the frozen horizon and not accepted by the CDC. These requests appear to mitigate errors between the subsidiary last forecast and the real customer demand he faces. In week 5, the subsidiary is informed of a promotion (see table 1). In orange in table 2 and table 3, appear the impact of the promotion information on the supply requirements.

In red in table 2 and table 3, appear the process of request and acceptance of a change: it is first requested on week 3 on period t3 in SR, accepted in week 3 on t8 in SP, and maintained at week 4 on t8 in SR.

In figure 9, the propagation of the above variation till the factory is depicted. The initial sized capacity was 700 products per week, the amount requirements received from the CDC increase the workload, and the production planner decide to resize the capacity in the week 5 (first week of the second month) to become 850 for the weeks 8 to 12.

In table 4, the supply Requirement error is shown for weeks 2 to 6. This error can hardly be interpreted according to the game scenario. But it shows the imprecision of the plan.

This user experience enabled to validate the following requirements for the uncertainty integration :

- characterization of the uncertainties undergone by a decision-maker by analyzing deviations and variations in deterministic plans along a rolling horizon. Machine learning tools will be used to well characterize this uncertainty from data collected from the industrial case,
- categorization of products according to the type of uncertainty,
- consideration of uncertainties in the uncontrollable variables to develop and enrich a user decision support interface,
- evaluation of user decisions (plans) in terms of robustness and stability against different disruption scenarios.

4 Conclusion and Future Works

The game simulates the production and distribution of cosmetics supply chain reproducing the current functioning of PFDC planning. It reproduces 2 planning processes: a monthly that starts from sales forecasts to size the resources of the supply chain and a weekly process to adjust plans based on requests in case of perturbation. This version will allow us in the future to implement the complete Serious Game, confronting this time the current and future processes that integrate the functionalities of the project CAASC while considering uncertainty in planning parameters.

The planning errors (difference between scheduled quantities and the real demand (or the real deliveries)) will be the basis for characterizing uncertainties. Otherwise, the plans deviations through the rolling horizon (deviations between successive plans) allow to better isolate the perturbations and their propagation in the supply chain which will enable to make the uncertainties explainable.

The serious game session, as a user experience, enabled partners to validate the required functionalities for the project in terms of uncertainty modelling and integration of uncertainty models in the user decision support interface.

Acknowledgement

Authors want to acknowledge ANR for the funding of the CAASC project.

References

1. Jiang, Z., Lamothe, J., Bénaben, F.: Meta-Modeling of Collaborative Supply Chain. In: Mertins, K., Jardim-Gonçalves, R., Popplewell, K., and Mendonça, J.P. (eds.) *Enterprise Interoperability VII*. pp. 307–320. Springer International Publishing, Cham (2016).
2. van Donselaar, K., van den Nieuwenhof, J., Visschers, J.: The impact of material coordination concepts on planning stability in supply chains. *International Journal of Production Economics*. 68, 169–176 (2000).
3. Kadipasaoglu, S.N., Sridharan, V.: Alternative approaches for reducing schedule instability in multistage manufacturing under demand uncertainty. *Journal of Operations Management*. 13, 193–211 (1995).
4. Koca, E., Yaman, H., Aktürk, M.S.: Stochastic lot siz-

- ing problem with nervousness considerations. *Computers & Operations Research*. 94, 23–37 (2018).
5. Guillaume, R., Thierry, C., Zieliński, P.: Robust material requirement planning with cumulative demand under uncertainty. *International Journal of Production Research*. 55, 6824–6845 (2017).
 6. Birge, J.R., Louveaux, F.: *Introduction to Stochastic Programming*. Springer Science & Business Media (2011).
 7. Gholamian, N., Mahdavi, I., Tavakkoli-Moghaddam, R.: Multi-objective multi-product multi-site aggregate production planning in a supply chain under uncertainty: fuzzy multi-objective optimisation. *International Journal of Computer Integrated Manufacturing*. 29, 149–165 (2016).
 8. Dubois, D., Prade, H.: Representation and combination of uncertainty with belief functions and possibility measures. *Computational Intelligence*. 4, 244–264 (1988)..
 9. Fargier, H., Thierry, C.: The Use of Possibilistic Decision Theory in Manufacturing Planning and Control: Recent Results in Fuzzy Master Production Scheduling. 15.
 10. Grabot, B., Geneste, L., Reynoso-Castillo, G., Vérot, S.: Integration of uncertain and imprecise orders in the MRP method. *J Intell Manuf*. 16, 215–234 (2005).
 11. Sun, G., Liu, Y., Lan, Y.: Fuzzy two-stage material procurement planning problem. *J Intell Manuf*. 22, 319–331 (2011).
 12. Genin, P., Thomas, A., Lamouri, S.: How to manage robust tactical planning with an APS (Advanced Planning Systems). *Journal of Intelligent Manufacturing*. 18, 209–221 (2007).
 13. Hauge, J.B., Tundys, B., Rzezycki, A., Lim, T.: DEPLOYING SERIOUS GAMES FOR SUPPLY CHAIN MANAGEMENT: LESSONS LEARNED AND GOOD PRACTICES. 18 (2016).
 14. Muratet, M., Torguet, P., Jessel, J.-P., Viallet, F.: Towards a Serious Game to Help Students Learn Computer Programming. *International Journal of Computer Games Technology*. 2009, 1–12 (2009).
 15. Kaminsky, P.: A New Computerized Beer Game: A Tool for Teaching the Value of Integrated Supply Chain Management. 19.
 16. THE FRESH CONNECTION: the ultimate value experience, <http://www.advents.fr/le-blog-des-advengers/the-fresh-connection-le-serious-game-reference-en-supply-chain/>.
 17. Nonaka, T., Miki, K., Odajima, R., Mizuyama, H.: Analysis of dynamic decision-making underpinning supply chain resilience: A serious game approach. *IFAC-PapersOnLine*. 49, 474–479 (2016).
 18. Hauser, F., Pomponne, V., Jiang, Z., Lamothe, J., Benaben, F.: Processes orchestration for preventing and managing shortages in a supply chain a dermo-cosmetics use case. In: 2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC). pp. 1227–1234 (2017).
 19. Chapman, Clive: *Introduction to Materials Management*. Pearson India (2007).