



**HAL**  
open science

# An Efficient Framework for Tactical Management in Supply Chain Systems

Danielle Nya, Hassane Abouaïssa

► **To cite this version:**

Danielle Nya, Hassane Abouaïssa. An Efficient Framework for Tactical Management in Supply Chain Systems. 14th IEEE International Logistics and Supply Chain Management Conference, LOGISTI-QUA 2022, May 2022, Eljadida, Morocco. hal-03671018

**HAL Id: hal-03671018**

**<https://univ-artois.hal.science/hal-03671018>**

Submitted on 18 May 2022

**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.

# An Efficient Framework for Tactical Management in Supply Chain Systems

Danielle Nyakam Nya and Hassane Abouaïssa

Univ. Artois UR 3926, Laboratoire de Génie Informatique  
et d'Automatique de l'Artois (LGI2A) F-62400 Béthune, France  
(danielle.nyakamnya, hassane.abouaïssa)@univ-artois.fr

**Abstract**— Although dynamic supply chain management is nowadays quite widely studied, several problems related to their control remain a challenging task. Indeed, most of the methods are model-based control strategies where supply chain models play a major role. The increasing complexity of these systems makes their representation more difficult and fails to capture all the dynamic behavior of the supply chain networks. This paper proposes a new efficient and easy implementable framework for tactical management in supply chain systems. The developed approach rests on the use of model-free control in order to deal with the inventory control of supply chains. The provided numerical simulations of a petrochemical example shows the effectiveness and robustness of model-free controllers against the classic controllers.

**Keywords**—Supply chain management; model-free control; inventory control; intelligent controllers.

## I. INTRODUCTION

The study and control of supply chains have arisen interest on the research community and enterprises because of implicit economic benefits [1]. The excellent reviews provided in [2], [3], [4], [5], [6] permit to underline the importance of automatic theory methods in the management of the different processes in the supply chain systems. Successfully control algorithms have been then developed. The classical PID controllers was presented in [7] and applied by [8] in order to control the inventory level in supply chain at a desired values, considered as the optimal one aiming to satisfies the market demand timely and most effective way and to synchronize the incoming and outgoing flows of each supply chain component. [9], [10] have proposed the application of the differential flatness concept which seems to be more efficient for complex and highly nonlinear systems. Dynamic programming and optimal control methods aims to optimize an objective function that describes the performance of the system were applied by [11] and [12]. This standard

procedure allows to obtain an optimal state feedback control [2]. Early in 1999, [13] has proposed a PID like controller for the management of inventory levels in supply chains.

Robust control theory allows to take into account uncertainties concerning customer demand, machine failure and lead times as shown in [14], [15], [16]. In this framework, uncertainties are unknown but bounded quantities and constraints dictated by specifications and physical limitations [2]. More realistic and optimal results call for the introduction of forecasting techniques in order to capture the changing demand and uncertainties in the market in supply chain planing to maintain an inventory level in order to satisfy the customer demand. As depicted in the works of [17], [18], [19], model predictive control (MPC) has been applied to solve a dynamic optimization problem of the inventory. In [20], MPC control is used to demonstrate that safety stock levels can be significantly reduced and financial benefits achieved while maintaining satisfactory operating performance in supply chain. Concret applications of MPC and Internal Model Control (IMC) have been developed in [21], [22], [23].

It is important to underline that most of the developed control strategies are model-based where supply chain models play an important role. The increasing complexity of these systems makes their representation more difficult and fails to capture all the dynamic behavior of the supply chain networks. As stated in [24], writing a “good model”, where constraints and perturbations might be severe, is quite beyond our reach especially if online calibration ought to be performed. In addition, the use of more or less a good model, needs the identification of several parameters to assess a particular control strategy which is also true in the supply chain systems [26]. In this framework, a new setting of “model-free control” (MFC) and its corresponding intelligent controllers seems to be an efficient solution to tackle the problem in a new control-oriented tactical decision policy for inventory management in a production-inventory system and supply chain management

area that permits to answer, from our point of view, to the addressed problem. Such control strategy which avoids the use of any mathematical model of the studied supply chain, allows easily to take into account the inherent perturbations. In addition, its corresponding intelligent controllers are easy to tuned and to implement (See, e.g., [24], [25], for an in-depth presentation of model-free control and the meaning of intelligent controllers). Since its introduction in the field of automatic control, MFC already had many successful concrete applications (See e.g., [27], [28], [29] [30], [31], [32], [33], [34], [35] and the references therein).

This paper deals with the operational activities of supply chain dynamics and propose an efficient framework for tactical management in supply chain. The developed approach rests on the use of an Intelligent control algorithm, stemming from model-free control theory, which allows the regulation of inventory levels while ensuring a synchronization of the flow at the whole supply chain. A first attempts has already presented in [36] and [37]. The jointly use of MFC and Smith predictors has been developed in [38]. Here, the application of MFC is oriented towards a linear supply chain with application to a petrochemical problem stemming from [8]

The organization of the paper is as follow. Section II, describes the used model for the studied supply chain system. Section III, recalls the main principles of model-free control and its corresponding intelligent controllers. Simulation results of the proposed algorithm to linear supply chain, and analysis are provided in Section IV. Some concluded remarks and future works are reported in Section V.

## II. MATERIAL FLOW RATE MODEL FOR SUPPLY CHAINS

Several approaches stemming from traffic theory are used to deal with supply chain modeling and analysis. It is important to stress that several phenomena like transport and production, lead to unavoidable lead times or throughput times. Therefore, delay differential equations play a key role.

Following [39], a supply chain model can be modeled with analogy with traffic flow theory. Then, the set of elements of supply chains can modeled using linear differential equation. In order to understand the dynamic behavior of Supply Chain consider the following example of sequential chain (Fig. 1).

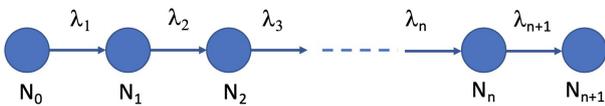


Fig. 1: Linear supply chain

Models of supply chain systems are based on a set of nodes (represented by circles) which represent the suppliers  $i$ , characterized by an inventory level  $N_i$ , ( $i = 1, \dots, n$ ). The production or incoming rate  $\lambda_i$ , depending if the node is producer (manufacturing cell, for exemple) or non-producer

(warehouse, supplier or distribution center, ...). This parameter could represent the production speed of this supplier.  $i = 0$ , corresponds to a resource center that provides raw materials and  $i = n + 1$ , is the final customer.

According to [8], the producer node is characterized by a variation of its production rate by varying its internal production policy. It is important to underline that the models either for a non producer or producer nodes, as provided by [8], fail to take into account explicitly the intrinsic parameter of delay. For this, a relatively modified model tacking into account this delay is introduced in both producer and non producer nodes.

### A. Non producer node model

Equation (1), describes the dynamic change in inventory level as a difference between the production or incoming rate  $\lambda_i$  and the delivery flow rate  $y_i$ .

$$\dot{N}_i(t) = \gamma\lambda_i(t - \theta) - y_i(t), \quad t \geq \theta \quad (1)$$

where, the delivery flow rate  $y_i(t)$  corresponds to the customer total demand.

$$y_i(t) = \sum_{j=1}^r F_{i,j} \lambda_j(t) \quad (2)$$

The output  $N_i(t) \geq 0$  is the inventory level, and  $\lambda_i(t) \geq 0$  represents the control variable. The adaptation time  $\theta$  is assumed to be known.  $F_{i,j}$  represents the stoichiometric ratio of the stock product in node  $i$  that is required by node  $j$ , (See e.g., [8]). Finally,  $\gamma$  is a yield parameter which might be poorly known.

In [38], the authors have provided a mathematical illustration of the so-called *bullwhip effect*. Indeed, if the desired inventory level either for production or non production node, is assumed to be constant i.e.,  $\dot{N}_i(t) = 0$ , then (1) yields  $\lambda_i(t) = \frac{y_i(t+\theta)}{\gamma}$ . In this case, the individual demand has to be “guessed”. In addition, no theoretical technique will ever produce rigorously accurate predictions. For simplicity’s sake let us presume here a constant bias  $b \neq 0$ , i.e.,  $\dot{N}_i(t) = \frac{b}{\gamma}$ . Thus,  $N_i(t) = \frac{b-\theta}{\gamma}(t - \theta) + N_i(\theta)$ ,  $t \geq \tau$ . Its absolute value  $|N_i(t)|$  becomes very large, at least from a purely mathematical standpoint, when  $t \rightarrow +\infty$ . Notice that, although the bullwhip effect phenomenon is more or less understood, the literature does not seem to contain any clear-cut definition of this effect.

### B. Producer node model

The incoming rate varies accordingly to production policies and process dynamical behavior. Change in the production rate involves several activities that require a delay time  $\theta$  which appears in (1). Then its dynamics can be represented by:

$$\dot{\lambda}_i(t) = \frac{1}{T_i} [W_i(t) - \lambda_i(t)] \quad (3)$$

where,  $W_i(t)$  represents the control variable that varies the production rate  $\lambda_i$ , in a producer node, in contrast with a non producer node, where  $\lambda_i$  corresponds only to the materials that are received from its suppliers.  $T_i$  is the adaptation time of the production rate  $\lambda_i$ . Equations (1) and (3) give the dynamic model of producer node.

The main objective of the designed controller for such systems is to keep inventory levels at a desired value by regulating the production or incoming rate. Either for a producer or non producer node the inventory level  $N_i$  are to be controlled indirectly through  $\lambda_i$ .

Physical limitations (bounds in the inventory levels  $N_i(t)$  and flow rates  $\lambda_i$  for a non-producer node and  $W_i$  for a producer node must be taking into account as follow:

$$\begin{cases} N_{i,min} \leq N_i \leq N_{i,max} \\ 0 \leq \lambda_i \leq \lambda_{i,max} \\ 0 \leq W_i \leq \lambda_{i,max} \end{cases} \quad (4)$$

Although the above models describe more or less the behavior of the system, the proposed model-free controller ignores these descriptions since its rests on an ultra-local model which is continuously updated. The following section recalls the principle of this paradigm.

### III. MODEL-FREE CONTROL: AN OVERVIEW

Model-free control is defined as an original concept based on the algebraic estimation and it is independent of any precise mathematical model of the system to be controlled. Since the first work of [24] several concret and successful applications around the world has be developed in most diverse fields as intelligent transportation systems [31], [35], [33], robotic [32], energy management [30], ....

Consider the input/output model of the system (5), that can be nonlinear in most cases and unknown or as stated in [34], at least poorly known.

$$E(y, \dot{y}, \dots, y^{(a)}, u, \dot{u}, \dots, u^{(b)}) = 0 \quad (5)$$

Following the principle of MFC, the system described by (5) is replaced by the so-called “*ultra-local (or phenomenological) model*”:

$$\boxed{y^{(v)} = F + \alpha u} \quad (6)$$

where:

- $y^{(v)}$  is the derivative of order  $v \geq 1$  of  $y$ . The integer  $v$  is selected by the practitioner. Several concert examples and applications show that  $v$  may be chosen quit low, i.e., 1, or only seldom, 2.
- $\alpha \in \mathbb{R}$  is a non-physical constant parameter. It is chosen by the practitioner such that  $\alpha u$  and  $y^{(v)}$  are of the same magnitude.

- $F$ , which is continuously updated, subsumes the poorly known parts of the plant as well as of the various possible disturbances, without the need to make any distinction between them.

#### A. Intelligent controllers

Assume that  $F$  is estimated and close the loop with the intelligent PID (*iPID*) controller,

$$u = -\frac{F_{est}(t) - y_{ref}^{(v)}(t) + C(e(t))}{\alpha} \quad (7)$$

where

- $y_{ref}$  is the reference trajectory,
- $e = y - y_{ref}$  is the tracking error,
- $F_{est}$  is an estimate value of  $F$ ,
- $C(e(t)) = K_P e(t) + K_I \int e(t) + K_D \frac{de(t)}{dt}$ ,
- $K_P$ ,  $K_I$  and  $K_D$  are the usual tuning gains.

Equations (6) and (7) yield

$$\ddot{e} + K_D \dot{e} + K_P e + K_I \int e = 0 \quad (8)$$

In (8),  $F$  does not appear anymore, which means that the unknown parts and disturbances of the system vanish. We are therefore left with a linear differential equation with constant coefficients of order 3.

The tuning of  $K_P$ ,  $K_I$  and  $K_D$  becomes therefore straightforward for obtaining a “good” tracking of  $y_{ref}$ . This is a major benefit when compared to the tuning of of “classic” PIDs, (See, e.g., [24], for a complet description of MFC concept),

#### B. Online estimation of $F$

Assume that  $v = 1$  in (6). In Laplace domain it becomes

$$sY = \frac{\Phi}{s} + \alpha U + y_0 \quad (9)$$

where

- $\Phi$  is a constant,
- $y_0$  is the initial condition corresponding to the time interval  $[t - \tau, t]$ .

In order to get rid of  $y_0$ , multiply both sides by  $\frac{d}{ds}$

$$Y + s \frac{dY}{ds} = -\frac{\Phi}{s^2} + \alpha \frac{dU}{ds} \quad (10)$$

For smoothing the noise, multiply both sides by  $s^{-3}$  which in time domain yields<sup>1</sup>.

$$F = -\frac{6}{\tau^3} \int_{t-\tau}^t ((\tau - 2\sigma)y(\sigma) + \alpha\sigma(\tau - \sigma)u(\sigma)) d\sigma \quad (11)$$

where  $\sigma$  is quite small and depends on the sampling period as well as the noise intensity.

<sup>1</sup>According to the equivalence:  $s^{-n} \rightarrow \int^{(n)}$ , (11) corresponds to the multiple integrals which are easily implemented as discrete linear filters.

#### IV. SIMULATION RESULTS: APPLICATION TO A PETROCHEMICAL PLANT

The conducted simulation study concerns the linear model of a petrochemical multi-product plant borrowed from [8], (See Fig.2).

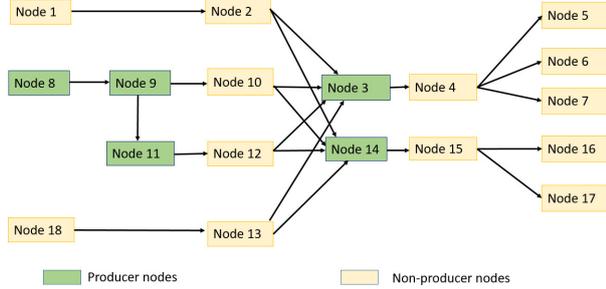


Fig. 2: Representation of the petrochemical plant

The number on the nodes identifies the numbering used through the simulations and figures presenting plots of the results. Hexane and catalyst are imported, whereas ethylene is obtained from a local refinery. The production of ethylene and butane is carried out by independent production plants (producer nodes). There exist intermediate storages for hexane, ethylene, butane and catalyst feedstocks (non producer nodes). Only five demand sources are taken into consideration from  $D_1$  to  $D_5$  (Nodes 5, 6, 7, 16 and 17).

The following table 1, stemming from [8] resumes the nomenclature for each node of the studied petrochemical plant.

TABLE 1: Node nomenclature

node	element	node	element
1	hexene ship	2	hexene store
3	reactor $R_1$	4	store $A_1, A_2$
5,6,7	client $D_1, D_2, D_3$	8	refinery
9	ethylene plant	10	ethylene store
11	butene plant	12	butene store
13	catalyst store	14	reactor $R_2$
15	store $B_1, B_2$	16,17	client $D_4, D_5$
18	Catalyst		

##### A. Model-free control of a non producer node

The studied petrochemical plant is composed of the following non producer nodes:

$C_{n-p} = \{1, 2, 4, 5, 6, 7, 10, 12, 13, 15, 16, 17, 18\}$ . Following Section III, each node can be described by the following phenomenological model:

$$\dot{N}_i(t) = F_i(t) + \alpha_i u_i(t) \quad (12)$$

<sup>2</sup>The linear character of the studied system shows that the use of an i-P is sufficient to deal with the control of the level. The integral part of the controller is already included in the estimation of  $F$ .

<sup>3</sup>See e.g., [8], or the different values of production ratios as well as initial conditions values.

where  $u_i = \lambda_i$  represents the control variable allowing to maintain the level at a desired positive value.  $F_i$  is estimated as above.

Consider as illustrative example the control of the level in the non producer node  $i = 4$ .

$$\dot{N}_4(t) = F_4 + \alpha_4 u_4(t) \quad (13)$$

The corresponding control  $u_4 = \lambda_4$  is obtained immediately

$$u_4(t) = -\frac{1}{\alpha_4} [[F_4]_{est} + N_{4,ref} + K_{P4}e(t)] \quad (14)$$

where

- $e(t) = N_4(t) - N_{4,ref}$  represents the tracking error.
- $K_{P4}$  is a tuning gain<sup>2</sup>.

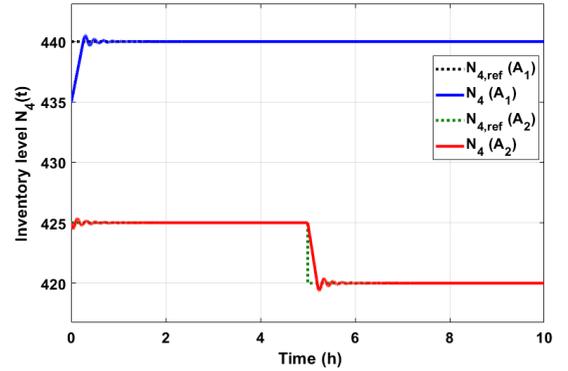


Fig. 3: Time evolution of the inventory level  $N_4$

At this node, Reactors  $R_1$  and  $R_2$  change from producing product  $A_1$  to  $A_2$  and  $B_2$  to  $B_1$  at the half of time of simulation. Excellent results are obtained despite the sudden change in the desired level (See. Fig.3)<sup>3</sup>.

The results in Fig. 4 show the time evolution of the level for the non producer node  $N_{15}$  which is storage node for  $B_1$  and  $B_2$ .

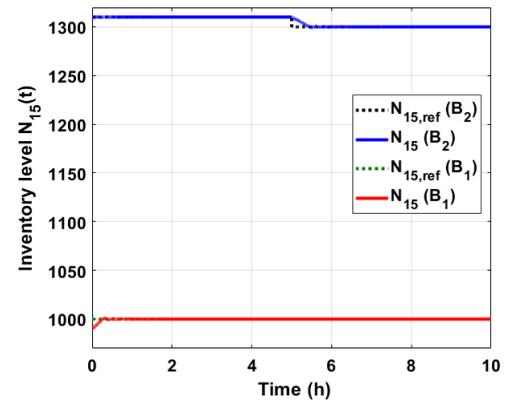


Fig. 4: Time evolution of the inventory level  $N_{15}$

As depicted in these figures, the proposed controllers show high efficiency against uncertainties and demonstrate how the desired values of each level in the studied supply chain are reached. In the same time, it guarantees the synchronization of the flows at different levels of the studied plant (See Fig.5).

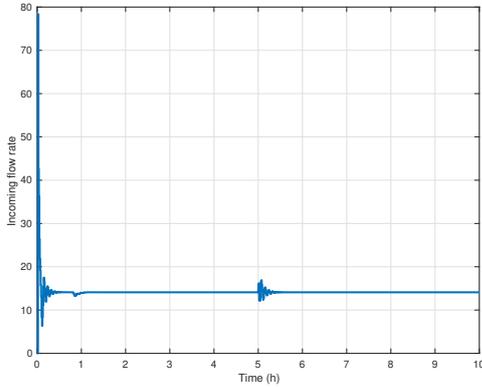


Fig. 5: Variation of the incoming flow rate  $\lambda_{15}$

### B. Model-free control of a producer node

In addition to the non producer nodes, the petrochemical plant contains a set of producer node:  $C_p = \{3, 8, 9, 11, 14\}$ . In the case of producer node, the control algorithm follows the same reasoning as in the non producer case. Then and Without a loss of generality, the obtained control, for each node reads:

$$W_i = -\frac{1}{\alpha_p} [[F_i]_{est} + \lambda_{i,ref} + K_{pi}e(t)] \quad (15)$$

Figure 6 shows the time evolution of the level at the producer node  $N_9$ . Here also, the controller manages efficiently the different nodes to the desired values and permits to synchronize the whole system.

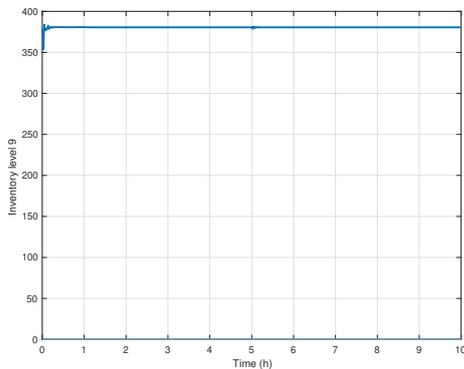


Fig. 6: Time evolution of the level of the producer node  $N_9$

Figure 7 shows the incoming flow rate variation at the node  $N_{11}$ .

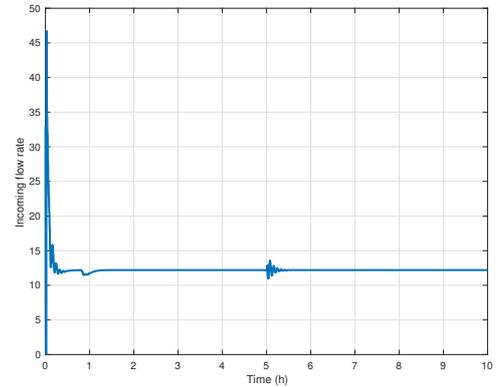


Fig. 7: Variation of the incoming flow rate  $\lambda_{11}$

## V. CONCLUSION

The model-based control of supply chain has been a subject of several studies and application and remain until today an open problem. Most of the proposed algorithms must faces the thorny problem of a realistic representation of the studied system. In addition, the control laws must also deal with uncertain customer demand as well as stochastic conditions.

In this paper, we focused on the development of an efficient framework for tactical management in supply chain systems, where the need for a mathematical model is no longer necessary. Simulations results show that a simple Intelligent proportional or iP controller seems to be more adapted to deal with such systems.

However, several further studies must be conducted in order to deal with the important issue of bullwhip effect and its attenuation. Critical supply chain systems which include perishable production must be deeply studied and controlled. Uncertainties of customer demands for example will be tacked into account by introducing a deterministic approach for demand forecasting. Several works as in [40] have demonstrated that the application of control theory approaches can easily reduce stock levels by up to 80% compared to 20-30% with MRP and hence reduce cost. These assessments must be demonstrated in the case of the proposed, in this paper, model-free control approach.

## REFERENCES

- [1] A. Bartoszewicz and M. Maciejewski, "Sliding mode control of periodic review perishable inventories with multiple suppliers and transportation losses," *Bulletin of Polish Academy of Sciences Technical Sciences*, vol. 61, No. 4, pp. 885–892, 2013.
- [2] H. Sarimveis, P. Patrinos, C. D. Tarantilis, and C. T. Kiranoudis, "Dynamic modeling and control of supply chain systems: a review," *Computers and Operations Research* 35 (11), pp. 3530–3561, 2008.

- [3] C. Riddalls, S. Bennett, and N. Tipi, "Modeling the dynamics of supply chains," *Int. J. Systems Science* 31 (8), pp.969–976, 2000.
- [4] I. Karaesmen, A. Scheller-Wolf, and B. Deniz, "Managing perishable and aging inventories: review and future research directions," in *Handbook of Production Planning*, eds. K. Kempf, P. Keskinoca, and R. Uzsoy, Kluwer, Dordrecht, 2008.
- [5] K. Hoberg, J. R. Bradley, and U. W. Thonemann, "Analyzing the effect of the inventory policy on order and inventory variability with linear control theory," *Eur. J. Operations Research* 176 (3), pp.1620–1642, 2007.
- [6] K. Subramanian, "Integration of control theory and scheduling methods for supply chain management," PhD Thesis, University of Wisconsin-Madison, Madison, 2013.
- [7] J. Wikner, M. Naim, D. Towill., "The system simplification approach in understanding the dynamic behavior of a manufacturing supply chain," *Journal of Systems Engineering*, vol 2, pp. 164–178, 1992.
- [8] A. Rodríguez-Angeles, D. América Morales, and A. Sánchez. "Dynamic Analysis and Control of Supply Chain Systems.," *Supply Chain the Way to Flat Organisation*. IntechOpen, 2009.
- [9] K. Hamiche, H. Abouaïssa, G. Goncalves and T. Hsu, "Real-time decentralized flatness-based control of dynamic supply chain systems," *Control, Decision and Information Technologies (CoDIT)*, 2016, International Conference on, Saint Julian, Malta IEEE, pp. 607–612, 2016.
- [10] K. Hamiche, H. Abouaïssa, G. Goncalves and T. Hsu, "Non-linear inventory levels control of dynamic supply chain systems," 3rd International Conference on Green Supply Chain, London UK, GSC, 2016.
- [11] H. Scarf, "The optimality of (s, S) policies for the dynamic inventory problem," *Proceedings of the first Stanford Symposium on Mathematical Methods in social sciences*. Stanford, CA: Stanford University Press; 1960.
- [12] D. Iglehart, "Optimality of (s, S) policies in the infinite horizon dynamic inventory problem," *Management Science* 9, pp.259–267, 1963.
- [13] A.S. White. "Management of inventory using control theory." *International Journal of Technology Management*, 17 (7-8), pp. 847–860, 1999.
- [14] F. Blanchini, R. Pesenti, F. Rinaldi and W. Ukovich, "Feedback control of production-distribution systems with unknown demand and delays," *IEEE Transactions on Robotics and Automation* N.16, pp. 313–317, 2000.
- [15] F. Blanchini, S. Miani and W. Ukovich, "Control of production-distribution systems with unknown inputs and system failures," *IEEE Transactions on Automatic Control*, 45, pp.1072–1081, 2000.
- [16] F. Blanchini, S. Miani and F. Rinaldi, "Guaranteed cost control for multi-inventory systems with uncertain demand," *Automatica* 40, pp. 213–223, 2004.
- [17] Dong Hai, ZHENG Hao, LI Yan Ping, "Model Predictive control for inventory management in supply chain planning," *Procedia Engineering* 15, pp. 1154–1159, 2007.
- [18] Wenlin Wang, Daniel E. Rivera, Karl G. Kempf, "Model predictive control strategies for supply chain management in semiconductor manufacturing," *International journal of production economics* 107, pp. 56–77, 2007.
- [19] Heikki Rasku, "Model Predictive control in supply chain and inventory management," Tampere university of technology. Institute of automation and control, 2004.
- [20] J. D. Schwartz, W. Wang, and D. E. Rivera. "Simulation-based optimization of process control policies for inventory management in supply chains." *Automatica*, vol. 42, no. 8, pp. 1311-1320, 2006.
- [21] J. D. Schwartz, and D. E. Rivera. "A process control approach to tactical inventory management in production-inventory systems." *International Journal of Production Economics*, 125 (1), pp.111–124, 2010.
- [22] W. Wang, D. E. Rivera, and K. G. Kempf, and K. D. Smith. "A model predictive control strategy for supply chain management in semiconductor manufacturing under uncertainty." *Proceedings of American Control Conference*, 5, pp. 4577–4582, 2004.
- [23] Q. Wang, J. Wu, N. Zha, and Q. Zhu. *Inventory control and supply chain management : A green growth perspective*. Resources, Conservation and Recycling, vol. 145, pp. 78-85, 2019.
- [24] M. Fliess, and C. Join. "Model-free control." *International Journal of Control*, vol. 86, no 12, pp. 2228–2252, 2013.
- [25] M. Fliess, and C. Join. "An alternative to proportional-integral and proportional-integral-derivative regulators: intelligent proportional-derivative regulators". *Int. J. Robust Nonlinear Control*, 2021. <https://doi.org/10.1002/rnc.5657>.
- [26] C. Join, J. Bernier, S. Mottelet, M. Fliess, S. Rechdaoui-Guérin, S. Azimi and V. Rocher, "A simple and efficient feedback control strategy for wastewater denitrification," *IFAC-PapersOnLine*, arXiv preprint arXiv:1703.05278, 2017.
- [27] O.Bara, M.Fliess, C.Join, J.Day and S.M. Djouadi, "Toward a model-free feedback control synthesis for treating acute inflammation," *J. Theoret. Biology*, 448, pp. 26–37, 2018.
- [28] N. Afsi, T. Bakir, S. Othman, A. Sakly, "Model-free control of a seeded batch crystallizer," *Canad. J. Chem. Engin.*, 96, pp. 1306-1313, 2018.
- [29] J.M.O. Barth, J.-P. Condomines, M. Bronz, L.R. Lustosa, J.-M. Moschetta, C. Join, and M. Fliess, "Fixed-wind UAV with transitioning flight capabilities: Model-Based or Model-Free Control approach? A preliminary study," *Int. Conf. Unmanned Aircraft Syst.*, Dallas, 2018. <https://hal.archives-ouvertes.fr/hal-01817515/en/>
- [30] H. Abouaïssa, O. Hasan Elhaj, C. Join, M. Fliess, and D. Defer, "Energy saving for building heating via a simple and efficient model-free control design: First steps with computer simulations," 21<sup>th</sup> International Conf. on System Theory, Control and Computing, IEEE - ICSTCC 2017, Sinaia, Romania, October 19–21, octobre 2017.
- [31] H. Abouaïssa, M. Fliess, and C. Join. "On ramp metering: Towards a better understanding of ALINEA via model-free control." *International Journal of Control*, vol. 90, no 5, pp. 1018–1026, 2017.
- [32] H. Abouaïssa, and S. Chouraqui. "On the control of robot manipulator: A model-free approach." *Journal of Computational Science*, vol. 31, pp. 6–16, 2019.
- [33] S. Choi, B. d'Andréa-Novel, M. Fliess, H. Mounier and J. Villagra, "Model-free control of automotive engine and brake for Stop- and-Go scenarios," 10<sup>th</sup> Europ. Control Conf. Budapest, 2010.
- [34] M. Fliess, C. Join and S. Riachy, "Revisiting some practical issues in the implementation of model-free control". 8<sup>th</sup> IFAC World Congress, IFAC WC:2011, Milan, Italy, 2011.
- [35] C. Join, H. Abouaïssa, and M. Fliess. "Ramp metering: modeling, simulations and control issues." arXiv preprint arXiv:2111.06610, 2021.
- [36] D. Nyakam Nya, S. Hachour and H. Abouaïssa, "Inventory Control in Supply Chain: a Model-Free Approach," 10<sup>th</sup> IFAC Conference on Manufacturing Modelling, Management and Control, 22–24, Nantes, France, June, 2022.
- [37] D. Nyakam Nya, and H. Abouaïssa. "Model-Free Control Policies for Inventory Management in Supply Chain", 8<sup>th</sup> International Conference on Control, Decision and Information Technologies, CoDIT 2022, Istanbul, Turkey, May, 17–20, 2022.
- [38] K. Hamiche, M. Fliess, C. Join and H. Abouaïssa, "Bullwhip effect attenuation in supply chain management via control-theoretic tools and short-term forecasts: A preliminary study with an application to perishable inventories," 6<sup>th</sup> International Conference on Control, Decision and Information Technologies, CoDIT 2019, Paris, France, April 2019.
- [39] D. Helbing, "Modeling supply networks and business cycles as unstable transport phenomena". *New J. of Physics*, 5(90), 2003, pp. 1– 28, .
- [40] A. S. White, Y. C. Yan, E. Akpunar and K. K., Hock. "Control strategies for inventory management", - eprints.mdx.ac.uk, 2002.