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Stochastic Modeling with Applications in Supply Chain Management and ICT Systems

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Abstract: Fast-growing technology and the development of IT services have yielded the idea of founding a new application of stochastic processes and their properties. We give a new connection between electronic process management and a relatively new stochastic process named the Non-central Polya-Aeppli process. This process is applied as a counting process in the mathematical construction of the given model, and it has been introduced as a counting process in electronic process management.

Keywords: electronic process management; stochastic processes; Non-central Polya-Aeppli process; information and communication technology (ICT); supply chain management (SCM)

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1. Introduction

Logistics is characterized by offering a variety of logistics activities and management solutions, such as services related to the transportation, storage, packaging, distribution, etc., of goods. The biggest challenge for the logistics sector is the question of how to keep customers satisfied and how to meet their expectations. The increasing globalization of the economy and intense competition gives the customer a need for reduced service time and cost reductions. Thus, to fulfill customers' needs, supply chain integration has been increased, see [1]. As such, logistics, information and communication technology (ICT) facilitates the integration of supply chain activities. The relevance and importance of ICT to logistics companies are seen in the provision of accurate information, which has to be obtained on time, allowing data sharing among companies and their partners in the supply chain. This leads to the enhancing of decision-making solutions, see [2]. Today's fast-growing technology companies leverage global supply chains and IT services. ICT supports multiple business processes in logistics and it is related to customer relationship management (CRM), IT international network services, cloud technology, delivery tracking and more. The present paper is a continuation of our previous research conducted in this direction introduced in [3]. The current investigation on the Non-central Polya-Aeppli process introduced in [4] focuses on the application of this stochastic process in the supply chain management (SCM) of the electronic industry. It is a sum of the Polya-Aeppli process introduced and characterized in [5,6] and a homogeneous Poisson process. The Polya-Aeppli process (PAP) is a compound Poisson process with a geometric compounding distribution and rate $\lambda_1 > 0$. It is given by the notation $N_1(t) \in PA(\lambda_1 t, \rho)$, where $\rho \in [0, 1)$ is a parameter known as a correlation coefficient, see [7]. It is an over-dispersed process related to the standard Poisson process, see [5,6]. This property gives good flexibility, especially when we speak about data with a big dispersion. A good indicator for this is the Fisher index of dispersion, which was introduced by Fisher in 1934 [8]. It expresses the ratio of a random variable's variance to its mathematical expectation, see [9]. The Fisher index can be calculated by the following formula:

$$FI(N) = \frac{\mathrm{Var}(N)}{\mathbb{E}(N)}. \tag{1}$$

As such, when we speak about data with a big dispersion, the over-dispersion property is very valuable.

In the present paper, we analyze the properties of the Non-central Polya-Aeppli process. It is applied as a counting stochastic process in electronic process management in which two types of customer requests, namely those that are unprocessed and not sent on time, are counted by the given process. Section 3 is devoted to electronic management and industry. The significant part of this paper is given in Section 4, where the application of electronic process management is implemented by the Non-central Polya-Aeppli process and its nice properties. It continues our previous study on stochastic processes and their application in supply chain management in the electronic industry [3].

2. The Non-Central Polya-Aeppli Process and Some of Its Characteristics

The probability mass function of the Non-central Polya-Aeppli process $N(t)$, see [8], is given by:

$$P(N(t) = i) = \\ = \begin{cases} e^{-(\lambda_1+\lambda_2)t}, & i = 0, \\ e^{-(\lambda_1+\lambda_2)t}\left[\frac{(\lambda_2 t)^i}{i!} + \sum_{j=1}^{i} \frac{(\lambda_2 t)^{i-j}}{(i-j)!} \sum_{k=1}^{j} \binom{j-1}{k-1} \frac{[\lambda_1(1-\rho)t]^k}{k!} \rho^{j-k}\right], & i = 1,2,\ldots \end{cases} \tag{2}$$

The probability generating function of the process is as follows:

$$\psi_{N(t)}(s) = e^{-\lambda_1 t[1-\psi_1(s)]}.e^{-\lambda_2 t(1-s)}, \tag{3}$$

where $\psi_1(s) = \frac{(1-\rho)s}{1-\rho s}$ is the probability generating function of the shifted geometric distribution with success probability $1-\rho < 1$ denoted by $Ge_1(1-\rho)$.

The counting process starts at zero, and for each $t > 0$, the corresponding distribution of the process is the Non-central Polya-Aeppli distribution, see [10]. Some useful and nice properties of this distribution are presented in [10]. The authors give some visualizations based on the idea of changing the different values of the parameters λ_1, λ_2 and ρ. The visualizations show that this corresponding distribution is a right-tailed distribution, and it could be a suitable distribution for data in an industry in which such kind of distribution is applicable. A good fact regarding the Non-central Polya-Aeppli process is that this stochastic process is a pure birth process, see [4].

3. Supply Management in Electronics

The description of the company's management from some certain information, including from the supplying of product materials, to the company's production during the supply chain from component producers and suppliers, and to the final step, i.e., the client's delivery, is called supply chain management (SCM), see [1]. SCM is also the management of interrelated parts that work together to produce and deliver products to customers accurately and quickly. Its goal is to achieve maximum customer satisfaction, lower costs and competitive business advantages. SCM software is a program which has been developed to control end-to-end business processes across the supply chain, perform demand planning and forecasting and manage supplier relationships. These systems are useful to businesses in industries across the world. SCM software is a helpful tool for automating, which comprises much of the physical SCM process and provides analytics and business intelligence for growth in terms of delivering goods on time. The benefit of this process is that it determines the customers' added value at a minimal cost [2,10–12].

Companies that integrate computer systems into their business benefit from information management and decision making to improve procurement management, and they also have better collaboration with partners and avoid delays in the delivery of material resources [13–16]. In Figure 1, we illustrate the SCM main components. It was generated by platform https://www.smartdraw.com/ (accessed on 21 July 2022). A theoretical and detailed description of the main components of SCM can be found in [14].

Figure 1. Main components and features of supply chain management. The diagram was generated by the platform SmartDraw available on https://www.smartdraw.com/ (accessed on 21 July 2022).

In Table 1, a list of the most popular supply chain management software for businesses of all sizes is presented. In our previous research [3], we presented popular SCM and ERP software, some of which have been developed by the IT industry in Bulgaria, such as-AVAMB LOGICIEL ERP [17], bgERP [18], Prim [19], TECHNO CLASS [20], Tonagen ERP [21], Zeron V/4 [22] and so on. The ranking of the best SCM software for 2022 in the world can be seen in [23–27]. More detailed information about the presented software can be found in [27].

Table 1. List of the most popular supply chain management software (SCM) for businesses of all sizes.

№	Product	Features	Website
1.	NetSuite	NetSuite is fully cloud-based SCM software that includes the following modules: demand; warehouse and inventory management; analytics and reporting; customer relationship and management, professional service automation; audit trail; tax; and workflow and cost management.	https://www.netsuite.com/ (accessed on 20 September 2022)
2.	GEP NEXXE	GEP NEXXE is an AI-powered digital platform that provides fully cloud-based SCM software. It is designed for complex, global demand and supply networks and it provides visibility and execution (inventory, warehouse management, logistics), planning (demand, supply, logistics) and collaboration (forecast, purchase order, capacity) in one cloud platform.	https://www.gep.com (accessed on 20 September 2022)
3.	Infor SCM	Infor SCM is a cloud-based enterprise supply management software. It is built on Infor ERP and is available on all devices, including mobile, tablet and desktop. It includes modules such as visibility and control, global trade and finance, planning and demand management, warehousing and transportation and product lifecycle management.	https://www.infor.com (accessed on 20 September 2022)
4.	SAP SCM	SAP is among the most popular SCM software available in over 180 countries and over 40 languages. It is a cloud-based platform that features predictive analytics, automation and IoT capabilities. The platform includes inventory optimization, demand forecasting sales and operation planning, supply planning, enhanced compliance, dashboard to manage all tasks from a single place and supplier management, among others.	https://www.sap.com (accessed on 20 September 2022)
5.	Oracle Cloud SCM	Oracle SCM is a fully cloud-based SCM platform and end-to-end business process integration. Oracle's cloud applications include enterprise resource planning, supply chain and manufacturing management, human capital management and customer experience.	https://www.oracle.com/scm (accessed on 20 September 2022)
6.	Coupa	Coupa Supply Chain Design & Planning provides smarter, faster supply chain decision making for enterprises around the world. The platform includes an innovative all-in-one supply chain modeling tool that helps transform designs from one project to a consistent and repeatable process. It provides benefits to its customers through the use of Amazon Web Services.	https://www.coupa.com/ (accessed on 20 September 2022)
7.	JAGGAER SCM	JAGGAER is SCM software that allows users to collaborate in real time with 100% of direct material suppliers through a modern supplier portal—web EDI (electronic data interchange). The platform includes all stages of SCM, namely ordering, receiving and invoicing goods.	https://www.jaggaer.com/ (accessed on 20 September 2022)
8.	Epicor Software Corporation	Epicor offers SCM software solutions integrating procurement, inventory, logistics, warehousing and distribution functionality with CRM and financial management. It aims to provide a tailored technology platform focusing on serving the needs of end-to-end supply chains.	https://www.epicor.com/ (accessed on 20 September 2022)
9.	E2Open	E2open is cloud-based, mission-critical, end-to-end SCM software that provides automated real-time information exchanges with and among partners. It features advanced material management, warehouse management, inventory planning and management, barcoding, EDI, purchase management, commerce connect and so on.	https://www.e2open.com (accessed on 20 September 2022)
10.	Microsoft Dynamics 365	Microsoft Dynamics Supply Chain Management (D365 SCM) is cloud-based software that combines traditional ERP and customer relationship management systems. It is focused on increasing the operational efficiency of businesses and the quality of the end product. It provides inventory and logistics management, automated warehouse operations, simplified procurement process, improved overall equipment process using IoT, effective geographical asset management, power BI analytics and so on.	https://dynamics.microsoft.com/ (accessed on 20 September 2022)

In SCM, some mathematical optimization techniques are applied. They can be used at different levels, taking into account factors such as transport route, distribution networks or warehouse operations. Popular mathematical modeling approaches that are used in SCM problems are linear and nonlinear programming, multi-objective programming, fuzzy mathematical programming, stochastic programming, heuristic algorithms, and metaheuristic and hybrid models [28–30].

Unfortunately, existing software solutions make little use of the advanced mathematical results. Usually, software is required to be able to address a large class of issues in order to be suitable for practical use. Software companies demand developers with broad competence (e.g., full-stack developers) to take care of various aspects of the product. Only the biggest international companies can afford to include mathematics-oriented experts in the development process. However, again due to the overall complexity of the product, the underlying science is usually limited to the basics of queueing theory and linked topics in computational algorithms. There is little focus on the optimization of the results with respect to business-related criteria. On the other hand, the current tendency, as we mentioned earlier, is to focus on multi-purpose software rather than custom specialized solutions, maybe mainly due to economic reasoning. As such, in our opinion, a trade-off between the breadth and depth of software capabilities must be always made, tailoring the solution to every situation.

4. Non-Central Polya-Aeppli Process and Its Application in Electronic Process Management

We consider that a certain business company produces two types of electronic components. The first type of electronic components is motion sensors and the second one is heat sensors. The customers' flow requests come to the business company electronically. Within a period of three days, the requests have to be processed. After this period, the ordered components have to be sent back to the customers. If the company does not complete the processing request and does not return the request on time to the client, then it has to pay a penalty fee for this delay.

Let the state of the business company at a time t where u is the initial capital is denoted by the following stochastic process:

$$P(t) = u + \pi(t) - S_{N(t)}, \quad t \geq 0,$$

where $\pi(t)$ is a non-negative function with finite variation. The sum $u + \pi(t)$ describes the company's revenue growth and the accumulated sum $S_{N(t)}$ determines the company's expenditures. Then, the process $P(t)$ defined on the complete probability space (Ω, F, P) represents the profit of the company's business in the time interval $[0, t]$, see [3].

Profit $\pi(t)$ is usually modeled as a deterministic algebraic function [31]. The company's profit model is essentially its plan to make the business viable and thriving. In detail, it shows how to realize the potential revenue planned in the profit or business model. There are four types of profit models:

- Production model: this involves the creation of products or service, which is sold to the client. The company usually buys raw materials and produces goods with added value;
- Rental/leasing model: the company owns equipment, machinery, land, buildings, vehicles, etc., which are provided to the customer for temporary use. After the end of the contract, the subject of the deal remains property of the owner;
- Advertising model: this involves providing a platform that businesses can use to promote their products or services. The customers pay for advertising, while the ads are usually free for their target audience;
- Commission model: this includes offering services to the clients.
- The company in our study case obviously follows the production business model.

Usually, the fixed costs can be well approximated. The same is true for the sales costs and, to some extent, the sales revenue per unit production. The volatile component is the sold quantity q. If the company is niched in B2B contracts, the produced quantity is preordered. Very often, contracts allow the quantity to be changed in some range (e.g., ±20%) but this option is only occasionally activated. In contrast, if the company is positioned in the B2C market, then the sold quantities are unknown in advance. Of course, there are always expectations based on market surveys, regression or other assumptions, but they do not guarantee sold production or satisfied customers. Thus, the sold quantities are suitable for stochastic modeling, but the underlying conjectures must be carefully selected. What is more in this case, the selling price p is also not a constant or even deterministic, but it is a function of many factors, such as product demand, economic conjuncture and many others. Modeling the sales revenue as a stochastic process is a complex problem and is a matter of other in-depth research.

The key components of a profit model are the following:

- Production component: the step a product or service has to go through before it can be sold to customers in its final form;
- Operation component: this involves all the equipment for the product and personnel;
- Sales and marketing component: this is about getting the product ready for people, aiming to create interest among potential customers;
- Delivery component: this comprises bringing the product or service to the end customer.

The profit model could be expressed in analytical terms in a simple way:

$$\pi(t) = pq - (F_t + wq), \tag{4}$$

where pq is the total sales revenue, wq is the total sales cost and F_t is the administration costs.

The total sales revenue is the sum of all incomes from the products that are actually sold as follows:

$$pq = \sum_{i=1}^{n} p_i q_i.$$

The total sales costs are the sum of all expenditures for all products sold as follows:

$$wq = \sum_{i=1}^{n} w_i q_i.$$

For our study case company, it sells $n = 2$ products.

The average unit production cost includes both the fixed and variable costs. If one wants to separate the fixed and variable costs, they may write the following:

$$w = \frac{f}{q_1 + q_2} + v_1 + v_2,$$

where q_i is the sold quantities from the i-th product, v_i is the variable costs per unit, and f is the fixed manufacturing costs.

There are a number of financial indicators which must be carefully controlled. The first is the profit margin:

$$\text{Gross Profit Margin} = \frac{p - w}{p},$$

$$\text{Net Profit Margin} = \frac{\pi(t)}{pq}.$$

The asset turnover ratio reveals the efficiency of the usage of assets to generate sales revenue. It shows how many dollars in revenue are generated for every dollar in assets as follows:

$$\text{Asset Turnover Ratio} = \frac{pq}{u + \pi(t)}.$$

The return on equity measures the investment success in business, which can be calculated as follows:

$$\text{Return on Equity} = \frac{\pi(t)}{u + \pi(t)}.$$

As discussed, some companies sign long-term contracts, and they know exactly the number and the size of their order in advance. Regarding our case study company (and many others), it receives the orders and collects them on a three-day basis, so the profit components depend on time.

$$\pi(t) = pq(t) - (F_t + wq(t)).$$

In this case, the ordered quantities are unknown in advance. There exist many approaches to forecast them, the most advanced of which are based on historical time series data. Amongst the most popular methods are ARIMA-type methods, neural networks and the modified ODE approach [32]. The time series could be forecasted in solitude [33] or coupled with other time series [34].

In contrast, the accumulated sum up for the time t of the company's penalties for requests that are unprocessed and returned on time is purely stochastic, and it is given as follows:

$$S_{N(t)} = \sum_{i=1}^{N(t)} Z_i,\ t \geq 0,$$

The process $\left\{S_{N(t)}, t \geq 0\right\}$ is a random sum of random variables with the condition that $S(t) = 0$. when the counting process $N(t) = 0$.

The counting process $N(t) = \sup\{n : \sigma_n \leq t\},\ t \geq 0$, where $0 \leq \sigma_1 \leq \sigma_2 \leq \cdots$ represents the time of request arrivals in the Non-central Polya-Aeppli process, see [4].

The interpretation of the counting process is that there are two types of requests that are unprocessed and returned on time to the customers. The first type is counted by the Polya-Aeppli process, and the second type is counted by the homogeneous Poisson process. The intensity functions of the two stochastic processes give the processing speed of the two types of requests that the company offers to the market. They can be measured by the orders flows that the business company could not send on time to its customers.

The relations between the time of the request's arrivals and the counting process $\{N(t), t \geq 0\}$ are given by the following:

$$\{N(t) = n\} = \{\sigma_n \leq t < \sigma_{n+1}\},\ n = 0, 1, \ldots$$

The sequence $\{Z_n, n = 1, 2, \ldots\}$ of independent and identically distributed random variables with common distribution function F, $F(0) = 0$ and expectation μ is independent of the counting process $N(t)$, see [10].

5. Conclusions

A new approach of using a counting stochastic process in electronic management and industry is given. The main aim of the present paper is to determine the firm's profit and to construct a good model with applications in supply chain management.

The importance of ICT for logistics and supply chain management (SCM) is seen in the provision of accurate information that allows data sharing within the company and supply chain partners. This improves decision-making policy. With SCM services, users can evolve supply chain processes into intelligent workflows and thus they can reach new levels of innovation. This study presents some essential components and features of SCM and a list of popular SCM and ERP software solutions.

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References

1. Chopra, S.; Meindl, P. *Supply Chain Management. Strategy, Planning & Operation*; Springer Gabler: Wiesbaden, Germany, 2007; pp. 265–275. [CrossRef]
2. Daugherty, P.J. Review of logistics and supply chain relationship literature and suggested research agenda. *Int. J. Phys. Distrib. Logist. Manag.* **2011**, *41*, 16–31. [CrossRef]
3. Lazarova, M.D.; Sapundzhi, F.I. Stochastic processes with applications in supply chain management of electronic industry. In Proceedings of the International Conference on Statistics and Machine Learning in Electronics, Sofia, Bulgaria, 12–13 May 2022. Available online: http://ir.bas.bg/ccs/2022/9_lazarova.pdf (accessed on 19 June 2022).
4. Lazarova, M.D.; Minkova, L.D. Non-central Polya-Aeppli process and ruin probability. *Ann. Acad. Rom. Sci. Ser. Math. Appl.* **2019**, *11*, 312–321.
5. Minkova, L.D. The Polya-Aeppli process and ruin problems. *J. Appl. Math. Stoch. Anal.* **2004**, *3*, 221–234. [CrossRef]
6. Chukova, S.; Minkova, L.D. Characterization of the Polya-Aeppli process. *Stoch. Anal. Appl.* **2013**, *31*, 590–599. [CrossRef]
7. Minkova, L. A generalization of the classical discrete distributions. *Commun. Statist. Theory Methods* **2002**, *31*, 871–888. [CrossRef]
8. Fisher, R.A. The effect of methods of ascertainment upon the estimation of frequencies. *Ann. Eugen.* **1934**, *6*, 13–25. [CrossRef]
9. Xekalaki, E. Under and over dispersion. In *Encyclopedia of Actuarial Science*; Teugels, J.L., Sundt, B., Eds.; John Wiley&Sons: Hoboken, NJ, USA, 2006; Volume 3, pp. 1700–1705.
10. Lazarova, M.D.; Minkova, L.D. Non-central Polya-Aeppli distribution. 44-th International Conference on Applications of Mathematics in Engineering and Economics (AMEE'2018). In *AIP Conference Proceedings*; AIP Publishing LLC: Melville, NY, USA, 2018; Volume 2048, p. 020022.
11. Soto, A.P.; Meroño, C.A. Analyzing e-business value creation from a resource-based perspective. *Int. J. Inf. Manag.* **2008**, *28*, 49–60. [CrossRef]
12. Colin, M.; Galindo, R.; Hernández, O. Information and communication technology as a key strategy for efficient supply chain management in manufacturing SMEs. *Procedia Comput. Sci.* **2015**, *55*, 833–842. [CrossRef]
13. Available online: https://simfoni.com/sourcing/ (accessed on 20 September 2022).
14. Stanton, D. *Supply Chain Management For Dummies, For Dummies*, 1st ed.; John Wiley & Sons: Hoboken, NJ, USA, 2020.
15. Report: Global Supply Chain Management Software Market 2021–2025. Available online: https://www.researchandmarkets.com/ (accessed on 20 September 2022).
16. AVAMB LOGICIEL ERP. Available online: https://avamb-logiciel.com/ (accessed on 20 September 2022).
17. bgERP. Available online: https://bgerp.com/ (accessed on 20 September 2022).
18. Prim. Available online: https://prim.bg/ (accessed on 20 September 2022).
19. TECHNO CLASS. Available online: https://techno-class.com/ (accessed on 20 September 2022).
20. Tonagen ERP. Available online: https://tonegan.bg (accessed on 20 September 2022).
21. Zeron V/4. Available online: https://zeron.bg (accessed on 20 September 2022).
22. Business Dictionary: Supply Chain Definition, 2019. Available online: https://link.springer.com/content/pdf/bbm%3A978-3-030-15058-7%2F1.pdf (accessed on 20 September 2022).
23. Report: Enterprise Resource Planning (ERP) Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2021-2026. Available online: https://www.researchandmarkets.com/reports/5441989/enterprise-resource-planning-erp-market-global#src-pos-29 (accessed on 20 September 2022).
24. Available online: http://web.cbn-bulgaria.com/ (accessed on 20 September 2022).
25. Available online: https://technologyadvice.com/erp/ (accessed on 20 September 2022).
26. Griswold, M. The Gartner Supply Chain Top 25 for 2022. Available online: https://www.gartner.com/en/articles/the-gartner-supply-chain-top-25-for-2022 (accessed on 20 September 2022).
27. Supply Chain Management Software. Available online: https://www.softwareworld.co/top-supply-chain-management-software/ (accessed on 20 September 2022).
28. Mula, J.; Peidro, D.; Díaz-Madroñero, M.; Vicens, E. Mathematical programming models for supply chain production and transport planning. *Eur. J. Oper. Res.* **2010**, *204*, 377–390. [CrossRef]
29. Lee, Y.; Golinska-Dawson, P.; Wu, J. Mathematical models for supply chain management. *Math. Probl. Eng.* **2016**, *2016*, 6167290. [CrossRef]
30. Ali, S.; Nakade, K. A mathematical optimization approach to supply chain disruptions management considering disruptions to suppliers and distribution centers. *Oper. Supply Chain. Manag.* **2015**, *8*, 57–66. [CrossRef]
31. Mattessich, R. Budgeting models and system simulation. *Account. Rev.* **1961**, *36*, 384–397.
32. Georgiev, S.G.; Idirizov, B.B. Jump-diffusion modelling of the gold and crude oil futures prices and predictive analysis of their economic impact. In *AIP Conference Proceedings*; AIP Publishing LLC: Melville, NY, USA, 2022; Volume 2459, p. 030009.

33. Georgiev, S.G.; Idirizov, B.B. Predictive analysis and evaluation of the Bulgarian economy's most significant indicators. *Proc. Annu. Sci. Conf. Univ. Ruse Union Sci.* **2020**, *59*, 35–36.
34. Georgiev, S.G.; Idirizov, B.B. TSA & ML predictive modelling of EU financial and economic indices. 13-th Conference on Euro-American Consortium for Promoting the Application of Mathematics in Technical and Natural Sciences (AMiTaNS'2021). In *AIP Conference Proceedings*; AIP Publishing LLC: Melville, NY, USA, 2022; Volume 2522, p. 100004.

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