REVIEW

Of the *member* of the dissertation council for the dissertation of Yulia Evgenevna Lonyagina on the topic: "Mathematical modeling of the equilibrium product flows distribution", submitted for the degree of *candidate* (PhD) of Physico-Mathematical Sciences in the speciality 1.2.3 — Theoretical Informatics, Cybernetics.

In her dissertation research, Yulia Evgenevna Lonyagina considers the problem of analyzing the emergence of a non-zero product flow between suppliers and consumers distant from each other under perfect competition. Mathematical modeling of product flows has been widespread in the scientific community for a long time, as commodity and product flows are an essential part of the global supply chains. Today we can observe the growth in the scale and complexity of economic relations, which is why logistical and operational problems become much more complicated and traditional tools can no longer cover the entire range of emerging tasks. Therefore, the task of distributing single-commodity flows does not lose its relevance. Furthermore, over the past decades, the possibilities and tools of applied mathematics have expanded significantly, making it possible to build more and more accurate models of various processes and systems, take them into account, and find new patterns. The latter, in turn, are extremely in demand today due to the limited resources and highly competitive environment of the modern market. Thus, the development of optimization models for product flow distribution is practically significant and the relevance of the topic is beyond doubt.

The dissertation consists of an introduction, three chapters, and a conclusion. The full scope of the dissertation is 103 pages. The first chapter is devoted to the problem of finding an equilibrium flow distribution in a single–commodity network under conditions of fixed volumes of supply and demand. The second chapter of this dissertation research is devoted to the study of equilibrium in the single–commodity market in a situation where either demand or supply is fixed, while the opposite market parameter is elastic. The third chapter focuses on the study of the equilibrium flow distribution in a single–commodity network under the elasticity of supply and demand as well as under the condition of market balance. The basic results of the research can be listed as follows:

1. Conditions for the existence and uniqueness of admissible values of purchase and sale prices under the equilibrium distribution of product flows.
2. Conditions for the emergence of non–zero product flows between suppliers and consumers under equilibrium distribution in the case of elastic supply and demand functions.
3. Analytical representation of the conditions for refusing to supply the product to the consumer and the volumes of partial satisfaction of demand in the case of an equilibrium flows distribution in the case of a shortage of supply.
4. Analytical representation of the conditions for refusing to purchase a product from a supplier and the volume of partial purchases in the case of an equilibrium flows distribution in the case of a supply surplus.
5. Methodology and algorithm for optimizing the topology of a single–commodity network based on the analytical representation of the equilibrium flows distribution.

The reliability of the main provisions of the study is provided by the correct formulation of problems, the use of a systematic approach in the subject area analysis, the use of modern mathematical approaches, and the consistency of the results obtained with the results of the other researchers' works. The proofs of obtained scientific results are based on rigorous mathematical reasoning of all formulated statements. Moreover, the main results of this dissertation research were presented at various international conferences. The novelty of the dissertation is offered by the consideration of various cases of elasticity and fixed supply and demand; and the study of situations of balance, deficit, and surplus.

Nevertheless, there are several remarks on this research:

1. Is it possible to prove Lemma 2 from Section 1.1 for the case of m suppliers and n consumers? Which assumptions should be made to generalize this Lemma?
2. How can one use the relocation conditions under shortage (overproduction) to mitigate risks in real supply chains? The examples given do not answer this question clearly.
3. Obtained results seem to contribute to long-term planning and management. Can one use any of your results for short-term planning or management?

However, it is worth mentioning that, despite these remarks, the dissertation is written at a high level and it creates a positive impression. The research conducted by the author has scientific and practical significance, and it deserves to be highly commended.

Dissertation of Yulia Evgenevna Lonyagina on the topic: "Mathematical modeling of the equilibrium product flows distribution" *meets* the basic requirements established by Order No.11181/1 dd. 19.11.2021 "On the procedure for awarding academic degrees at St. Petersburg State University". The applicant Yulia Evgenevna Lonyagina *deserves* to be awarded the academic degree of *candidate(PhD)* of Physico-Mathematical Sciences in the speciality 1.2.3 — Theoretical Informatics, Cybernetics. No violations of paragraphs 9 and 11 of the specified Order have been detected.

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