UDC 656.073

THE PARTICULARITIES OF INFORMATION EXCHANGE BETWEEN PARTICIPANTS DURING THE ORGANIZATION OF SUPPLY CHAINS IN RAILWAY TRANSPORT

A. A. Khoroshevich

Candidate of Economic Sciences, First Deputy Head of the State Association "Belarusian Railway", Associate Professor of the Department of Economics and Logistics of the Belarusian National Technical University, Minsk, Belarus, e-mail: khoroshevich@mail.ru

Abstract

The article formulates the principles of information exchange between participants of supply chains during the organization of railway freight transportation. In the research, the features of supply chains organization in railway transport were initially determined and their typology was substantiated. Consideration of supply chains in the sphere of railway transportation established the need to change the constituent and substantive elements of the extended and maximum chains, and at the same time determined the formation of a specific approach to determining the composition of the main links and areas of data exchange. In contrast to the classical understanding, in the proposed typology, an extended supply chain is formed from a simple one by including in its composition logistics, information and financial intermediaries, as well as other market entities, which is standardly provided for by the maximum supply chain.

Taking into account the established specifics, the participants in supply chains were further determined when organizing railway transportation in domestic and international traffic (reflecting options for both direct and extended supply chains), as well as with the participation of the carrier in intermodal transportation (as an example of building a maximum supply chain). The principles of information interaction of participants (shippers, consignees, cargo owners, freight forwarding organizations, financial organizations, government agencies, shipping line operators and road carriers) within the framework of the formed material, digital and financial flows with the organization of corresponding models were formulated. In conclusion, it was established that the scale of the established cooperation with each of the participants in the supply chain directly depends on the type of transportation and the adopted work technology.

Keywords: supply chains, railway transport, extended and maximal chains, information interaction, data exchange.

ОСОБЕННОСТИ ИНФОРМАЦИОННОГО ВЗАИМОДЕЙСТВИЯ УЧАСТНИКОВ ПРИ ПОСТРОЕНИИ ЦЕПЕЙ ПОСТАВОК НА ЖЕЛЕЗНОДОРОЖНОМ ТРАНСПОРТЕ

А. А. Хорошевич

Реферат

В статье сформулированы основы информационного взаимодействия участников цепей поставок при организации железнодорожных грузовых перевозок. В рамках проведенного исследования первоначально определены особенности построения цепей поставок на железнодорожном транспорте и обоснована их типология. Рассмотрение цепей поставок в плоскости железнодорожных перевозок установило необходимость изменения составляющих и содержательных элементов расширенной и максимальной цепей поставок и одновременно обусловило формирование специфического подхода к определению состава их основных звеньев и областей обмена данными. В отличие от классического понимания в предложенной типологии расширенная цепь поставок формируется из простой включением в ее состав логистических, информационных и финансовых посредников, а также иных рыночных субъектов, что стандартно предусматривает максимальная цепочка поставок.

С учетом установленной специфики в дальнейшем определены участники цепей поставок при организации железнодорожных перевозок во внутриреспубликанском и международном сообщении (с отражением вариантов как для прямой цепи поставок, так и для расширенной), а также при участии перевозчика в интермодальных перевозках (в качестве примера построения максимальной цепи поставок). Сформулированы основы информационного взаимодействия участников (грузоотправителей, грузополучателей, грузовладельцев, экспедиторских организаций, финансовых организаций, органов государственного управления, операторов морских линий и автомобильных перевозчиков) в рамках формируемых материальных, цифровых и финансовых потоков с построением соотвествующих моделей. В завершении установлено, что масштаб устанавливаемого сотрудничества с каждым из участников цепи поставок напрямую зависит от типа перевозки и принятой технологии работы.

Ключевые слова: цепи поставок, железнодорожный транспорт, расширенные и максимальные цепи, информационное взаимодействие, обмен данными.

Introduction

Building supply chains in the modern conditions of development of the global market of transport and logistics services, characterized by high instability and a significant level of competition, requires a competent approach to determining the composition of participants and establishing their information interaction. High-quality data exchange between all participants in the supply chain, including in the volume of shipping and shipping documents, helps to speed up the transportation process and reduce the labor intensity of a number of operations by ensuring the completeness of the transmitted information.

The noted advantages determine the high relevance of the formation of the most complete information interaction within the organization of railway transportation, which is possible only with the initial establishment of conjugation points and key areas of data exchange. Taking into account the above, the main goal of the study was to determine the basics of information interaction of supply chain participants in the organization of railway freight transportation in various variations.

Organization of supply chains in railway transport

Researchers (including R. B. Ivut [1, 2], I. A. Elovoy [3], V. I. Sergeev [4, 5], V. V. Dybskaya [6], E. R. Abramova [7], A. P. Tyapukhin [8], O. M. Kulikova [9], C. Harland [10], Zh. Chen, N. G. Hall [11], etc.) have addressed the issues of evolution and identification of determinants of development of the supply chain management concept. Have been paying attention to for over twenty years. Considering various areas of supply chain organization, these researchers came to the conclusion that a supply chain is: a) a network of interconnected and interdependent organizations that jointly control, manage and improve flows from suppliers to end

consumers [12, p. 14; 13, p. 101;]; b) an ordered sequence of interacting links managed by participants that perform various functions during the passage of flows from the source of origin to the point of repayment [14, p. 25; 15, p. 23; 16, p. 39].

Within the framework of the functioning of railway transport, the supply chain should be interpreted as a set of interacting links that ensure the flow of goods, services and information from the consignor to the consignee [17, p. 104; 18, p. 126]. A supply chain link can be represented by both individual organizations and divisions, processes, technologies and activities involved in promoting the flow.

In the process of building supply chains, depending on the composition of the main links, they are formed within one of three types: direct, extended or maximum. In general terms, a direct supply chain consists of a focal company, a first-level supplier (cargo owner) and a first-level consumer (cargo owner) who participate in the external and internal flows of goods, information and finance. An extended supply chain additionally includes second-level suppliers and consumers. A maximal supply chain consists of a focal company and all participants in the chain from material suppliers to end consumers, as well as logistics and other intermediaries (agents) [19, p. 11–12; 20, p. 28–29].

In the context of the functioning of railway transport, the use of this classification and approach to distinguishing between participants in supply chains is significantly complicated. Taking into account the specifics of freight railway transportation, it would be more correct to use the typology presented in Figure 1.

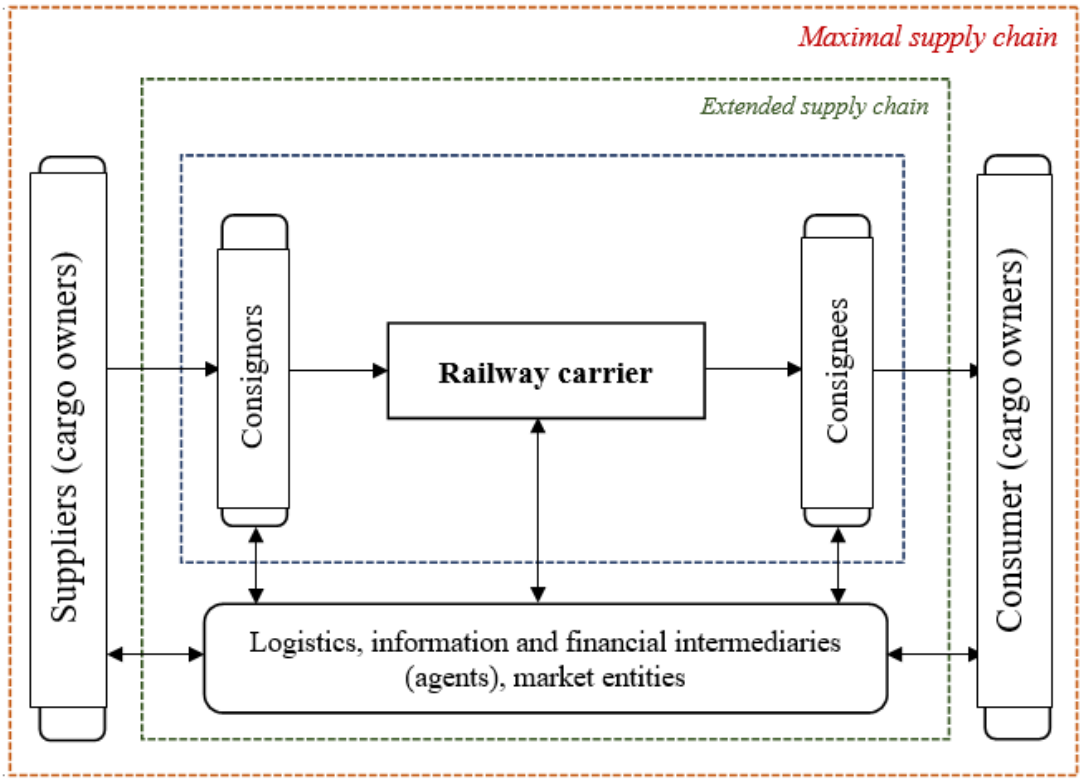

Figure 1 – Typology of supply chains in railway transport

In contrast to the typology used in the scientific literature, within the framework of supply chains in railway transport, it is necessary to change the constituent and substantive elements of the extended and maximum chains. Thus, if in the classical sense modern researchers characterize the extended supply chain as a set of a focal company and suppliers and consumers of the first and second levels, then in the noted typology, the extended supply chain differs from the simple one by the inclusion of logistics, information and financial intermediaries, as well as other market entities – which is standardly provided for only by the maximum supply chain. This substitution of concepts is made due to the specifics of the industry under consideration and more frequent and necessary interaction of railway carriers with various types of logistics and financial intermediaries. Expansion of the supply chain to suppliers and consumers (for the classical theory of suppliers and consumers of the second and subsequent levels) simultaneously allows us to talk about the organization of a maximum supply chain, characterized by increased transparency and flexibility.

Effective supply chain management in this context involves the formation of a cooperation option within which, when building a maximum supply chain, all first-order relationships (relationships of the railway organization with shippers, consignees and intermediaries) for the railway carrier are manageable, and all second-order relationships (relationships of shippers with suppliers (cargo owners), consignees with consumers (cargo owners), as well as relationships of shippers, consignees and cargo owners with intermediaries) are tracked. Taking into account the above, it can be concluded that successful supply chain management is impossible without the formation and subsequent maintenance of high-quality information interaction between a wide range of participants, the key ones of which are:

- shippers;
- consignees;
- freight forwarding organizations at each of the sections of the route (if the route passes through the territory of several transit countries, freight forwarding companies will be involved in each of them);
- sea line operators and road carriers (when organization intermodal cargo transportation);
- customs declarants involved by consignors and consignees to perform customs operations;
- cargo owners (parties to the purchase and sale agreement when organizing transportation with the involvement of intermediary companies and container terminals);
- financial organizations;
- government bodies (including customs authorities).

When building a supply chain, flows of goods, information and finances are formed between its participants, as well as corresponding return flows. The completeness of data exchange within the formed flows is largely determined by the initially established level of information interaction and the quality of the established connections.

https://doi.org/10.36773/1818-1112-2025-138-3-197-202

Information exchange between the participants during the organization of supply chains

The level of information interaction between participants in supply chains when organizing freight railway transportation, as well as their composition, is largely determined by the nature of the transportation. Thus, when organizing intra-republican transportation in the classical version, there will be actual interaction between three direct participants in the transportation (consignor, consignee and railway carrier) and additional participation of financial organizations in the framework of ensuring payment for services (Figure 2).

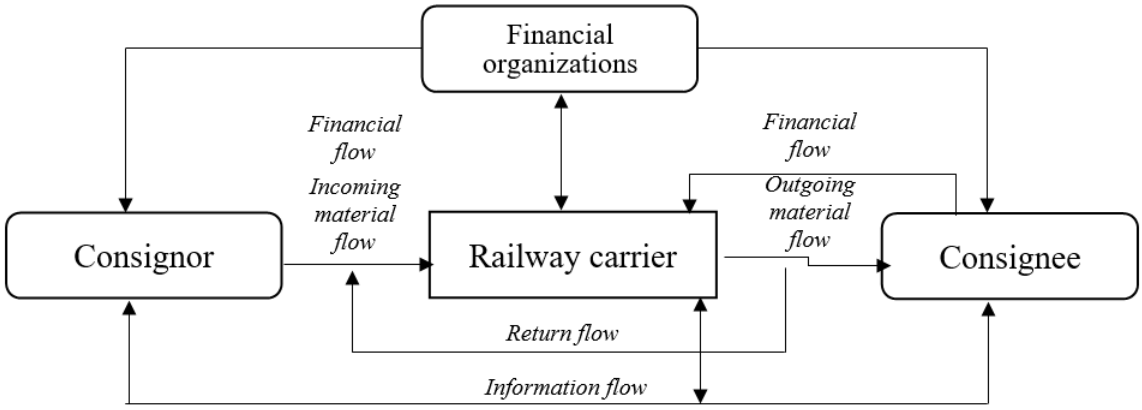

Figure 2 – Data flows within the framework of the classic variant of intra-republican railway transportation (direct supply chain)

As can be clearly seen, data flows within the classical version of organizing intra-republican railway transportation are evenly distributed between all participants in the transportation and actually provide for the organization of a direct supply chain. In this case, the incoming material flow is formed from the consignor to the railway carrier, and the outgoing material flow comes from the carrier. Financial flows are simultaneously directed to the railway carrier, both from the consignor and from the consignee.

The information flow of data accompanies both the material and financial flows. Thus, within the material flow, information is transferred in the volume of the railway bill and shipping documents, as well as key data characterizing the transportation and movement of the train along the route. Information support of the financial flow consists of the formation and provision of the necessary documentation (invoices and certificates of completion) and tracking the timeliness and completeness of the transactions carried out.

In this case, the information interaction between the railway organization and consignors, consignees and financial intermediaries necessarily requires the inclusion of the following areas:

- exchange of primary data and documents with consignors and consignees;
- interaction with consignors and consignees within the framework of transportation and formation of material and financial flows;
- interaction of the carrier with financial organizations within the framework of execution and documentary registration of financial transactions.

Thus, the organization of freight railway transportation in intra-republican traffic provides for the establishment of the simplest relationships based on cooperation between the railway organization and consignors and consignees. In this case, standard information systems and typical work technology are used as part of the technological support for data exchange.

The organization of international freight transportation provides for the development of a system of interaction and information linking of the carrier in addition to the above option with freight forwarding companies and customs authorities. Data flows generated during the organization of international railway transportation are presented in Figure 3.

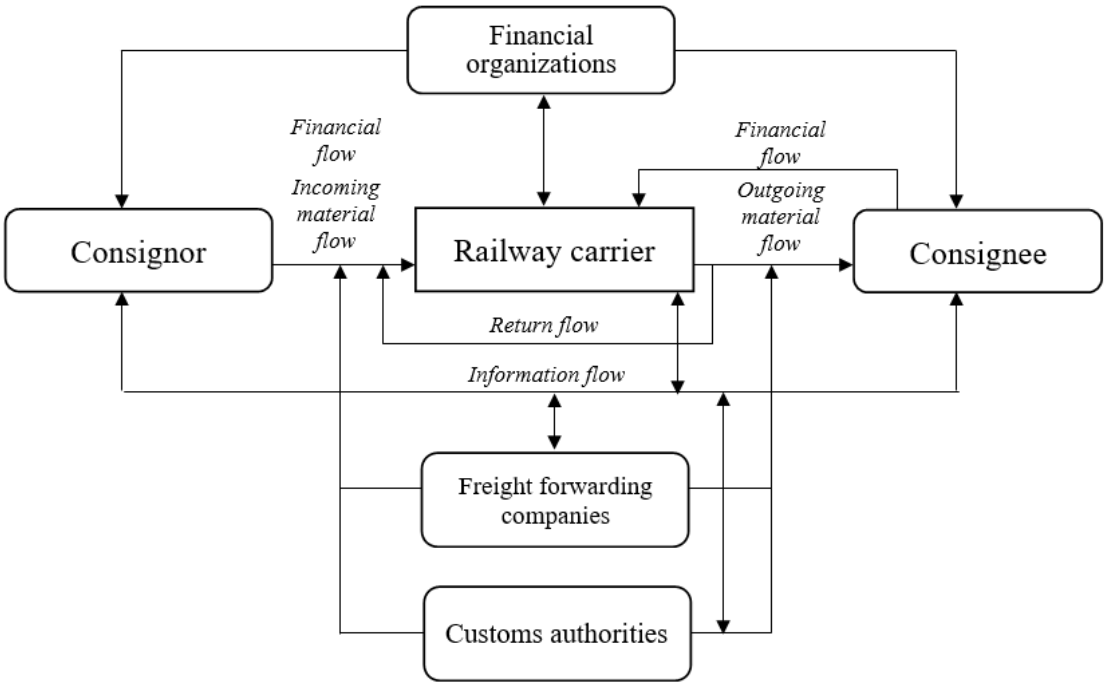

Figure 3 – Data flows generated in international railway transportation with a small number of participants (extended supply chain)

https://doi.org/10.36773/1818-1112-2025-138-3-197-202

In this option, the railway organization, along with consignors and consignees, ensures interaction with freight forwarding companies and customs authorities included in the general information flow. In this case, the key areas of the established information interaction are:

• data and document exchange with other railway carriers, consignors, consignees and freight forwarding companies in the volume of shipping, accompanying and other documents;

• interaction with consignors, consignees at the stage of concluding transportation contracts, as well as with freight forwarders within the framework of transportation;

• interaction with customs authorities within the framework of customs operations and financial companies within the boundaries of financial transactions. Simultaneously with the organization of a common information flow, the organization of international transportation requires the carrier to build a financial flow in a new format, which provides for the inclusion of forwarders acting as the main payers under the transportation contract when traveling through the territory of transit countries, and also (if necessary) on the side of the consignee.

An important feature of this option is the need for the interconnection of information flows between all railway carriers participating in the transportation of goods. At the same time, the degree of coordination in the work between such participants should have the highest level within the framework of all types of flows (material, financial and information).

At the same time, the organization of international freight railway transportation often requires the involvement of additional participants and the corresponding organization of a maximum supply chain. Data flows in this case will take the following form (Figure 4).

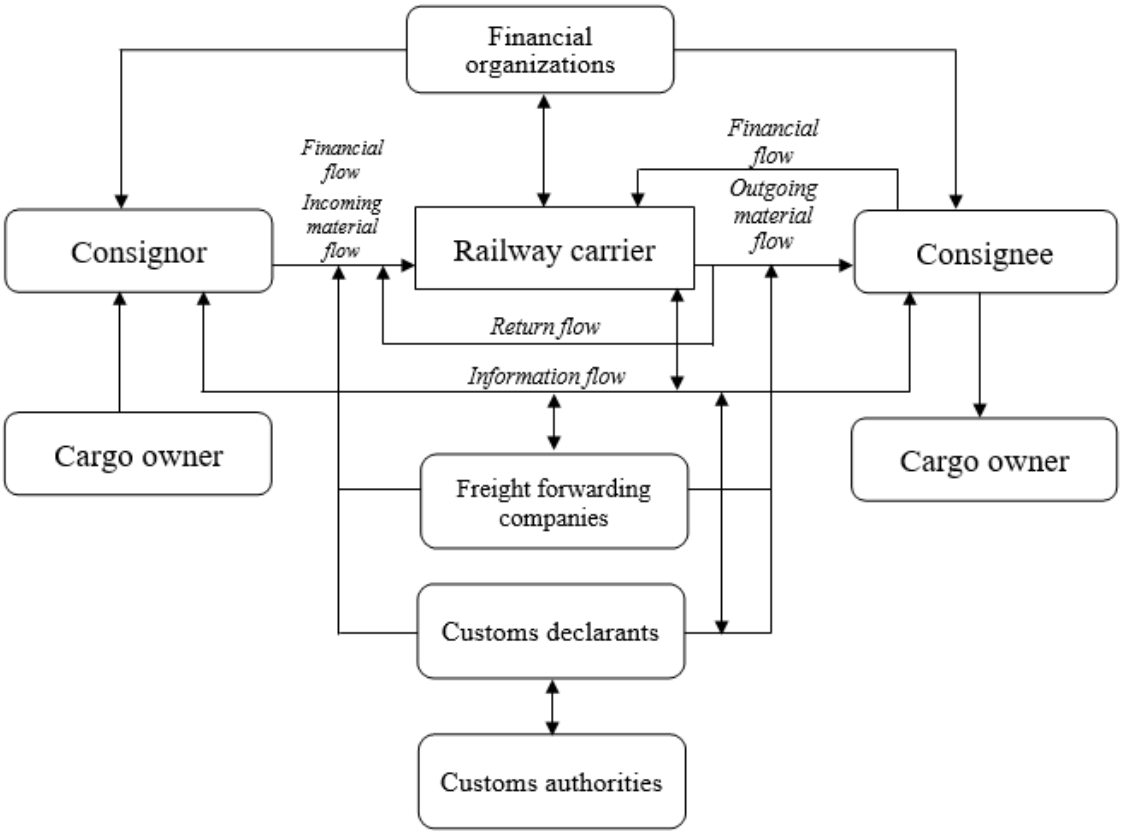

Figure 4 – Data flows within the framework of the organization of international railway freight transportation when building a maximum supply chain

When organization a maximum supply chain, its participants are supplemented by suppliers and consumers who are the actual owners of the goods at the initial and final points, as well as customs declarants. The organization of high-quality information interaction in this version provides for:

• data and document exchange with other carriers, consignors, consignees and forwarders in the volume of shipping, accompanying and other documents, as well as interaction between consignors, consignees and cargo owners;

• interaction with consignors, consignees at the stage of concluding transportation contracts, as well as with forwarders within the framework of transportation;

• interaction with financial companies within the framework of registration of financial transactions and with customs declarants within the boundaries of receiving information and completing customs procedures.

Thus, when building a maximum supply chain, interaction should be ensured at two levels: at the first level - data exchange between the carrier and other administrations, consignors, consignees and forwarders, and at the second level – the formation of relationships between consignors and consignees with cargo owners. Communication with customs authorities is simultaneously provided through customs declarants who ensure the implementation of customs operations.

The last and most extensive interaction option is the option in which the organization of a maximum supply chain is carried out within the framework of organizing intermodal transportation. Data flows in this case will be as follows (Figure 5).

The main distinguishing feature of the presented option is the inclusion of sea line operators and/or road carriers in the composition of the supply chain participants. Information interaction when organizing international intermodal transportation involves the inclusion of the following key areas:

• data and document exchange with other carriers (sea line operators and/or road carriers, as well as railway organizations) in the volume of the SMGS consignment note, shipping and permitting documents;

• interaction with freight forwarders within the framework of transportation, as well as with consignors and consignees – at the beginning or end of transportation within the framework of railway transport;

• interaction with financial companies within the framework of financial transactions and with customs declarants within the boundaries of receiving information and completing customs procedures.

Organization of interaction within the framework of execution and transfer of transport and accompanying documents in this case is provided with carriers participating in the supply chain on an equal basis with the railway organization. Direct cooperation with consignors and/or consignees is practically not observed, while interaction with forwarding companies is maintained.

https://doi.org/10.36773/1818-1112-2025-138-3-197-202

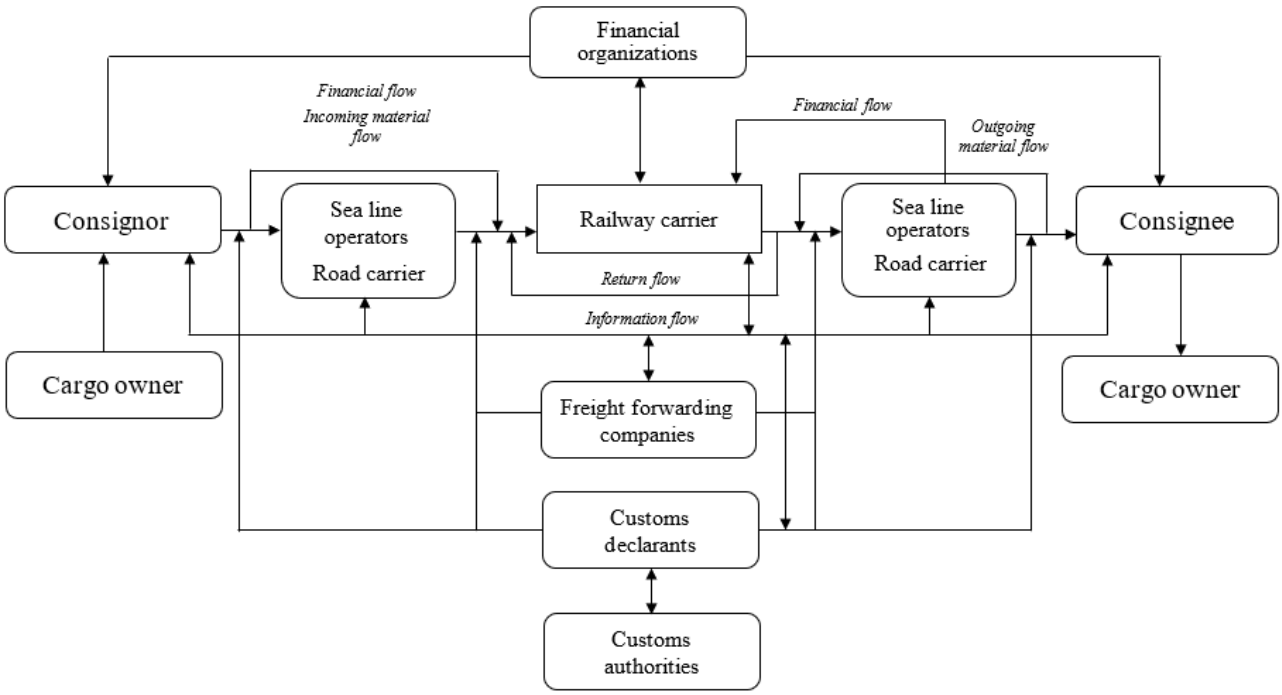

Figure 5 – Data flows during the organization of maximum supply chain within the framework of intermodal international transportation involving railway transport

Conclusion

Thus, for effective supply chain management in modern conditions, it is necessary to form and maintain relationships with all participants in the transportation process, ensuring high-quality information interaction. Key participants in supply chains in railway transport are: consignors and consignees (cargo owners when organizing transportation using intermediary companies), freight forwarding organizations, financial organizations, government agencies (including customs authorities), operators of shipping lines and road carriers (when organizing intermodal transportation of goods), etc.

A distinctive feature of building supply chains in railway transport is the change in the constituent and substantive elements of the extended and maximum chains, which requires a specific approach to determining the areas of data exchange. The scale of the established information cooperation with each participant in the supply chain directly depends on the type of transportation and the adopted technology of work.

References

1. Ekonomicheskij mekhanizm razvitiya transportno-logisticheskoj deyatel'nosti na predpriyatiyah: monografiya / R. B. Ivut', P. I. Lapkovskaya, O. V. Myasnikova, D. N. Mesnik. – Minsk : BNTU, 2022. – 240 s.
2. Ivut', R. B. Ob"ektno-orientirovannyj podhod pri modelirovanii cepej postavok / N. V. Stefanovich, R. B. Ivut', O. I. Mojsak // Avtotraktorostroenie i avtomobil'nyj transport : materialy mezhdun. nauch.-prakt. konf. – Minsk : BNTU, 2020. – S. 212–215.
3. Elovoj, I. A. Upravlenie potokami v logisticheskih cepyah (teoriya, metodologiya, organizaciya) : monografiya / I. A. Elovoj, M. A. Gonchar. – Gomel' : Belorus. gos. un-t transp., 2020. – 226 s.
4. Sergeev, V. Problema vidimosti cepi postavok i ispol'zovanie koncepcii supply chain control tower / V. Sergeev, I. Sergeev, K. Hlobystova // Logistika. – 2020. – № 3. – S. 35–43.
5. Sergeev, V. I. Logistika i upravlenie cepyami postavok – professiya XXI veka : analiticheskij obzor / V. I. Sergeev. – M. : Izd. dom Vysshej shkoly ekonomiki, 2019. – 271 s.
6. Cifrovye tekhnologii v logistike i upravlenii cepyami postavok: analiticheskij obzor / V. V. Dybskaya, V. I. Sergeev, N. N. Lychkina [i dr.] ; pod red. V. I. Sergeeva. – M. : Izd. dom Vysshej shkoly ekonomiki, 2020. – 190 s.
7. Abramova, E. R. Logisticheskaya koordinaciya sovremennye aspekty, vidy i mekhanizmy v upravlenii cepyami postavok : monografiya / E. R. Abramova. – M. : INFRA-M, 2020. – 103 s.
8. Tyapuhin, A. P. Metodologiya cifrovizacii upravleniya cepyami postavok : monografiya / A. P. Tyapuhin, V. S. Starodubcev. – M. : Rusajns, 2024. – 345 s.
9. Kulikova, O. M. Proektirovanie effektivnoj logisticheskoj cepochki postavok / O. M. Kulikova, S. D. Suvorova // Regional'nye problemy preobrazovaniya ekonomiki. – 2021. – № 4. – S. 122–129.
10. Harland, C. Supply Chain Management. Concepts, Challenges and Future Research Directions / C. Harland. – Springer Nature, 2024. – 187 p.
11. Chen, Zh. Supply Chain Scheduling / Zh. Chen, N. G. Hall. – Springer, 2022. – 698 p.
12. Pavlov, A. K. Organizaciya rasshirennyh cepej postavok na rynke mebel'noj produkcii v usloviyah realizacii politiki importozameshcheniya : dis. ... kand. ek. nauk : 08.00.05 / A. K. Pavlov. – Sankt-Peterburg, 2021. – 173 s.
13. Berezhnaya, G. G. Funkcionirovanie cepi postavok v usloviyah otvetstvennogo biznesa / G. G. Berezhnaya // Vestnik Brestskogo gosudarstvennogo tekhnicheskogo universiteta. – 2021. – № 2 (125). – S. 100–102.
14. Logisticheskij podhod k upravleniyu konkurentosposobno-st'yu sub"ektov hozyajstvovaniya v usloviyah perekhoda k ustojchivomu razvitiyu Respubliki Belarus' / M. A. Slonimskaya, E. B. Malej, O. S. Gulyagina [i dr.] ; pod nauch. red. E. B. Malej. – Novopolock : Polockij gosudarstvennyj universitet, 2021. – 340 s.
15. Timraliev, I. V. Mezhdunarodnye cepi postavok: ponyatie, sushchnost', sovremennoe sostoyanie i osobennosti upravleniya / I. V. Timraliev // Vestnik Rostovskogo gosudarstvennogo ekonomicheskogo universiteta (RINH). – 2021. – № 1. – S. 21–27.
16. Myasnikova, O. V. Razvitie proizvodstvenno-logisticheskih sistem: teoriya, metodologiya i mekhanizmy cifrovoj transformacii / O. V. Myasnikova. – Minsk : Institut biznesa BGU, 2021. – 267 s.
17. Horoshevich, A. A. Osobennosti klassifikacii cepej po-stavok na zheleznodorozhnom transporte / A. A. Horoshevich // Innovacii: ot teorii k praktike: sb. nauch. st. po materialam IX Mezhdunar. nauch.-prakt. konf. CH. 1, g. Brest, 19-20 okt. 2023 g.; redkol. G. B. Medvedeva [i dr.]. – Brest : Izd-vo BrGTU, 2023. – S. 103–106.

18. Horoshevich, A. A. Perekhod k prozrachnym cepyam postavok v novyh ekonomicheskih usloviyah funkcionirovaniya zheleznodorozhnogo transporta / A. A. Horoshevich // Rynok transportnyh uslug (problemy povysheniya effektivnosti) : mezhdun. sb. nauch. tr. ; pod obshch. red. V. G. Gizatullinoj. – Minsk, 2024. – S. 125–132.
19. Krylatkov, P. P. Upravlenie cep'yu postavok (SCM) / P. P. Krylatkov, M. A. Priluckaya. – Ekaterinburg : Izd-vo Ural. un-ta, 2018. – 140 s.
20. YUldashev, A. A. Primenenie cifrovyh ekosistem v cepi postavok / A. A. YUldashev // Napravleniya razvitiya blagopriyatnoj biznes-sredy v usloviyah cifrovizacii ekonomiki. – 2022. – № 1 (4). – S. 26–34.

Список цитированных источников

1. Экономический механизм развития транспортно-логистической деятельности на предприятиях: монография / Р. Б. Ивуть, П. И. Лапковская, О. В. Мясникова, Д. Н. Месник. – Минск : БНТУ, 2022. – 240 с.
2. Ивуть, Р. Б. Объектно-ориентированный подход при моделировании цепей поставок / Н. В. Стефанович, Р. Б. Ивуть, О. И. Мойсак // Автотракторостроение и автомобильный транспорт : материалы междун. науч.-практ. конф. – Минск : БНТУ, 2020. – С. 212–215.
3. Еловой, И. А. Управление потоками в логистических цепях (теория, методология, организация) : монография / И. А. Еловой, М. А. Гончар. – Гомель : Белорус. гос. ун-т трансп., 2020. – 226 с.
4. Сергеев, В. Проблема видимости цепи поставок и использование концепции supply chain control tower / В. Сергеев, И. Сергеев, К. Хлобыстова // Логистика. – 2020. – № 3. – С. 35–43.
5. Сергеев, В. И. Логистика и управление цепями поставок – профессия XXI века : аналитический обзор / В. И. Сергеев. – М. : Изд. дом Высшей школы экономики, 2019. – 271 с.
6. Цифровые технологии в логистике и управлении цепями поставок: аналитический обзор / В. В. Дыбская, В. И. Сергеев, Н. Н. Лычкина [и др.] ; под ред. В. И. Сергеева. – М. : Изд. дом Высшей школы экономики, 2020. – 190 с.
7. Абрамова, Е. Р. Логистическая координация современные аспекты, виды и механизмы в управлении цепями поставок : монография / Е. Р. Абрамова. – М. : ИНФРА-М, 2020. – 103 с.
8. Тяпухин, А. П. Методология цифровизации управления цепями поставок : монография / А. П. Тяпухин, В. С. Стародубцев. – М. : Русайнс, 2024. – 345 с.
9. Куликова, О. М. Проектирование эффективной логистической цепочки поставок / О. М. Куликова, С. Д. Суворова // Региональные проблемы преобразования экономики. – 2021. – № 4. – С. 122–129.
10. Harland, C. Supply Chain Management. Concepts, Challenges and Future Research Directions / C. Harland. – Springer Nature, 2024. – 187 p.
11. Chen, Zh. Supply Chain Scheduling / Zh. Chen, N. G. Hall. – Springer, 2022. – 698 p.
12. Павлов, А. К. Организация расширенных цепей поставок на рынке мебельной продукции в условиях реализации политики импортозамещения : дис. ... канд. эк. наук : 08.00.05 / А. К. Павлов. – Санкт-Петербург, 2021. – 173 с.
13. Бережная, Г. Г. Функционирование цепи поставок в условиях ответственного бизнеса / Г. Г. Бережная // Вестник Брестского государственного технического университета. – 2021. – № 2 (125). – С. 100–102.
14. Логистический подход к управлению конкурентоспособностью субъектов хозяйствования в условиях перехода к устойчивому развитию Республики Беларусь / М. А. Слонимская, Е. Б. Малей, О. С. Гулягина [и др.] ; под науч. ред. Е. Б. Малей. – Новополоцк : Полоцкий государственный университет, 2021. – 340 с.
15. Тимралиев, И. В. Международные цепи поставок: понятие, сущность, современное состояние и особенности управления / И. В. Тимралиев // Вестник Ростовского государственного экономического университета (РИНХ). – 2021. – № 1. – С. 21–27.
16. Мясникова, О. В. Развитие производственно-логистических систем: теория, методология и механизмы цифровой трансформации / О. В. Мясникова. – Минск : Институт бизнеса БГУ, 2021. – 267 с.
17. Хорошевич, А. А. Особенности классификации цепей поставок на железнодорожном транспорте / А. А. Хорошевич // Инновации: от теории к практике: сб. науч. ст. по материалам IX Междунар. науч.-практ. конф. Ч. 1, г. Брест, 19-20 окт. 2023 г.; редкол. Г. Б. Медведева [и др.]. – Брест : Изд-во БрГТУ, 2023. – С. 103–106.
18. Хорошевич, А. А. Переход к прозрачным цепям поставок в новых экономических условиях функционирования железнодорожного транспорта / А. А. Хорошевич // Рынок транспортных услуг (проблемы повышения эффективности) : междун. сб. науч. тр. ; под общ. ред. В. Г. Гизатуллиной. – Минск, 2024. – С. 125–132.
19. Крылатков, П. П. Управление цепью поставок (SCM) / П. П. Крылатков, М. А. Прилуцкая. – Екатеринбург : Изд-во Урал. ун-та, 2018. – 140 с.
20. Юлдашев, А. А. Применение цифровых экосистем в цепи поставок / А. А. Юлдашев // Направления развития благоприятной бизнес-среды в условиях цифровизации экономики. – 2022. – № 1 (4). – С. 26–34.

Material received 24.09.2025, approved 14.10.2025, accepted for publication 17.10.2025