Selected Aspects of Model Approach to Logistics System of Poland

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The paper presents selected aspects of an innovatory approach to formalization of a notation of Polish Logistics System regarding transport co-modality issue. The importance of external transport in logistics process implemented by Polish Logistics System was discussed. The preliminary identification of Polish Logistics System model elements and links between them were made. As a result the formalization of notation of Polish Logistics System structure was proposed.

Keywords: Logistics system, system, national logistics system, modeling, model for national logistics system

1. INTRODUCTION

The paper comprises the description of assumptions of a model approach towards Logistics System of Poland (***LSP***), ensuring efficient use of existing subsystems in external transport (***LSP^{K}***). In its scope, the paper regards issues currently discussed in European Union and concerning the development of certain types of transport and their use in the performing of logistical processes.

The review of the assumptions of the notion for Logistics System of Poland requires definition of fundamental terms such as system, logistics system, national logistics system and transport convenience.

The notion of a system is understood as a depiction of a particular aspect of reality in the form of a set of distinguished elements and a set of relations between those elements [2]. It is crucial for both the included elements of a system and established relations between them to be non-accidental. They must secure a functional integrity of a modeled system. Moreover, as noticed by M. Jacyna, a system recognized as a functioning entirety must comprise as many elements and relations as there are required for the accurate performance of determined functions [3].

Taking the above into consideration, and following the pioneer for general system approach Ludwig von Bertalanffy, a system is defined as a set of elements maintaining mutual relation [4]. The general aspect of systems theory enforces specifications for the affiliation of elements to the system. In other words, one must specify which elements belong to a particular system and what sort of relation between them is present, crucial to the determined research purpose. Furthermore, one must bear in mind the fact that the presence of a system is conditioned by its realization of determined goals.

In this respect, the notion logistics system means a non-disruptive transportation of loads from producers to recipients. During transportation process, many participants repeatedly attend (logistic operators, forwarders, transporters, etc.), operating within production, supply, or distribution, thus constituting links between logistics processes. To ensure efficient flow of goods, it is necessary to coordinate all participants operations as well as to integrate goods transfer with all the information on it as part of a fully operational logistics system.

Logistics system can therefore be regarded as a set of subsystems: supply, production, distribution, transport and storage, along with the relations

between them. It is of a service character, i.e. it supports the realization of primary objective and its target is the accomplishment of a determined logistical task [4].

Logistics system can be viewed from several perspectives. The analysis of material goods flow occurring within a particular country accounts for macroeconomic approach towards logistics processes. In this regard we deal with national and international macrologistics system. Considering the definition of a system, the elements of a logistics system are constituted by various economic subjects participating in the goods distribution process along with accompanying information. Crucial for the proper realization of logistical processes, in the national dimension, is the infrastructure [6]:

- linear, which consists of existing transportation system (e.g. railway, road, sea, air, etc.),
- base, constituted by facilities for freight attendance (e.g. stations, exchange points, store complex, logistics centers, etc.) with the equipment,
- informative, constituted by mixed media, standards for information exchange and its flow precaution,
- as well as appropriate means of transport.

Accordingly, a national logistics system is a system which encompasses entire economy whilst territorially the whole state.

Loads transfer in national logistics system is conducted by the use of various means of transport. In this respect the improvement of national logistics system can be achieved through rational use of external transport. Therefore the objective is to achieve convenience in transport, which is perceived not as a property of the transport itself but as an attribute of concurrent functioning (including cooperation) of all transport subsystems.

According to European Commission, the term 'commodity' describes effective use of the means of transport, operating individually or integrated multi-mobile in European Transportation System with the intention of optimal and balanced usage of resources [5]. In addition, in accordance with UE policy, wherever possible, particularly in long distance transportation, in urban area and in heavy-traffic transport passageways, it is essential to change transportation to be more environmentally friendly. Concurrently, each form of transportation needs to be adjusted to become more environmentally friendly, safer and more energy saving. Furthermore, 'commodity', which means effective use of each form of transportation and combined transport, should benefit in optimized and balanced use of resources.

2. THE MEANING OF TRANSPORT IN NATIONAL LOGISTICS SYSTEM

As mentioned before, the crucial role in the realization of logistics processes is fulfilled through transportation subsystems. With regard to transport 'commodity', it is necessary to aim at rational use of available forms of transportation in the process of distributing material goods. During this process we can use individual carriage subsystems e.g. railway, automotive, air, sea, etc. It is also possible to use combinable forms, so called 'combined' or 'intermodal' transport.

The significance of each form of transport in the Logistics System of Poland is determined through its individual specifications as well as the extent and character of particular supply flow. Thus, road transport, with regard to its superlative territorial character, currently participates the most in carriage of loads, particularly of break loads (among other things). Railway transport is predisposed for long distance bulk traffic, particularly for goods train consignment. Furthermore, with adequate parcel demand, delivered by means of road transport it is possible to use railway transport in this market segment as well.

Unlike road and rail carriage, sea transport applies primarily to international carriage. It enables goods exchange between Poland and distant countries of European as well as other continents. This type of transport is used in carrying time-fast loads in bulk. Inland water transport, considering its underdeveloped connection network and fairly difficult navigation conditions in Poland, can be applied only seasonally in bulk traffic whose carriage routes correspond with the course of inland water routes.

For evident reasons, pipeline transport is predisposed for liquid and gaseous loose bulk

carriage. However, it requires considerable investment which can only be realized with sufficiently large and regular carriage demands.

Last of the considered transport subsystems, namely air transport, in cargo traffic fulfills a complementary function to other forms of transport, in case of the necessity of rapid transportation of high value goods, or in a situation when the loss, as a consequence of overdue delivery time carried out by means of e.g. road transport, is of substantial value.

According to the thesis in question, it is highly recognized to combine the benefits of particular forms of transport and consequently to realize carriage through the use of varied transportation. Consequently, a well-balanced use of various forms of transport requires complex cargo management stations enabling the change of a means of transport and possibly a form of transport as well as the change of the form of cargo flow and its storage. These are i.e.: logistics centers, sea ports, combined transport terminals (intermodal), transshipment stations.

3. BASIC FUNCTIONS OF LSP

The functions of a logistics system are closely dependent on the very form of the system along with the branch it operates within. The Logistics System of Poland (LSP) is a structure limited physically by the state borders. However, it is a part of a more complex system – European and, with regard to geographical location of Poland, intercontinental. Considering its extent and assumed goals, LSP encompasses every possible function which is included in the definition of logistics, most particularly applied logistics, which means that it deals with transforming the flow of cargo and associated information with respect to time, place, and form according to a particular service level and at minimal cost.

Thus the Logistics System of Poland accomplishes transformations with regard to:

- *TIME*: including short-term storage – segregating and consolidating material flow, long-term storage – current, ensuring the continuity of operativeness of distribution and production as well as long-term storage – substitute, allowing accumulation of goods for strategic, defensive and other purposes meaningful to the effective functioning of the entire ***LSP***.
- *PLACE*: transporting materials of various forms between functional units of ***LSP*** ensuring realization of basic transformations in those. Carriage can be realized through different branches of transport and their combinations in order to guarantee the effective use of diverse forms of transport.
- *FORM*: which is regarded as a change in the physical form of materials as a consequence of actions engaged in functional units of ***LSP***. Within form transformation, one can recognize production which modifies physical character of materials and also changes in loading character – commissioning, packing, repacking, as well as shipping.

The transformations above are realized in order to satisfy socio-economical demands of the state. The task for LSP, proceeding from the definition of applied logistics and affecting the functions of LSP, is to lower the costs of transportation and stock servicing (logistical). Costs reduction can be achieved through:

- combining supply operations (orders consolidation),
- combining distribution operations (consignment consolidation),
- combining merchandise shipment,

as well as

- implementing of 'commodity' solutions of transport,
- controlling the flow of materials with the intention of an effective use of infrastructure.

4. DESCRIBTION OF THE MODEL OF LOGISTICS SYSTEM OF POLAND

4.1. STRUCTURAL ELEMENTS OF LSP

The functions of ***LSP*** are determined by subsystems (functional blocks) of a general system. Considering the above, one can assume that the elements of ***LSP*** are constituted by particular links, where acquiring, processing and consumption of material goods are realized. Consequently, the elements of ***LSP*** are divided into supplies sources, goods outlets as well as various staging posts. One could distinguish the following subsystems of ***LSP*** (Fig. 1).

- *IMPORT*; a subsystem generating imported material flow for ***LSP***, elements of import subsystem (border crossings: sea, land, railway, air, etc.) account for ***IM*** set, by pattern:

$$\boldsymbol{IM} = \{\boldsymbol{i}_1, \boldsymbol{i}_2, ..., \boldsymbol{i}_{\boldsymbol{im}}, ..., \boldsymbol{i}_{\overline{\boldsymbol{IM}}}\} \quad (1)$$

- *OUTPUT, FARMING, FISHERY* (further referred to as a subsystem for natural sourcing), this subsystem generates material flow for ***LSP***, elements of this subsystem (mines, farmsteads, etc.) account for ***ZP*** set, by pattern:

$$\boldsymbol{ZP} = \{\boldsymbol{z}_1, \boldsymbol{z}_2, ..., \boldsymbol{z}_{\boldsymbol{zp}}, ..., \boldsymbol{z}_{\overline{\boldsymbol{ZP}}}\} \quad (2)$$

- *PRODUCTION and SERVICES*, elements of production and services subsystem (industrial plants, service stations, etc.) account for ***PU*** set, by pattern:

$$\boldsymbol{P} = \{\boldsymbol{p}_1, \boldsymbol{p}_2, ..., \boldsymbol{p}_{\boldsymbol{pu}}, ..., \boldsymbol{p}_{\overline{\boldsymbol{PU}}}\} \quad (3)$$

- *EXPORT*, a subsystem transferring material flow from ***LSP*** to other countries, elements of export subsystem (border crossings: sea, land, railway, air, etc.) account for ***EK*** set, by pattern:

$$\boldsymbol{EK} = \{\boldsymbol{e}_1, \boldsymbol{e}_2, ..., \boldsymbol{e}_{\boldsymbol{ek}}, ..., \boldsymbol{e}_{\overline{\boldsymbol{EK}}}\} \quad (4)$$

- *TRANSIT*, elements of transit subsystem (harbors, border crossings, etc.) account for ***T*** set, by pattern:

$$\boldsymbol{T} = \{\boldsymbol{t}_1, \boldsymbol{t}_2, ..., \boldsymbol{t}_t, ..., \boldsymbol{t}_{\overline{\boldsymbol{T}}}\} \quad (5)$$

- *WHOLESALE DISTRIBUTION*, elements of wholesale distribution subsystem (wholesale outlets, distribution centers, logistics centers, etc.) account for ***DH*** set, by pattern:

$$\boldsymbol{DH} = \{dh_1, dh_2, ..., dh_{dh}, ..., dh_{\overline{DH}}\} \quad (6)$$

- *RETAIL DISTRIBUTION*, elements of retail distribution subsystem (shops, etc.) account for ***DD*** set, by pattern:

$$\boldsymbol{DD} = \{dd_1, dd_2, ..., dd_{dd}, ..., dh_{\overline{DD}}\} \quad (7)$$

- *PUBLIC CONSUMPTION*, elements of public consumption subsystem (hotels, restaurants, hospitals, etc.) account for ***KZ*** set, by pattern:

$$\boldsymbol{KZ} = \{kz_1, kz_2, ..., kz_{kz}, ..., kz_{\overline{KZ}}\} \quad (8)$$

- *PRIVATE CONSUMPTION*, elements of private consumption subsystem (households, etc.) account for ***KI*** set, by pattern:

$$\boldsymbol{KI} = \{ki_1, ki_2, ..., ki_{ki}, ..., ki_{\overline{KI}}\} \quad (9)$$

- *RECYCLING*, a particular subsystem with input from all remaining functional units and output in production and services. Elements of recycling subsystem (enterprises conducting refuse sorting with the intention to reuse them, etc.) account for ***RE*** set, by pattern:

$$\boldsymbol{RE} = \{\boldsymbol{r}_1, \boldsymbol{r}_2, ..., \boldsymbol{r}_{\boldsymbol{re}}, ..., \boldsymbol{r}_{\overline{\boldsymbol{RE}}}\} \quad (10)$$

- *CARGO HANDLING STATIONS* – a subsystem where transformations of the batches of goods are performed in view of time and form (transport and loading). Elements of this subsystem (logistics centers, sea ports, transshipment terminals, etc.) account for ***PP*** set, by pattern:

$$\boldsymbol{PP} = \{p_1, p_2, ..., p_{pp}, ..., p_{\overline{PP}}\} \quad (11)$$

- *EXTERNAL TRANSPORT* – a subsystem designed to control processes occurring among other subsystems. Elements of this subsystem (transport connections, means of transport, etc.) account for ***TZ*** set, by pattern:

$$\boldsymbol{TZ} = \{tz_1, tz_2, ..., tz_{tz}, ..., tz_{\overline{TZ}}\} \quad (12)$$

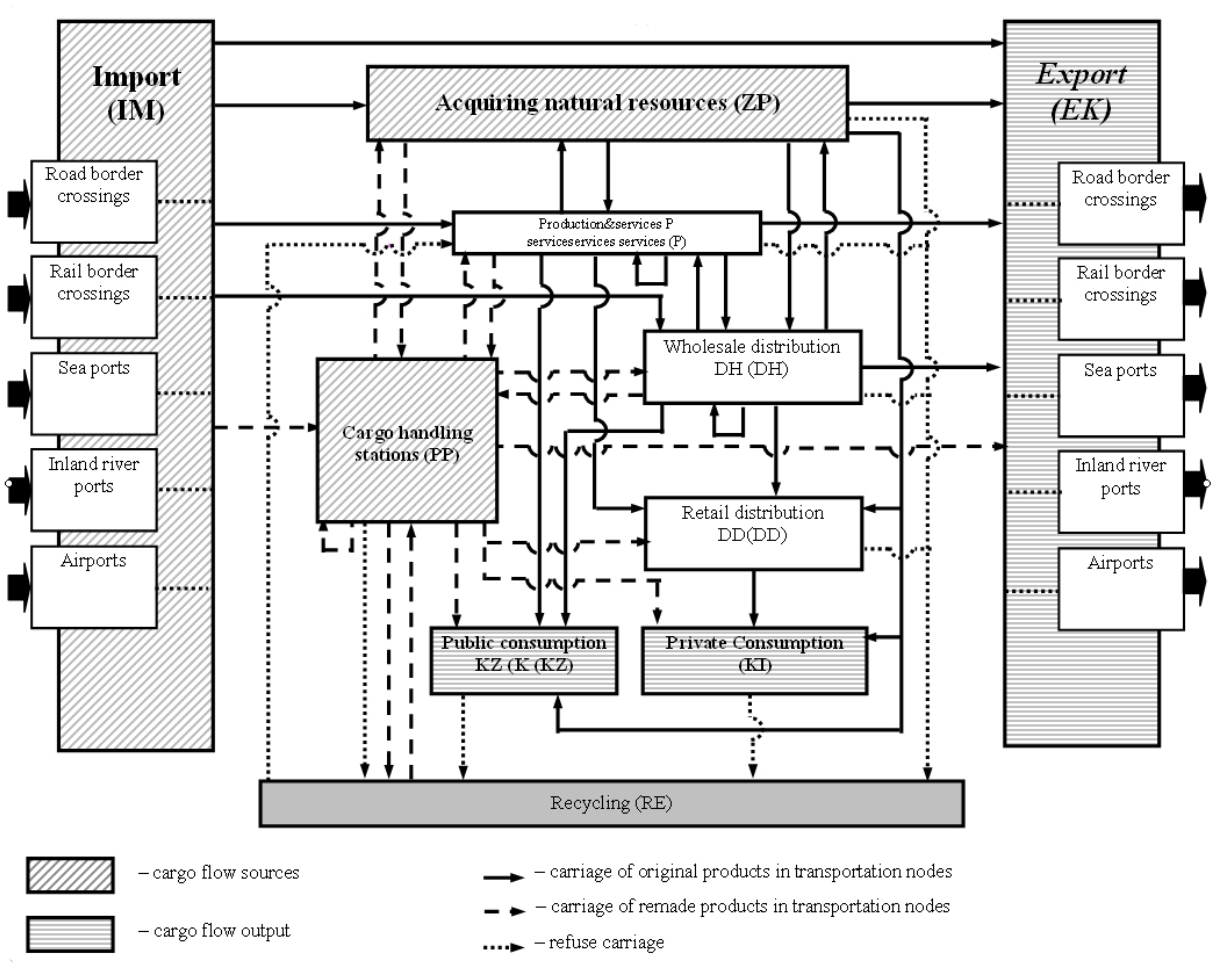

Fig. l. Diagram of relations between functional units in Logistics System of Poland
Source: Target 1 'Formulation of the assumptions of the concept of national logistics system' Nr R10 0027 06/2009

All distinguished elements of ***LSP*** are subsystems and can be regarded as individual systems. Following the definition, each system is characterized by an established set of components and various relations combining the elements with one another as well as with system environment. At the same time it is worth noticing that the relations within the system determine the nature of relation between particular components. Therefore among other relations between the components of ***LSP*** we find the following:

- type of transport which can be applied to attend particular elements of ***LSP***,
- connection between transportation subsystems by means of determined transportation nodes,
- potential ways of material goods flow through ***LSP***.

Considering established assumptions as well as the definition of a system the formal notation of the structure of ***LSP*** can be represented as:

$$\boldsymbol{S}^{LSP} = \left\langle \boldsymbol{A}^{LSP}, \boldsymbol{R}^{LSP} \right\rangle \qquad (13)$$

where:

$\boldsymbol{S}^{LSP}$ – structure of ***LSP***,
$\boldsymbol{A}^{LSP}$ – set of components of ***LSP***,
$\boldsymbol{R}^{LSP}$ – set of relations between components of ***LSP***.

In accordance with the previous conclusion a set of components in ***LSP*** is the following sum of sets:

$$\boldsymbol{A}^{LSP} = \boldsymbol{IM} \cup \boldsymbol{ZP} \cup \boldsymbol{PU} \cup \boldsymbol{EK} \cup \boldsymbol{T} \cup \boldsymbol{DH} \cup \boldsymbol{DD} \cup \cup \boldsymbol{KZ} \cup \boldsymbol{KI} \cup \boldsymbol{RE} \cup \boldsymbol{PŁ} \cup \boldsymbol{TZ} \qquad (14)$$

where:

- $\boldsymbol{A}^{LSP}$ – set of components of ***LSP***,
- ***IM*** – set of components of import subsystem,
- ***ZP*** – set of components of acquiring natural resources subsystem,
- ***P*** – set of components of production and services subsystem,
- ***EK*** – set of components of export subsystem,
- ***T*** – set of components of transit subsystem,
- ***DH*** – set of components of wholesale distribution subsystem,
- ***DD*** – set of components of retail distribution subsystem,
- ***KZ*** – set of components of public consumption subsystem,
- ***KI*** – set of components of private consumption subsystem,
- ***RE*** – set of components of recycling subsystem,
- ***PP*** – set of components of cargo handling stations subsystem,
- ***TZ*** – set of components of external transport subsystem.

Among the components of import and export subsystems one can distinguish:

- rail border crossings,
- road border crossings,
- sea ports,
- airports,
- inland river ports.

These will constitute the components connecting Logistics System of Poland with the surroundings, here recognized as Poland's bordering countries. Furthermore, they will operate as elements of the subsystem of cargo handling stations ***PP***.

All components of ***LSP*** can be divided into sources $\boldsymbol{Z}^{LSP}$, outlets $\boldsymbol{U}^{LSP}$ and intermediate elements $\boldsymbol{P}^{LSP}$ where processing of cargo flow is present. The relations occurring in ***LSP*** are generally noted as:

$$\boldsymbol{R}^{LSP} \subset \boldsymbol{A}^{LSP} \times \boldsymbol{A}^{LSP} \tag{14}$$

The character and the number of the abovementioned relations is dependent both on the number of participants in the process of transportation from source to outlet as well as on the form of transport applied to accomplish distribution process. Model types of relations can be noted as:

- type of transport which can be applied to attend particular elements of ***LSP***, e.g.:

$$\boldsymbol{R}1^{LSP} \subset \boldsymbol{ZP} \times \boldsymbol{TZ} \tag{15}$$

- connection between transportation subsystems by means of determined transportation nodes:

$$\boldsymbol{R}2^{LSP} \subset \boldsymbol{TZ} \times \boldsymbol{PP} \times \boldsymbol{TZ} \tag{16}$$

- potential ways of material goods flow through ***LSP***, e.g.:

$$R3^{LSP} \subset ZP \times TZ \times P \times TZ \times P \times TZ \times \times D \times TZ \times KI \tag{17}$$

4.2. NOTATION OF THE MODEL FOR LOGISTICS SYSTEM OF POLAND

In accordance with the assumptions above, logistics system of Poland is distinctive for its structure which defines its components and relations between them (as well as with the neighborhood). Certainly the LSP structure in question is essential for the realization of fundamental functions of LSP which, as stated before, relate to the realization of transformations significant for socio-economic needs of the state, concerning cargo flow and associated information, with regard to: time (particularly storing), place (transport) and form (mainly processing). Therefore, besides the structure, a considerable element of LSP is the extent of tasks the system is expected to perform.

Constituting a system of services for other spheres of economy (mining, production, etc.) national logistics system realizes tasks due to sending and reception of loads occurring in particular spheres of economy. With this regard the resources of ***LSP*** are limited to two of its elements: external transport subsystem as well as transshipping and storing subsystem.

Actions performed within ***LSP*** are decisions concerning assignment of LSP resources to achieve determined objectives. These activities are defined as organization. Thus as a result of organization, the Polish logistics system possesses a determined method of performing logistical tasks. The organization of ***LSP*** is liable to ensure the required effectiveness of the system.

Therefore, it must be determined with regard to the criteria for the costs of logistics services (transportation and storage).

The possibility to apply particular resources of ***LSP*** to the realization of logistics tasks and the quality of resources are conditioned by the features of ***LSP*** components (e.g. transportational capabilities of particular means of transport, carriage as per types of transport, or servicing capabilities of standard and intermodal transshipment stations or adjusting forwarding and receiving stations to operate by means of individual form of transport). Hence, a model of ***LSP*** requires consideration of features of all its elements.

The instrument for analysis and assessment of operativeness of functioning or outlined logistics systems is a model of such system. It is essential for the designed model to imitate those features of a genuine system which are significant for research purposes. Considering the character and the objectives realized by logistics system it is necessary for its model to include such aspects as:

- structure – illustrating relations between elements of an explored logistics system ***LSP***;
- structure elements characteristics of ***LSP*** – demonstrating the imitation of genuine features of elements of a logistics system (fundamental for the choice of equipment e.g. technical, economical, organizational, etc.);
- logistics task of ***LSP*** – determining the extent of system load with cargo flow (forwarding and receiving);
- organization of ***LSP*** – demonstrating the connection between logistics system resources and materials flow being handled.

Model of the Logistics System of Poland in terms of transport 'commodity' can be noted as an orderly quartet by pattern:

$$\boldsymbol{MLSP}^{K} = \left\langle \boldsymbol{S}^{LSP}, \boldsymbol{F}^{LSP}, \boldsymbol{QZ}^{LSP}, \boldsymbol{O}^{LSP} \right\rangle \qquad (18)$$

where:

$\boldsymbol{MLSP}^{K}$ – model of Logistics System of Poland,
$\boldsymbol{S}^{LSP}$ – structure of logistics system of Poland,
$\boldsymbol{F}^{LSP}$ – a set of attributes of the structure elements of ***LSP***,
$\boldsymbol{QZ}^{LSP}$ – the extent of logistics tasks to be accomplished by ***LSP***,
$\boldsymbol{O}^{LSP}$ – the manner of realizing logistics tasks by ***LSP*** , with consideration for 'commodity'.

5. CONCLUSIONS

A logistics system, considering its supportive function for realization of fundamental objectives of economic subjects, should secure non-disruptive transfer of loads from forwarders to recipients. It requires an appropriate technical infrastructure such as transportation infrastructure as well as internal and external means of transport, transshipment installations, non-mechanical devices as well as human and information resources.

The instrument of support for the analysis of logistics system is its model. The constructing of the model enables recognition of structure elements of the system model, the extent of tasks to be accomplished and crucial for the system conditioning the qualities of its structure elements.

The Logistics System of Poland encompasses cargo transportation system along with logistics centers, intermodal transport terminals and standard transshipment stations essential for servicing major economic-industrial centers and markets in terms of materials supply and goods distribution.

The logistics tasks of ***LSP*** can be realized by means of various forms of transport as well as other elements of logistics infrastructure (e.g. logistics centers). However, according to the policy of EU it is crucial to tend to the effective use of resources of particular type of transport. The realization of such an objective is possible with respect to the model of the logistics system of Poland formulated on the basis of assumptions discussed in this paper.

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