

# OPERATIONAL REQUIREMENTS AND PREFERENCES TOWARDS FORWARDER TECHNOLOGY

Stelian A. BORZ<sup>1</sup>  
Martin ZIESAK<sup>2</sup>

Daniela ROMMEL<sup>2</sup>  
Gediminas VASILIAUSKAS<sup>3</sup>

**Abstract:** *Forwarders are expensive machines that fulfil the operational needs of a limited pool of customers, therefore innovation in this kind of technology needs to be pushed and sustained by the market demand. This study analysed the requirements and preferences of forwarder users in five European countries by means of a questionnaire structured on issues such as performance requirements, market analysis and innovation potential. Expectations for the future forwarder technology are related to uncertainties stemming from the operational and regulatory environments. Machine flexibility as well as acceptable purchasing and operating costs could be the solution expected by customers. These parameters are supported by the modular approach of the Forwarder 2020 project which enables customers to adapt the technology to their needs.*

**Keywords:** *forwarder, market, capability, innovation, development.*

## 1. Introduction

Forestry is continuously changing to adapt to new needs, even more so in the last decades when multifunctional demands have considerably increased [13]. Obviously, one of the greatest challenges of the future will be to sustainably satisfy an increasing need for wood from fewer forest resources.

In timber harvesting operations, for instance, this challenge will require

innovations able to provide effective [5], [9] and intelligent solutions [5], as well as to transfer knowledge and technology to developing or transitional economies [5].

In delivering wood to industries, however, a significant effort and resource commitment are often required to convert the trees into logs and transport them to various customers, including off-road transportation processes [11]. At the same time, automation is seen in many

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<sup>1</sup> Department of Forest Science, *Transilvania* University of Brasov, Şirul Beethoven no. 1, Brasov 500123, Romania;

<sup>2</sup> Berner Fachhochschule Hochschule für Agrar-, Forst- und Lebensmittelwissenschaften (HAFL) Abteilung Waldwissenschaften Fachgruppe Forstliche Produktion Länggasse 85, CH-3052 Zollikofen;

<sup>3</sup> Faculty of Agricultural Engineering, Institute of Agricultural Engineering and Safety, Vytautas Magnus University, Studentu str. 15b, LT-53361 Akademija, Kaunas distr., Lithuania;

Correspondence: Stelian Alexandru Borz; e-mail: [stelian.borz@unitbv.ro](mailto:stelian.borz@unitbv.ro).

industries as a way of increasing operational effectiveness. Nevertheless, mechanized harvesting systems such as those consisting of a harvester and a forwarder are still considered to be partly automated [8]. Acknowledging the crucial role of harvester related innovation in delivering effective machines [1], there is still a lot of room for innovation in off-road transportation because, in general, machines such as forwarders are quite system-flexible and versatile since they may be used in harvesting systems along with different equipment used for tree felling and processing [11].

On the one hand, the forest sector is characterized by a low growth rate compared to other industries, and its companies are typically seen as conservative, isolated, and limited in terms of knowledge transfer and focus on innovation [4]. On the other hand, little is known about how forestry-related companies approach product development [3]. To this end, product innovation is the outcome of the efforts put in developing new products or in improving existing ones [2], and is often achieved through a market oriented (market pull) approach. This is even more important in the case of forwarder technology which is expensive [e.g. 12] and targets, in many countries characterized as potential markets, a limited customer population [10] whose operational requirements need to be known in advance to ensure the development of a successful product. In addition, forwarder related innovation is demanding and the costs of product development are high, which are just additional reasons to test the markets in order to avoid failures.

This study was designed within the

framework of the Forwarder2020 project [6] - which targets innovations related to increased effectiveness and control of the machines - and it aimed to benchmark the user' preferences and problems related to forwarder technology.

## 2. Materials and Methods

The study is based on a structured questionnaire designed and developed in close collaboration by Hohenloher Spezial-Maschinenbau GmbH & Co. KG (HSM) and Berner Fachhochschule (BHF), within the framework of the Forwarder2020 project [6]. The main aim was to identify the user and market demands related to forwarder technology in Central, Western, Northern and Eastern Europe, by not overloading the respondents with a high number of questions and by selectively receiving information and giving space for opinions and comments. Initially, the survey document was developed in the German language, then it was further translated into languages of other targeted countries: English, Lithuanian, and Romanian.

The questionnaire was structured into three main sections, the first of which contained a set of questions related to the development of forwarder technology, while the second section consisted of questions related to forwarder marketing aspects. The third section was designed to get general comments and complementary feedback from the respondents.

The first section aimed to collect descriptive data about the respondents, such as their experience in working with a forwarder, the number of employees in the respondents' company, and the company location. Further questions were designed to get information on the typical

operational environment referring to terrain slope and hauling distances.

Finally, questions about the users' perception about the importance of productivity, ecology, and ergonomics were asked. For this purpose, the items were created using bipolar scales that gave respondents the opportunity to rate them as "very important", "important", "somehow important", and "not important at all". The productivity question covered items such as driving speed, fuel consumption, and location-independent information on machine condition. Ecology covered CO<sub>2</sub> emissions, soil compaction, and operation on sensitive soils, while the ergonomics questions referred to whole-body vibrations of the driver.

The next items were designed to ask the respondents about the specific IT & control systems they were using as well as to give them the opportunity to specify what kind of sensors would be of help in their activity.

The second part of the questionnaire contained three questions. The first one aimed to collect data by "yes" or "no" answers complemented by comments about the factors that had a significant impact on the performance of the forwarder market in the last 10 years. The included items were competition, price structure, poor road network, legislation, NGOs, and unfavorable and unpredictable environmental conditions.

The second question aimed to get responses concerning the most important parameters affecting the decision to buy a new machine, and it was designed as a multi-response question with the following items: producer (label), price, technical innovation, and adaptation to the site-specific harvesting situation.

The third question was designed to get information from the respondents on their perception in relation to the most traded innovations on the forwarder market in the last 10 years, as an ordered list of three innovations.

The third and final part of the questionnaire was designed to collect additional comments from the respondents who felt that they could provide other kind of information. The questionnaire was complemented by a cover letter explaining the aim of the study and the intended use of the data.

While the survey was designed to be administered via regular mail, there were some cases in which the responses were obtained via other communication channels. Specifically, copies of the questionnaire and cover letters were delivered to forwarder professionals from Austria, Germany, Lithuania, Romania, and Switzerland holding at least one forwarder machine, aiming as a first population to the users of HSM machines and as a second population to the users of other brands.

As the customer (user) population is quite limited in many countries [10] - *e.g.* in Romania the number of harvesters and forwarders was estimated at fewer than 50 units in 2012 [14], the aim of the study was to distribute the questionnaire to a representative number of users. At least in the Romanian case, this presupposed a benchmarking of the existing users prior to the document distribution.

In total, a number of 48 forest organizations sent back a filled in questionnaire, as shown in Table 1. A detailed regional breakdown is interesting for Romania in particular, having a high number of returned questionnaires, as presented in Figure 1.

Number of responses per country

Table 1

Country	Federal state, region	Responses
Austria	Vorarlberg	1
Switzerland	Aargau, Bern, Freiburg, Solothurn, Thurgau	4
Germany	Baden-Württemberg, Bayern, Hessen, Nordrhein-Westfalen	7
Lithuania	Alytaus, Kaunas, Kauno apskritis, Klaipėdos, Panevezio apskritis Panevezys, Siauliai, Silute, Telsiu, Vilniaus	11
Romania	Bihor, Bistriţa-Năşăud, Braşov, Călăraşi, Dolj, Harghita, Maramureş, Mureş, Neamţ, Prahova, Satu Mare, Sibiu, Suceava	25

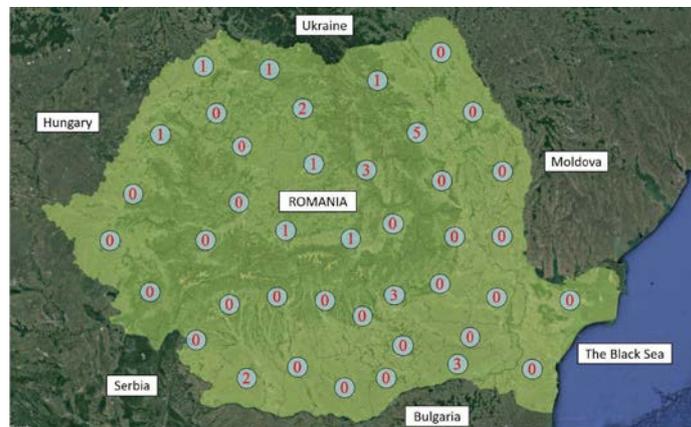


Fig. 1. Response rate in the case of Romania - distribution of responses at county level

Due to limited space, this study deals only with the most important parts of the data given by respondents. The data coming from the filled in documents was translated into English, then it was centralized and analysed using simple statistical procedures. For some parts of the responses which included analysis of text provided in the comments, text mining techniques were used to extract the main themes provided by the respondents.

The statistical analysis was carried out in Microsoft Excel while text mining was carried out using the on-line free-to-use

tool Word Cloud [7] after some preparation of the text that aimed to remove context-specific words.

### 3. Results and Discussions

#### 3.1. Respondents

Figure 2 shows an overview of the respondents by considering their experience in working with a forwarder. Roughly 50% of the respondents were categorized as machine owners or entrepreneurs irrespective of the country/group of countries included in the study.

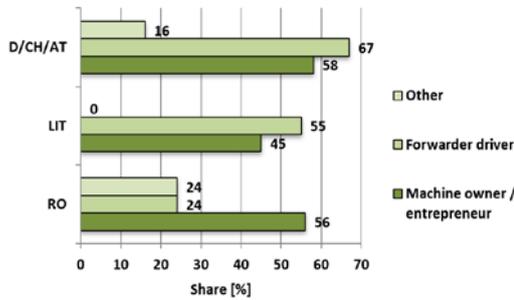


Fig. 2. Share of respondents according to their experience in working with a forwarder

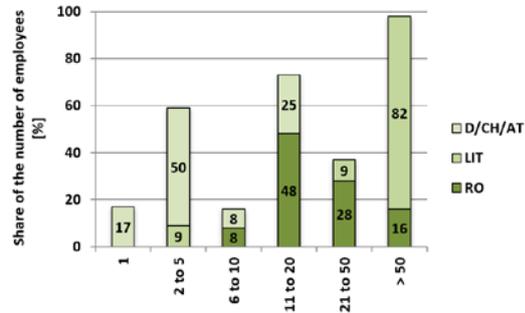


Fig. 3. Share of respondents according to the number of employees in the company

In the analysed sample, many of the respondents were, at the same time, both machine owners and forwarder operators and there were cases in which the company consisted of a single employee (Figure 3). In regards to the number of employees in the surveyed companies (Figure 3), the situation was quite different at country level. For Germany, Switzerland, and Austria, most of the respondents stated that their companies have 2-5 employees, while in Lithuania most of them belonged to companies with more than 50 employees, and in Romania almost half declared that their companies employ 11 to 20 people.

### 3.2. Typical Operational Environment: Type of Terrain and Hauling Distances

Forwarders are versatile machines that can be operated in terrains characterized by various slope conditions. Nevertheless, the type of terrain on which the respondents typically use forwarders was somehow, country-specific in this study. In

Lithuania (Figure 4), for instance, many of the respondents declared that they use forwarders in rather flat forested terrains, which is consistent with the country's general topography. In Germany, Switzerland, and Austria, the predominantly declared use was that specific to terrains characterized by slopes lower than 40%.

A particular example of forwarder share of use in relation to terrain type was Romania (Figure 4), where the responses were quite evenly distributed between the three terrain categories: lower than 20%, 20-40%, and higher than 40%, showing that forwarder owners often work in locations different than the company location. Therefore, they would require flexible solutions that could be easily adapted to various terrains. Typical hauling distances ranged widely in the case of Romania (Figure 5), with most of the answers indicating the use of forwarders across distances ranging from 0.5 to more than 1 km; in some cases, the typical hauling distances were indicated to reach up to 2-3 km.

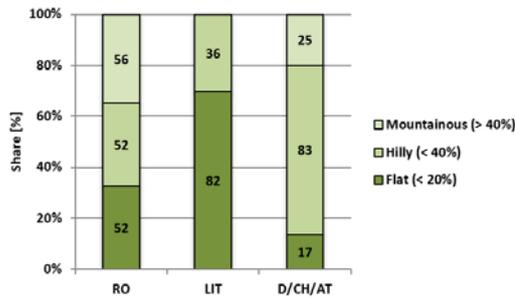


Fig. 4. Share of forwarder use in relation to the terrain slope

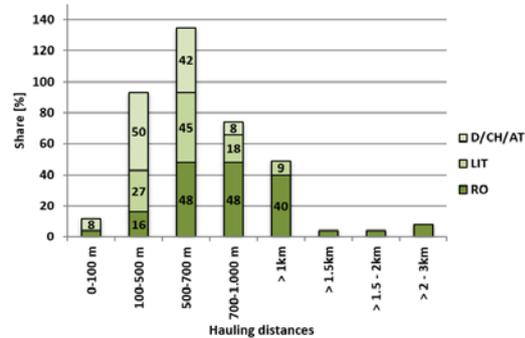


Fig. 5. Share of forwarder use in relation to the hauling distance

In the rest of the surveyed countries, the typical hauling distances, as stated by the respondents, ranged between 0.1 and 0.7 km with only minor cases when they exceeded 1 km (Figure 5). From this point of view, and at least in the case of Romania, the development of forwarder technology should also be focused on those capabilities able to compensate for the productivity losses due to increased hauling distances.

### 3.3. Preferences on Forwarding Capabilities

The preferences on forwarding capabilities were evaluated by bi-polar scales and the results are shown in Figure 6-11. They could be interpreted both, as current practice issues and as expectations of the users in relation to the development of forwarder technology.

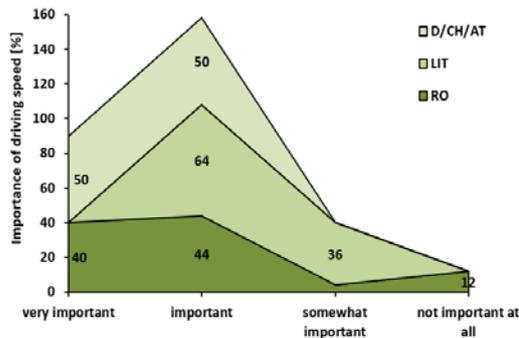


Fig. 6. Share of responses concerning the importance of driving speed in forwarding operations

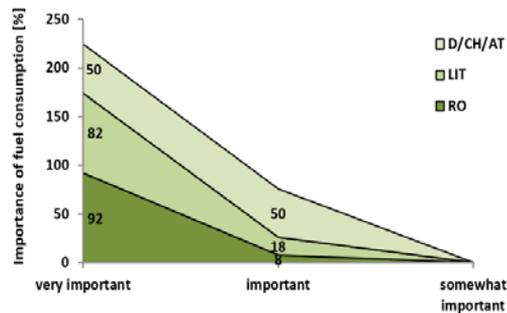


Fig. 7. Share of responses concerning the importance of fuel consumption in forwarding operations

In particular conditions, such as those of forests characterized by low accessibility and high forwarding distances, one can expect a compensation in terms of productivity by operating a machine able to travel at an increased speed. The

responses related to the importance of driving speed as an additional capability are shown in Figure 6. This capability was rated as important or very important (64-100%) by most of the respondents, irrespective of the country of origin. In the

case of fuel consumption (Figure 7), the situation was even more contrasting, with the majority of respondents placing a great interest in this capability.

Since by being able to reduce fuel consumption one could reduce the operational costs, this feature was evaluated as being of great importance, particularly in Romania (92%), probably in relation to the current forest accessibility and extraction intensity situation. Remote production-monitoring is a capability that

could help companies improve the management of their operations. Such capabilities were rated as important or very important (>80%) in countries such as Lithuania and Romania (Figure 8). One could expect that by adding such capabilities, companies would be enabled to make real-time decisions, a feature that is quite important for remote operational areas, not only in case of machine breakdowns, but also for the purpose of active process control [15].

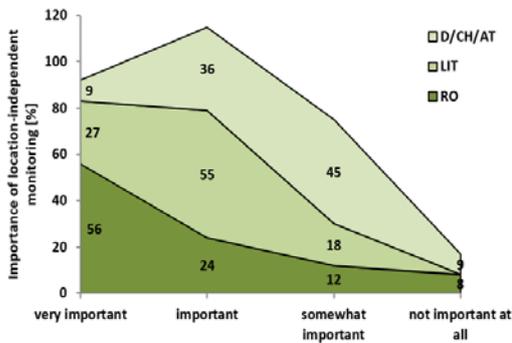


Fig. 8. Share of responses concerning the importance of remote monitoring in forwarding operations

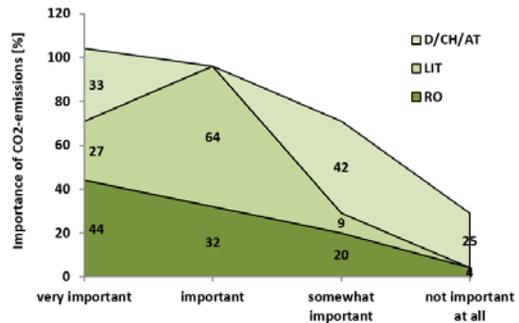


Fig. 9. Share of responses concerning the importance of CO<sub>2</sub>-emissions in forwarding operations

The responses to the items designed to test the preferences on environmental

and ergonomic capabilities are shown in Figures 9-11.

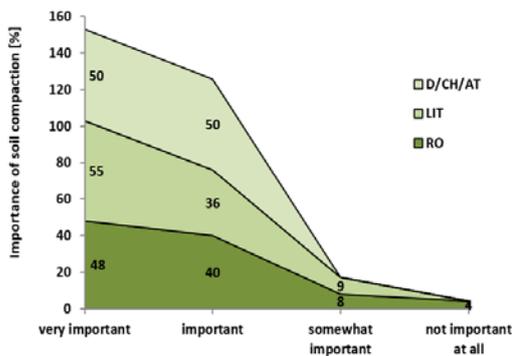


Fig. 10. Share of responses concerning the importance of soil compaction in forwarding operations

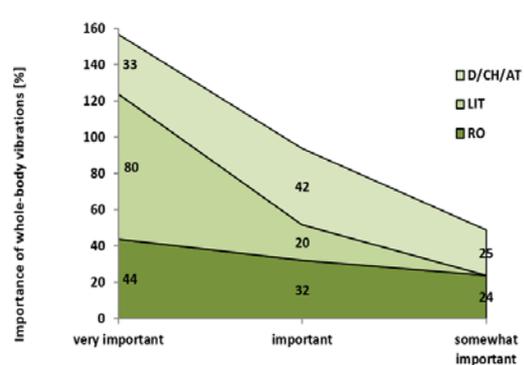


Fig. 11. Share of responses concerning the importance of whole-body vibrations in forwarding operations

The most obvious polarity was the one regarding the capability to reduce the soil impact in terms of compaction (88-100%). In many countries, this is an important feature to be able to comply with existing forestry-related regulations. In Romania, for instance, this would be a less important capability when dealing with bladed skidding roads, but it is still important in those cases in which the forwarder needs to access the location of logs by using undisturbed, natural soils, when such a practice is accepted by owners or managers of the forest.

### 3.4. Market Analysis

The results in the responses related to the performance of the forwarder market are shown in Figure 12 and they were quite heterogenous in respect to the respondents' country of origin, and therefore to their specific and contextual, legal, operational, and market related environments. Nevertheless, some trends characterizing countries or groups thereof may be seen in the data. In particular, the performance of the forwarder' market was seen to be affected by unfavourable environmental conditions, especially in Romania. Among the explanations for this, the respondents included reasons such as the ability of forwarders to compensate for the time lost due to unfavourable weather conditions and to a limited time window for operation, by increased productivity compared to the existing, mostly skidding machines.

On the other hand, legislation was seen as a factor affecting the performance of

the forwarder' market in Germany, Switzerland, and Austria, while NGOs were considered to be an important negative factor in Germany, Switzerland, Austria, and Romania, although their activity was seen by many respondents (*e.g.* Romania) as purely subjective and non-informed. Poor forest accessibility as a factor affecting the forwarder' market was specific to Romania and it is related to the results shown in the sections above. The Romanian reasons for considering the road network a factor that positively affected the performance of the forwarder' market were generally related to an increased performance of systems in which they operate - increased loads per turn and substitution of other machines by integrated capabilities (*i.e.* loading-unloading) - as well as to various technical limitations in developing new forest roads.

Price structure was evaluated as a serious factor by the respondents from Germany, Switzerland, Austria, and Lithuania. The reasons provided were, however, limited in this case (*i.e.* low price of timber that affects the ability of companies to purchase innovative machines).

Competition was seen as relevant by most of the respondents. Particular reasons for this outcome were both positive and negative. Some considered that competition triggered innovation in those capabilities related to productive, environmental, and ergonomic performance, while others saw a decreasing trend in the quality of marketed machines due to competition.

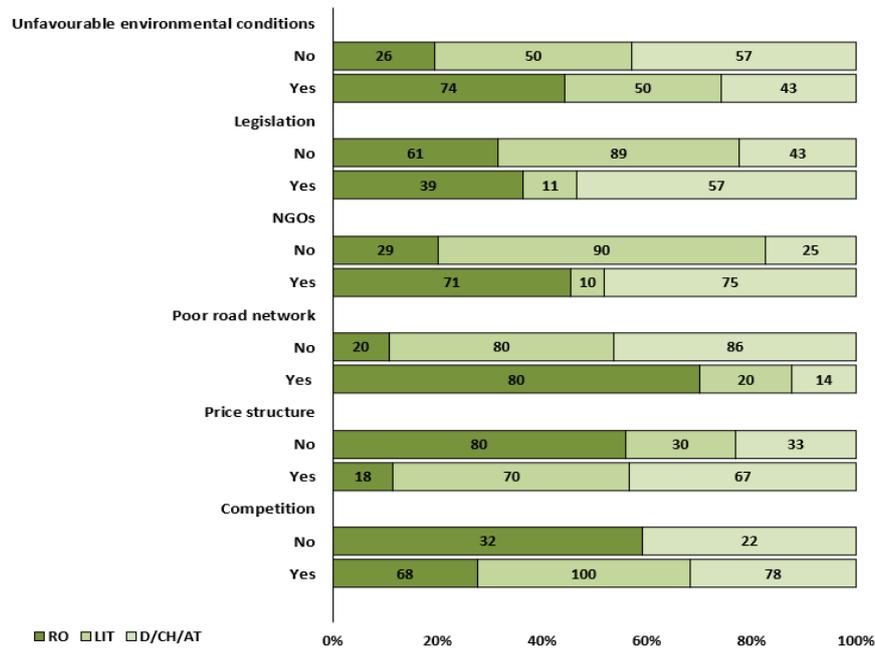


Fig. 12. Share of responses concerning the factors impacting the forwarder's market performance

Excepting the price structure, in the case of Romania, the respondents indicated that unfavourable environmental conditions, legislation, NGOs, poor road network, and competition affected the forwarder market in the last 10 years. In the case of Lithuania, the situation was quite the same, excepting the conditions of road network, NGOs and legislation, while in the case of Germany, Switzerland, and Austria, the factors that affected the market were seen to be, in general, legislation, NGOs, price structure and competition.

### 3.5. Factors Affecting the Machine Buying Behaviour

Figure 13 shows the results related to the factors considered important in the

respondents' view when planning to buy a new forwarder.

While the producer/brand seemed to be very important in the case of the Romanian market, fewer than half of the respondents from Germany, Switzerland, Austria and Lithuania considered it important.

The purchasing price was important in all the countries covered in this study (>50% of the responses), in particular in Romania, Germany, Switzerland, and Austria (>70% of the responses), while the technical innovations and the capability to adapt to different operational environments were important, in particular, for respondents coming from Romania, Germany, Switzerland and Austria (>50% of the responses).



#### 4. Conclusions

According to this study, the following may be concluded:

1. In the analysed countries there is a wide variability in terms of company size. This fact may affect the users' ability to invest in new machines and/or in machines integrating the latest technical innovations as a block, therefore a flexibility in terms of innovation options would be required for small companies, at least in Romania;
2. The typical operational environments were found to be quite different in terms of terrain slope and hauling distance. In many of the Romanian cases, the latter was among the factors that triggered the switch to forwarder machines;
3. While being particularly interested in balancing their income by an increased operational performance, the respondents were well aware of the importance of the environmental and ergonomic aspects of their operations; nevertheless, the solutions should be contextually developed to cover the given operational needs and management regulations;
4. Besides some context-specific factors such as the poorly developed road network, the changes in the performance of the forwarder market were attributed, in general, to environmental conditions, legislation, NGOs, and competition. Some of them may be approached by technology development and innovation while others may need quite different approaches, even if they could include innovation;
5. In the purchasing behaviour, price, technical innovation, and the flexibility of machines were important in the respondents' view. Solutions should be developed to balance such needs;
6. By considering the above, one could expect from the future forwarder technology to be pointed towards the development of machines able to balance the uncertainties stemming from the operational and regulatory environments with acceptable purchasing and operating costs. Developing such machines is the core of the Forwarder2020 project which is framed around a modular development, giving users the free choice to purchase innovations specific to their operational environment, in direct relation to an improved environmental protection, increased efficiency and better decision making;
7. Acknowledging here the response distribution of the countries as a potential limitation of this study that could bias some of the outcomes the targeted population of forwarder users is generally small, as presented in the Materials and Methods section. Therefore, at least for the Lithuanian and Romanian cases, the results stand for quite an accurate estimation of the forwarder market.

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