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# The Role of Internal Conditions in the Implementation of the Lean Green Concept: American, Japanese and Polish Experiences

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**Abstract**
Lean Green is a concept which is implemented as a part of the sustainable development strategy, share allowing for reduction of the company's costs related to, on the one hand, efficient use of energy factors and on the other optimum use of production factors aimed at minimisation of wastefulness, in particular in the area of post-production waste and pollution. The purpose of the article is to identify the determinants, internal stimuli and to specify the force with which they affect the implementation of the Lean Green concept in companies on various continents: America, Asia and Europe. For the purpose of better recognition of the examined problem, analysis of results of studies was made in consideration of the following criteria: country where a given company operates and share of persons outside the company in the process of implementation of this concept. In article uses the one-way ANOVA methodology, the Shapiro Wilk and Levene tests and the non-parametric Kruskal Wallis test. Hitherto studies have confirmed that the determinants are regional, which indicates the necessity of directional studies.

**Keywords**
Lean, Lean Green, Lean Green implementation, conditions of Lean Green implementation.

## Introduction

The Lean Green concept includes environmental aspects (Hines, 2009). Actions taken by organisations that are aimed at curbing the negative effect of these organisations on the environment often include reduced consumption of resources, such as materials, energy, water or gas (Kazancoglu et al., 2018). The progressing degradation of the environment in many dimensions has been an obvious fact for a long time. The shrinking natural resources of the Earth, the deepening of the greenhouse effect and increasing pollution are some of the results of development, economic changes, and, above all, irrational human behaviour. Excessive consumption and actions aimed at making a quick profit lead mankind to self-destruction and set the environment and economic development against each other. Therefore, searching for balanced development (Verrier et al., 2016; Abualfaraa et al., 2020) which would combine and respect both the requirements of environmental protection and technological progress is nowadays an enormous challenge that requires taking immediate action (Garza-Reyes et al., 2018; Chugani et al., 2017). The ecological consciousness of the society is increasing. According to research, environmentally-friendly activities constitute an essential factor that determine the number of clients (Chen, 2008). Visible environmentally-friendly actions make an important criterion for choosing between one company and the other (Parmar & Desai, 2019. The factor that limits the environmentally-friendly behaviour of customers refers to the fact that the products of environmentally-friendly companies are often more expensive than of other companies (Tseng et al., 2019).

Introduction of the Lean Green premises to business practice, even though it seems extremely important and valid, often ends in failure, as there is no systemic model for implementing them (Tseng et al., 2019; Siegel et al., 2019). Apart from a systematic, staged process of implementation, the model of application of the Lean Green concept should also include conditions that accompany the implementation of its subsequent stages. It should be added that there is

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a broad range of factors that condition the success of implementation of the Lean Green concept. Such conditions are classified into various categories, for the purposes of this study it was assumed that these conditions will be divided into external and internal, as is the case with any analysis, including the SWOT analysis.

The issue of identification, classification and categorisation of internal conditions of implementation of the Lean Green concept has been the object of studies of domestic and foreign scientists (Mangla et al., 2018; Garza-Reyes, 2015; Banawi & Biles, 2014; Gaikwad & Sunnapwar, 2020). In the reference books referring to the implementation of the process management on which the Lean Green concept relies, attention is focused on three elements (Kumar et al., 2016): processes, people and technology, whereas employees are the critical area of implementation of the concept, whereas technology refers to tools aiding process efficiency (Jeston & Neils, 2014). In the theory pertaining to the broadly understood implementation of changes, internal conditions are divided into "soft" and "hard" components (Mishra, 2018; Prasad et al., 2016). The "hard" conditions refer primarily to the structure, technique and technology, financial conditions and conduct compliant with the adopted implementation procedure of the Lean Green concept, whereas the "soft" ones concern human resources, their stances and engagement and, in the opinion of numerous researchers, the stances and engagement of human resources may determine the success of the introduced concepts (Zarębska, 2002; Grabara et al., 2019). Similar dualism is also perceptible is the approach proposed by Bhasin and Burcher, who assume that an organisation applying the Lean concept is an integrated socio-technical system comprising a number of tools and management practices, the consistent application of which leads to elimination of waste, reduction in fluctuation of suppliers, clients and internal processes (Anvari et al., 2011; Shah et al., 2008). Two categories of conditions are identified: cultural and technical (Thanki & Thakkar, 2018; Sundar et al., 2014). Technical conditions include familiarity with Lean tools and practices; what is more, it is emphasised that in order to be successful in the implementation of the Lean concept, it is necessary to implement at least two of them in the first place and then make effort aimed at implementation of the entire concept (Chen, 2008). Apart from it, technical conditions also include: continuous improvement (Kaizen), organisation of cellular manufacturing, one piece flow, process mapping, SMED, supplier development system, reduction in the number of suppliers, 5S, TPM, analysis of value creation chain and identification of seven sources of waste (overproduction, waiting, transportation, overprocessing, inventory, motion and defects) (Paneru, 2011).

Summing up, it may be concluded that literature manifests a clear dichotomy in the approach to the conditions of the Lean including Lean Green implementation process. On the one hand, we are dealing with hard conditions – technical ones – and on the other with soft – cultural, which put man in the centre of attention. According to authors, conditions of any actions taken in companies may be, most generally, divided into: financial, technical, organisational and cultural (Fig. 1). These groups of conditions affect and permeate each other, creating a unique situational structure for every company, which will be described and explained in the next part of this study.

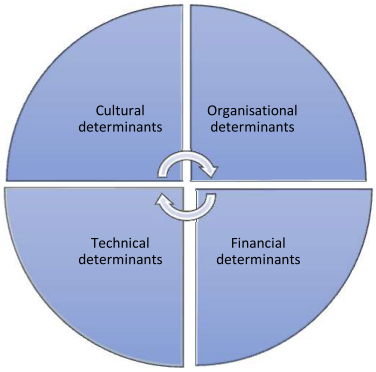


Fig. 1. System of internal determinants of the implementation process of the Lean Green concept

Financial conditions constitute important factors defining all decisions made in a company. Implementation of the Lean Green concept is, theoretically, a technical/ organisational/ cultural rather than a financial challenge, yet in spite of it, it generates the necessity of incurring specific financial costs in practice. Therefore, after identifying the necessity of implementing the Lean Green concept, it is necessary to assess the potential with respect to the resources necessary for its implementation, primarily human and financial. Oftentimes, financial resources are necessary to hire and/or train persons of key importance for efficient implementation of the Lean Green concept. On the other hand, technical conditions refer to the machines and devices held, which comprise the technological lines in line with the adopted principles of production organisation. Technical and organisational determinants govern the form of the adopted processes and production procedures whereas these, in turn, condition the applied technologies and control and management tools. Organisational determinants refer to the mode of a company's organisation

and its organisational structure. A company's organisation is a consequence of both the adopted style of management, as well as the company's organisational culture and is coupled with the organisational structure, which reflects the adopted model of a company's organisation (flat or hierarchical structure) and organisational priorities (processes or functions). The last group of internal determinants includes cultural determinants. In reference books, these determinants seem to be essential for successful implementation of the Lean Green concept; in principle, all studies emphasise the superiority of "soft" determinants with respect to "hard" ones in the area of strength and essence with which they shape the concept's implementation processes, thus their closer investigation is justified.

The goals of the article include:

- identification, on the basis of literature studies, of internal conditions of the implementation of the Lean Green concept; The implementation of the Lean Green concept is understood as a process consisting of two main stages, pre-investment and investment (Siegel et al., 2019; Almanei et al., 2017; Ruttimann, 2018).
- determination, on the basis of empirical studies, of the power with which individual conditions influence the efficiency of the Lean Green concept implementation;
- indication of differences in perceiving the impact of subsequent conditions in the USA, Japan and Poland;
- definition of differences in perceiving the impact of subsequent conditions, depending on the participation in the process of implementation of the Lean Green concept of persons from the outside. The study is to compare the American approach – where external experts are most often used, and the Japanese approach where all concepts are implemented using the company's human resources (Prasad et al., 2022; Alefari et al., 2017).

Such studies seem justified and have not been performed to date. Selection of countries from which the companies derived was not accidental, as the Japanese approach is often juxtaposed with the American one, (Stoner & Wankel, 1996) whereas Poland was included in the group given the fact that the authors have extensive access to Polish companies.

## Materials and methodology

Cultural conditions and organisational conditions define and supplement each other, whereas their mutual correlation was considered a significant cause for describing them together (Sułkowski, 2013; Bortolotti et al., 2015). Imagining a change in the former without changes in the latter is hard. It is often emphasised in reference books that in the case of implementation of the Lean Green concept, cultural conditions constitute, on the one hand, the conditions most strongly determining the success of actions taken and, on the other, they are the most difficult to shape (Taherimashhadi & Ribas, 2018; Kull et al., 2014; Dahlgaard & Dahlgaard-Park, 2006).

Sole organisational culture was defined as a set of guidelines in the form of numerous unwritten principles pertaining to proper behaviour. Through the prism of these principles, the employees perceive and understand the world surrounding them, including conduct at the work place (Morgan et al., 2010; James & Jones, 2014). Lean culture and philosophy should become a mode of thinking, both tactical and operational, of all members of the organisation, at the same time constituting an action-stimulating mechanism (Bhasin & Burcher, 2006; Cagliano et al., 2011).

Whilst defining cultural conditions of the Lean Green implementation, it was decided that they refer to a change in the organisational culture through implementation of certain modes of conduct (Koenigsaecker, 2000; Nordin et al., 2012):

- making decisions at lowest levels of the organisation;
- communication of a clearly defined vision and indication of what the organisation believes in and how it is going to look like upon completion of transformation;
- ensuring existence of a change strategy, as a result of which intensification of communication processes aimed at provision of information on how individual goals will be accomplished is indispensable;
- development of relations with suppliers based on mutual trust and engagement, which may be reflected in long-term periods of cooperation and percentage share of orders implemented on the basis of long-term contracts;
- fostering conditions enabling organisational learning by means of organisation of trainings, workshops or integration meetings; systematic continuous focus on clients, their inclusion in project processes.

Reference literature also features opinions that the fulfilment of three conditions results in a significant probability of change in the organisational culture; the first condition is the eloquence of superiors, as they have to reflect the values of the culture that they want to create (Bortolotti et al., 2015). Authenticity and truth without a shadow of delusion and hypocrisy are the key factors conditioning the pro-

cess of cultural changes (Bennis & Goldsmith, 2003). The second condition is convincing the employees that the present-day culture of the company is so inconsistent with the current one in the industry that keeping it up may cause the company's collapse. And finally, there is the third factor which says that even though the change of culture theoretically seems to be a change not entailing investment outlays, the company's management board has to invest in programmes and projects newly shaping the internal environment. These projects must encompass change in the organisational structure and management and frequently also incorporate costs related to hiring managers who can act as the archetypes of conduct and desired stances (Morgan et al., 2010).

Studies confirm that apart from cultural conditions, organisational conditions, shaping the principles of management of human resources, also exert a significant impact on the implementation of the Lean Green concept. A stiff, hierarchic organisational structure is the major barrier for the implementation of the Lean Green concept (Aagrawal & Graves, 1999; Yauch & Steudel, 2002; Bamber & Dale, 1999). When speaking about hierarchy in the organisational structure, it is worth mentioning that from the point of view of Lean, human resources are divided into three groups: managerial personnel, Lean personnel and direct production employees (Czerska, 2014). Yauch and Steudel noted the co-dependency between cultural and organisational conditions and concluded that cultural conditions play a key role in hindering establishment, design, implementation and exploitation of Lean organisational and production solutions, such as manufacturing cells (Yauch & Steudel, 2002; Pachura, 2017). On the other hand, Aagrawal and Graves proved that hierarchic organisational dependencies deepen the separation between the subsequent stages of the production process, i.e.: design, production, assembly and testing and control of ready-made products. Such dismembering of production leads to the hindering of implementation of Lean practice in organisations (Aagrawal & Graves, 1999). Similarly, when product designers, process engineers and direct production employees are isolated from one another by the place of work performance, the attempt at decentralising the power is a challenge, whereas the possibilities of introducing practices aimed at continuous improvement become more difficult. Such situation hinders the implementation of Kaizen, which is a basis for any activities aimed at full implementation of the Lean Green concept (Detty & Yingling, 2000).

Attention should be paid to the studies of a team comprising Alaskari, Ahmad, Dhafr, and Pinedo-Cuenco who, based on over one hundred papers available on-line, identified key factors conditioning success in the implementation of the Lean concept and tools (Alaskari et al., 2012). Review of papers allowed for selecting over eighty factors, which were grouped according to the scope of their similarity. As a result of such work, the list of conditions was reduced to eighteen conditions that have fundamental significance in the implementation of the Lean tools. Conclusions from the conducted studies, including the list and the weight of identified conditions, confirmed the prior assumptions made by the authors of this study that the most important role in the correct implementation of the Lean process is played by conditions related to the organisational culture and human resources. The most important conditions were: engagement of top management, change of organisational culture, efficient leadership, efficient communication, comprehensive training and learning, determination of goals, treatment of the Lean Green process in the long-term category, visible engagement of Lean Green leaders, treatment of the Lean Green concept more as a philosophy of action than a strategy. Subsequent less important conditions determined on the basis of literature are: financial possibilities, engagement and values of employees at all levels of organisational structure, seeking engagement and trust of production employees, treatment of constant effort aimed at introduction of change as key, problem solving by engaged employees (Ślusarczyk, 2017), realistic schedule of changes, standardisation and high motivation of personnel for improvement (Sundar et al., 2014; Dües et al., 2012; Daroń & Górska, 2019; Chiarini, 2014; Thanki et al., 2016).

Based on the conducted literature studies, identification of internal conditions favouring the process of implementation of the Lean Green concept was made. These conditions were grouped by applying the division into cultural and organisational and technical and economic factors. Striving for better recognition and understanding of these factors, the organisational and cultural factors were consistently assigned to the following categories: pressure to change, strong leadership, competent people, effective first step, effective remuneration (Alaskari et al., 2012; Ślusarczyk, 2017) (Table 1)

Literature studies carried out as part of this article allowed for identification of important determinants, separated from scientific knowledge, which determine implementation of the management concept. Special attention was paid to determinants originating from the internal environment, which play – in the authors' opinion – a key role; furthermore, being aware of them allows for shaping them, which translates directly to the efficiency in implementation of

Table 1
Internal conditions conducive to the implementation of Lean Green concept

| CULTURAL AND ORGANISATIONAL CONDITIONS |
|---|
| **Pressure to change** |
| Creation of a work environment and culture in which employees will not be afraid of change |
| Employees' understanding of the need to change and the need to implement the Lean Green concept and the effects of its implementation |
| Making sure that the change strategy is in place, including a detailed implementation plan |
| Change of the system and structure to support the implementation and maintenance of the Lean concept |
| **Vision and Leadership** |
| Communication of a clearly defined vision and indication of what the organisation believes in and what it will look like when the transformation is complete |
| Personal involvement of top management in the implementation of the Lean Green concept |
| Eloquence and authenticity of the top management reflecting the values of the Lean Green culture |
| Personal involvement of operational managers in the process of implementing the Lean Green concept, acting as the agents of changes |
| Shaping commitment by involving executive employees both in conceptualisation and implementation of the LG concept |
| Ensuring participation (co-decision) of executive employees in management<br>Making decisions at the lowest levels of the organisation |
| Ability to mitigate conflicts (conflicts of interest between employees and the company, between various departments of the company and cooperating companies) and remove their sources |
| Promoting lean leadership |
| Bringing up concept leaders according to the *sensei* principle |
| Flexible and flat organisational structure |
| Systematic assessment of the degree of Lean implementation and public communication of information about effects and degree of implementation |
| Focus on streamlining processes and maintenance of effects of changes, not only on economic and financial results |
| Focus on benefits in a further perspective of time |
| **Competent People** |
| Creation of a work environment and culture in which employees are willing to share knowledge especially in the area of Lean Green |
| Fostering conditions that enable organisational learning by organising Lean Green trainings, workshops or integration training |
| Creation of conditions necessary for teamwork |
| Fostering conditions that stimulate creativity and readiness for creative work at each position (improvement of reporting system) |
| Measurement of program acceptance |
| High share of employees working in accordance with the LG concept in the total number of employees |
| **Effective First Step** |
| A convincing and realistic vision of the programme, employees' understanding of new needs and required attitudes |
| Continuous efforts to maximise stability in a changing environment (standardisation) |
| Employees' general understanding of the essence of the Lean Green concept, its strategy, tactics and tools |

Table 1 [cont.]

| CULTURAL AND ORGANISATIONAL CONDITIONS |
|---|
| **Effective Employee Remuneration** |
| Appropriate incentive system including both non-financial and financial awards for the managerial staff |
| Appropriate incentive system including both non-financial and financial awards for the executive staff |
| **Correctly Functioning Communication System** |
| Intensification of the processes of horizontal (between cells) and vertical communication (supervisor – subordinate) aimed at transferring information on how the individual stages and goals of the implementation of the Lean Green concept will be achieved |
| Providing everyone with access to information focused on specific individual goals and exchange of information among all employees |
| TECHNICAL AND FINANCIAL CONDITIONS |
| Provision of adequate financial resources |
| Having modern technique and technology conducive to the Lean Green organisation |
| Having space for the appropriate redesign of production lines in accordance with the Lean Green concept |
| Possibility of introducing new IT systems supporting the concept |

the Lean Green concept. After identification of conditions, they were grouped; this list of factors was the starting point for the preparation of a research tool (Alaskari et al., 2012).

## Methodology

The study was carried out in the second quarter of 2020 and had the form of a categorised interview with the use of an interview survey. The respondents were asked to determine the impact of individual factors on the process of implementation of the Lean Green concept, assigning a numerical value from the range of 1–5 to every factor determining the strength of impact, where 1 is no impact and 5 is very strong impact. The study covered CEOs or directors responsible for implementation of the Lean Green concept in automotive sector companies. Sixty-three CEOs of companies in three countries – Poland, Japan and the USA – provided answers to the questions included in the survey presented in the methodology section of this paper. All companies belonged to a group of enterprises with more than 250 employees; what is more, the Lean Green concept was formally included in the strategy of every company. Polish companies were branches of larger units, whereas all Japanese companies were separate autonomous units, and in the American companies, the situation was more diversified: 12/17 were autonomous units, whereas 5/27 were branches of larger enterprises. In general, the majority of surveyed companies was incorporated before 2020 (49/63). As far as aid of people from outside in the process of implementing the Lean Green concept is concerned, it is worth noting that Japan made use of people from outside in a very limited degree and only at the preparation stage (2/16); in Polish conditions, this aspect was diversified: 9/30 did not use any aid, whereas other companies declared external aid at the selected stage of concept implementation. As far as American companies are concerned, only 1 out of 17 implemented Lean Green without the aid of external consultants (Table 2).

In order to identify the differences between the three countries regarding seven factors that explain the initiative to implement the Lean Green concept, we used the one-way ANOVA methodology. The assumptions of normality and equal variance in all groups were also taken into account, by using the Shapiro Wilk and Levene tests. In cases when these assumptions did not hold, we used the Kruskal Wallis non-parametric test (when the assumption of normality did not hold) or an adequate post-hoc test (when the assumption of equal variance did not hold) (Thanki et al., 2016). We could have chosen to transform the data, using one of the common data transformations suggested by Tabachnick and Fidell (Agresti & Finlay, 2009), yet we decided to use non-parametric tests due to the small size of the sample.

In order to check if aid provided by people outside the company during the Lean Green implementation process had any effect on one or several among the seven conditions, we transformed the seventh question of the survey ("Was the implementation of Lean Green

Table 2
Characteristics of surveyed companies

| Country | | Poland | Japan | USA |
|---|---|---|---|---|
| Number of companies | | 30 | 16 | 17 |
| Is the enterprise a branch of a concern or an autonomous unit? | branch of a corporation with foreign capital and know-how | 28 | | 1 |
| | branch of a corporation with domestic capital and know-how | 2 | | 4 |
| | autonomous unit | | 16 | 12 |
| Since when has the company/branch of the corporation been operating? | after 2015 | | | |
| | between 2010 and 2015 | 2 | | |
| | between 2000 and 2010 | 7 | | 5 |
| | before 2000 | 21 | 16 | 12 |
| Is Lean Green included in the formal strategy? | Yes | 30 | 16 | 17 |
| | No | | | |
| Is Lean Green implemented with the aid of people outside the company? | No | 9 | 14 | 1 |
| | Yes, at the preparation stage | 7 | 2 | 9 |
| | Yes, at the implementation stage | 5 | | 4 |
| | Yes, at the stage of control and integration of the entire system | 9 | | 3 |
| | Yes, at the improvement stage | | | |

done with the aid of people outside the company?") into a binary variable (we kept the "no" answer, and we transformed all the "yes" stage related answers into a broader "yes" answer, regardless of the stage when aid from outside the company was provided), and used the $t$ test for independent samples. The assumptions of normality and equal variance in all groups were also taken into account by using the Shapiro Wilk and Levene tests. When these assumptions did not hold, we used the Mann–Whitney U non-parametric test (Tabachnick & Fidell, 2007).

When testing the assumption of normality, the Shapiro Wilk test returned values that would not allow us to reject the null hypothesis for three out of six cultural and organisational factors – "pressure to change", "effective first step" and "correctly functioning communication system". In all these cases we could not use the independent samples $t$ test, as the procedure based on average and standard deviation is suitable only for normal distributions. Therefore, we used the Mann–Whitney U test for these three conditions ("pressure to change", "effective first step" and "correctly functioning communication system").

The values for the Levene test – used for checking the assumptions of equal variance in all groups – allowed us to reject the null hypothesis, one in case of one condition out of all seven "effective employee remuneration". Considering the fact that for this conditions the assumption of normality does hold, in this case we used the $t$ test for independent sample with non-equal variance in both groups.

## Results and discussion

### Intercultural differences

For two out of six cultural and organisational factors – "effective first step" and "correctly functioning communication system" – the assumption of normality did not hold: for "effective first step" factor, the Shapiro Wilk test for Japan has a value of 0.873, corresponding to a $p$-value of 0.03, a value lower than 0.05; for "correctly functioning communication system" factor, the Shapiro Wilk test for Poland has a value of 0.927, corresponding to a $p$-value lower than 0.05 (0.041); the same test applied to the same factor ("correctly functioning communication system") but on the distribution for the USA has a value of 0.8, corresponding to a $p$-value of 0.002. Therefore, for these two cultural and organisational factors ("effective first step" and "correctly functioning communica-

tion system") we decided to use a non-parametric test – Kruskal Wallis – instead of using ANOVA.

The values for the Levene test – used for checking the assumptions of equal variance in all groups – would not allow us to reject the null hypothesis, not even for one factor out of all seven of them. That means that in the next analysis, we can use the post hoc tests that are based on the equal variance in all groups assumption.

### Pressure to change

The F value for one way ANOVA has a value of 52.45 for 2 degrees of freedom between groups and 60 degrees of freedom within groups, which corresponds to a $p$-value lower than 0.05 (0.000000000000067 actually). This means that there are significant differences between the three countries regarding the pressure to change. In order to clarify these differences, we used the Scheffe post hoc test, which identified significant differences among all three countries. The differences are presented in Fig. 2.

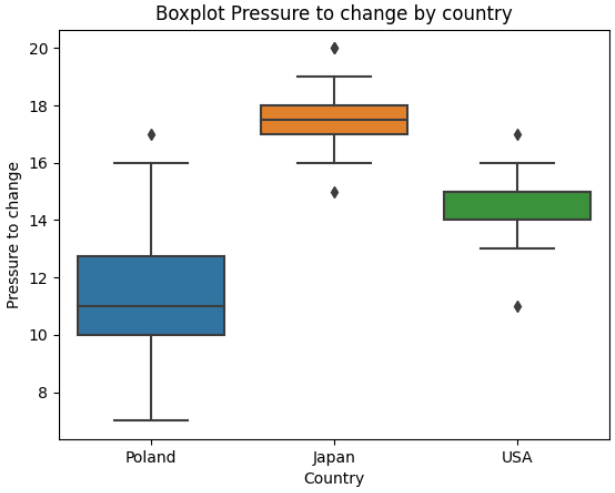


Fig. 2. Boxplot – Pressure to change by country

### Vision and leadership

The F value for one way ANOVA test has a value of 62.77 for 2 degrees of freedom between groups and 60 degrees of freedom within groups, corresponding to a $p$-value lower than 0.05. Based on this result, we used the Scheffe test for identifying the differences between the three countries. The only statistically significant differences were observed between Japan and Poland, and between Japan and the USA; there were no significant differences between Poland and the USA, when taking the "vision and leadership factor" into consideration. The differences are presented in Fig. 3.

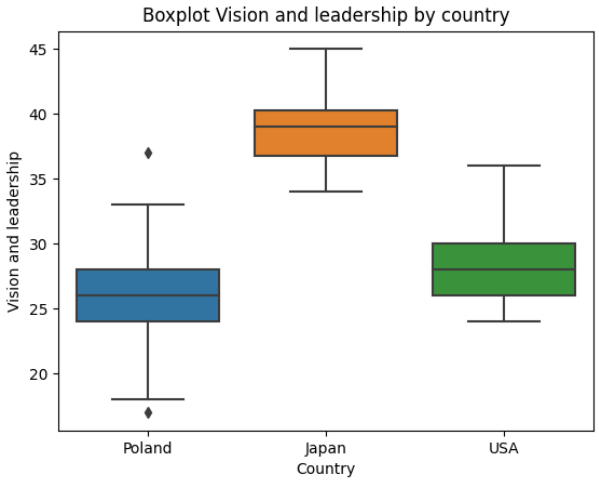


Fig. 3. Boxplot – Vision and leadership by country

### Competent people

The F value for one way ANOVA has a value of 14.84 for 2 degrees of freedom between groups and 60 degrees of freedom within groups. This corresponds to a $p$-value lower than 0.05 and at least one statistically significant difference between the three countries is expected. The Scheffe post-hoc test revealed that only the differences between Japan and Poland and the one between Japan and the USA are statistically significant. There is no significant difference between Poland and the USA. The differences can also be observed in the next boxplot – Fig. 4.

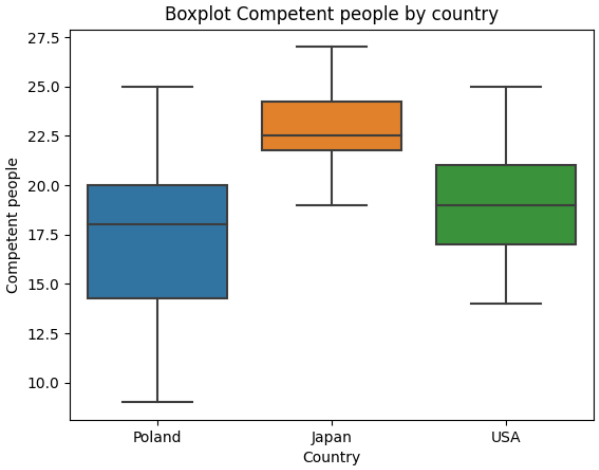


Fig. 4. Boxplot – Competent people by country

### Effective first step

For this condition, the Shapiro test for Japan sample had a value of 0.873, corresponding to a $p$-value lower than 0.05 (0.03 actually). This means that the

scores are not normally distributed, therefore we cannot use ANOVA to analyse the results. Therefore, we chose a non-parametric approach and used the Kruskal Wallis test, which in this case has a value of 19.29, corresponding to a $p$-value lower than 0.05. This means that at least one difference between the three countries is statistically significant. Because the normality assumption did not hold, we could not use the Scheffe post hoc test, therefore we decided to implement the Tamhane post hoc test, as this post hoc analysis can be implemented even in cases when the normality and equal variance in all groups do not hold. The results show significant differences between Japan and the USA and between Japan and Poland, but, once again, no statistical differences between Poland and the USA. The differences can also be observed in the next boxplot – Fig. 5.

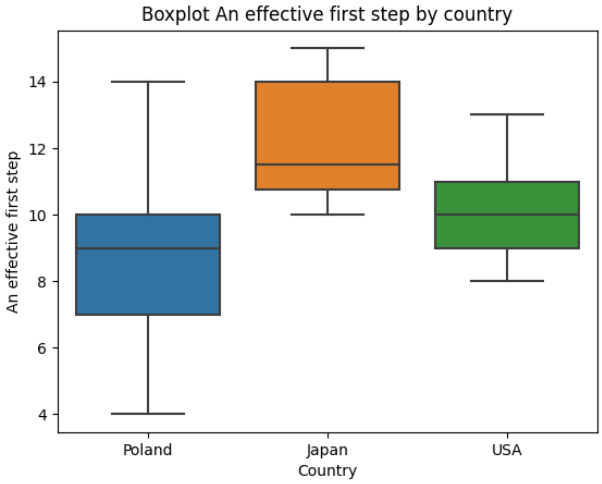


Fig. 5. Boxplot – Effective first step by country

### Effective employee remuneration

The F value for one way ANOVA has a value of 2.48 for two degrees of freedom between groups and 60 degrees of freedom within groups, corresponding to a $p$-value of 0.09, so higher than 0.05; therefore, we can conclude that there are no statistically significant differences between the three countries in this case. The boxplot in Fig. 5 sheds more light on these conclusions, presenting quite similar quartile based distributions for all three countries (Fig. 6).

### Correctly functioning communication system

The first conclusion related to this factor is that the Shapiro test for Poland and the USA had values representing $p$-values lower than 0.05 in both cases (0.927 for a $p$-value of 0.04 in the case of Poland, 0.8 for a

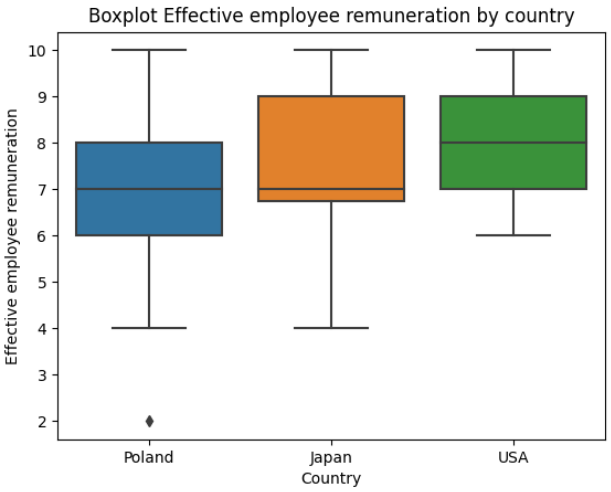


Fig. 6. Boxplot – Effective employee remuneration by country

$p$-value of 0.002 in the case of the USA). Therefore, because the assumption of normality does not hold, we used a non-parametric approach instead of ANOVA. The Kruskal Wallis test had a value of 15.1415, corresponding to a $p$-value of 0.0005, lower than 0.05. This means we can reject the null hypothesis, and we expect at least one statistically significant difference between the countries. In order to test this, we used the Tamhane post hoc test (we could not use the Scheffe test, because the assumption of normality does not hold in this case), and we identified statistical differences between Poland and Japan and between Poland and the USA. There is no statistically significant difference between Japan and the USA. The differences are presented in the next boxplot (Fig. 7).

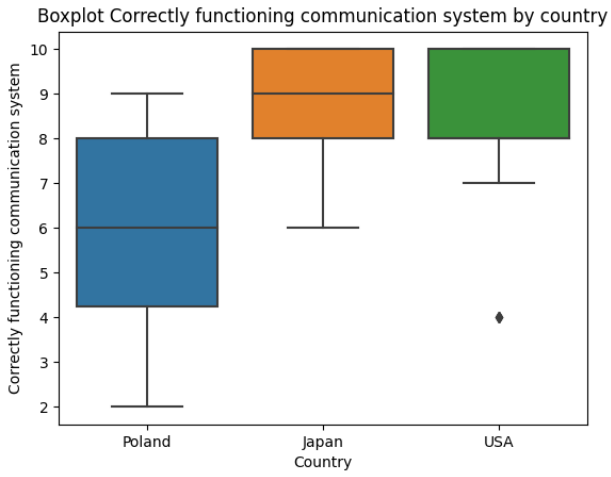


Fig. 7. Boxplot – Correctly functioning communication system by country

### Technical and financial factors

The F value for one way ANOVA has a value of 1.376 for 2 degrees of freedom between groups and 60 degrees of freedom within groups, corresponding to a $p$-value of 0.26 lower than 0.05. This means that the null hypothesis cannot be rejected, therefore we can conclude that there are no statistical differences between the three countries (taking the scores for this factor into consideration). The quartile based distributions for all three countries are presented in the next plot – Fig. 8.

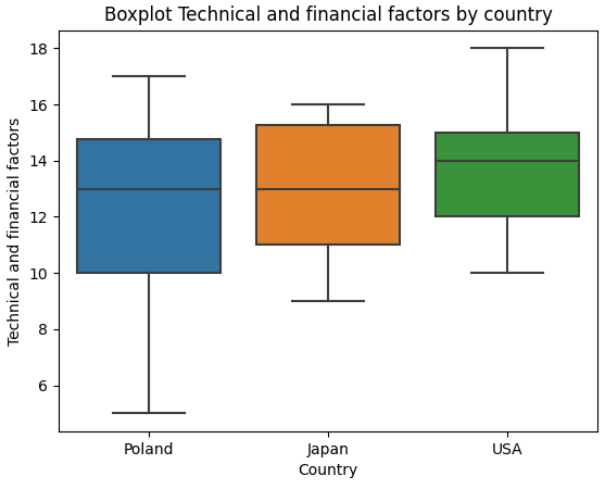


Fig. 8. Boxplot – Technical and financial factors by country

## Lean Green implementation with external aid

In order to check if aid provided by people outside the company during the Lean Green implementation process had any effect on one or several among the seven conditions, we transformed the seventh question of the survey ("Was the implementation of Lean Green done with the aid of people outside the company?") into a binary variable (we kept the "no" answer, and we transformed all the "yes" stage related answers into a broader "yes" answer, regardless of the stage when aid from outside the company was provided), and used the $t$ test for independent samples. The assumptions of normality and equal variance in all groups were also taken into account by using the Shapiro Wilk and Levene tests. When these assumptions did not hold, we used the Mann–Whitney U non-parametric test.

When testing the assumption of normality, the Shapiro Wilk test returned values that would not allow us to reject the null hypothesis for three out of six cultural and organisational factors – "pressure to change", "effective first step" and "correctly functioning communication system". In all these cases we could not use the independent samples $t$ test, as the procedure based on average and standard deviation is suitable only for normal distributions. Therefore, we used the Mann–Whitney U test for these three conditions ("pressure to change", "effective first step" and "correctly functioning communication system").

The values for the Levene test – used for checking the assumptions of equal variance in all groups – allowed us to reject the null hypothesis, one in case of one condition out of all seven "effective employee remuneration". Considering the fact that for this conditions the assumption of normality does hold, in this case we used the $t$ test for independent sample with non-equal variance in both groups.

### Pressure to change

For this factor, the Shapiro test for the distribution in the sub-sample where no aid from outside the company has been provided during the process of Lean Green implementation has a value of 0.90 corresponding to a $p$-value of 0.03, so lower than 0.05. That means that in this case the normality assumption does not hold, a conclusion confirmed by the Q–Q plot presented in Fig. 9.

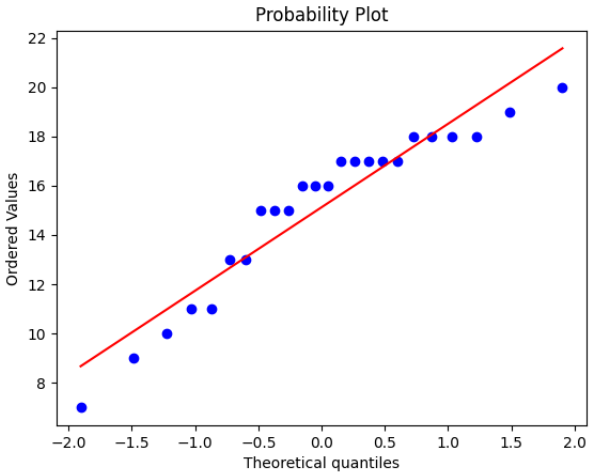


Fig. 9. Probability Plot – Pressure to change

Therefore, instead of the $t$ test for independent samples, we used the Mann–Whitney U test. This test has a value of 279 for a $p$-value of 0.036 (lower than 0.05), which means that there is a difference between the two samples, confirmed by the boxplot in Fig. 10.

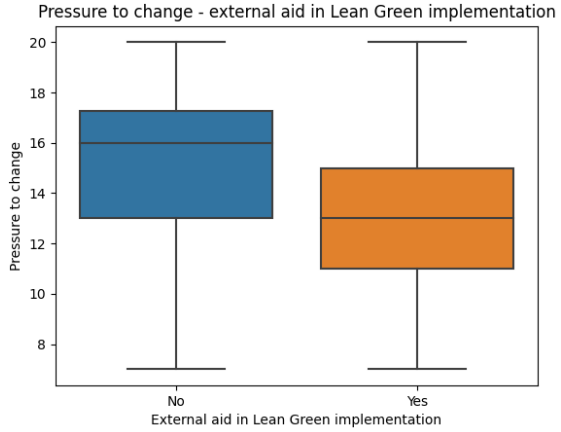


Fig. 10. Boxplot – Pressure to change – external aid in Lean Green implementation

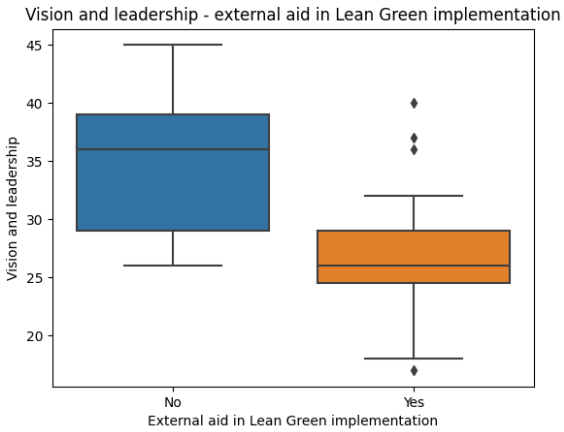


Fig. 12. Boxplot – Vision and leadership by external aid in Lean Green implementation

## Vision and leadership

The $t$ test for independent samples has a value of 6.20, corresponding to a $p$-value of 5.30, higher than 0.05, therefore we can conclude that there is no difference between the two groups. Although the quartiles in the "No" group in figure 10 have higher values than the ones in the "Yes" group, the outliers in the second group do not allow for observing a difference between the two samples. However, the presence of outliers in the "Yes" group and the "not so aligned dots near the main diagonal" in the Q–Q plot for the same "Yes" presented in the Fig. 11 indicated that we need to use a non-parametric test.

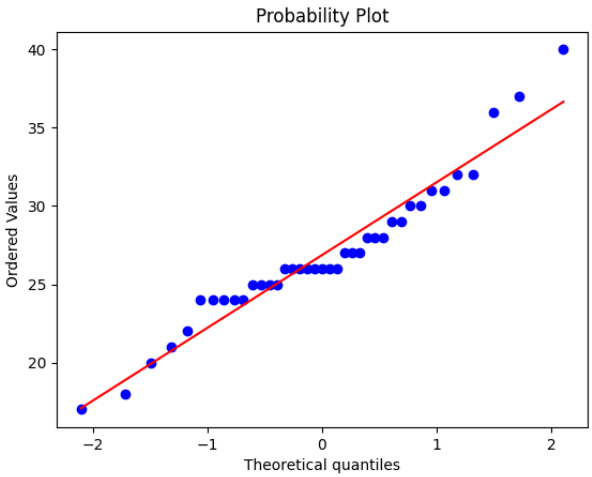


Fig. 11. Probability Plot – Vision and leadership by external aid in Lean Green implementation

When using the Man-Whitney test, we could observe a significant difference between the two groups – a value of 122 for a $p$-value lower than 0.05 (Fig. 12).

## Competent people

The value for the $t$ test for independent samples is 1.999, for a $p$-value of 0.049, which means that there are differences regarding this factor between the group receiving aid from outside the company in implementation of Lean Green, and the group which did not get that sort of aid during the implementation process. The differences are presented in Fig. 13.

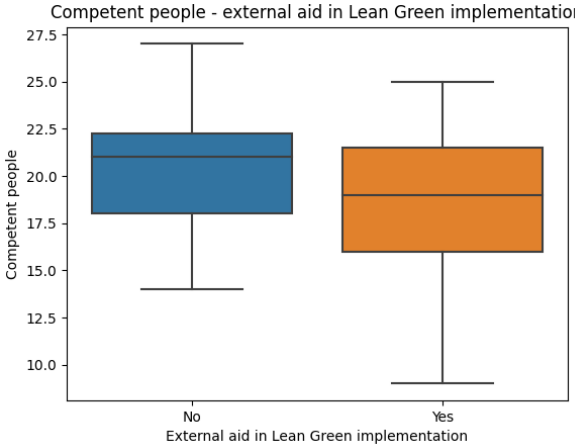


Fig. 13. Boxplot – Competent people by external aid in Lean Green implementation

## Effective first step

For this condition, the Shapiro test for the "No" sample had a value of 0.903, corresponding to a $p$-value lower than 0.05 (0.026 actually), a result confirmed by the Q–Q plot in Fig. 14.

This means that the scores are not normally distributed, therefore we cannot use the $t$ test to analyse the results. Therefore, we chose a non-parametric

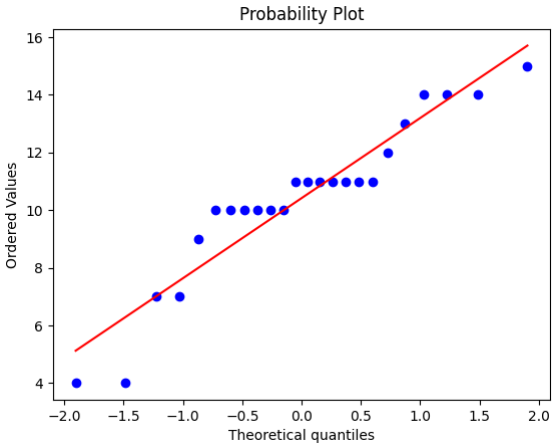


Fig. 14. Probability Plot – Effective first step – external aid in Lean Green implementation

approach, and used the Man-Whitney test, which in this case has a value of 352, corresponding to a $p$-value lower than 0.05. The difference between the two groups is presented in the boxplot in Fig. 15.

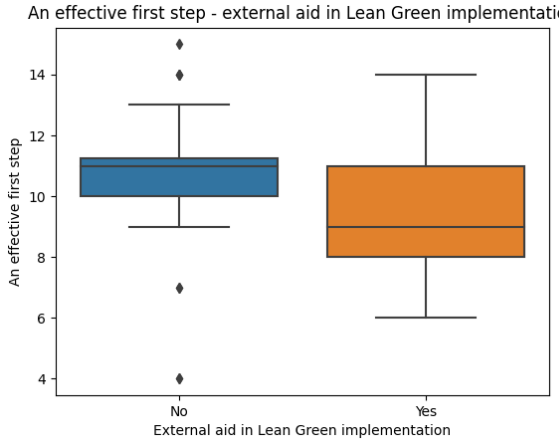


Fig. 15. Boxplot – Effective first step – external aid in Lean Green implementation

### Effective employee remuneration

For this factor, the Levene test – implemented in order to check the equal variance in all (two) groups assumption had the value of 4.02, corresponding to a $p$-value of 0.049. Therefore, the equal variance assumption does not hold, and in this care we used the independent sample $t$ test for non-equal variances. The $t$ value is 0.32, corresponding to a $p$-value higher than 0.05 (0.744); therefore, we can conclude that there is no significant difference between the groups, a result presented in the boxplot in Fig. 16.


Fig. 16. Boxplot – Effective first step – external aid in Lean Green implementation

### Correctly functioning communication system

For this factor, the Shapiro test – to check the normality assumption – for the "No" sample had a value of 0.857, corresponding to a $p$-value lower than 0.05 (0.003 actually), a result confirmed by the Q–Q plot in Fig. 17.

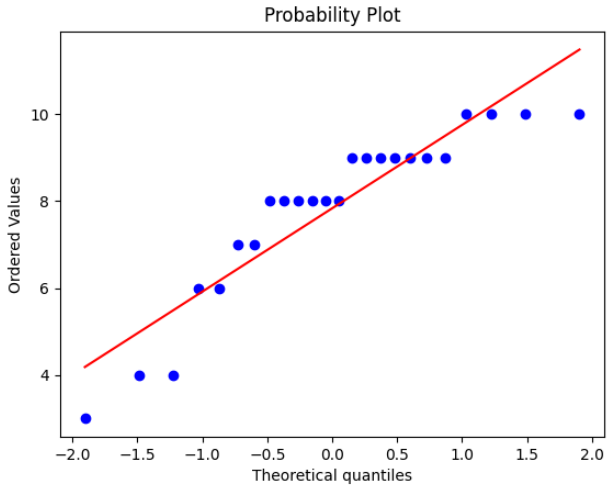


Fig. 17. Probability Plot – Correctly functioning communication system by external aid in Lean Green implementation

Similar results were received for the sample dedicated to answers from companies that received external aid in the Lean Green implementation process: the Shapiro test has a value of 0.927 for a $p$-value of 0.01, a result represented in the Q–Q plot in Fig. 18.

Based on these distributions, we chose to use a non-parametric test for testing the differences between the two groups, the Man-Whitney U test. The test has

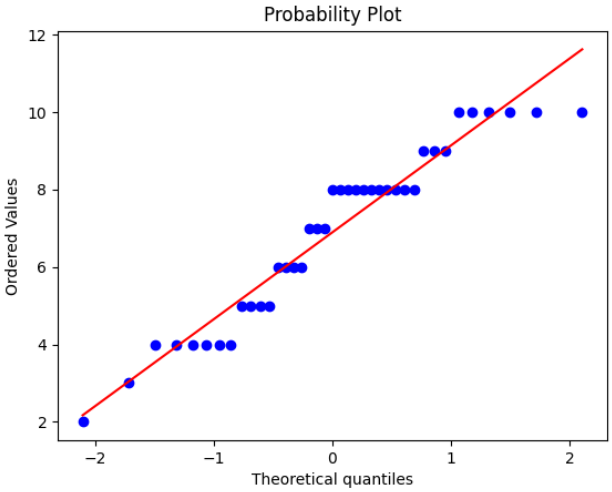


Fig. 18. Probability Plot – Correctly functioning communication system by external aid in Lean Green implementation

a value of 350, corresponding to a $p$-value of 0.045. This means that there is a significant difference between the two groups, as can be seen in the boxplot in Fig. 19.

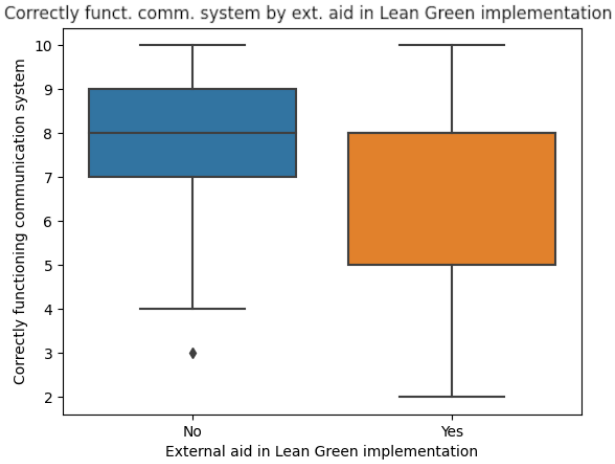


Fig. 19. Boxplot – Correctly functioning communication system – external aid in Lean Green implementation

### Technical and financial factors

A $t$ value for the $t$ test for independent samples is 0.05, corresponding to a $p$-value of 0.956. This means that there is no significant difference between the two groups, a conclusion confirmed by the boxplot in Fig. 20.

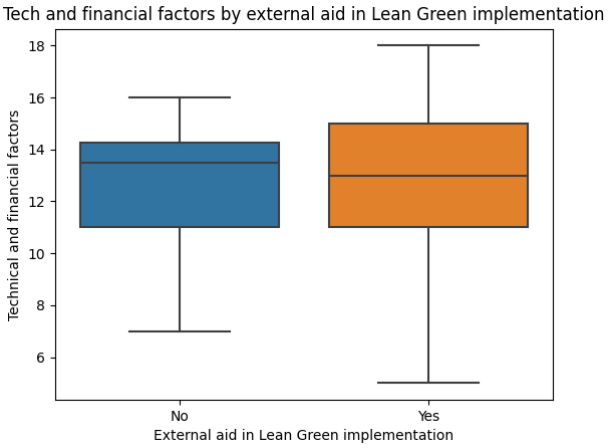


Fig. 20. Boxplot – Technical and financial factors – external aid in Lean Green implementation

## Conclusions

The quantitative analysis conducted on the answers provided by sixty-three CEOs from three countries (Japan, Poland and the USA) evidenced that there are cultural differences regarding the factors that can explain the Lean Green implementation. Japan has higher scores than the USA and Poland on four out of seven factors: "pressure to change", "vision and leadership", "competent people" and "effective first step". A difference between the USA and Poland on the scores for the first factor, "pressure to change", can also be noticed in the sense that the CEOs from the United States assigned more importance to this factor than the CEOs from Poland. No significant difference was recorded between the three countries when taking two out of seven factors into consideration: "effective employee remuneration" and "technical and financial factors". However, Poland has lower scores than both the USA and Japan on another factor, namely "correctly functioning communication system".

As far as external aid is concerned, the first conclusion is that the aid in implementation provided by people outside the organisation (regardless of the stage when such help was provided) decreased the internal "pressure to change". However, the same variable (aid in implementation provided by people outside the organisation) did affect the "vision and leadership" scores – we received higher values for the group where assistance from outside the company was not available. The same group recorded higher values on the "competent people" condition, but this relation can be understood both ways: either the companies got or developed more competent people on

this topic (Lean Green implementation), because they knew that aid from outside the company was not available, or the same companies did not need any external help because the Lean Green implementation process was managed very well by the competent people that were already there when the implementation started. While no relation was noted between the technical and financial conditions and the aid provided by people outside the company during the Lean Green implementation process, higher values on "effective first step" and "correctly functioning communication system" conditions were recorded for the companies that implemented the Lean Green concept without any help from people outside the organisation.

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