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Strategy for building digital platforms for industrial waste management

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Abstract

In modern conditions, to increase the efficiency of industrial waste management, a radical transformation of the business processes within industry enterprises, the introduction of modern digital technologies, the use of platform business models are required. The purpose of the article is to study the role of digital platforms to improve the efficiency of interaction between companies working in the field of waste disposal and recycling. The study analyses the participation of internal and external company stakeholders in the industrial waste processing industry. Empirical analysis is carried out on the basis of qualitative and quantitative analysis based on in-depth expert interviews. The sample includes interviews with the heads of 150 Russian industrial waste processing enterprises. All the companies considered have practical experience on digital platforms.

Keywords: digital platforms, stakeholders, recycling, industrial waste.

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Стратегия построения цифровых платформ для управления промышленными отходами

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Аннотация

В современных условиях для повышения эффективности управления переработкой промышленных отходов требуется коренная трансформация бизнес-процессов предприятий отрасли, внедрение современных цифровых технологий, использование платформенных бизнес-моделей. Целью статьи является исследование роли цифровых платформ для повышения эффективности взаимодействия компаний, работающих в сфере утилизации отходов и их переработки. В исследовании проводится анализ участия внутренних и внешних заинтересованных сторон компаний отрасли переработки промышленных отходов. Эмпирический анализ проводится на основе качественного и количественного анализа, опирающегося на глубинные экспертные интервью. Выборка включает руководителей 150 российских промышленных предприятий по переработке отходов, все рассмотренные предприятия имеют практический опыт работы на цифровых платформах.

Ключевые слова: цифровые платформы, заинтересованные стороны, переработка, промышленные отходы.

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Статья подготовлена по результатам исследований, выполненных за счет бюджетных средств по государственному заданию Финуниверситета.

Introduction

Waste management has traditionally been a physical and mechanical sector specialised in the collection, sorting, recycling, or incineration of waste. It is expected that digital platforms will have the potential to serve multiple purposes for industrial waste processing enterprises, for example, when integrated into the concept of “Industry 4.0”. The problem of industrial waste in the world can be solved through cooperation with all stakeholders involved in the waste value chain, from upstream to downstream. However, it is increasingly being targeted by solution providers who promise more efficient and effective operations through digital technologies such as smart containers, on-demand semi-autonomous trucks, or artificial intelligence for material recognition and robotic automation. The introduction of digital platforms in the waste sector has also led to a transformation in the cost structure, which affects both technological and financial choices.

The main problem of this study is to find out the relationship between the stakeholders of waste management enterprises and digitalisation.

1. Literature review

1.1. Role of digital platforms

Platform business has become one of the latest research topics in a number of management disciplines. The platform serves as an interface that facilitates interaction between different parties, usually complementaries and clients. For example, Amazon, the Tambouris world's largest e-commerce retailer, has over 2.5 million merchants offering customers over 12 million items [Tiwana, Ramesh, 2001; Knoeri et al., 2011; Bonina et al., 2021]. A recent article in the *Journal of Management* reports that the literature on platforms is largely shaped from the perspective of an industrial organisation that sees platforms as two-sided or multi-sided markets in which transactions and interactions between complementary parties and customers take place. The theoretical constructs in such studies are mainly focused on the interdependence between different parties in the market, network effects and platform competition. At the same time, a new perspective is rapidly developing that moves away from the prevailing concept as it more clearly conceptualises the platform and its associated complementary elements as the creation of a unique organisational form or "meta-organisation" [Asadullah, Kankanhalli, 2018].

This organisation-centric perspective emphasises the interdependence between platforms and complementaries, that is, how platform owners manage relationships with complementaries and how the collective actions of complementers and partner firms determine the success of a platform. Notably, [Heidrich, Harvey, 2008] gives a compelling account of how platforms resemble the hybrid organisations familiar to strategists and management professionals. They argue that platforms "can be seen as hybrid structures between organisations and markets, providing a mix of market and hierarchical power, and a mix of market and hierarchical incentives." The implicit assumption underlying this literature is that studying the strategy of platform owners is the key to understanding platforms as meta-organisations, since by providing and controlling the use of critical production assets, platform owners are the link in multilateral relationships [Neves da Rocha, Pollock, 2019].

Developing this point of view, we see the platform as an alternative to the "firm against the market" to solve the managerial problem of coordinating the diverse activities and interests of partner firms [Rochet, Tirole, 2003; Jingyi Wang, Tao Bai, 2021]. More strikingly, we notice that an important characteristic of a platform in today's world is its use of digital technology to create and capture value. Embracing digital transformation not only facilitates the incubation of new products and services for customers, but also significantly changes the way platform owners develop certain tools to achieve the desired platform management outcomes. E-commerce platforms such as Alibaba and JD.com [Cremona, Lin, 2014; Cane, Parra, 2020] use instant messaging capabilities to enable complementary businesses to obtain customer information and respond quickly to customer requests and needs, while taxi booking platforms, such as Didi and Lyft [Berg, Wilts, 2019; Neves da Rocha, Pollock, 2019] use digitization technology that keeps complementers from misbehaving offline. Mobile operating systems such as Android use a modular architecture that provides complementaries with autonomy to carry out value-creating activities, while online feedback systems are mainly used on e-commerce platforms to evaluate seller performance and drive corrective action. It is with the help of these digital technologies that platforms can better coordinate activities within an organisation and become modern hybrids that combine elements of markets with hierarchies. Therefore, in order to deepen our knowledge about the impact of digital technologies on platform management, we pay special attention to digital platforms, which are a type of platform that serves as a standardised digital interface and uses digital technologies to facilitate interaction between different parties. We believe that, in addition to looking at traditional management mechanisms such as pricing, direct integration, or contracting, understanding how organsational relationships resort to digital means of coordination will offer a much-needed technological lens to push the boundaries of organisational management research [Rochet, Tirole, 2003; Kovacic et al., 2020].

Definition of digital platforms

Researchers in industrial organisations usually interpret a platform as a specific type of market that facilitates interaction between different groups of participants, such as complementaries and consumers, and interdependence within or between these groups gives rise to "network externalities," which describe how the utility of a user increases with the number of other users on the same side (i.e., direct network effects) or the other side (i.e., indirect network effects) of the platform market. Following this perspective, earlier work on platforms has explored in detail how various market mechanisms (e.g., pricing structures) are used by traditional marketplaces (as diverse as malls, bazaars, and newspapers) or network industries to create network effects and shape market dynamics. In contrast, little attention has been paid to the various interactions between platform owners and platform complementaries, or the impact of platform architecture on the participation of platform complementaries [Asadullah, Kankanhalli, 2018].

However, inspired by the emergence of new platform business models, a growing number of scholars are looking at how digital technology has enabled platform owners to coordinate the activities of various parties on the platform. Digital platforms refer to a type of platform that serves as a standardised digital interface and use digital technologies to facilitate interaction between different parties. For example, Uber is a digital platform that uses its big data analytics and matching algorithms to provide a passenger with the most suitable driver. Thanks to the principles of modular design, the functionality of digital platforms can be extended by independent heterogeneous agents that use standardised interfaces and platform components, on the basis of which these agents can create their own additional products. In addition, digital platforms go beyond conventional market mechanisms by using digital tools to coordinate activities within an organisation. For example, when coordinating who can use which resources on a platform, in addition to setting go-to-market criteria to weed out low-quality complements, digital

platforms (e.g., Github, iOS, Android) can selectively expose their interface by setting limits about the use of software tools by complementaries, such as APIs and SDKs. Such design features reflect the unique ability of digital platforms to orchestrate the value-creating activities of complementers without explicitly calling out contracts or hierarchies. However, this ability has not been systematically explored in the platform literature [Kintscher et al., 2020].

Organisational perspective of digital platforms

Recent research has begun to examine platforms as an organisational form [Cremona, Lin, 2014] from an organisational standpoint [Berg, Wilts, 2019]. Organisations are characterised by "the conscious and deliberate coordination of activities within identifiable boundaries, in which members come together on a regular basis through a series of implicit and explicit agreements, committing to act collectively to create and allocate resources and capabilities through a combination of command and cooperation." In understanding the various forms of non-contractual inter-organisational collaboration, [Tiwana, Ramesh, 2001] offer one of the pioneering attempts to conceptualise platforms as a type of meta-organisation in which legally autonomous entities (firms and individuals) are subject to the informal authority of the platform firm. Holger and others [Asadullah, Kankanhalli, 2018] represent the latest recognition of this important shift in the conceptualisation of platforms by academic managers, i.e., from pricing to management, as they seek to make the connection between platforms and hybrids. Thus, hybrids will be characterised by a specific combination of market incentives and modalities of coordination involving some form of hierarchical relationship.

There are two notable similarities between digital platforms and our established understanding of hybrids. In hybrid organisations, interfirm relationships are only loosely contractualised, and relationships are rooted in technological complementarity or organisational synergy.

On digital platforms, complementarity between co-specialising producers (e.g., platform owners and complementaries) similarly underlies the emergence of a cooperative organisation. Indeed, the very logic of the organisation as a platform is to use the generative potential of the distributed innovation agency and the specialisation economy. Second, hybrids rely on partners to pool strategic resources and share decision-making rights while maintaining separate ownership of key assets, so special devices are required to coordinate partner collaboration and arbitrate rewards. Similarly, digital platforms are organised according to a set of relational contracts whereby platform owners transfer decision-making rights across borders, and complements in turn waive some remuneration rights to platform owners [Schmalensee, 2014].

Digital transformation for social innovation business models

Digital platforms rely on Internet technologies to bring together multiple stakeholders. Social entrepreneurs who strive for continuous improvement and innovation in business models should invest in digital transformation. It is important to use an approach that understands the dynamic impact of technology on business [Schmalensee, 2014].

The platform may rely on algorithms to improve the quality of matching, increase participation and engagement. This can automate more tasks, collect data for analytics, and provide a superior experience for stakeholders and platform employees. The platform can use digital technologies to segment stakeholders. It can create premium profiles for non-profit organisations and other stakeholders who want to use the platform more intensively and need additional support. Another opportunity is to use digital technologies to expand the range of stakeholders.

Finally, the digital and non-digital elements of the platform must be well designed and coordinated. Humans must meticulously perform any task that is not easy to automate. This ensures that all stakeholders of the platform will have a consistent experience. Platform developers should also be aware of cost-based design approaches and issues.

1.2. Digital platform in recycling

Although intensive industrialisation has boosted global GDP, waste production is still recognised as a blind spot in manufacturing. With a growing shortage of critical raw materials, the second life of products and used materials is becoming an inevitable option to advance the circular economy. Consequently, industrial users are gradually moving from a linear economy to a circular economy in waste management. This contributes to the recovery of resources through recycling and reduces the negative impact of the linear economy. For this reason, identifying new opportunities and challenges associated with the recycling, reuse, and recovery (3R) scheme is important to develop and deploy suitable technologies that drive innovative digitalisation [Tambouris, Migotzidou, 2015].

In an increasingly complex, interdependent, and interconnected era, digitalisation is playing a critical role in the waste sector in building a global sustainable economy, changing the way companies do business, how they organise business, and how they create and use value.

Technological progress allows digitalisation to offer practical solutions for the waste sector with long-term benefits for society. Digitalisation, which embraces the circular economy of waste recycling, has become a driving force behind the growth in value creation by improving the efficiency of resource recovery operations and reducing operating costs with traceability of waste streams. Fig. 1 shows the digital platform for industrial waste management.

The recycling sector has the potential to seize the opportunities of a circular economy through digitalisation. Although landfill is a main tool for waste disposal, the future lies in digitalising waste recycling in the market.

Embracing digitisation in the waste industry will keep the recycling system running and businesses alive. This helps the waste industry to move towards sustainable solutions with the ability to trace waste streams.

Internet + digital platform processing, based on enterprise industry characteristics. There are three main actors involved in the maintenance of the digital recycling platform: producers, consumers, and platforms. The recycling platform brings together consumers and producers from both sides, which together constitute a two-sided market for the operation of the recycling platform. When consumers need to recycle waste, they submit

the relevant information to the digital platform through online recycling websites or offline recycling stores, and the platform will match the relevant manufacturers based on the type of waste, recyclability, and details, as well as other information provided by consumers.

As more consumers choose a recycling platform, the remanufacturing opportunities that manufacturers get through the platform will increase, and as more and more manufacturers join the digital platform, competitive pressure will increase and service quality will improve.

Policymakers, practitioners, and scientists have long touted digital technologies such as smart waste containers or artificial intelligence for material recognition and robotic automation as key tools for more efficient and effective waste management. While these advances promise an increasingly digital future for waste collection, sorting, and recycling, little is known about the current level of digitalisation of waste management companies.

Digital recycling platforms are managed by a recycling management system that is limited to policy oversight. In addition, the recycling management system is governed by policies, and relevant policy rules are put forward for the digital recycling platforms it manages. In turn, the achievements of digital recycling platforms also receive feedback from the entire recycling management system, which can be both positive and negative [Xiaodong Zhu, Wei Li, 2021].

1.3 Recycling stakeholders

The term "recycler" generally refers to different types of stakeholders in the recycling system, although in a restrictive sense, it refers to a recycler who performs the necessary processes with recyclable materials that result in usable materials. The recycling system includes the trading (buying and selling) of waste that is considered waste. Stakeholders are those who participate in the recycling system [Kojima, 2008].

The simplified approach made it possible to shape a criterion based on the significance of the stakeholders for the processing enterprise, dividing them into two groups:

- key stakeholders – they have a direct impact on the organisation's activities;
- secondary stakeholders are – non-governmental organisations and the media that influence the actions of the main stakeholders through the formation of public opinion.

Trade relations between types of recyclers affect the level of trade as well as the flow of recyclables within the country and to foreign countries.

Stakeholders of processing companies are proposed to be classified into internal and external. Key stakeholders include: shareholders and investors; employees; customers; suppliers; governments and communities. However, the division of stakeholders into internal and external is quite obvious. The trading system and specific types of stakeholders are described in table 1.

Table 1 and the descriptions above provide a comprehensive outline of how stakeholders interact with processing companies. This information can be collected in a similar way for other, larger organisations and for other functional areas within an organisation, such as its health and safety management or its production management systems. However, further analysis of these rankings may reveal deeper management opportunities and challenges.

2. Description of the study

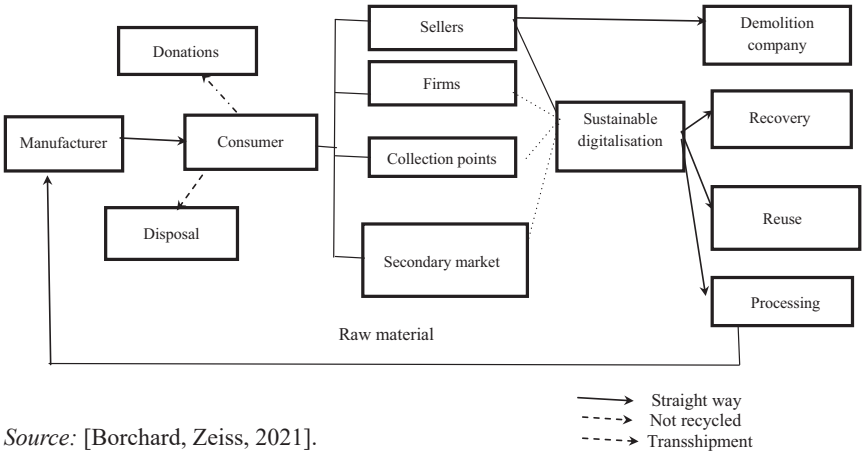
The sample of the study includes interviews with the heads of 150 Russian industrial waste processing enterprises. All companies reviewed have hands-on experience with digital platforms.

The analysis included enterprises for the processing of industrial waste with more than 100 employees. Industrial waste processing enterprises continue to develop, therefore both large and small enterprises are included: construction waste processing enterprises – 9.5%; metal processing enterprises – 5.7%; chemical and mineral waste processing enterprises – 8.2%; food processing enterprises – 13.3%; others – 3.8%. All enterprises in the analysis are private companies. However, the state intervenes in the activities of these enterprises for the processing of industrial waste to a limited extent.

The annual sales volume of these companies is as follows: between 500 million and 1 billion rubles – 21.9%, from 100 to 500 million rubles – 29%, less than 100 million rubles – 17.2%. According to the evaluation criteria, 10% of these 150 industrial waste processing enterprises are in unsatisfactory economic conditions, 30.3% – satisfactory, 53.7% – good and excellent – 5%.

Section 2.3 discusses in detail stakeholders' relations in an industrial waste treatment plant. Internal stakeholders are necessary for the proper functioning and development of an organisation, while external stakeholders only indirectly influence the organisation. Companies that want to function and develop normally should focus, in addition to financial, organisational and technological aspects, on the analysis of interactions arising from the relationship between quality and stakeholders in processing companies.

Fig. 1. Digital platform for industrial waste management



Source: [Borchard, Zeiss, 2021].

Table 1
Stakeholders in waste management

Stakeholders	Roles	Effects for the company
Employees	Establish and formalise industrial waste	Impact directly through work procedures
Suppliers and contractors	Provide materials and services that can guide industrial waste management practices	Direct effect, since the specification of raw materials or services may determine waste practices
Municipal authorities	Develop strategy and legislation	Local government influences the system directly through planning; monitoring and provision of waste management services. Directly affected by recovery goals and consultation process
Competitors	General customer interest. Can establish best practice	To encourage recycling businesses
Creditors, insurers and shareholders	Provide funds for insurance companies	Indirect effects such as cash receipts
Clients	Buying goods or services	Can affect the system directly
Associations and professional institutions	Creating and disseminating best practices in the industry	Influence the system indirectly through the provision of guidelines; growing interest in the sustainability of various industries
Local communities	Consumers	Influences the system indirectly through the choice of products and directly if there are local environmental problems
Non-governmental organisation (NGo)	Non-elected representation of sectors of the public	Possible indirect effects through lobbying for environmental or planning issues

Source: [Heidrich, Harvey, 2008].

Table 2
Involvement of internal stakeholders in the work of the digital platform for the disposal of industrial waste

Involvement	Stakeholder engagement, waste management (%)		The degree of interaction intencity [Knoeri et al., 2011; Asadullah, Kankanhalli, 2018]		1 – low 5 – high					Not involved
	Rank	Companies	Rank	Average	1	2	3	4	5	
Production	1	90	1	4.9	10.4	12.1	14.4	22	30.8	10
Sales department	2	85	3	4.0	9	11	16.1	20.2	28.8	15.5
Top management	3	80	2	4.7	5.1	1.5	18.8	20.4	25.8	20.5
Development research	4	70	4	3.8	8.21	9.2	12.8	19.5	20.5	31.3

Source: compiled by the author.

Table 3
Involvement of external stakeholders in the work of the digital platform for the disposal of industrial waste

Involvement	Stakeholder engagement, waste management (%)		The degree of intensity of interaction [Knoeri et al., 2011; Asadullah, Kankanhalli, 2018]		1 – law 5- high					Not involved
	Rank	Companies	Rank	Average	1	2	3	4	5	
Industrial companies – consumers of waste	5	69.2	7	2.8	11.5	12.5	13.5	15.5	29.5	31.1
Suppliers	6	65.8	5	3.5	12.3	10.3	17.5	20.3	22.3	35.2
Regional municipal government	7	60.0	6	3.1	5.8	9.3	12.2	15.2	18.2	40.2
Joint venture partners	8	55.2	8	2.6	3.2	8.3	10.5	15.2	18.2	45.8
Competitors	9	50.1	9	2.0	4.5	7.2	9.5	11.2	17.5	52.2
Consumer companies abroad	10	45	10	1.9	2.5	5.8	7.63	12.7	15.8	56.8

Source: compiled by the author.

Table 4
Involvement of internal stakeholders

Number of stakeholder involvement	Number of enterprises	Production	Sales department	Top management	Development research
0	8	—	—	—	—
1	10	2	5		3
2	13		5	4	4
3	51	13	9	15	10
4	68	68	68	68	68

Source: compiled by the author.

In processing companies digitalisation is possible to achieve success through external stakeholders and high-quality interaction: increasing the volume of pro-consumer research (with a focus on interviews and observations), implementing loyalty programs, reducing product costs by implementing standards and minimising or eliminating defective products and complaints, improving by outsourcing activities and sales, or by taking actions that internationalise the organisation. Creating such integrated solutions for external stakeholders will have a positive effect on internal ones.

A five-point Likert scale was used to measure the intensity of interaction with internal and external stakeholders of industrial waste reuse and recycling companies and to assess the economic condition of a company by assigning companies "close to bankruptcy" and "excellent" ratings.

3. Research results

An empirical analysis of internal and external stakeholders with the largest contribution to the company is presented, out of 150 industrial waste processing companies are studied. Although the above paragraph represents a large number of stakeholders, the empirical analysis used only some of the most important stakeholders in all small and large waste management organisations.

The highest degree of involvement of processing enterprises in production (on average 4.9) and the lowest degree of involvement in development research. In terms of the intensity of interaction, the second place is occupied by the top management of enterprises, and the third place is occupied by the sales department in the production waste of enterprises.

Suppliers have the highest involvement of external stakeholders in industrial waste management, with an average score of 3.5. Consumer companies abroad are concerned about the low involvement of enterprises in waste processing. The regional municipal administration ranks second and is not yet actively involved in many waste processing enterprises. 0 to 5 for internal waste management stakeholders and 0 to 10 for external stakeholders.

Table 4 presents data that show the distribution of stakeholders into different groups depending on the number of partner groups involved in the interaction.

Top management and production occupy a major place among the external stakeholders of waste processing enterprises. In 45.5% of the companies included in the empirical analysis all groups of internal stakeholders are involved in processing and reusing industrial waste.

16% of companies do not involve external stakeholders in recycling. In 20% of the companies included in the empirical analysis, all groups of external stakeholders are involved in the process of recycling and reuse of industrial waste.

Table 6 shows the relationship between internal and external stakeholder involvement.

20% of waste management enterprises have internal and external stakeholders 5.3% of waste management enterprises have no more than one internal and external stakeholder.

Table 5
Involvement of external stakeholders

Number of stakeholder involvement	Number of enterprises	Industrial companies-consumers of waste	Suppliers	Regional municipal government	Joint venture partners	Competitors	Consumer companies abroad
0	24	—	—	—	—	—	—
1	15	2	3	4	2	3	1
2	25	2	2	5	6	3	7
3	30	4	5	7	4	7	8
4	11	2	4	1	3	1	—
5	15	2	1	3	—	2	2
6	30	30	30	30	30	30	30

Source: compiled by the author.

Table 6
The relationship between the participation of internal and external stakeholders

Internal stakeholders (% of the company)	External stakeholders (% of the company)							Total
	0	1	2	3	4	5	6	
0	5.3							5.3
1	3	3.67						6.67
2	1	3	5					8.67
3	2	1	8	18	5			34
4	5	2	3.3	2	2.3	10	20	45.3
Total	16	10	16.67	20	7.3	10	20	100

Source: compiled by the author.

4. Discussion of research results

Differences in the intensity of engagement with specific stakeholder groups were examined in table 7, using analysis of variance to identify statistical differences. Industrial waste treatment companies with good and excellent economic positions have a high level of participation as external stakeholders in the form of foreign fig suppliers. The implementation of the plans is necessary for the mutual involvement and stimulation of all internal and external stakeholders of the business.

The role of joint ventures is reduced in companies that define the economic situation as excellent, which indicates a lower intensity of the company's interactions. This research shows the growth of every internal and external stakeholder. The local government is one of the main stakeholders of the processing company. According to this rating data, production is in favor of the company's performance. These results provide insight into the company's role in terms of internal and external stakeholders, as well as the importance of stakeholder engagement

5. Practical recommendations

The main goal of stakeholders is to achieve transparency in decision-making through stakeholder participation and feedback within the company. Many waste management organisations still do not communicate openly with stakeholders. This is supported by this study, in which the failure of top managers to control stakeholders through proper communication and adequate information sharing in the early stages of projects led to project failure. An empirical analysis has been developed and results have been obtained to measure and describe the interaction of internal and external stakeholders in the waste management processes of Russian companies. While we confirmed in the previous section that many stakeholders are involved in the waste management process, it is emphasised that among the few internal and external stakeholders selected for the sample, internal stakeholders are more involved than external stakeholders. The waste management process will also be able to attract more external stakeholders through digital platforms. The results of this study suggest that the internal activities of waste processing enterprises should be strengthened with the interaction and involvement of external stakeholders. In addition, the results of this study also examined how the involvement of external and internal stakeholders affects the economic performance of a company. It is concluded that companies with high economic status have a high level of interaction between external and internal stakeholders. (e.g., foreign suppliers and government involvement). Waste recycling companies have themselves assessed their economic situation,

Table 7
Company performance and partner involvement

Company performance	Share of companies from interested parties				Interaction intensity, average					
	Unsuccessfully N = 13	satisfactorily. N = 58	Good N = 60	Excellent N = 19	Unsuccessfully N = 13	satisfactorily. N = 58	Good N = 60	Excellent N = 19	f	Static Significance
Production	56.8	84.1	75.1	81.0	2.6	2.8	3.6	4.29	3.681	0.014
Sales department	65.7	85.1	47.1	78.5	3.5	3.9	4.0	4.3	2.156	0.052
Top management	25.0	14.0	56.4	86.2	4.17	4.20	4.22	4.25	4.256	0.047
Development research	25.0	15.1	56.3	63.8	3.46	3.6	3.85	4.0	6.129	0.056
Industrial companies – consumers of waste	69.7	89.6	39.7	78.3	2.6	2.8	3.0	3.9	0.124	0.289
Suppliers	50.5	85.6	15.7	15.8	3.0	3.2	3.5	4.0	0.147	0.069
Regional municipal government	50	56.3	56.7	89.1	2.6	3.0	3.5	4.5	0.369	0.056
Joint venture partners	42.8	58.6	58.4	26.8	4.0	4.2	4.5	4.7	1.236	0.048
Competitors	47.8	96.7	23.6	56.9	3.6	3.5	3.8	3.9	2.368	0.047
Consumer companies abroad	69.3	58.1	56.9	85.6	3.8	4.0	4.5	4.8	3.562	0.082

and the increasing use of digital platforms for this could change the economic situation. In general, the extent to which the level of contact with stakeholders and the intensity of their interaction are related to company performance is examined.

Conclusion

Many businesses use digital platforms despite the quality of the work available. Since employees working on the digital platforms of recycling companies are considered self-employed, they do not have a fixed income. The lack of stable income and the lack of security offered by the platforms, as well as the lack of long-term skill development, put them in a precarious position. With regard to short-term measures that may have an immediate effect, the municipality should consider how to regulate the digital economy. In the longer term, policymakers need to think about how to prepare stakeholders for a successful decent-work negotiation. For this reason, policymakers must find a middle ground that allows stakeholders to participate in the economy by providing a social safety net that will protect them socially without diminishing the opportunities created by digital platforms. While effective implementation is yet to come, policymakers must look for creative ways to empower and protect stakeholders without impacting digital platforms.

Digitalisation is critical to help industrial waste management achieve its goals by boosting the transformation towards a sustainable circular economy by narrowing the material loops with increased resource efficiency. By fostering technological innovation in products and processes, digitalisation promotes efficient waste minimisation and longer life for products, and reduces transaction costs.

Investing in smart city initiatives can improve planning, preparation and response to global pandemics that require timely and comprehensive action.

The literature shows that digitalisation is a driving force, helping to move towards low-carbon development strategies within the circular economy.

The use of digital solutions for the recycling industry is a viable solution to strengthen the circular economy, resource-saving and low-carbon economy. In the age of Industry 4.0 digital solutions can improve waste recycling practices. With digitalisation, a proper waste management system is mandatory to protect the environment and public health.

Through digitalisation, the waste sector can contribute to the country's circular economy on the path to sustainable development. Digitalisation not only improves the management of industrial waste, but also maximises the efficiency of its use through recycling.

Waste management organisations consider the role of stakeholders as an important determinant of quality, thereby increasing the efficiency and competitiveness of the company. This ensures that the correct level of quality is achieved. It also limits the impact of internal and external conditions on the efficiency of the waste recycling process. So, one of the most important determinants of quality management and the implemented strategy of a waste processing organisation is the satisfaction of internal and external stakeholders, measured by the quality of goods and services offered by organisations. This means digitalisation, mobility, globalisation, etc.

In general, the industrial waste company confirms the goals of digitalisation, and the three most commonly expected results of digitalisation are increased process transparency, increased efficiency, and improved quality.

Improving stakeholder participation in downstream enterprises will enable enterprises to gain long-term competitive advantages. This study presents the results of a survey of 150 processing companies in Russia and analyses the interactions of external and internal stakeholders. Using data from waste management companies, internal and external stakeholders analyse how the business is driving efficiency gains. Stakeholder participation can play a mediating role in cross-functional coordination within a company, and it determines the success of external stakeholder involvement in the cross-process. This data analysis raises several questions.

1. Does the interaction between internal and external stakeholders affect the performance of the waste management company?

2. How does digitalisation affect the work of internal and external stakeholders?

3. Does a reduction in the number of partners and stakeholders in a processing company and a change in the degree of interaction mean the effectiveness of the company's economic efficiency?

The study also has limitations. First, since recycling companies are still growing in Russia, this study was conducted by collecting data from not only large companies but also small recycling companies. Although these companies have different stakeholders, a random number of stakeholders were selected for the sampling. The study provides an overview of the contribution of digital platforms to waste management as well as the internal and external stakeholders of waste management companies.

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