

The Impact of Industry 4.0 on Türkiye's Foreign Trade in Line with Sustainable Development Goals

Asena Boztaş, Rabia Ulunç

Sakarya University of Applied Sciences Türkiye, Sakarya

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Abstract

Industry 4.0, together with the revolutionary developments in information and communication technologies, brings about radical transformations in many sectors. These transformations have significant impacts on Türkiye's foreign trade strategies and sustainable development goals. Industry 4.0 promotes economic growth through the adoption of sustainable production and consumption models and ensures more efficient use of environmental resources. While Türkiye's foreign trade is strengthened by the digital and technological innovations offered by Industry 4.0, this process also increases international competitiveness and contributes to the realisation of sustainable development goals. This study comprehensively analyses the effects of Industry 4.0 on Türkiye's foreign trade along with sustainable development goals, and examines how Türkiye has benefited from this transformation process and its effects at the international level.

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INTRODUCTION

Industry 4.0 refers to a transformation process defined by the rapid development of digital technologies and the integration of these technologies into production processes. This transformation has profound effects not only on production but also on economic and social structures. Foreign trade, which plays an important role in Türkiye's economic structure, is undergoing major changes with the innovations brought by Industry 4.0. While digitalisation and automation are reshaping Türkiye's foreign trade strategies, they are also increasing Türkiye's international competitiveness and providing the opportunity to become a more effective player in global markets.

On the other hand, the impact of Industry 4.0 on sustainable development goals is also noteworthy. Sustainable development is an understanding of development that covers environmental, economic and social dimensions and is supported by the goals set by the United Nations. Industry 4.0 makes significant contributions to the realisation of these goals and offers improvements in areas such as environmentally friendly production processes, resource efficiency and social equality.

In this context, this study aims to comprehensively analyse the effects of Industry 4.0 on Türkiye's foreign trade together with the Sustainable Development Goals through descriptive analysis. Taking into account Türkiye's economic, environmental and social dynamics, it will examine the effects of this technological transformation on the country and its contribution to sustainable development goals.

Review of The Literature and Research Hypotheses

What Is Industry 4.0?

Industry 4.0, also known as the Fourth Industrial Revolution (Özsoylu, Endüstri 4.0, 2017), enables communication between various stakeholders or cooperating parties involved in industrial production, access to data and the use of this data to create significant value.

Information technologies, digital infrastructure and digital tools are decisive elements for the 3rd Industrial Revolution. These elements have brought change and development to society and economy. With the spread of digital technology and digital automation, it is observed that cyber-physical systems, real-time data processing and interconnected value flow have evolved to a new stage. At the same time, this situation also affects and shapes the development of the world. With the interconnection of sensors, information technologies and production tools, industrial chains including economic, technological and commodity flows have gone beyond a single company (Özsoylu, Industry 4.0, 2017) and a new era has begun.

Cyber-physically connected systems enable data to be analysed with the help of the internet. Thanks to these analyses, new criteria can be determined and better quality products can be produced with more economical costs. (Özsoylu, Industry 4.0, 2017) These developments will lead to the emergence of new transformations over time. This new process that will emerge is recognised as Industry 4.0, the fourth industrial revolution. (Özsoylu, Industry 4.0, 2017)

The concept of Industry 4.0 emerged after a project led by the German government. This project refers to a project involving advanced technology. The term Industry 4.0 was first used at the Hannover Fair in 2011 (Soylu, 2018).

Industry 4.0 is based on technology and devices that automatically communicate with each other when needed. The concept of Industry 4.0 refers to smart factories that will be established and operational in the future. Computers manage the systems. Therefore, processes are monitored more clearly and accurately, and intervention possibilities are available at any time in any situation.

Industry 4.0 is an approach that aims to ensure compliance and resistance to high quality criteria in engineering, planning, production and logistics processes. It also aims to maximise measures such as cost, availability and resource consumption (Soylu, 2018).

What Are Sustainable Development Goals (SDGs)?

The concept of sustainable development is a concept that aims to keep people, economy and environment together in a balanced way and to build the present and future in a better way by ensuring the efficient use of natural resources. It aims to provide an easier and more beautiful life by meeting the needs of the society. While doing this, it also aims to teach how to use natural resources more correctly and efficiently by protecting the environment. Thus, by creating awareness in the society, the economy can be corrected, social justice and the welfare level of people can be increased.

The concept of sustainable development has been adopted by the United Nations, the European Union and some non-governmental organisations as well as some international organisations. Within the scope of their activities together, there are concepts such as sustainable development, sustainable education, sustainable environment, sustainable economy (Yalçın, 2022).

The importance of sustainable development is increasing due to factors such as epidemics all over the world, exacerbation of natural disasters (earthquakes, floods, fires, etc.), serious hunger and thirst problems in some regions, excessive pollution of the seas and the environment. Nature has the opportunity to renew itself after a certain period of time. However, humans take this opportunity away from nature. People cannot realise some things before something happens to them. However, after that problem or disaster has passed, they continue in the same way.

The biggest reason for this is the lack of education, environment, society awareness is not fully established. Our world is getting worse and worse. People became even more unconscious and started to behave more carelessly.

Education forms the basis of sustainable development and many other issues. Education is the beginning of everything. Education starts in the family first and foremost. Therefore, mothers and fathers should have the necessary level of education and consciousness. Because children do what they see, not what they are told. Therefore, parents should be a good example for their children. Teachers should also have adequate level of education and awareness. Teachers should provide the necessary behaviours and consciousness not only in academic terms but also in terms of life values. Teachers, just like parents, should set a good example for their students and guide them in line with sustainable development goals. In fact, sustainable development goals should be included in education curricula and made into a course. Practices should also be developed in nature. If these consciousnesses are created at an early age, the root of the problems can be addressed and permanent solutions can be found in the future. A child means a society, a country. One child can change many things in the future. That's why 'One' is many. If children are raised in a good way, they become conscious, educated individuals when they grow up. They can approach the people around them with the same awareness and raise awareness with different suggestions. Sustainable development goals will thus be fully realised.

United Nations (UN) Sustainable Development Goals

The UN has set 17 goals in line with sustainable development and these goals were adopted by the UN General Assembly in 2015 and are aimed to be realised in 2030. (Sustainable development and basic principles, 2023)

Sustainable development goals are goals that aim to achieve sustainable development in terms of economic, social and environmental aspects. These goals aim to ensure economic growth, social justice, protection of the environment and conscious use of natural disasters.

In this way, by meeting the needs and ensuring sustainable development, a healthier, safer and livable society will be created for future generations.

Sustainable Development Goals (SDGs): (Sustainable development and basic principles, 2023)

1. Ending poverty
2. Eliminate hunger
3. Providing good health services for a healthy and balanced life
4. Ensuring equality in education
5. Protect the rights of women and girls
6. Improving water and hygiene infrastructure
7. Increasing energy efficiency and consumption of renewable energy sources
8. Increasing employment
9. Making infrastructure investments
10. To ensure justice
11. Working for a better quality of life in cities
12. To create a sustainable consumption and production system
13. To reduce environmental pollution, to take necessary measures related to climate change
14. Protecting seas, oceans and other water resources
15. Protecting forests
16. Working for a just and sustainable world
17. Ensure global co-operation and support

The UN emphasises that in order to achieve all these goals, countries and the business world as well as non-governmental organisations should cooperate. Each goal is also specified in detail. In order to realise these goals, countries need to develop and implement comprehensive plans. These plans should be formulated in a way to take into account the economic, social and environmental dimensions of sustainable development. Countries should also submit annual reports to monitor the achievement of the goals.

The UN should continue to encourage countries to realise the sustainable development goals. These are global goals that concern all countries of the world. In order to achieve success, all countries must act with the same commitment. In order to fully achieve the sustainable development goals, a common work, understanding and international co-operation is required. Countries should share their knowledge, experience and plans with each other. If a common effort and co-operation can be achieved at the global level rather than individual efforts, these goals can be fully realised.

In this context, the study has 2 hypotheses. These are: Hypothesis 1: Industry 4.0 technologies affect Turkey's foreign trade; Hypothesis 2: Industry 4.0 applications contribute to Turkey's achievement of sustainable development goals.

METHODS

In this study, descriptive analysis and document analysis methods were used. Descriptive analysis was employed to evaluate the impact of Industry 4.0 technologies on Turkey's foreign trade and sustainable development goals, while document analysis was conducted through the examination of written sources such as Turkey's Industry 4.0 strategy documents, foreign trade reports, government policies, and reports published by international trade organizations. This method contributed to understanding existing policies and practices in their historical and theoretical context and expanded the scope of the study by supporting it with qualitative data. The combined

use of descriptive and document analysis enabled a more in-depth examination of the relationship between Industry 4.0 and sustainable development goals.

RESULTS AND DISCUSSION

Türkiye's Foreign Trade Profile

When analysed in terms of foreign trade, balance of payments and economy, Türkiye's situation can be evaluated:

In the periods before the 1980s, an import substitution approach was adopted as an economic strategy in Türkiye. The aim of this strategy was to make production within the country. For this purpose, domestic production was encouraged. Instead of buying goods from abroad, it aimed to produce these goods within the country. Later on, this strategy started to change itself into an economy that opened outwards. From 1980 onwards, Türkiye gradually transitioned to an open economy.

Türkiye, together with the European Union (EU), entered the Customs Union (CU) in 1996 with the European Community-Türkiye Association Council Decision No. 1/95. (Orkunoğlu Şahin, Türkiye's Foreign Trade Development in the 1980-2021 Period, 2022)

The Customs Union had a positive impact on Türkiye's foreign trade for a short period of time. If we look at its long-term effect, it has caused some economic losses. Türkiye's foreign trade volume increased in the 1980s.

In 1980, Türkiye's foreign trade volume was approximately 10 billion dollars and towards the end of the 1990s it exceeded 80 billion dollars. (Orkunoğlu Şahin, Türkiye's Foreign Trade Development in the 1980-2021 Period, 2022)

Türkiye's foreign trade volume in 2004 rose to \$417 billion with a 40% increase in imports and a 30% increase in exports. (Orkunoğlu Şahin, Türkiye'nin 1980-2021 Dönemi Dış Ticaret Gelişiminin İrdelenmesi İrdelenmesi, 2022)

When we look at the years 2010, 2016 and 2020, it is seen that there has been a decrease. By 2017, policies were followed to increase economic growth and reduce unemployment in Türkiye.

The state has become a guarantor for companies with financial resources such as the Credit Guarantee Fund to support companies to attract loans. (Orkunoğlu Şahin, Türkiye's Foreign Trade Development in the 1980-2021 Period, 2022)

Türkiye experienced a financial crisis in 2018. With this crisis, the Turkish Lira depreciated. Subsequently, inflation and debt burden also increased. Despite all this, Türkiye's foreign trade volume reached 408 billion dollars in 2014-2021. (Orkunoğlu Şahin, Türkiye's Foreign Trade Development in the 1980-2021 Period, 2022)

Effects of Industry 4.0 on Türkiye's Foreign Trade

Cyber physical systems combine the real world with the virtual world with the help of the internet and sensors. It also expands the structure of the real world with the virtual world. Thus, it will be possible to observe the harmony between production chains or to recognise and eliminate any problems. At the same time, the automation of manufacturing processes will reduce the burden of people and reduce error rates. Thus, costs will decrease, returns will become more positive and reliability will increase.

From Türkiye's point of view, this situation will especially affect foreign trade positively. As automation increases in production processes, error rates will decrease and reliability will increase. This will lead to an increase in exports. As exports increase, Türkiye's foreign trade deficit will decrease.

Türkiye has a number of problems in terms of production processes. One of these is that exports are too dependent on imports; the second is that the production and foreign trade structure of the production sector is insufficient in terms of technology. (Nuroğlu, 2018) Although some steps have been taken to solve these problems, unfortunately, they have not been very successful. Therefore, Industry 4.0 can provide a transformation for Türkiye's foreign trade, that is, it is an opportunity.

Factories in Türkiye have not been fully automated. The sectors with a high level of development in Türkiye are materials, computers, electronic and optical products, and automotive and white goods sub-industry. (Yıldırım, 2017) Some of these sectors have no knowledge about intelligent systems, while others have little knowledge. Some of them are also interested in smart systems and want to develop in this field.

Türkiye is taking steps to ensure foreign trade and internal development. One of the aims of transition to high technology is to reduce the foreign trade deficit. Afterwards, it is to increase the production industry and the ratio of high-tech products in exports. (Nuroğlu, 2018) Once these are achieved, Türkiye will start to have its own technology industry and will increase its competitiveness in terms of industry.

Industry 4.0, the efficiency of manufacturing processes will increase. They will be of better quality, more reliable and more environmentally friendly. In other words, as Türkiye adapts to Industry 4.0, its manufacturing industry and exports will develop positively. Industry 4.0 is a great opportunity for Türkiye's development.

Impacts of Industry 4.0 on Sustainable Development Goals (SDGs)

Since Industry 4.0 is a digital transformation process, it aims to provide a transformation in terms of sustainable development goals.

Industry 4.0 technologies, together with digitalisation and automation processes, enable the creation of new business opportunities as they increase productivity in the business world. With these new job opportunities, labour demand increases. As the necessary trainings are provided to adapt to technology and employees are provided to work in jobs according to their skills, the existing working positions will be distributed in a balanced way. Thus, Industry 4.0 will prevent unemployment and poverty.

Industry 4.0 is also of great importance in terms of health services. Artificial intelligence technologies enable accurate diagnosis of diseases. This means starting the right treatment without wasting time. A remote video examination system has been developed, and patients who cannot go to the hospital or health centre are treated. The health sector has made progress towards predictive, participatory, patient-centred, personalised, preventive and widespread healthcare (Korkmaz, 2020).

Since the beds will also have advanced technology in the future, patients will be better observed. Devices will be reduced to the size of transport, and intervention will be possible at any time and anywhere without wasting time. Thanks to 3D printers, the diagnosis of doctors will be clearer. This means that treatments can be started without wasting time.

Industry 4.0 also brings innovations in the field of education. Tools such as printers, smart boards, tablets are used in smart classrooms. Thus, education becomes more efficient. Students' motivation will also increase as learning will be more permanent. Since distance education is now possible, it is possible to connect to lessons and receive training anywhere and anytime. With virtual reality, learning becomes more permanent as students' 5 sensory organs become active. Since students' potentials will be better discovered, they will be guided according to their abilities. Digital learning platforms have recently become an indispensable part of our lives and provide numerous benefits. Learning is realised through internet networks and online systems.

At the same time, there are numerous learning areas within a platform. Coding, software, language, maths, photography, design and hundreds of other business areas are also available. Thanks to mobile tools, it offers training opportunities at any place and time.

Industry 4.0 also aims to establish smart cities. Smart cities are cities where environmentally sensitive physical, digital and human systems are integrated into the environment and life; improve people's quality of life; offer a modern, competitive, functional and sustainable future; and are supported by advanced living technologies. (What are Smart Cities?, no date) Thanks to these cities, smart transport and infrastructure systems will also be established. With the smart environment, environmental pollution will be prevented. It will also ensure that measures are taken on climate change.

Industry 4.0 has also caused some transformations in the field of justice. Since easier access to information is provided, the functioning of justice can be helped. Data can be analysed more easily and quickly. Legal procedures are accelerated thanks to applications such as electronic documentation and electronic signature. More attention is paid to the protection of personal data. This increases confidence in justice.

Industry 4.0 can also be effective on the cleanliness and efficiency of seas and other water resources. Thanks to the observation of water quality and the organisms living in the water, early warning systems can be established and intervention can be possible when any problems are observed. Marine pollution can be reduced by producing environmentally friendly technologies. Even today, there are various applications for these. Examples of some of these are; the machine that cleans plastic waste in the oceans, robotic boat that can clean up to 150 tonnes, garbage bins that collect garbage in the water. (Güler, 2019)

Finally, if we look at the effects of Industry 4.0 on the protection of forests, especially in the summer months, forest fires show a great increase and a large part of the forests are destroyed in these fires. Since the formation of a new forest takes years, technologies can be produced to prevent these fires in the first place. With the help of sensor networks, drones or soil analyses, the conditions of forests and soil can be observed. Thus, possible dangers or fires can be detected earlier and intervened early. Smart agricultural practices can also be popularised and soil fertility can be increased.

Implications of The Sustainable Development Goals for Türkiye

The sustainable development goals (SDGs) will impact Türkiye in many positive ways. These goals provide strategies to improve and enhance Türkiye's economic development, enabling the growth of the economy. Economic growth is supported by measures such as promoting innovation, adopting technological advances and creating new job opportunities. Poverty reduction is an important part of the sustainable development goals and includes strategies such as ensuring fairness in income distribution, strengthening social assistance programmes and supporting people living below the poverty line. Poverty reduction improves the overall quality of life of the population and ensures social peace. Increasing employment and creating new job opportunities will reduce unemployment and bring more people into the labour force. Increasing qualified labour force and decreasing unemployment rates will make the country stronger economically and socially.

Elimination of inequalities is also an important component of sustainable development goals. These goals aim to take various measures on issues such as gender equality, income equality and social justice. Reducing inequalities increases social peace and life satisfaction of individuals. Improving education, health and justice systems is also one of the focal points of sustainable development goals. Improvement of these systems increases the general welfare of the people and

leads to a healthier and better educated society. Protecting the rights of persons with disabilities and ensuring their full participation in society is an indicator of social justice and equality.

Protection of natural resources and increasing energy efficiency constitute the environmental dimension of sustainable development goals. These goals aim to combat climate change and protect the environment. Raising public awareness contributes to the increase in environmentally conscious individuals and the adoption of sustainable lifestyles. Developing smart cities, improving transport and infrastructure systems and reducing environmental pollution make urban life more sustainable.

Sustainable development goals will also positively affect Türkiye's international relations as they are globally determined goals. The realisation of these goals will enable Türkiye to contribute to global sustainability efforts and increase its prestige in the international arena. Moreover, achieving the sustainable development goals will help Türkiye become a stronger and more resilient country in economic, social and environmental terms.

CONCLUSION

The contributions of Industry 4.0 to Turkey's sustainable development goals are multifaceted and substantial. Technological advancements, digital transformation, and the adoption of smart production systems are supporting Turkey's economic growth and enhancing its global competitiveness. These transformations generate new opportunities in Turkey's foreign trade, diversifying exports and enabling Turkey to play a more active role in international markets. Specifically, technologies such as automation, digitalization, and data-driven processes have significantly enhanced the efficiency and competitiveness of Turkish industries. Improved productivity, reduced production costs, and shortened lead times have made Turkish products more competitive internationally. For instance, smart manufacturing technologies have facilitated increased exports in sectors such as automotive, electronics, and textiles. Nevertheless, to fully leverage these benefits, there is a need for further investment in technology infrastructure and workforce training.

The impact of Industry 4.0 on Turkey's environmental management is also significant. Advances in energy efficiency and environmental sustainability are key aspects of this transformation. Smart energy systems and resource optimization play crucial roles in reducing environmental pollution and addressing climate change. Turkey's investments in renewable energy and energy efficiency strategies are essential for achieving its sustainable development goals. Technologies that optimize resource use, improve energy efficiency, and minimize waste align with environmental sustainability objectives. For example, smart energy systems and cleaner production processes have contributed to reducing Turkey's carbon footprint, supporting goals related to climate action and responsible production.

Moreover, smart city projects and infrastructure innovations are transforming Turkey's urbanization process. These projects enhance the environmental and social sustainability of cities while improving transportation systems' efficiency. The implementation of smart city solutions supports economic growth by boosting logistics and operational efficiency in both domestic and international trade. Additionally, Industry 4.0 technologies facilitate digital transformation in health, education, and justice systems, thereby improving social welfare and service quality. Innovations in digital health applications, education technologies, and the justice system enhance the quality of life and promote social equality.

In conclusion, effectively utilizing the opportunities provided by Industry 4.0 is crucial for Turkey to achieve its sustainable development goals and enhance its position in global trade. The integration of Industry 4.0 technologies and the implementation of appropriate measures aligned

with sustainable development goals will contribute to making Turkey a stronger and more resilient country, both economically and environmentally. However, widespread adoption of these technologies across all sectors remains a challenge, and ongoing efforts in innovation and regulatory alignment are required to maximize their impact on achieving sustainable development objectives.

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