

## INDUSTRY 4.0 AND ITS IMPACT ON RESHORING TRENDS IN THE GLOBAL ECONOMY

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**Methods.** The results of the study were obtained through the application of scientific research methods, namely: abstraction – to define the reshoring trends on the influence of sustainable development goals based on Industry 4.0; analysis and synthesis – to determine the likelihood of reshoring of companies located abroad according to the degree of similarity between its technology situation; comparative studies – to establish the intensity of reshoring based on different technical solutions and type of manufacturers.

**Results.** Industry 4.0 represents the fourth industrial revolution, emphasizing the crucial role of intelligent machines and smart automation in business activities. It has been demonstrated that these technologies provide the necessary flexibility for companies to overcome the difficulties of reshoring and at the same time maintain their competitiveness in the global value chain. Industry 4.0 solutions bring valuable insights into the supply chain during reshoring initiatives. Armed with Industry 4.0 technologies, managers are better equipped to achieve successful operations by controlling material flows before, during and after relocation of the company divisions. These technologies will offer valuable insights into various aspects, such as switching costs, supply chain governance, manufacturing planning, financial incentives and workforce planning. This enables companies to make informed decisions and optimize their reshoring strategies for long-term success. The main reasons for the spread of reshoring have been identified and its most widespread forms in the developed countries of the world have been singled out. The influence of Industry 4.0 technologies on the reshoring process is demonstrated and the current trends in its development are determined.

**Novelty.** The scientific novelty of the research results lies in identifying the current trends of reshoring in the countries of the European Union and the USA and the influence of sustainable development goals on reshoring initiatives based on Industry 4.0.

**Practical value.** The results of the study actualize the processes inherent in the modern economy, which is becoming more and more globalized. The identified modern trends of the reshoring initiative allow companies to build and implement more effective reshored business functions based on Industry 4.0 technologies.

**Keywords:** reshoring trends, technological progress, manufacturing, technology levels, Industry 4.0, technical solutions.

**Statement of problem.** International trade has changed significantly since the early 1990's: the liberalisation of cross-border transactions, advances in information and communication technology, reductions in transport costs and innovations in logistics have given firms greater incentives to break up the production process and locate its various stages across many

countries. As a result, global supply chains have become very common, accounting for around a half of global trade in 2021–2022 [3].

The Russia-Ukraine conflict and other disruptions, like the COVID-19 pandemic, the climate crisis have fueled an increasing interest in reshoring as an alternative strategy. International political cooperation has begun to

falter. The combination of these trends has forced a rethinking of global supply chains and catapulted their resilience to the top of policymakers' agendas.

One-year anniversary since the Russia-Ukraine war began, when Russia invaded Ukraine after supporting the separation of Ukrainian territory. The impact has been global. Immediately, aid agencies worried that Ukraine's grain would be stuck in ports, unable to reach countries that rely on it. This was just one example of how the regional conflict has forced countries around the world to source food, raw materials, fossil fuels and other key items from new trading partners [2].

However, businesses contemplating reshoring may encounter significant challenges due to potential risks, such as disrupted supply chains, unforeseen delays and production issues stemming from the unavailability of local labor, insufficient infrastructure and necessary resources.

Nevertheless, in challenging times, should managers opt to reinvent the wheel through reshoring, or is offshoring operational functions to specialists a more viable and cost-effective strategy that allows businesses to focus on their core strengths for accelerated growth and increased profitability?

A new «reshoring» trend is set to upend global supply chains as firms look to source products – such as clothes and computer chips – closer to home, turning away from manufacturing powerhouses like China and others countries in Asia.

**Analyses of recent papers.** Reshoring in the industry has become one of the most pressing problems of recent times. Task uncertainty is another factor influencing offshoring and reshoring decisions. Here, to some extent uncertain potentials of technological innovations in manufacturing processes, e.g. by an intensified use of Industry 4.0, come also into play. The higher and more specific investments in advanced production technology are, the higher the possibility to integrate the specific manufacturing operations at one focal plant, favoring rather reshoring than additional offshoring activities.

The transformation of manufacturing, integrating localization capabilities via digital

technology, has rendered managers more inclined to contemplate reshoring [4].

Company's reshoring decision is influenced by host-country factors, such as overseas supply chain complexity and offshore supplier dependence. Supply chain governance in reshoring initiatives is vital for the successful execution and management of the reshoring process. Importantly, Industry 4.0 technologies can be advantageous for optimizing supply chain networks [6]. For example, employing open-source cloud-based physical systems with IoT and digital twins can foster transparency and enhance visibility into processes, essential for a resilient supply chain [5, 7]. Ford's One Manufacturing System enables its employees to work on multiple models and platforms within the same facility, facilitating the production of gas, electric and hybrid vehicles. Utilizing flexible robots, Ford has reinforced its reshoring initiative, returning 3250 jobs from Mexico to Michigan and Ohio in 2016 [10].

Although numerous scholars have explored the potential of Industry 4.0 technologies for production and supply chain governance, few have examined it from a marketing perspective to guide sales and brand management [8]. This framework extends the management team's scope beyond resource alignment to include consumers seeking brands offering localization with sustainable capabilities.

**Aim of the paper.** The purpose of this article is to enhance understanding of the reshoring phenomenon in the post-COVID-19 and Russia-Ukraine war era by examining current reshoring trends in research and providing novel insights on the influence of sustainable development goals on reshoring initiatives based on Industry 4.0.

**Materials and methods.** Nowadays we can see a significant shift in this year's Reshoring Index, which reflects a broader rewiring of global supply chains. As a result of those shifts, in 2022, US imports of manufacturing goods from the 14 Asian LCCs and regions tracked in our annual study totaled 14.1 percent of US domestic gross manufacturing output, down from 14.49 percent in 2021. This significant trend shift marks the first time that domestic manufacturing growth outpaced Asian LCC imports growth since 2019, resulting in a

positive 2022 Reshoring Index of 39 (figure 1). This is no small feat given that Asian LCC imports increased another 11 percent vs. the

previous year and, for the first time in history, topped \$1 trillion [11].

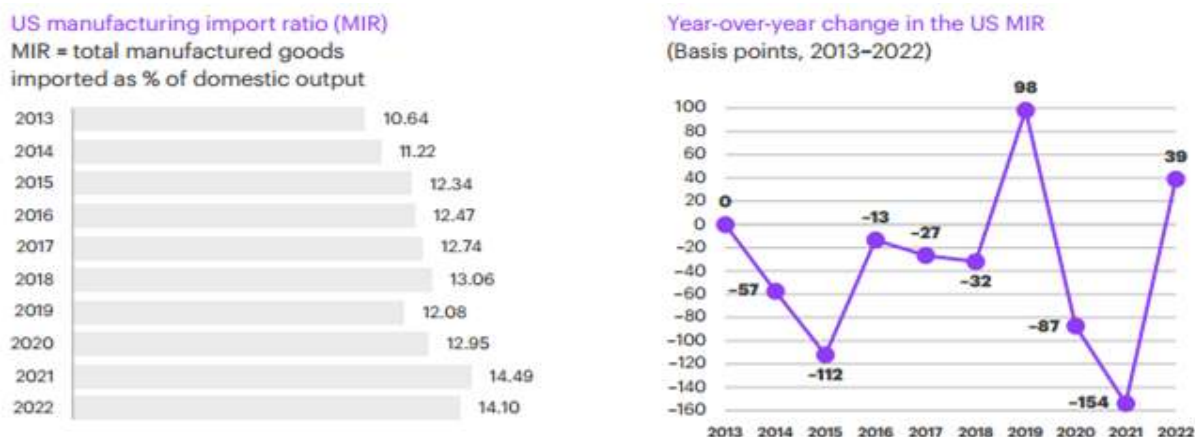


Figure 1. US gross domestic manufacturing output rose at a faster pace than the US manufacturing from 14 Asian low-cost countries and regions, resulting in a positive score on the Reshoring Index  
Sources: [1]

We can consider three factors contributing to reshoring trend:

1. Historically, companies haven't wanted to report (advertise) leaving Asian low-cost countries for fear of retaliation.

2. Rather than stating the country from, many cases simply refer «returned from offshore».

3.«Automatic reshoring» – cases where new investments are displacing imports of products that are disproportionately made abroad do not frequently report on Country from.

Subsequently, we expect the true percentage of reshoring from Asian low-cost countries to be much higher than what is reported.

Table 1

Reshoring by International Region, from 2010 till 2022

Region from	Jobs	Companies	Jobs/Company	% of reporting
Asia	140562	1193	118	72%
North America	41723	181	231	21%
Western Europe	9809	135	73	5%
Middle East	1771	27	66	1%
Eastern Europe	1134	8	140	1
South/Central America	405	8	50	0%
Africa	70	3	26	0%
Australia/Oceania	0	5	0	0%

Source: [1]

The numbers here illustrate two power shifts:

1) The U.S. is successfully taking back a greater share of manufacturing from Asia. 2022 reshoring job announcements from Asia were so great that they moved cumulative reshoring from Asia up by 9% points from last year – from 63% to 72%.

2) By way of FDI, Asia has increasing

involvement in the U.S. economy, especially in relation to Western Europe's involvement. For the first time, Asia accounted for more than 50% of all new job announcements (53%), beating Western Europe by 10% in FDI in the U.S.

Reshoring entails benefits and costs, it can benefit firms and consumers if it provides better control of production processes. Reshoring can also reduce the negative effects that disruption

in one country can have in others.

Technological progress may make it easier to reshore the production of strategic goods and technologies, such as semiconductors, biotechnology, medical manufacturing, pharmaceuticals, but doing so still requires large investments and time.

It is generally agreed that manufacturing High-Tech products is more desirable than Low-Tech: more investment, more R&D, higher pay, less risk of loss to low-wage countries, etc.

In 2022 Electrical Equipment remained the top industry. Computers and Electronics

moved to 2nd, bumping Transportation to 4th place. Chemicals moved up to 3rd place [1].

Reshoring phenomenon encourages any country to become competitive on all tech levels to balance the trade deficit and employ a broader range of workers. High-Tech products represent too small a percentage of mass consumption to allow any country to focus only on High-Tech. For example, country has a huge dependency on China for consumer goods and personal electronics. A central challenge/goal is to upskill their workforce such that they can work competitively on more highly automated production of lower-tech products [9].

Table 2

Technology Levels, Reshoring + FDI in 2022, %

Product Technology Level	Reshoring		Foreign direct investments		Reshoring + Foreign direct investments	
	Jobs	Companies	Jobs	Companies	Jobs	Companies
High	64	52	50	37	58	47
Medium-High	23	21	36	33	28	26
Medium-Low	7	13	11	20	9	16
Low	5	14	4	9	5	12
High + Medium-High	87	73	85	71	87	72
Medium-Low + Low	13	27	15	29	13	28

Source: [1]

Industry 4.0 represents the fourth industrial revolution, emphasizing the crucial role of intelligent machines and smart automation in business activities [8]. These technologies provide the necessary flexibility for firms to manage the complexities of reshoring while maintaining competitiveness in global value chain activities.

Consider the main the three technology trends which affect international production configurations in specific ways.

1. Digitalization in the supply chain. Digitally enhanced international production networks tend to concentrate more value in a few developed economies.

2. Advanced robotics and AI. Several considerations put the reshoring trend in some perspective. First, automation is not going to affect all manufacturing industries equally. The use of industrial robots is still confined to few industries, such as automotive and electronics.

For these industries, the two key dimensions of technical feasibility and economic feasibility point toward increasing adoption of robots. In other industries, such as textiles and apparel, robots are not yet taking hold because the employment of human labor is still economically more convenient than robotization and the technical feasibility of robots handling soft materials is only just emerging.

By 2030, it is expected that more advanced, efficient and productive robots will improve the technical and economic feasibility of robotization across the board. Still, the employment of robots, and related to that, the opportunities for reshoring will remain highly heterogeneous across industries and activities. Second, the link between automation and reshoring mainly builds on the expectation that as labor costs become less important as a share of total costs, MNEs will automatically reshore

production in search of the technologies and skills needed to support robotization.

3. Additive manufacturing (3D printing). 3D printing is potentially one of the most revolutionizing technologies for global value chains.

3D printing enables the shift from mass production and economies of scale to masscustomization. In 3D printing, value added stems from the design/programming phase – delivering the specifications for replicable 3D printing – and the customer-related activities, addressing the clients’ needs. The manufacturing step tends to be a highly commodified, low value added activity

replicated in many countries. Relatively low-cost standard 3D printers make the creation of small batches economically feasible, lowering the minimum requirements for efficient technical scales. At the same time, 3D printing makes it possible to produce a significant variety of product at no additional marginal cost – a technological breakthrough compared to traditional manufacturing. The focus and source of value switches then from economies of scale to economies of scope.

Due to Kearnye’s annual Reshoring index report the most Reshored business function in such industries (Table 3).

Table 3

Reshoring Index survey demographics

Company industry	Manufacturing executives	Chief executive officer (CEOs)
Food and beverage	12	12
Computer and telecon	7	19
Automotive and textile	6	12
Apparel and textile	5	8
Primary metal, fabricated metal, large machinery	17	5
Electrical equipment, appliances, components	28	16
Chemicals, paper, plastics, rubber	7	9
Furniture, household goods, toys	9	5
Health, pharma, medical devices	3	6
Others	6	8

Source: [1]

To elucidate the relationship between reshoring and Industry 4.0 technologies, authors [12] carried out a market place evidence analysis by examining a sample of reshoring instances.

Table 4 encapsulates cases, demonstrating how Industry 4.0 technologies have supported companies in reshoring their business operations.

Table 4

Marketplace evidence analysis of reshoring with Industry 4.0 technologies

Reshoring company	Industry	Reshored business function	Industry 4.0 technology implementation
General Electric	Consumer products	Assembly line	Automation accelerates production by employing robotic arms to pick and place components in a precise and repeatable manner. Additionally, automation reduces labour costs by diminishing the need for manual labour and enabling the assembly line to operate with fewer workers.
Neurophotometrics	Biotechnology	New product development	3D Printing. Neurophotometrics collaborated with Markforged to develop a 3D-printed swab for use in diagnostic testing for COVID-19. 3D printing allows Neurophotometrics to test prototypes within 36 hours, significantly improving their time-to-market performance.

Premier Plastics	Medical manufacturing	Thermoforming production lines	Industrial robotics. Developing new robotic automation system to shorten production time.
Jabil Healthcare (formerly Nypro)	Medical manufacturing	Medical moulding and assembly line	Industrial robotics are used to perform unsafe and repeatable tasks.
Maxim Integrated	Semiconductors	Production and monitoring of factory	Develop cyber-physical system (CPS) development platform that incorporates real-time intelligence, adaptive manufacturing and distributed control functions to facilitate the efficient production and monitoring of the factory floor.
Agropur	Dairy products	Production line	Utilizing 3D scanning and digital twins, Prevu3D has assisted Agropur in rapidly capturing detailed 3D models of their production plants and manufacturing lines. This technology enables Agropur to monitor the performance of their production lines in real time.
McLaren Technology Group	Motor vehicles	Production line	Equipped with active aerodynamics, race-ready chassis control and carbon ceramic brakes, the hybrid engine with monocoque achieves fuel efficiency, boasts an exceptional power-to-weight ratio and exhibits minimal turbo lag.
Ypsomed	Medical technology products	Localization in production line	5G mobile edge cloud technology, in conjunction with sensors on crates and augmented reality for indoor localization, enables real-time evaluation of machine data, virtualization of resources and quality assurance in industrial environments.
Rīgas Dzirnainieks AS	Food products	Automation of production process	Sustainable production, featuring electrical transmission, water restoration and energy efficiency indicators, has become possible through the use of supervisory control and data acquisition (SCADA) systems with human-machine interface (HMI).

Source: [12]

Furthermore, it is vital for managers to evaluate the overall impact of reshoring on their brands and consumers in distant markets, utilizing Industry 4.0-enabled tools. By integrating reshoring with a localization strategy and adopting an Industry 4.0 approach, companies can reap substantial benefits. Armed with Industry 4.0 technologies, managers are better equipped to achieve successful operations by controlling material flows before, during and after relocation. These technologies will offer valuable insights into various aspects, such as switching costs (including labour, transportation and regulatory costs throughout the product lifecycle), supply chain governance, manufacturing planning, financial incentives

and workforce planning. This enables companies to make informed decisions and optimize their reshoring strategies for long-term success.

We consider technology profiles for manufacturing activities working within the framework of industry 4.0 as a whole, which we use as a conceptual basis to identify the characteristics of the technology-related scenarios in which we analyse the reshoring processes. We identify the likelihood of reshoring of companies located abroad according to the degree of similarity between its technology situation and that involved in the technology scenarios established.

Likelihood of reshoring of companies located abroad according to the degree of similarity between its technology situation

Type of company	Technical solutions	Intensity of reshoring
End product Manufacturers	High combinatorial complexity with high technological complexity	Low, in general. Interest in reshoring would grow with the technological weakness of the offshoring context and decreases in disinvestment costs.
	Low combinatorial complexity with high technological complexity	Limited. The technological weakness of the offshoring context increases interest in reshoring.
	Low combinatorial complexity with low technological complexity	Intense pressure to reshore. Limited technology requirements favour localisation in search of favourable cost conditions in technologically weak contexts.
System manufacturers	High technological complexity with low technological complexity	Low sensitivity of plants to reshoring processes. The greater the relational demands with which the plant works are, the more likely it is to reshore. The technological weakness of the context can explain interest in reshoring such plants
	Low technological complexity with low technological complexity	Sensitivity to reshoring processes. The greater the relational demands with which the plant works are, the more likely it is to reshore.
Part/component Manufacturers	Low combinatorial complexity with low technological complexity	Particularly sensitive to reshoring processes plants with limited internal potential, located in technologically weak contexts. The general nature of their processes means that their markets are highly competitive, which determines the need for efficient adaptation of ICT applications.

**Conclusions.** Reshoring can bring many high-level manufacturing jobs back to the United States and Europe with new opportunities in the modern manufacturing space. Industry 4.0 on the factory floor attracts a more tech-savvy, younger population of workers since these operators are more comfortable with certain technologies. Digital technologies are paving a new future where machines and people work collaboratively to ensure top efficiency and lower costs with employees having access to more fulfilling tasks. To counter high unemployment, it's imperative that manufacturers create appealing jobs while reducing workforce risks during reshoring initiatives. One of the best ways for mid-sized manufacturers to ensure success is by embracing new technologies. Industry 4.0 solutions can bring all information into a single, user-friendly dashboard that encourages team productivity while reducing inconvenient data silos. Real-time data allows for preemptive manufacturing decisions to encourage optimal efficiency. Manufacturers must find innovative ways to get ahead of local and global competition and

Industry 4.0 solutions bring valuable insights into the supply chain during reshoring initiatives.

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## ІНДУСТРІЯ 4.0 ТА ЇЇ ВПЛИВ НА ТЕНДЕНЦІЇ РЕШОРИНГУ В ГЛОБАЛЬНІЙ ЕКОНОМІЦІ

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**Методологія дослідження.** Результати дослідження отримано шляхом застосування наукових методів дослідження, а саме: абстракції – для визначення тенденцій розвитку решорингу під впливом цілей сталого розвитку на основі Індустрії 4.0; аналізу і синтезу – для виявлення ймовірності решорингу компаній, розташованих за кордоном, з огляду на подібність застосованих ними технологій; компоративного аналізу – для встановлення інтенсивності решорингу на основі різних технічних рішень та типу компаній.

**Результати дослідження.** Індустрія 4.0 являє собою четверту промислову революцію, яка характеризується вирішальною роллю інтелектуальних машин та інтелектуальної автоматизації в бізнес-діяльності. Продемонстровано, що ці технології забезпечують необхідну гнучкість для компаній, яка дозволяє подолати труднощі решорингу і зберегти при цьому свою конкурентоспроможність в глобальному ланцюгу створення вартості. Рішення Industry 4.0 приносять цінну інформацію до ланцюжка постачань під час ініціатив з решорингу. Озброєні технологіями Industry 4.0, менеджери ТНК отримують кращі можливості для контролю матеріальних потоків до, під час і після переміщення підрозділів компанії. Ці технології надають цінну інформацію про різні аспекти діяльності компанії, зокрема про витрати, що пов'язані з переміщенням, управлінням ланцюгом постачань, плануванням виробництва, а також про фінансові стимули та планування робочої сили. Це дає змогу компаніям приймати обґрунтовані рішення та оптимізувати свої стратегії решорингу для досягнення довгострокового успіху. Виявлено основні причини поширення решорингу та виокремлено його найбільш розповсюджені у розвинутих країнах світу форми. Продемонстровано вплив технологій Індустрії 4.0 на процес решорингу та визначено сучасні тенденції його розвитку.

**Новизна.** Наукова новизна результатів дослідження полягає у визначенні сучасних тенденцій решорингу в країнах Європейського Союзу та США, а також встановленні впливу цілей сталого розвитку на решорингові ініціативи на основі Індустрії 4.0.

**Практична значущість.** Результати дослідження актуалізують процеси, властиві сучасній економіці, яка все більше стає глобалізованою. Визначені сучасні тренди ініціатив решорингу дозволяють компаніям будувати та впроваджувати більш ефективні бізнес-функції решорингу на основі технологій Індустрії 4.0.

**Ключові слова:** тренди решорингу, технологічний прогрес, виробництво, технологічні рівні, Індустрія 4.0, технічні рішення.

*Надійшла до редакції 3.11.23 р.*