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SMART MANUFACTURING AS A STRATEGIC DETERMINANT OF UKRAINE'S INDUSTRIAL POLICY AMID GLOBAL STRUCTURAL TRANSFORMATIONS

Abstract

This article substantiates the development of smart manufacturing as a key determinant of Ukraine's industrial policy in the context of global transformations. Trends in global deindustrialization are analyzed using the Lawrence model, which reveals a unidirectional dynamic: rising GDP per capita leads to a declining share of manufacturing in GDP. Ukraine is currently undergoing accelerated deindustrialization marked by pendulum-like fluctuations, which necessitates the implementation of reindustrialization policies that align with contemporary needs. The study identifies both external and internal factors shaping demand and supply for manufacturing output and evaluates the effectiveness of current «Made in Ukraine» policy initiatives. To operationalize the logic of local protectionism, the research proposes creating registries of goods, services, and activities aligned with Industry 4.0 technologies, as well as the establishment of special regulatory regimes based on industrial parks.

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Problem Statement

In the current political and economic environment, the increasing relevance of state industrial policy is critically important, since manufacturing determines the long-term competitiveness and resilience of the economy, while providing the foundation for ensuring an adequate level of national security. At present, industry is transitioning from operating under the principles of the Third Industrial Revolution to becoming a smart industry aligned with the requirements of the Fourth Industrial Revolution. This transformation modernizes existing production capacities and their institutional environment and leads to their relocation at the global level. One example of an instrument that influences this process is tariff policy. It is therefore no coincidence that the executive branch of the world's leading economy, the United States, has intensified its revisions of import tariffs (resulting in increases) as a tool to create favorable conditions for the revival of industry based on new technological foundations. Such a policy will inevitably lead other major economies, such as the European Union and China, to revise their tariff and industrial strategies, thereby prompting a search for a new trade and technology equilibrium in the global system.

Since the early 1990s, Ukraine has followed a path of economic deindustrialization, a trend worsened in recent years by full-scale military hostilities. The internal contradiction – arising from a historically determined decline in industry's role in GDP and employment alongside growing productivity potential driven by the adoption of Fourth Industrial Revolution technologies and integration into the

EU economic space – calls for an adequate industrial policy, which still remains unformalized at the legislative level.

Attempts to design a modern state industrial policy that corresponds to contemporary challenges in 2024 have remained at the stage of registered draft laws (Draft Law «On Industrial Policy and Predictability of the Real Sector of the Economy,» No. 11331 of 11.06.2024 (Verkhovna Rada of Ukraine, 2024a); Draft Law «On Industrial Policy and Ensuring the Continuity of Business Activity under Martial Law,» No. 11331-1 of 17.06.2024 (Verkhovna Rada of Ukraine, 2024b); Draft Law «On the Fundamentals of State Industrial Policy,» No. 11331-2 of 17.06.2024 (Verkhovna Rada of Ukraine, 2024c)).

The importance of this issue is nonetheless unequivocally recognized by government representatives. For example, the Strategy for the Digital Development of Innovation in Ukraine until 2030 mandates conducting research on the implementation of Industry 4.0 and Industry 5.0 practices and supporting the creation of conditions for the operation of Industry 4.0 implementation centers across Ukrainian regions, including fab labs at higher education institutions (Cabinet of Ministers of Ukraine, 2024). Therefore, Ukraine faces the challenge of formulating and implementing an industrial policy aligned with contemporary transformations in the global economy, which necessarily implies the «smartization» of industry.

Literature Review

The analysis of recent studies and publications on the formation of modern industrial policy indicates that this issue is of relevance to the scientific community.

Thus, Bulfone et al. (2024) draw attention to the fact that nothing has more vividly demonstrated the declining attractiveness of neoliberalism in recent years than the revival of industrial policy. A number of ambitious political initiatives, such as the U.S. CHIPS and Science Act (U.S. Congress, 2022a), the Inflation Reduction Act (IRA) (U.S. Congress, 2022b), the EU Green Deal Industrial Plan (GDIP) (European Commission, 2023), and South Korea's Green New Deal (European Parliament, 2021), demonstrate that the return of industrial policy has become more than an isolated deviation from globalization. They also point to a tectonic «reconfiguration of capitalism» (Durand, 2023), through which the boundaries between markets, institutions, and states are gradually being reconsidered. In the EU, processes are intensifying that aim at easing regulatory constraints and promoting both national and cross-border industrial policy, as well as protecting the single market from unfair foreign competition and excessive foreign influence (Di Carlo & Schmitz, 2023).

Mariotti (2025) examines new trends such as the zero-sum reconfiguration of globalization, the return of states to interventionism and techno-nationalism,

and analyzes the industrial strategies of leading powers aimed at economic autonomy and security. The author concludes by assessing the potential of open strategic autonomy to serve as a positive reference point for EU industrial policy without undermining the principles of open economy and multilateral cooperation.

Győrffy (2024), using the example of the battery industry for electric vehicles through a comparative analysis of the economic models of Sweden and Hungary, argues that liberal democracy is compatible only with Sweden's coordinated market economy model, while in Hungary the illiberal regime and the dependent market economy model mutually reinforce each other against the backdrop of growing societal awareness of the drawbacks of dependency, such as inefficient resource allocation, environmental damage, and constraints on modernization opportunities. Accordingly, the EU's strategic goals are ensured only by the Swedish model, whereas the Hungarian model deepens institutional divergences within the EU.

Donnelly (2023) analyzes policies on microchips and critical ICT infrastructure in the United States and the EU, focusing on the growing role of geopolitical threats, from the perspective of Stephen M. Walt (1987), as a driving force of industrial policy, export control, self-sufficiency, and friend-shoring. In the United States, strong and bipartisan threat perception fosters a comprehensive and well-funded industrial policy. In the EU, concerns are also present; however, divergences in national priorities weaken political realism, maintaining adherence to liberal approaches to global supply chains and adopting a realistic stance toward capacity-building regardless of immediate threats.

International organizations also devote significant attention to industrial policy. For example, during June and July, the OECD prepared a series of substantial analytical materials: (1) *Productivity Among Firms Patenting in Fourth Industrial Revolution Technologies: A Focus on Canadian Firms* (Calvino et al., 2025); (2) *The Market Implications of Industrial Subsidies* (OECD, 2025c); (3) *An Institutional Framework for Industrial Policy* (OECD, 2025a); (4) *Quantifying Industrial Strategies 2019–2022: Trends and Priorities Across 11 OECD Countries* (OECD, 2025b). According to OECD (2025b), support for industrial policy increased between 2019 and 2022. Grants and tax expenditures rose from an average of 1.40% of GDP to 1.53% of GDP. At the same time, the volume of financial instruments also increased from an average of 2.00% of GDP in 2019 to 2.12% of GDP in 2022. Calvino et al. (2025) demonstrate that larger and more productive companies are more likely to hold 4IR patents.

In Ukraine, under the conditions of ongoing deindustrialization, the issues of industry and industrial policy implementation are also the focus of continuous attention (Mazur, 2016; Amosha et al., 2018; Zaloznova, 2018; Kushnirenko, 2020; Venger, 2020; Vyshnevskyi, 2022; Deineko et al., 2023; Pidorycheva & Bash, 2025). Although all Ukrainian authors acknowledge the existing problems, the theoretical and practical basis for the formation of modern industrial policy

remains insufficiently developed in the context of global trends and national specificities, which hinders the development of an applied industrial policy.

Based on the analysis of previous research, one important scientific and practical problem remains unresolved: establishing a theoretical basis for the development of smart manufacturing under the conditions of the historically determined trend toward deindustrialization.

Therefore, **the purpose of the article** is to substantiate the theoretical foundations and provide practical recommendations for the development of smart manufacturing as a determinant of Ukraine's industrial policy under the conditions of contemporary global transformations.

Methodology

The methodological basis of the study encompasses several mutually complementary methods. Theoretical analysis and synthesis of scientific literature were used, in particular with regard to global trends toward deindustrialization. The key methods applied were statistical and comparative analyses based on World Bank data. The statistical analysis focused on the dynamics of the share of manufacturing in GDP and employment, as well as on GDP per capita, while the comparative analysis was used to assess Ukraine's situation relative to global trends and the experience of the United States.

For data visualization and systematization, graphical and tabular analyses were used. In addition, systems analysis was applied to classify the factors influencing demand and supply in Ukrainian manufacturing. The method of analogies and case studies (situational analysis) served to illustrate theoretical propositions using the example of modern U.S. industrial policy. Finally, through generalization and formulation of recommendations, academic conclusions were translated into practical advice for business and government.

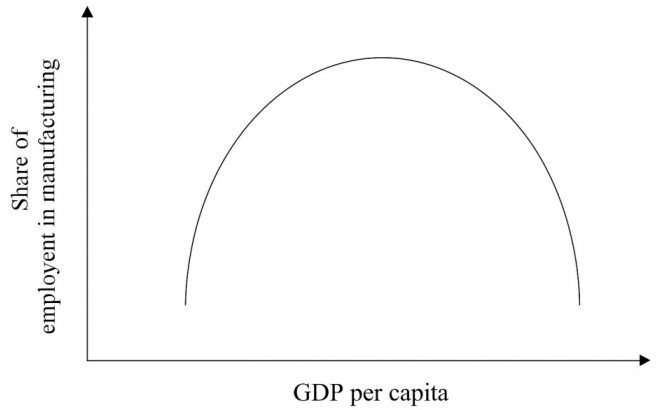
Research Results

Ukraine in the Context of Global Trends

One of the theoretical elements guiding this study is the work of Professor R. Lawrence (2024), presented in *Behind the Curve: Can Manufacturing Still Provide Inclusive Growth?* The book analyzes the relationship between manufacturing and the overall development of the economy (Figure 1) and challenges the idea that jobs in the manufacturing sector of the United States were fundamentally undermined by international trade or that U.S. trade policy is largely responsible for the reduction of employment in the U.S. economy. Accordingly, the author argues that the thesis positing the revival of industrial policy and the manufacturing sector as the key to restoring the U.S. middle class is insufficiently substantiated.

Figure 1

Curve showing the relationship between the share of employment in manufacturing and GDP per capita



Source: made by the authors based on Lawrence (2024).

On this basis, the growth of global GDP per capita in the long term must lead to a decrease in the share of manufacturing in GDP.

As will be demonstrated further using the example of Ukraine, this relationship is, strictly speaking, one-directional: when GDP per capita increases, the share of manufacturing declines; however, when GDP decreases, the share of manufacturing does not increase.

It is generally well known that the share of agriculture decreases as an economy develops. Similarly, in recent decades, the share of services has increased alongside economic growth. Accordingly, the share of employment in manufacturing follows an inverted U-shaped curve. In the early stages of a country's economic development, the share of employment in manufacturing increases, reaching a peak, and subsequently declines. Almost every major industrially developed country has already passed this peak, as have many developing countries.

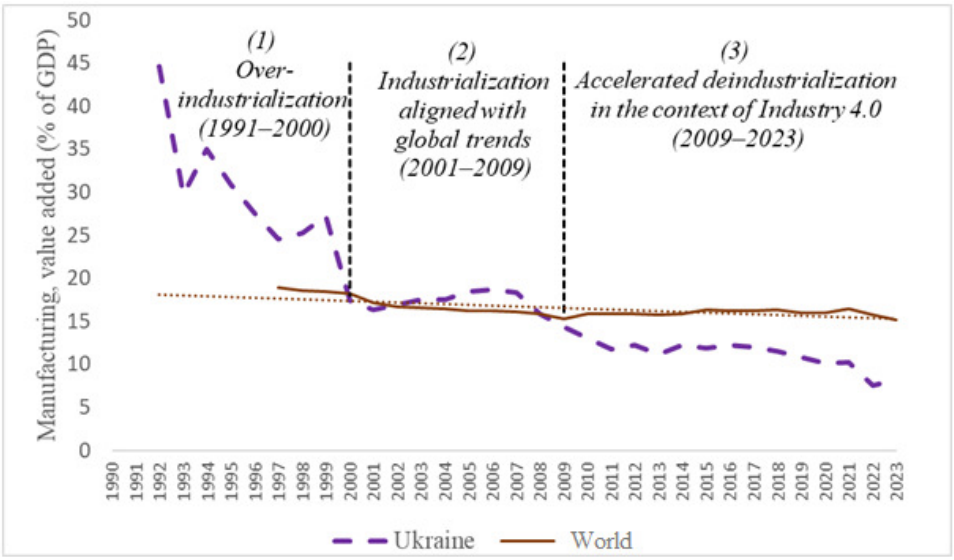
As a result, the author concludes that individual countries predominantly believe they understand their own problems in manufacturing without realizing that these issues are part of a common structural shift. For example, China reached a peak in manufacturing employment at 19.3% in 2013. This level, as Professor Lawrence notes, is significantly lower than the peaks industrial economies achieved during their development. This phenomenon, called «premature deindustrialization», means that latecomer countries face increasing difficulty in reaching those levels (Lawrence, 2024). However, employment in China's broader manufacturing sector (including mining, utilities, and construction) was about 30% in 2013, and after a decline to 29% in 2015, it resumed growth and reached 32% in 2023 (World Bank, n.d.-b).

Against this backdrop, Ukraine's manufacturing sector has long surpassed its peak level of employment. Three distinct stages can be identified in Ukraine's industrial development (see Figure 2). Initially, the country experienced over-industrialization (1991–2000), followed by a phase consistent with global trends (2001–2009). Currently, the country is undergoing accelerated deindustrialization compared with global trends (2009–2023). The emerging task now is to transform this deindustrialization into the «smartization» of manufacturing.

At present, a process is observed that is analogous to how agriculture once became a component of manufacturing, and the stratum of peasants, which had dominated the structure of employment for millennia, has not only decreased by an order of magnitude but transformed into workers employed in manufacturing production.

Figure 2

Stages in the transformation of Ukrainian manufacturing, 1991–2023



Source: compiled by the authors based on data from the World Bank (n.d.-b).

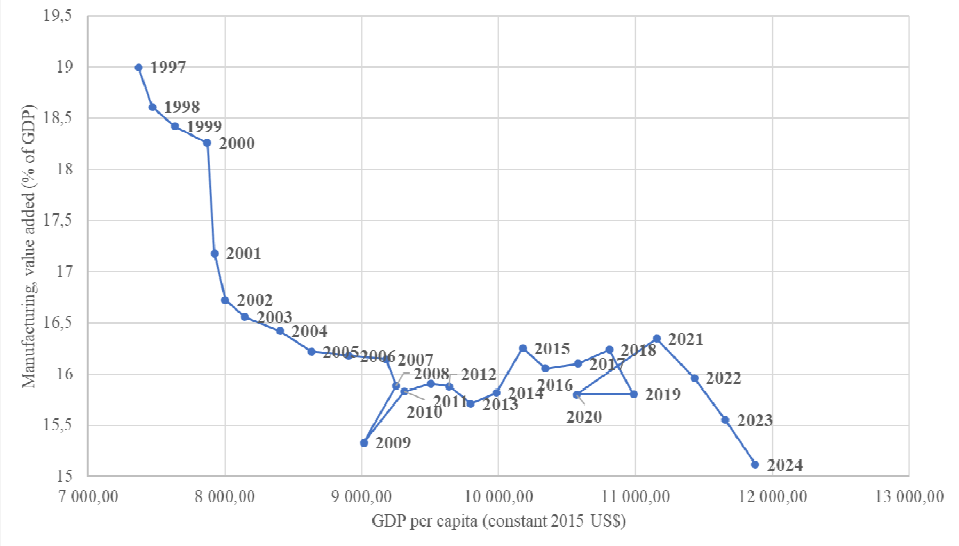
Manufacturing is becoming a component of the services sector (through the use of smart devices and digital platforms). At the same time, the share of software in the value of goods is continually increasing. For example, according to estimates by Luca de Meo, CEO of Renault Group, the share of software in the value of a car will rise to 40% by 2030, up from 20% in 2022 (De Meo, 2023). In China, a fleet of 100 autonomous electric mining dump trucks operates at the Yimin coal mine in Inner Mongolia. The vehicles are controlled through a cloud service using a 5G-A network and artificial intelligence algorithms. This makes it possible to transmit HD video and to optimize routes, waiting time, and operational efficiency in real time, while minimizing occupational injury risks and maximizing the advantages of collaborative fleet operation (Huawei, 2025).

Manufacturing in the context of overall economic dynamics

As noted earlier, the general global trend in industrial development is characterized by the following logic: the more economically developed a society is, the smaller the proportion of its GDP accounted for by manufacturing (see Figure 3). During 1997–2024, the share of value added created in manufacturing declined worldwide from 19% to 15.2% of GDP, while GDP per capita increased by a factor of 1.6.

Figure 3

Share of manufacturing in GDP against the backdrop of GDP per capita dynamics worldwide, 1997-2024

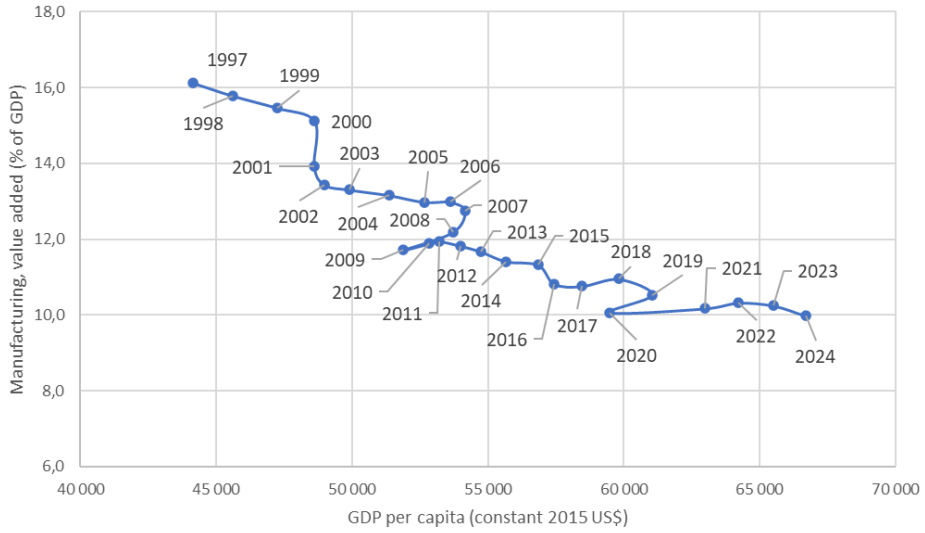


Source: compiled by the authors based on data from the World Bank (n.d.-a, n.d.-b).

The dynamics observed in the United States are in many respects consistent with the global pattern (see Figure 4). The decline in the share of manufacturing in GDP from 16.1% in 1997 to 10.0% in 2024 occurred alongside growth in GDP per capita, which increased by a factor of 1.5.

Figure 4

Share of manufacturing in GDP against the backdrop of GDP per capita dynamics in the United States, 1997-2024



Source: compiled by the authors based on data from the World Bank (n.d.-a, n.d.-b).

The trajectory of manufacturing development and economic transformation in Ukraine contrasts starkly with the dynamics in the world and in the United States (see Figure 5). Ukraine has experienced a spiral of deindustrialization against the backdrop of economic degradation. There has been an accelerated decline in the share of manufacturing in GDP from 45% in 1992 to 8.2% in 2023. At the same time, GDP per capita dynamics has shown pendulum-like fluctuations without growth, remaining below $2,600 (in constant 2015 US dollars), which is more than five times lower than the global average.

Figure 5

Share of manufacturing in GDP against the backdrop of GDP per capita dynamics in Ukraine, 1992-2024

Source: compiled by the authors based on data from the World Bank (n.d.-a, n.d.-b).

The theoretical trend (Figure 1) toward a declining role of manufacturing is, in a certain sense, confirmed. That is, both Ukraine and the world are on the descending part of the curve (the turning point has been passed), and the reduction in the share of manufacturing in GDP is on average historically determined.

Based on the results of his research, Professor R. Lawrence argues that «the growth of productivity within manufacturing itself compels the share of employment in this sector to decline» (Lawrence, 2025). This is beyond doubt. However, the assertion that «manufacturing gives way to services» (Lawrence, 2025)

requires more thorough consideration. Rather, the production process is integrating an increasing number of services. Returning to the earlier example of coal mining in Inner Mongolia, one can observe that the main distinction from the traditional model lies in the implementation of high-technology services related to the collection, transmission, processing, and use of data within the production process.

Thus, the more high-tech manufacturing becomes, the smaller the share it occupies in the economy over time (all other things being equal in a closed economic system). Of course, if sufficiently large external markets of demand exist and continue to expand, it is potentially possible to achieve both an increase in the technological sophistication of production and a rise in employment.

An attempt at reindustrialization: An example of contemporary U.S. policy

Considering that, according to statistics from the World Bank (n.d.-a), there have only been isolated cases in the past 60 years when, at the level of individual states, the volume of manufacturing as a share of value added in GDP demonstrated growth two or more times over a relatively long period (more than three years)[1], or when employment in industry increased (Table 1). In other words, when the graph of the percentage of manufacturing in GDP displayed two or more sufficiently pronounced local maxima. Accordingly, if a country has entered a «deindustrialization» trend, a stable, relatively long-term reversal is extremely rare. D. Rodrik confirms this thesis, noting that «one looks in vain around the world for successful examples of reversing deindustrialization» (Rodrik, 2024). However, such examples certainly exist with respect to industry in the broader sense (Table 1).

Therefore, considerable attention is drawn to the contemporary industrial policy of the United States, implemented by the administration of President D. Trump (Reynolds, 2025; Smith, 2025; The White House, 2025), the essence of which lies in the combination of two key directions.

[1] As a preliminary example, the Republic of Korea can be cited, which attained 27.6% of its Gross Domestic Product (GDP) from manufacturing output in 1988. Subsequently, this figure decreased to 24.1% in 2003. The subsequent peak was recorded in 2011 (28.2%). The second illustrative case is Turkey, which initially reached a local maximum in 1989 (23%), followed by a local minimum in 2010 (15%), and a recovery in 2021 (22%). The third example involves Mexico, where similar fluctuations were observed with considerable frequency. Three local maxima of 22% (in 1970, 1988, and 1997) were interspersed by two local minima–17% in 1982 and 19% in 1992. Following this period, at least one additional local minimum (17% in 2009) and a local maximum (21% in 2021) can be identified (World Bank, n.d.-d).

Table 1

Examples of notable reindustrialization of employment in industry (% of total employment, modeled ILO estimate), 1991–2023

Country	Trend direction	Period, years	Duration, years	Local extremum, %	Difference between extrema, p.p.
Romania	↓	1991-2000	9	34; 26	-8
	↑	2000-2008	8	26; 32	**+6**
	↓	2008-2012	3	32; 28	-4
	↑	2012-2023	11	28; 33	**+5**
Bulgaria	↓	1992-2003	11	44; 32	-12
	↑	2003-2008	5	32; 36	**+5**
Poland	↓	1991-2002	11	33; 29	-4
	↑	2002-2008	8	29; 32	+3
	↓	2008-2010	2	32; 30	-2
	↑	2010-2019	9	30; 32	+2
Thailand	↑	1991-1996	5	16; 22	+6
	↓	1996-1998	2	22; 19	-3
	↑	1998-2007	9	19; 21	+2
	↓	2007-2011	4	21; 19	-2
	↑	2011-2016	5	19; 24	**+5**
China	↓	1997-2002	5	24; 21	-3
	↑	2002-2012	10	21; 30	**+9**
Mexico	↓	1991-1995	4	23; 22	-1
	↑	1995-2000	5	22; 27	**+5**

Source: compiled by the authors based on data from the World Bank (n.d.-c).
Note: The industry sector includes manufacturing, extractive industries (mining), public utilities, and construction.

The first direction envisages the protection of the domestic market from imports through an increase in import tariffs. Protectionism is intended to preserve and expand market niches for producers of industrial goods within the United States, and ultimately to contribute to the protection of existing and the creation of new high-paying jobs.

The second direction is aimed at creating more favorable conditions for conducting business in the sphere of high-technology manufacturing within the country, through the reduction of energy costs, the formation of a supply of cheap money (as evidenced by the pressure of the Trump administration on the leader-

ship of the Federal Reserve System[2]), and state financing of strategic sectors of industry. An indirect instrument reinforcing this direction is the fight against illegal migrants, who limit market incentives for the modernization of the production base by forming a supply of cheap labor.

The implementation of both the first and the second directions faces certain difficulties. The increase in tariffs on imported goods will inevitably lead to higher costs for end consumers. The rapid creation of new production capacities, alternative to those operating abroad, is not always possible. For example, during his first term, D. Trump did not succeed in increasing the share of employment in manufacturing. Under President D. Biden, this tendency continued (Rodrik, 2024).

Such a policy, which has not been in demand for decades, objectively reflects the loss of technological leadership. If the United States has started to rely primarily on tariff methods to protect domestic producers, this means that its technological dominance has largely come to an end and its potential to extract innovation rent has been exhausted. Competitors are producing similar goods at a lower cost.

In any case, the United States remains a trendsetter in many respects, so there is a significant probability that other countries or unions (for example, the EU) will fully or partially adopt U.S. policy. Accordingly, when forming Ukraine's industrial policy, it is advisable to consider both the United States' approaches and the consequences of implementing them.

Directions of smartization of manufacturing production in Ukraine

Compared with the United States, Ukraine has significantly fewer domestic resources and far fewer opportunities to influence external trading partners to support large-scale industrial policies aimed at transitioning from Industry 3.0 and below to Industry 4.0 and 5.0.

Tables 2 and 3 present the systematization of the positive and negative external and internal factors influencing demand and supply for manufacturing production in Ukraine.

Internal positive economic factors that stimulate demand for industrial products include growth in state orders for defense products, increased average wages, reduced unemployment, and the implementation of preferential lending and enterprise subsidies programs. External positive economic factors include the expansion of sales markets through existing free trade areas and the growth of global demand for food industry products.

[2] See Tunik-Fryz (2025) for details.

Factors that negatively impact domestic industrial demand include low household and business purchasing power, a reduction in the number of consumers, and stringent credit conditions. Externally, demand for industrial products is constrained by global economic instability, logistical issues, and an increase in industrial imports against the backdrop of ongoing large-scale military action.

Table 2

External and internal factors influencing demand (consumption) for manufacturing production

Impact	Positive (increase)	Negative (decrease)
Internal	- Growth of demand for defense products within the country; - Increase in average wages against the backdrop of declining unemployment; - Implementation of preferential lending and subsidization programs for manufacturing enterprises.	- Low purchasing power of households (despite the growth of average wages) and businesses, primarily in comparison with EU member states; - Decline in the number of consumers (both individuals and legal entities); - Stringent credit conditions (relatively high NBU rate of 15.5%, orientation of commercial banks toward risk minimization).
External	- External financing, including expenditures of the state budget; - Expansion of markets through the establishment of free trade areas (EU, Canada, Turkey, Israel, the United Kingdom, etc.); - Increase in global demand for food products driven by the growth of the world's population and the rising purchasing power of developing countries.	- Decline or suspension of economic activity in a significant number of territories due to full-scale military actions; - Global economic instability and slow economic growth of EU member states; - Decrease in demand for domestic industrial exports, including due to logistical problems with exporting goods caused by ongoing military actions; - Increase in volumes of industrial imports, creating competition for domestic production.

Source: compiled by the authors.

It should be specifically noted that, from the standpoint of protecting the domestic market, the usefulness of concluding free trade agreements with more economically developed countries is questionable. For example, agreements with Turkey or Israel, where manufacturing production is rapidly developing, including in the high-technology sphere, create substantial additional competition for domestic producers.

The production of industrial goods is also influenced by multidirectional factors (Table 3). Internal stimulation of production takes place through state programs of industrial support. External positive impulses relate to international investments, in particular under the Danish partnership model, and the expansion of access to external markets through trade agreements.

The negative impact on manufacturing production in Ukraine is mainly conditioned by rising supplier prices and the shortage of labor. Damage and destruction of production and logistical infrastructure, energy dependence, limited access to raw materials, as well as the postponement of capital investments by international investors due to high risks, constitute the main external factors of negative influence.

Table 3

External and internal factors influencing supply (production) of industrial goods

Impact	Positive (increase)	Negative (decrease)
Internal	- State programs and measures to support manufacturing (preferential lending, special economic zones); - Partial restoration of labor force volumes and a decline in unemployment (the unemployment rate decreased to 11.2%[3] in July 2025 – the lowest since March 2022; state retraining programs, in particular for veterans).	- Rising supplier prices[a]; - Decrease (shortage) of the labor force, including highly skilled workers.

[3] See the *Ukraine's Economy During the War* tracker published by the Centre for Economic Strategy (n.d.) at https://ces.org.ua/ukraine-economy-tracker.

Impact	Positive (increase)	Negative (decrease)
External	- International investments (the Danish partnership model[b]).	- Damage or destruction of production and logistical infrastructure due to military hostilities; - Energy dependence (high prices and limited supply of imported energy resources); - Restrictions on access to raw materials and components; - International investors reduce or postpone capital investments in Ukraine due to high risks (for example, BlackRock has halted the search for investors for Ukraine's reconstruction[c]); - Increased competition due to the expanded access of foreign producers to the domestic market under trade agreements (EU, Canada, Israel, Turkey, the United Kingdom, etc.).

Source: compiled by the authors. Notes: [a]Ukrainian Chamber of Commerce and Industry (2025); [b]Ministry of Economy, Environment and Agriculture of Ukraine (2025a); [c]Leonard et al. (2025).

Taking into account the factors set out above, the capacities of Ukrainian manufacturing for smartization through the market mechanism alone are extremely limited and, accordingly, insufficient for the harmonious development of manufacturing in accordance with the requirements of Industry 4.0 (5.0). Thus, the global trend toward deindustrialization is complicated by Ukraine-specific factors, which necessitates the conduct of a prudent policy based on the principles of local protectionism (Vyshnevskyi, 2023).

In light of current conditions, this movement appears natural. The government is therefore implementing a number of initiatives within the framework of the «Made in Ukraine» state policy, whose medium-term goal is to increase the share of manufacturing in the structure of GDP to 20% (Ministry of Economy, Environment and Agriculture of Ukraine, 2025b). At the same time, programs and initiatives are being introduced to stimulate demand and supply (Table 4). In previous research, this approach was defined as local protectionism.

Table 4

Programs and initiatives under the «Made in Ukraine» policy: Demand- and supply-side approaches

Demand-side incentives (consumption)	Supply-side incentives (production)
- «Affordable Loans 5-7-9%» Program for HOAs and housing cooperatives (amount: up to UAH 5 million; term: up to 5 years; rate: 7% per annum); - Compensation program for agricultural producers for the purchase of Ukrainian-made machinery and equipment (compensation up to 25%; localization over 60%); - Compensation program of 15% of cost (excluding VAT) for the purchase of Ukrainian-made energy, construction, wheeled, and special equipment (localization level at least 40%); - «Own Business» grant program; - eOselya affordable mortgage program; - Localization (List of localized goods. In procurements through tender procedures for urban transport, municipal equipment, railway transport, and energy-engineering products, at least 20% Ukrainian content is required); - «School Bus» Program; - «National Cashback» Program; - Labelling of goods «Made in Ukraine.»	- «Affordable Loans 5-7-9%» Program for all (amount: up to UAH 150 million; term: up to 10 years); - Grant program for the development of processing enterprises (amount up to UAH 8 million, covering up to 50% of the cost of a processing development project; for drone manufacturers–up to 80%); - Grants program for veterans (amount UAH 0.5–1 million; condition: creation of new jobs); - Development of industrial parks[a]; - Activities of «Made in Ukraine» offices; - eRobota; - Programs within the activities of the ECA (insurance of direct investments; insurance of investment loans; insurance of foreign economic contracts); - State program for stimulating the establishment and functioning of industrial parks.

Source: compiled by the authors based on Ministry of Economy, Environment and Agriculture of Ukraine (2025b) and Zrobleno v Ukrayini [Made in Ukraine] (n.d.). Note: [a] This program stipulates the provision of financing of up to 150 million hryvnia (UAH) to facilitate the construction of essential infrastructure for industrial parks. The funds are allocated on a non-repayable basis, covering up to 50% of the estimated cost of works, such as site development (or land improvement) or the construction of engineering and transport infrastructure.

Thus, two potential approaches to stimulating the development of smart industry can be identified: (a) improving or expanding the existing programs presented in Table 4, or (b) creating additional ones.

The programs and initiatives considered in Table 4 can be adapted to stimulate the smartization of industrial production from both the demand and supply sides. However, to identify specific programs for fiscal and economic stimulation, it is necessary to determine, within the regulatory and legal framework, which goods, services, and activities correspond to Industry 4.0 technologies and thus support the expansion of smart production.

The current approach, applied for example by the Government of Ukraine and the State Statistics Service of Ukraine (Derzhstat) (Verkhovna Rada of Ukraine, 2022), uses UKTZED codes (the Ukrainian Classification of Goods for Foreign Economic Activity) to allocate goods into groups by the degree of their technological complexity, but it is no longer relevant to present-day realities. Thus, a flower pot produced by means of 3D printing and a UAV part produced by the same method, according to this classifier, will be assigned to different categories.

A flower pot is a simple household plastic article classified under UKTZED Group 39 (Plastics and articles thereof; for example, Code 3924 90 – other household articles of plastics) and is assigned to the medium-low-technology level.

The method of production (3D printing) does not change the basic classification, since technological intensity is assessed by industry and product type rather than by the specific process. 3D printing is considered innovative, but for simple plastic articles (such as flower pots) it does not raise the level to high technology.

By contrast, a plastic UAV screw (as a component of a propeller) produced by 3D printing can be assigned UKTZED Code 8807 10 00 00 («Propellers and rotors; parts thereof»), since the screw is a specific part of an unmanned aerial vehicle corresponding to Group 88. This group can be classified as high-technology.

Therefore, by analogy with the existing list of goods for which the degree of localization is determined[4], it appears advisable to create a registry of: (1) goods indicating the degree of technological intensity with respect to the use of Industry 4.0 technologies; (2) services indicating the degree of technological intensity with respect to the use of Industry 4.0 technologies; (3) activities indicating the degree of technological intensity with respect to the use of Industry 4.0 technologies.

For example, the degree of localization of a smartphone manufactured in Ukraine[5] is insignificant, given that the overwhelming majority of components are imported. However, such a business creates potential for substantially localized production in the future. Therefore, in the medium term, it appears advisable to establish lower localization requirements for this type of production.

[4] For the list of localized products for 2025, see Ukraine's *Prozorro Electronic Public Procurement System* (Prozorro, n.d.) at https://prozorro.gov.ua/uk/search/products?yearCreated=2025.
[5] See, for example, the Ukrainian Sigma mobile brand (https://sigmamobile.net/products/smartfony/).

In sum, combining these lists with the degree of localization creates conditions for the appropriate targeting of public procurement and the application of other fiscal and economic instruments to stimulate the development of smart manufacturing. In this context, a promising direction is the deployment of regulatory «sandboxes,» i.e., platforms (Ustymenko et al., 2025), on the basis of industrial parks, for the pilot testing of special incentive regimes for the development of smart manufacturing without violating free trade agreements.

Conclusions

The transformation of industry into smart industry is a historically conditioned trend. The analysis of global trends, in particular R. Lawrence's model, on average confirms a one-directional movement along the curve: an increase in GDP per capita leads to a reduction in the share of manufacturing in GDP, but not vice versa. Having passed its peak of manufacturing employment in the early 1990s, Ukraine is experiencing accelerated deindustrialization, complicated by pendulum-like fluctuations in GDP-per-capita dynamics. At the same time, as statistical analysis shows, cases of medium- and long-term reindustrialization at the national level are isolated, yet they demonstrate the fundamental possibility of such processes, including in Ukraine.

Although in the long term the share of industry will decline as it transforms in accordance with the technologies of Industry 4.0 and, from the standpoint of statistical accounting, will continue to play a smaller role, in reality it will require greater attention to preserve innovation potential and an adequate level of economic security. Therefore, Ukraine faces the task of anticipatory smartization of manufacturing, which should positively affect the overall economic situation. Considering that industrial development in Ukraine does not translate into overall economic achievements, the government's target benchmark of a 20% share of manufacturing in GDP should be complemented by overall macroeconomic benchmarks such as GDP per capita.

Focusing the «Made in Ukraine» state policy on stimulating the output of domestic smart products using smart technologies is a relevant task for ensuring reindustrialization adequate to contemporary requirements. In sum, the principal goal of manufacturing smartization should be the long-term and sustainable increase of real GDP, taking into account the principles of economic security.

The following recommendations follow from the analysis. Considering that current classifiers (for example, UKTZED) are inadequate for assessing technological intensity in the era of Industry 4.0/5.0, since they ignore the specifics of production processes (for example, 3D printing), it appears advisable to create registries and gradations of goods, services, and activities according to their

compliance with Industry 4.0 technologies, which will make it possible to strengthen the emphasis of the «Made in Ukraine» state policy on contemporary high-technology sectors. It is also potentially useful to deploy special regulatory regimes on the basis of industrial parks to test incentives for the development of smart manufacturing without violating international obligations.

The scientific novelty of the study lies in substantiating the development of smart manufacturing as a key determinant of Ukraine's state policy. The study's adaptation of R. Lawrence's deindustrialization model reveals a Ukraine-specific anomaly: the contraction of the manufacturing sector occurs against the backdrop of economic degradation rather than modernization. This has made it possible to expand the substantiation of the concept of local protectionism as a basis for industrial policy under conditions of limited resources and geopolitical challenges. The practical novelty is reflected in the proposed instruments: the creation of registries of goods, services, and activities by the level of technological intensity (Industry 4.0) and the introduction of regulatory «sandboxes» on the basis of industrial parks. This proposal addresses the systemic problem of the inadequacy of current classifiers and enables the targeted support of high-technology production.

Further research will model the quantitative economic impact of regulatory regimes aimed at stimulating the development of smart manufacturing.

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