

SEARCH SPACE FOR THE OPTIMAL PRODUCTION PLACEMENT

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Purpose: The purpose of the paper is to develop a conceptual framework for identifying the search space for the optimal production placement (SSOP) and to systematize the main factors that determine its formation. The study aims to demonstrate that the correct definition of SSOP is a fundamental stage in justifying optimal production placement.

Design/methodology/approach: The study is based on a systemic and conceptual analysis of spatial economic organization. The authors apply a theoretical synthesis of location theory, facility location research, and contemporary developments in global production organization. On this basis, a classification approach is used to distinguish different types of SSOP and to analyze the influence of production-side and place-side factors on their formation.

Findings: The research identifies five main types of search space for optimal production placement: global (universal), nationally secure, economically secure, production-logical, and place-logical. It is demonstrated that the boundaries of SSOP are determined by economic, technological, security, and spatial factors. The study shows that the same optimality criterion may lead to different location decisions depending on the type of SSOP adopted. Therefore, the correct definition of SSOP becomes a critical prerequisite for scientifically justified decisions on production placement.

Research limitations/implications: The study is conceptual in nature and focuses primarily on the theoretical justification and classification of SSOP types. As such, it does not provide empirical validation or quantitative testing of the proposed framework. Further research is required to identify and systematize detailed subtypes within the production-logical and place-logical SSOP, as well as to develop robust quantitative methods and models for determining SSOP boundaries for specific goods, technologies, and market conditions. In addition, future studies should incorporate empirical case analyses and comparative cross-country research to verify the applicability of the proposed approach under different economic, technological, and institutional settings.

Originality/value: The paper proposes a systematic conceptualization of the search space for optimal production placement and introduces a structured typology of SSOP. The study highlights the importance of explicitly incorporating SSOP boundaries into the formulation of optimal location criteria, which is often overlooked in traditional location analyses.

Keywords: spatial economic organization; location factors; production location.

Category of the paper: Research paper.

1. Introduction

Research on issues related to improving the placement of goods production is important, as optimal production placement is a significant and sometimes even a decisive factor in its efficiency. Therefore, production placement should not be carried out on random or intuitive decisions, but requires scientifically grounded methodological approaches. One of the promising areas for improving the production placement is the research of the search space for the optimal placement (SSOP). Correct identification of the SSOP makes it possible to reduce the volume of spatial modeling, which, in turn, enables the simplification, cost-effectiveness, and acceleration of information support processes without losing the quality of scientific justification.

The issue of the correct spatial economic organization, within which the concept of SSOP was formed, has been the subject of research since the inception of economic science. Despite the long history of this research, a systemic answer to the key problems of SSOP has not yet been formulated (Drezner, Eiselt, 2024; Card et al., 2025; Marianov, Eiselt, 2024). This applies both to research on the optimal production placement of material goods (Melo et al., 2009; Owen, Daskin, 1998; Chakravarty, 2005) and to the production placement of intangible goods, i.e., services (Roig-Tierno et al., 2013; Fildes et al., 2022; Hernandez, Bennison, 2000). Some research focuses on the factors that determine production placement (Falck, Heblich, 2008; Krenz, 2024; Mueller, Morgan, 1962), while others focus on the barriers that limit it (Cordeiro et al., 2024; Newell et al., 2006; Alsheyadi, 2024). Research focusing on SSOP in high-production-cost countries is of particular scholarly value (Kano et al., 2020; Ancarani, 2019; Castagnoli, 2022). A significant amount of scientific research is focused on developing methods for justifying the optimal placement of facilities in various fields (Hale, Moberg, 2003; Hamacher, Nickel, 1998; Eldemir, Onden, 2016), with the aim of creating universal approaches suitable for improving the spatial economic organization, in particular through improving the identification of SSOP. A critical review of the existing body of research on the search space for optimal production placement (SSOP) across specific strands reveals a pronounced bias toward the analysis of individual regions (Malecki, 1987; Sekeroglu, Celik, 2025; Sternberg, 2022) and countries (Bakar et al., 2022; Deichmann et al., 2008; Mohammed, Luundo, 2019), thereby reflecting a predominantly political-geographical orientation. However, the absence of a systemic and integrative analytical framework results in a fragmented understanding of the phenomenon, leaving insufficiently explored a wide range of factors that have shaped, continue to shape, and are likely to shape the formation of SSOP.

2. Types of search space for the optimal placement (SSOP)

According to the approach developed in our previous research (Stadnicki, Terebukh, 2022; Stadnicki, Bashynska, 2023), one of the key stages in justifying production placement is to define the space boundaries in which the search for a location or a system of locations for effective (optimal) placement is conducted. SSOP can cover various levels: from global (including the entire planet and even outer space, which, due to its properties, is gradually becoming attractive for the production placement of certain goods) to local (for example, a basic-level administrative-territorial unit or part thereof). The size of the SSOP is determined by a system of factors, among which economic, technological, and security factors are key. According to the proposed approach, it is reasonable to identify the following types of SSOP:

1. Global (universal) — covers the entire planet and outer space.
2. Nationally secure — formed in accordance with state decisions.
3. Economically secure — depends on investor decisions.
4. Production-logical — determined by the characteristics of the "production" side.
5. Place-logical — determined by the properties of the "place" side.

The global (universal) type of SSOP means that the search for a location or locations for effective (optimal) placement is carried out within the widest possible spatial boundaries — not only within the jurisdictions of individual countries, but also in areas outside their sovereignty. Such areas do not belong to any state, but are regulated by international law. These include, in particular, the deep-sea floor and outer space.

The issue of production placement in outer space deserves attention as an emerging extension of the global (universal) SSOP. At the present stage, space-related production activities can be grouped into three main areas: information systems (e.g., communication, navigation, Earth observation), scientific research in microgravity conditions, and industrial production of advanced materials for high-tech industries.

In addition, prospective directions include resource extraction from celestial bodies, space tourism, and waste disposal. The unique properties of space — such as microgravity, vacuum, and high solar energy availability — create specific conditions for material processing, enabling the production of high-purity crystals, advanced pharmaceuticals, and materials with enhanced physical properties.

In the long term, space industrialization is increasingly considered a potential response to global challenges such as environmental degradation and resource scarcity. However, due to current technological and economic constraints, outer space should be treated primarily as a potential, rather than dominant, component of the global SSOP.

Choosing a global type of SSOP during the determination of production placement ensures that the realistic optimal options (rather than the “calculated optimal” options, obtained as a result of incorrect determination of the SSOP type) are not left out of the analysis. At the same

time, this approach requires significant calculations for a large number of potential locations, taking into account production costs for different capacity options and transportation costs to all possible sales markets. Therefore, if abandonment of the global SSOP type does not create a risk of obtaining incorrect results and does not affect the validity of the conclusions, it is advisable to narrow the search space to rational boundaries that correspond to the purpose and context of a particular study.

One of the key factors limiting the SSOP is national security. The COVID-19 pandemic and Russia's military aggression against Ukraine have been powerful catalysts for many countries and intergovernmental associations to establish a nationally secure type of SSOP for the production of strategically important goods — electricity, medicines, food, weapons, etc. The definition of this type of SSOP means that the appropriate goods may be sold on the market of a particular country (or integration association) only if their production is located on the territory of that country or, in extreme cases, on the territory of allied countries (e.g., other EU members). Given the growing risks of disruptions in global logistics chains caused by the pandemic and geopolitical factors, external cost advantages are gradually giving way to the priority of internal supply stability.

A striking example of the implementation of a nationally secure type of SSOP is “Pharmaceutical Strategy for Europe”, which aims to reduce dependence on supplies from third countries (primarily China and India) by creating conditions for the production placement of critically important medicines within the EU. As of 2020, more than 60% of the raw materials used by the European pharmaceutical industry came from these countries. Disruptions in pharmaceutical production in Asia, export bans, and transport restrictions related to the COVID-19 pandemic have caused medicine shortages and price increases in the European market. In response, the EU's strategic goal is to strengthen pharmaceutical autonomy by transferring the production of medicines and active pharmaceutical ingredients (APIs) to the territory of EU member states, which should increase the resilience of the healthcare system and its ability to respond to crisis situations.

After 2022, and especially since early 2024-2025, the EU has experienced a strategic shift toward the accelerated development of its own defense-industrial complex (DIC), resulting from a decline in the United States of America's willingness to guarantee European security. The new EU strategy for the defense industry (European Defense Industry Strategy, EDIS) provides for:

- investment in European weapons and ammunition factories,
- financial and political support for the location of DIC enterprises in EU member states,
- prohibition or restriction of cooperation with arms and ammunition manufacturers outside the EU, even if their products are cheaper or technologically attractive (in particular, with Israel, South Korea, and the USA).

Sometimes, in order to strengthen national security, the concept of a nationally secure type of SSOP is applied not only at the level of the country as a whole, but also to individual components of its territorial structure. In Poland, these levels are gminas, counties, and provinces. In this case, the production of certain goods intended for consumption within a specific administrative unit must be located within its territory. Similarly, the concept of energy self-sufficiency of gminas, the smallest administrative units in Poland, is implemented (Stec, Szymańska, 2022).

The concept of energy self-sufficiency of gminas in Poland is a strategic initiative aimed at providing each gmina, the basic administrative unit of the country, with its own production of energy from renewable sources to meet local needs. This approach combines energy security, environmental sustainability, and economic efficiency at the local level. Within this concept, there is no single national standard for the share of energy that needs to be covered by local production. At the same time, the results of studies conducted in a number of Polish gminas show that the potential of renewable energy sources can meet up to 76.1% of the needs of the local community (Woch et al., 2017).

The need to strengthen national security is the main driver behind the development of the concept of energy self-sufficiency for gminas in Poland. With the growing threat from Russia, especially after the full-scale invasion of Ukraine, it has become clear that centralized energy systems are highly vulnerable: a single enemy sabotage is enough to leave a significant part of the country without power. Distributed (decentralized) energy production offers several strategic advantages:

- greater resistance to attacks — the enemy is physically incapable of destroying thousands of small installations located throughout the country,
- community autonomy — a gmina can function independently for a certain period of time, even in case of a large-scale energy crisis,
- rapid recovery — damaged elements are easy to replace, unlike large energy hubs,
- increased local responsibility and participation — communities invest directly in their own energy security.

This logic is consistent with Ukrainian approaches to critical infrastructure protection, in particular, the development of autonomous power sources for hospitals, schools, and local authorities. In Poland, this model is supported by both the government and the EU as part of its energy transition programs (Green Deal). At the same time, it is based on a pragmatic response to the immediate threat of war.

In terms of improving the economic security of companies, the COVID-19 pandemic has led to a profound structural reassessment of risks in global logistics chains. Companies are increasingly shortening their length, strengthening their own resilience and supply chain management. Production is returning closer to key sales markets in order to:

- reduce logistical risks (supply disruptions, delays, rising transport costs),
- improve quality control and technological processes,
- cost reduction under conditions of rising freight rates.

In addition to traditional criteria (salary levels, tax conditions, access to resources), modern companies are increasingly taking additional factors into account:

- the possibility of disruptions in logistics,
- infrastructure stability (transport networks, energy supply),
- geopolitical stability.

The management of these risks is gradually being integrated into corporate strategies as a separate component of the risk management system. This means that the production placement is considered not only through the prism of costs and revenues, but also as a tool for ensuring the long-term sustainability of the business model. Companies are creating special units to monitor geopolitical and infrastructure risks, applying scenario planning, and diversifying supplies to minimize the likelihood of critical disruptions. Thus, spatial decisions in production are increasingly becoming an element of strategic risk management.

In modern conditions, the SSOP of production is gradually narrowing toward more stable, less distant, and more predictable locations, even if they are not characterized by minimal costs. In other words, an increasingly higher priority in production placement is given to those spaces that ensure short, controllable logistical chains and a high reliability of supply. A striking confirmation of this trend is the relocation of part of the production of American and European companies from China to Mexico, Poland, Turkey, and the Baltic countries — that is, to countries that combine relative proximity to sales markets with political and economic stability.

The concepts of “reshoring” and “nearshoring” are closely related to nationally and economically secure types of SSOP. “Reshoring” is the process of returning production to its country of origin after it has been moved abroad (usually to countries with lower production costs, such as China, India, or Vietnam). The main goal of “reshoring” is to reduce logistical risks, shorten supply chains, strengthen product quality control, and strengthen the national economy by creating new jobs and preserving technological sovereignty. An example is a USA company that manufactured electronics in China but decided to move part of its production back to the USA due to geopolitical tensions, increased moving costs (transportation costs and customs duties), and a desire for greater supply chain resilience.

“Nearshoring” is the transfer of production capacity from distant countries (e.g., in Asia) to geographically closer countries. This approach reduces logistics costs and delivery times, lowers the risks associated with disruptions in global supply chains, and simplifies communication between the producer and the sales market. An example is a German company that previously produced automotive components in China but decided to locate its plant in Hungary or Poland to be closer to the European sales market.

A comparison of “reshoring” and “nearshoring” is provided in Table 1.

Table 1
Comparison of Reshoring and Nearshoring

| Characteristic | Reshoring | Nearshoring |
|-----------------------|--|---|
| Location of transfer | To the country of origin | To a geographically closer country |
| Main goal | Regaining control and stimulating the national economy | Reducing logistics costs and risks |
| Often associated with | Political motives | Economic expediency |
| Typical example | Relocation of production from China to the USA, owned by USA investors | Relocation of production from China to Mexico, owned by USA investors |

Source: own elaboration.

Often, the factor that determines the formation of SSOP (production-logical type of SSOP) is the properties of the “production” side, which are related to:

- the goods to be produced,
- production technology,
- the resources needed for the production process,
- pollution generated as a result of production.

The production-logical type of SSOP largely depends on the specifics of the goods to be produced. An illustration of this is the centralized heat supply system in a settlement where the heat source (thermal power plant or boiler house) must not be located more than 10 km from consumers. In such a situation, the SSOP is defined as a circle with a radius of 10 km centered on the respective settlement. A similar principle applies to the production of certain confectionery products, which cannot be located more than 30 km from the sales market. At the same time, it is possible to produce for several sales markets, which leads to competition with producers located outside the 30-kilometer SSOP around a single market (for example, a city). This affects the choice of a specific location within the SSOP, but does not change its boundaries.

Thus, the SSOP is determined by the properties of the ‘production’ side, while the “competition chain” affects not the SSOP, but the optimal locations within its boundaries. This does not lead to the formation of a single large SSOP serving many sales markets, although it does create a transitive interaction effect, where production can become part of a broader chain rather than just a local service center. Thus, the SSOP is determined by the internal characteristics of production, and the optimum within its boundaries is formed under the influence of external strategic interrelationships. This position is universal and applies to infrastructure and network solutions — energy, logistics, water supply, education, etc.

The impact of technology on the formation of SSOP is best illustrated by electricity generation, which is possible using various technologies, resulting in significant differences in the determination of SSOP. For example, coal-fired power generation (1) is concentrated in areas where this resource is extracted, as it is cheaper to transmit electricity to consumers than to transport large volumes of coal for production close to the sales market. The location of

electricity generation by solar power plants (2) is focused on areas with high solar radiation potential. Only when the intensity of solar flux exceeds a certain threshold can a specific location be considered promising for the placement of a solar power plant.

The location of electricity generation by burning natural gas (3) is focused on areas with concentrated demand, as transporting gas by pipeline for production close to the sales market is relatively cheap. The location of power plants in close proximity to consumers makes it possible to avoid the electricity losses that inevitably occur when it is transmitted over long distances. In addition, gas-fired power plants are characterized by relatively low levels of environmental pollution, which is an important factor when locating them in densely populated areas.

Electricity generation by wind power plants (4) is focused on areas with significant wind energy potential, since only when the wind flow intensity exceeds a certain threshold value can a specific location be considered promising for their placement. Thus, even with an identical benefit — electricity — the location factors and, accordingly, the SSOP for each production technology will be different.

The properties of resources significantly influence the formation of SSOP, which is best illustrated by low-mobility and immobile resources. For example, immobile climatic resources (solar radiation, wind, temperature regimes) naturally form the SSOP of the production of respective goods (e.g., tourism, energy, agriculture). In turn, the low mobility of fresh raw materials (e.g., fresh fish, vegetables, and fruits) is one of the key factors determining the SSOP of enterprises that process it. Fresh fish, vegetables, and fruits are characterized by:

- a short shelf life without processing (from several hours to several days),
- sensitivity to temperature and mechanical damage,
- a decrease in quality during long-term transportation, even under refrigerated conditions,
- high weight and volume at a low unit cost, which makes transportation economically inefficient over long distances in fresh form.

These properties make this fresh raw material immobile, i.e., difficult and unprofitable for long-distance transportation in its original form. Accordingly, processing plants are located near the places of origin — fruit growing or fishing.

The impact of pollution generated during the production process is an important factor in determining the search space for the optimal placement (SSOP). Enterprises whose activities are accompanied by significant levels of pollution tend to locate in areas where:

- environmental legislation is less stringent,
- enforcement of environmental standards is weak,
- payments for negative environmental impacts are low or non-existent.

An example is the relocation of many chemical and textile companies from EU countries to South Asia (in particular, Bangladesh, Pakistan, and Cambodia), where environmental standards remain low. Similarly, electronic waste (e-waste) is often processed in West African countries (Ghana, Nigeria), where hazardous substances are disposed of using primitive methods that are unacceptable in the EU.

Regarding the impact on SSOP of the characteristics (properties) of the “place” factor. This impact determines which features of a particular space (geographical, legal, political, infrastructural, etc.) make it promising or unpromising for a particular type of production. For example, mountainous areas are poorly suited for mass production due to logistics, but are well suited for tourism-related crafts (an example would be craft cheese production in the Alps). Desert areas are suitable for solar farms and hydrogen production, but have limited infrastructure for all other types of production. Thus, the properties of space determine not only the possibilities but also the limitations for the formation of SSOP, setting specific conditions for the optimal location of production.

A specific characteristic of the “place” dimension is the legal status of the relevant space, which can significantly influence the formation of SSOP. For example, special economic zones provide incentives that stimulate production, and the membership of countries in certain regional economic groupings creates a single economic space (e.g., EU countries). Regional economic integration is a process whereby several countries in the same region join forces to form a common economic space. It may include:

- the removal of trade barriers;
- coordinating economic policy;
- creation of supranational institutions.

The main goal of integration is to increase economic efficiency, expand markets, and strengthen competitiveness.

Looking at regional economic integration through the lens of SSOP, it can be argued that integration associations actually expand or reformat the SSOP of production. This happens due to:

- the removal or reduction of trade barriers — producers can choose the location without fear of export duties to participating countries,
- simplification of the movement of production factors — labor, capital, and technology move more freely,
- unification of standards and rules – the number of legal barriers between participating countries is reduced,
- joint infrastructure projects – new transport and energy corridors change logistics conditions.

Thus, regional integration not only removes barriers but also creates new opportunities for optimizing the location of production, influencing the formation of SSOP.

Another characteristic of the “place” factor that influences the formation of SSOP is the currency used within the relevant space (country or integration group) to finance expenses. A telling example is the decision made by the South Korean corporation Hyundai in the early 21st century to locate a new car plant in the USA. As a result, the city of Montgomery, Alabama, was chosen (production started in 2005). The basis for identifying the USA as SSOP was that the company received revenue from the sale of cars on the American market in US dollars.

If a significant portion of expenses (wages, utilities, localised components, energy) is paid in dollars, then:

- currency risk is reduced — the company does not need to convert large amounts of revenue into Korean or other currencies to cover expenses, and dependence on exchange rate fluctuations is reduced,
- financial planning becomes more stable — expenses and income in one currency make it easier to forecast financial flows and ensure the predictability of the business model.

An important characteristic of the “location” factor is infrastructure accessibility. Locations near ports, railways, and highways are strategically advantageous for many types of production. A prime example is the logistics parks in the Netherlands near Rotterdam, equipped with direct connections to the railway network, pipelines, and intermodal terminals. Accordingly, the space affected by infrastructure forms a specific SSOP, within which the optimal production placement is determined by the accessibility of transport and communication corridors.

An important characteristic of the “place” factor is demographic and social potential, as high-tech production requires a highly skilled workforce. This leads to a focus on locations near university cities, where an appropriate environment for knowledge and innovation is formed. Notable examples include IT clusters in Krakow, Lviv, and Brno. Since demographic and social potential has its own sphere of influence, it directly determines the formation of the respective SSOP.

Obviously, the above list of characteristics of the “place” that influence the formation of the SSOP is not exhaustive. At the same time, the examples given convincingly demonstrate that the characteristics of the “place” — geographical, legal, political, infrastructural, socio-demographic, and others — can significantly determine the parameters of the SSOP and form specific conditions for the optimal production placement.

When studying the issue of optimal placement of goods production, one should take into account the influence of the correct definition of SSOP on the choice of optimal locations and production volumes. The influence of SSOP lies in the fact that the justification of optimal decisions always refers to a specific SSOP, rather than an undefined space. Therefore, the application of the same criterion of optimal placement (for example, minimization of total production costs and costs of moving goods to sales markets) for different types of SSOP (for example, nationally secure or global) can lead to different results regarding the locations and volumes of production in these locations.

Thus, SSOP is so important that it must be taken into account when formulating the criteria for the optimal placement of goods production. The impact of SSOP is that any criterion for optimal placement applies specifically to a particular SSOP, rather than to an abstract space. Therefore, the formulation of the criterion must always include information about the boundaries of the SSOP. The criterion for optimal placement, taking into account SSOP, does not necessarily give a different result than the criterion without spatial restrictions. However, justification within one type of SSOP may lead to different conclusions about the optimal placement and production volumes than a similar justification within another type of SSOP.

3. Conclusions

In summary, we emphasize the key points:

1. The correct definition of the search space for the optimal placement (SSOP) is a determining factor in improving the production placement.
2. The issue of spatial economic organization, within which various forms of SSOP have been raised, has been studied since the very beginning of the development of economic science. At the same time, a systemic answer to these questions has not yet been formulated, as numerous important factors that have influenced, influence, and will influence SSOP have been overlooked.
3. It is advisable to distinguish five types of SSOP: global (universal), nationally secure, economically secure, production-logical, and place-logical.
4. The properties of the “production” side that influence the formation of SSOP are related to: the goods planned for production; production technology; resources necessary for production; pollution generated during production.
5. The properties of the “location” side that influence the formation of SSOP cover the characteristics of a specific space (geographical, legal, political, infrastructural, etc.) that make it promising or unpromising for a particular type of production.
6. The formulation of the criterion for optimal production placement must always include information about the boundaries of the SSOP, since the application of the same criterion to different types of SSOP can lead to different results regarding optimal locations and production volumes.

Further research on SSOP is promising in several areas. First of all, this concerns the identification of subtypes within the fourth (production-logical) and fifth (place-logical) types of SSOP, which will be based on the specific properties of the “production” and “location” sides. It is also important to justify the type of SSOP for various goods that can be produced using interchangeable technologies. In-depth research in these areas will contribute to the

improvement of the theory of SSOP for the goods production and, accordingly, the development of the theory of production placement, which is key to improving business efficiency.

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