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Maritime spatial rent for modelling maritime spatial development[1]

Abstract: The paper focuses on problems related to modelling the development of maritime economic space. This entirely new issue has emerged from the recent changes in the intensity of use of marine areas. First, the economic significance of maritime space is discussed, followed by a simple model based on maritime spatial rent which aims at explaining the patterns of its development. This model encapsulates the interplay between both market and public choice factors that affect the development of maritime space. The paper also includes a discussion of attempts to obtain a monetary value of maritime spatial rent for key offshore maritime sectors in Poland. The paper concludes with suggestions on further developments in this field.

Keywords: maritime spatial rent, maritime spatial development, maritime economy

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Morska renta przestrzenna a zagospodarowanie przestrzeni obszarów morskich

Streszczenie: Autorzy analizują procesy modelowania rozwoju przestrzeni morskiej w jej ekonomicznym wymiarze. To nowe zagadnienie całkiem niedawno przykuło uwagę badaczy śledzących wzrost tempa i zakresu użytkowania obszarów morskich. W artykule zostało przedstawione gospodarcze znaczenie przestrzeni morskiej, a następnie zaprezentowano prosty model oparty na morskiej rencie przestrzennej, jako narzędziu objaśniania zmian w zagospodarowaniu przestrzennym obszarów morskich. Model ten ujmuje oddziaływanie zarówno sił rynkowych, jak i decyzji wyboru publicznego, które wpływają na rozwój przestrzeni morskiej (jej zagospodarowanie przestrzenne). W artykule omówiono również próby zmierzenia wartości pieniężnej morskiej renty przestrzennej w odniesieniu do kluczowych sektorów gospodarki morskiej w Polsce. Tekst kończy się propozycjami dalszego rozwoju badań w tej sferze.

Słowa kluczowe: morska renta przestrzenna, zagospodarowanie przestrzenne obszarów morskich, gospodarka morska

Introduction

Economic space is not flat. Productivity is much higher in large metropolitan areas (World Bank 2009). Approximately 70% of extremely wealthy individuals, persons who own assets that are worth $30 million or more, live in ten global metropolises, with Hong Kong ranking first (White et al. 2018, p. 19). In global terms, production is concentrated in the U.S., Europe and East Asia. According to the World Bank data on the 2017 GDP, the combined GDP of the U.S., China, Japan and Germany was higher (50.6%) than that of all the remaining countries. However, as a rule, sea space was omitted in discussions on the concentration of economic activities.

This trend has changed only recently (Zaucha 2009b). Although in the past seas also played an important economic role, e.g. determining location patterns and productivity on land (Bakker et al. 2018), their direct use was limited mainly to navigation and fishery as well as coastal tourism. In the middle of the 20th century, offshore drilling began on the U.S. coasts, and Norway started to experiment with mariculture in fjords. Nowadays, the range of sea uses is much wider (see the next section), and scarcity of the sea space even prompts multi-use combinations (Depellegrin et al. 2017; Bonnevie et al. 2019), in particular in the North Sea (Sangiuliano 2018). At this stage, seas and oceans have become increasingly developed, requiring, therefore, a more profound analysis and understanding.

Progress in scientific research and in economic modelling, specifically, has not caught up with this development. Maritime (marine[2]) spatial economics does not exist at all. Even the concept itself is vague and undefined. The definition provided by the seminal publication of Fujita et al. (2000), according to which spatial economics combines research on international trade with urban and regional

[2] The adjectives marine and maritime in relation to space will be used interchangeably following the proposal of Zaucha and Gee (2019) although, for some authors, they have slightly different meanings, i.e. relating marine to natural and maritime to economic processes constituting the space in question (OECD 2016, p. 21; Cormier et al. 2015, p. 1).

developmental patterns excludes sea areas from the analysis of this branch of economics. Also Jones (2017) views spatial economy "as a complex network of economic flows within a hierarchical urban system" (Jones 2017, p. 486). Yet, there are no urban nodes at sea nor people inhabiting the sea space. As a result, the spatial patterns of economic development would require a different approach. This paper tries to fill in this gap by proposing a number of tentative solutions regarding the modelling of maritime economic space, identifying the key obstacles in that regard and suggesting a number of ways forward.

The changing patterns of sea use

The increase in the economic use of sea areas is an already visible process, one that has been discussed in a number of political documents and reports. As stated by the European Commission (EC 2016, p. 2), oceans hold the key to the future for the European Union and many nations around the world. According to the OECD (2016, p. 13), in 2010 the Blue Economy yielded global products and services worth €1.5 trillion, or 2.5% of world gross value added, providing 31 million jobs. According to EU estimates (EC 2019), the Blue Economy sectors providing employment for 4 million people in the EU with an average salary of €26,400 per annum, contributed to the EU economy with a gross added value of €180 billion.

New methods of procuring the benefits of the sea (EC 2014b, p. 3) have emerged while the current ones are undergoing profound transformations (Zaucha 2009b). Newcomers such as offshore renewable energy generation (wind, tide)[3], artificial islands for tourist and housing purposes, maritime protected areas, extraction of polymetallic concretions, wreck diving, sea angling and pescatourism, or bioprospecting, have just started to colonise the sea or are in the early stages of the process. The development has been unevenly spread, with its concentration around the coasts of Western Europe. In consequence, the North Sea has become a pioneer in maritime spatial governance in order to cope with the aforesaid challenges.

However, a similar tendency regarding a more efficient use of sea space (e.g. multi-use) can also be observed even in the Mediterranean Sea (Depellegrin et al. 2019) and the Eastern Atlantic (Calado et al. 2019). This situation shows quite a new phenomenon, i.e. the occurrence of conflicts over the use of maritime space, at times concerning areas at a distance from the coast. These conflicts may result in contradictory claims to the seas and, recently, their occurrence has extended even to high seas, i.e. sea areas beyond national jurisdictions (Altvater et al. 2019).

The current situation in the Arctic, a result of climate change (Janicki 2012), can serve as an illustration. Many scholars are of the opinion that public policies should be adjusted accordingly in order to prevent such conflicts and ensure

[3] For instance, employment in the EU wind energy sector increased by 14% in one year (2016-17) (EC 2019, p. 3)

maximum benefits for the society from the use of sea space (e.g. Kyriazi et al. 2016; Bonnevie et al. 2019). All of the above leads to the conclusion that maritime space has acquired alternative costs and there is a dire need for economic research on the patterns and mechanisms shaping its development. In addition, one should keep in mind that seas and oceans deliver important benefits without any human effort, including maritime landscapes carbon capture and storage, coast stability, biodiversity or nutrient absorption, among many others. Such benefits are named ecosystem services if related to the biotic part of the sea space (Lillebø et al. 2016).

Key factors determining the use of maritime (marine) space

There are several factors behind the increased economic interest concerning the use of sea space in new ways. The initial motivating agents were related to demography and the growing demand for new jobs. The accelerated development of the Blue Economy was among the solutions provided for the elimination of poverty in developing countries (Barbesgaard 2016, p. 1). As pointed out by the OECD (2016, p. 18), "by mid-century, enough food, jobs, energy, raw materials and economic growth will be required to sustain a likely population level of between 9 and 10 billion people", and "the potential of the ocean in helping meet those requirements is huge".

A related concern is that of limited resources. For instance, as the rate of domesticated land has increased rapidly in the previous century[4], sea space can be viewed as an alternative to land. This shift has already resulted in the creation of large artificial islands for dwelling purposes in some countries. On a number of occasions, the sea provides better conditions for the location of certain economic activities (i.e. bigger and, therefore, more efficient offshore wind turbines than turbines on land). Equally important to the increase in demand for high-quality services and resources is technological change.

Technological development uses the sea to achieve more appealing and promising economic ends. One example is energy production from waves and tides, a non-exhaustible resource and more predictable (and therefore more economically efficient) than wind which requires an alternative replacement source (so-called back-up for non-windy days). The technology for this particular purpose is at the testing stage. Due to technological reasons (technology that makes its mariculture possibe, which is not the case with cod, for instance), salmon is currently one of the most popular fish in the European market. As such, mariculture has become the fastest growing source of animal protein in the world (Hryszko et al. 2014).

The technological driver of blue growth takes the form of a feedback loop. Technological progress, which facilitates further use of the sea for economic growth, increases the demand for sea surveillance which, in turn, requires new technologies for that purpose, stimulating the development of marine technology

[4] Anthropocene website http://www.anthropocene.info/ga-es11.php

and the formation of marine clusters. Improved knowledge of the sea facilitates the emergence of new sea uses and the continuation of the process. The third economic driver is an increase in incomes and the prosperity of European Societies, which results in a growing demand for sea-related leisure time services, particularly those concerning marine tourism. Yachting and cruising can serve as an example. They have been developing rapidly in the EU. Coastal tourism represented the sector with the highest growth (26.1%) of gross value added in the EU in 2009-2017 (EC 2019, p. 20).

Nonetheless, economic motives are among many other determining agents in the use of marine space. They play a key role in attracting the business sector to the sea but, in the EU, an equal role is played by environmental concerns. Seas and oceans are treated as valuable habitats requiring careful protection. For instance, more than 60% of Polish territorial waters is covered by NATURA 2000 as areas established under the EU legal framework. All over the world, maritime protected areas have been created (Agardy 1997; Stelzenmüller et al. 2013). In addition, social and cultural elements have recently started to play a more prominent role in shaping maritime space (Saunders et. al 2019; Gee et al. 2017; Gee & Siedschlag 2019). Immaterial benefits derived from sea, such as cultural identity, aesthetic appreciation, or personal and community competences, might prompt people to organize themselves in order to protect those values for the present and future generations.

Finally, sea space is also shaped by natural processes such as erosion, transportation of sediments, the depth of the photic zone, salinity, etc. When developing a specific part of the sea, these processes must be takem into consideration: adapted to or altered. Several complex processes caused by multiple factors also exist. Among them, climate change, particularly a rise in sea levels resulting for ice melting in the Arctic and Antarctic, has come to the forefront. The Intergovernmental Panel on Climate Change predicted that, under the current gas emissions patterns, the global sea level will rise 52–98 cm between 2000 and 2100 (Church et al. 2013, p. 1140). If correct, this might mean that Polish territory will be deprived of the Vistula River estuary due to the flooding of the Żuławy area.

A perfect summary of the discussion is provided by the following quote from the OECD report: "The new 'ocean economy' is driven by a combination of population growth, rising incomes, dwindling natural resources, responses to climate change and pioneering technologies" (OECD, 2016, p. 3). From the perspective of modelling the development of maritime space, one can conclude that this space is shaped by an interaction of market forces and public policies. The latter seems to be of key importance as a consequence of the specific nature of sea space as a factor of production and location.

The complexity of modelling the development of maritime space

In social sciences, the category of space has many overlapping meanings and a wide semantic value. Space can be treated as: a limited non-renewable resource

(or renewable in the long run if carefully managed), a rare final good, a condition of development, an inherent value (heritage value or existence value) and, finally, an instrument of policy implementation (Zaucha 2007, pp. 12–13). Space is the subject of research and investigation by: physicists, biologists, geographers, economists, political scientists, spatial planners, sociologists, philosophers and scholars of culture. As Faludi notes (2013, p. 8), "Territory is not necessarily a fixed entity enveloping all major aspects of social and political life within its boundaries. Rather, it is the object of negotiation and compromise, open to multiple interpretations." This also applies to maritime space.

Seas and oceans satisfy many human needs through the market and outside the market, a truth which extends to the aforesaid cultural values. As observed by many scholars, seas and oceans have what is termed existence or intrinsic value[5]. The problem is that they are considered to be common-pool resources or goods (Ostrom et al. 1994, p. 7), a category characterized by competitiveness of consumption and non-excludability (Daly & Farely 2011, p. 169). Therefore, seas and oceans may share the fate of deserts or virgin forests. According to game theory, maximizing individual payoffs here and now at the expense of the resource itself is profitable (Wołyniec 2013, p. 58). Consequently, there are conflicts over the use of maritime areas that lie beyond national jurisdictions, which may result in contradictory claims to the seas. Thus, exploitation patterns of maritime space result not only from pure economic reasons but are conditioned by important intervening factors such as geopolitics of space, regulatory regimes and different national policy orientations (which are often geopolitical in nature). Politics at various levels plays an important role here and the final outcomes might also be shaped by vested interests, asymmetry of information and the economic position of the various actors determining their ability to influence public decisions (e.g. Flannery et al. 2019).

In order to model the economic development of sea space, one should first consider the complexity described above. Various mechanisms and patterns of development pertaining to maritime space interact with each other. For that reason, maritime space still lacks its own theoretical considerations which can help explain and predict its development[6]. The key economic concept that might simplify further discussion is (in line with mainstream economics) the notion of rent provided by marine space. In this paper, such rent will be discussed not only from a private but also social perspective due to the importance of the aforesaid intervening factors related to non-market benefits and externalities. In addition, in order to simplify the discussion, we will temporarily abstain from heuristics and the concepts of political economy, relying instead on the less realistic, but still acceptable on economic grounds, assumptions of rationality, according to which both private and public actors shaping the economic use of sea space calculate and compare the benefits offered from different alternatives.

[5] This is the inherent value of an entity.

[6] The ideas presented in the paper are discussed more extensively in the monograph by Zaucha (2018a), in Polish.

Maritime spatial rent

The focus in this paper is on maritime space being either a factor of production or the location component necessary for furnishing society with goods and services, including public ones. In such a case, sea users providing these goods and services try to secure access to maritime space that is suitable for their purposes. In the conditions of a pure market, they would be willing to pay for such access. In economic terms, this means that they estimate the rent they accrue from using a given sea area. The decisions of the sea users are dependent on the patterns and value of maritime spatial rent.

The rent is a payment for the right to use the land in question. It is a monetary expression of the net benefits received by the lessee from the cultivation/use of the land and transferred to its owner. On the one hand, rent should compensate the owner for the inconvenience and discomfort associated with the relinquishment of power over the land (demand rent), and, on the other, it should not exceed the excess of benefits over the costs of land use to its user (supply rent). Most often, economics analyses the latter type of rent, assuming that it represents the remuneration for the solid factor (land) obtained after deducting the remuneration for the variable factors (capital, labour). Depending on whether the payment is regular or one-off, the monetary expression of the rent may be the lease payment or the price of the land (net accumulated rent discounted for the current period).

Different types of supply rent have been identified in the literature thus far. Their sources include: varied land productivity, different intensity of production factors applied to a given plot, scarcity of available land, location (in particular, distance from the markets) and related transport costs. They will be briefly reviewed below and then analysed from the maritime space perspective.

1. The source of **extensive differential** rent arise from the differences in soil fertility (see Ricardo 1957 [1817]). In a situation where on marginal plots (the least fertile, in which it still pays to grow plants) the differential rent tends to zero, and on more fertile ones the amount of expenditure per unit of land (ensuring production volume per unit of land to be equal to the level achieved on the marginal plots) it is lower than that on marginal ones, the volume of benefits is higher. In other words, the "land" factor is broken down into various fertility classes in the production function. In contemporary economics, fertility has been changed to the land's levels of suitability concerning different economic activities (e.g. construction, mining, etc.).
2. The reason for an **intensive differential rent** may be the difference in the proportions in which land is combined with other factors of production, i.e. capital and labour (see Ricardo 1953 [1817]). This rent is equal to the quantity of production factors used, multiplied by the difference between their average and marginal productivity, assuming that the quality of land is uniform and the transport costs are constant.
3. Under the assumption of long-term perfect competition, the market should provide an equalization of the marginal productivity of factors and, thus, also the intensive rent, which in this case would lose the attributes of differential

rent and strictly become scarcity rent. The reason for the **scarcity rent** is the limited supply of land with requisite characteristics. This limitation means that the market price of goods and services produced using land makes the use of land less profitable than the most suitable use for a given type of an economic activity.

4. Thünen rent (after the German researcher Johann Heinrich von Thünen (1826)) results from the difference in transport costs assuming space homogeneity, and therefore a similar level of productivity for each plot (uniform production costs per unit of land area regardless of its location). In this model, rent is a decreasing function of the distance from the market (cf. Dramowicz 1978, p. 58).

The concept of rent has also been extended to non-agricultural applications (Alonso 1964). In contemporary economics, rent is considered a surplus earned by any factor of production (not only land) over and above the minimum earnings necessary to activate such a factor in the production process (i.e. above transfer earnings). The reason for rent is the scarcity of a given factor or its specificity. However, land maintains its unique position due to its ability to safeguard rent in the long run. To sum up, it can be noticed – drawing on Blaug (1985) − that space, in its various applications, furnishes the users and its owners with additional benefits (rent) for various reasons but, above all, due to its scarcity and specificity. A similar situation can be noticed at sea. The behaviour of sea users indicates that different sea areas are not equally valuable to them. Sea users make use of various features of sea space to maximize their benefits. This trend may be related to the endowment of a given sea area with valuable resources (this is important for fisheries, mining, tourism or wind energy) but also to the distance of a particular areafrom the shore or port (important for shipping or laying cables and pipelines but also for wind energy).

Maritime spatial rent has appeared only recently when the sea space has become increasingly scarce. Nowadays, rent seems to determine the decisions of sea users who are part of the business sector. In general, thy attempt to develop maritime space that yields strictly positive rent by choosing available locations that maximize their profits. These choices might manifest themselves in what is commonly termed bid rent, i.e. the amount of money the users of a given part of land are willing to pay for earning the right to use it. The amount corresponds to the profits or utility provided by a given piece of land. The rent depends on the natural features of a given area, features which are decisive in terms of its productivity, and its distance to the areas it services.

The problem, however, lies in the absence of a maritime space market that would reveal the magnitude of such rent. In many cases, sea space users do not pay for its use. This applies to e.g. tourism and shipping, ports and fisheries. In the Polish context, the fee is paid only by offshore energy and mining companies, and these fees are regulated by public administration and not by the market. They do not reflect rent but are a component of costs. What constitutes a common element of the classic theory of rent and marine rent research is the fact of net benefits resulting from the use of sea space which are shared by its users. Thus,

maritime spatial rent can be equated to a decrease in net benefit in a situation where sea space would not be available. According to rent theory, maritime space users would be willing to pay such a value if they were forced to do so for the opportunity to use maritime space. In the case of fishing or shipping, it can be assumed that this is the entire net profit while, in the case of coastal tourism, only a part of it results from location benefits. For some users, sea space is homogeneous (the benefit results from lower transport costs at sea than on land), thus they pay attention only to the scarcity rent. For the others, e.g. fishing or mining important is also an extensive differential maritime spatial rent (due to natural endowments).

A key problem is the large scale of externalities related to the use of maritime space and other costs and benefits that are not valued by the market. These include all types of ecosystem services produced by the marine ecosystem with the exception of a few provisioning services. This category also includes abiotic benefits, e.g. underwater cultural heritage, the beauty of the sea landscape (seascapes). Maritime space also provides public goods (e.g. national defence) which have no market price but, rather, only a tax price that however does not always reflect the net benefits derived from national defence. As a result, two types of rent exist. The first (private rent) is perceived by the private sector and informs their business decisions. The second one (public rent) takes into consideration externalities, societal values, etc., and should inform the decisions of the public authorities in charge of the sea.

Private rent at sea

Spatial rent, as perceived by businesses, may be a useful tool in analyzing the market outcomes related to the development of space, as this approach mirrors the case of urban areas (Fujita, Thisse 2002, pp. 78–83). Taking into consideration the discussion in the previous section of the present paper, the costs of covering the distance at sea are mainly related to the proximity of the costs and terrestrial gateways servicing sea areas (e.g. ports, bathing beaches, etc.). As it regards maritime space, it seems appropriate to consider return to models which include the already existing (*a priori*) agglomerations of human beings, such as the existence of terrestrial gateways servicing sea areas, since the economies of agglomeration are absent in sea areas and people concentrate mainly on the coast. They are supplied with the products of sea areas. The most promising model in this case is the Thünen model, which assumes the existence of an exogenously designated market place, and which is used in the analysis of spatial development of cities (McCann 2013, pp. 107–153).

In essence, Thünen's concept includes an exogenously given sales market with two parameters forming spatial patterns around it. The two parameters are net benefits per unit area of the cultivation of different agricultural products and the costs of their transportation. The goods that yield high profits and have high transportation costs are cultivated near the sales market. The location of less profitable and expensive farming is further out, with the least effective soil use, but which

is also cheapest in transport per unit, the latter being a location that is even more distant. This is the result of the differences in the slope of the function of spatial rent, when transportation and production costs are subtracted from the total revenue. This results in Thünen's famous location rings (Blaug 1985). Similarly, it seems that spatial development of sea areas is formed as an interplay between distance and potential revenues and is concentrated around terrestrial gateways servicing sea areas (Szejgieć-Kolenda et al. 2018).

Applying the typical neoclassical approach (Fujita & Thisse 2002, p. 68), one can explain the maritime space use equilibrium pattern by changes in the bid rent function. Assuming that spatial rent decreases as the distance from the coast increases, it is plausible that the market forces at sea will lead to the formation of Thünen's semi-rings (assuming that the coastline is straight) around the terrestrial gateways servicing sea areas. The first semi-ring contains typical functions according to their proximity to the port (anchorages, dumping sites), followed by coastal tourism (dependent on coastal amenities), while others, such as wind energy at sea, lie further away, with fishing or sea tourism (yachting) even farther. The regularity of the rings can be spoiled by the heterogeneous productivity of the space due to natural conditions e.g. the existence of deposits, grouping of the fish stock or areas particularly susceptible to wind energy. However, a similar dilemma appears on land (McCann 2013, p. 127), which may bring about a concavity in certain fragments of the rent function, meaning that rent functions can intersect at several points. Consequently, similar methods of reaping the benefits of the sea may appear in several areas at various distances from the terrestrial sea gateway. Rescission of the assumption regarding the proportionality of transportation in favour of concavity (growing profits of the scale) will have similar results. However, the lack of maritime space with suitable characteristics may render it ineffective. This results from the fact that the rent curve, in this situation, becomes a discontinuous, non-monotonic function.

Figure 1 illustrates a hypothetical situation based on several preliminary estimates of spatial rents in Poland (see the next sections). The rents for ports and coastal tourism are steeper since both activities require space that is close to the coast. This is not the case with wind mills and fisheries, which reveal a less steep downward-sloping rent gradient. Navigation is a special case as its rent is of a tunnel nature and depends on the configuration of two or more terrestrial gateways linked by sea transport. Therefore, navigation is not included in Figure 1.

However, the general picture is more complex. Firstly, rent for renewable energy depends on market saturation. Continuous construction of new facilities might deplete rent with price decreases and back-up facility instalments that are necessary in cases of wind shortage. Secondly, if wind mill development blocks navigation, the port rent would be affected, as well. Thus, the market would not allow for such an outcome. Fishery is possible in several places dedicated to navigation as well as within wind farms. As such, the rent pattern will not exclude such activity entirely, except when it takes place in proximity to the coast. Thirdly, the picture does not cover commercial activities that do not exist in Poland, such as aquaculture, or those for which rent has not been computed yet, as is the case with

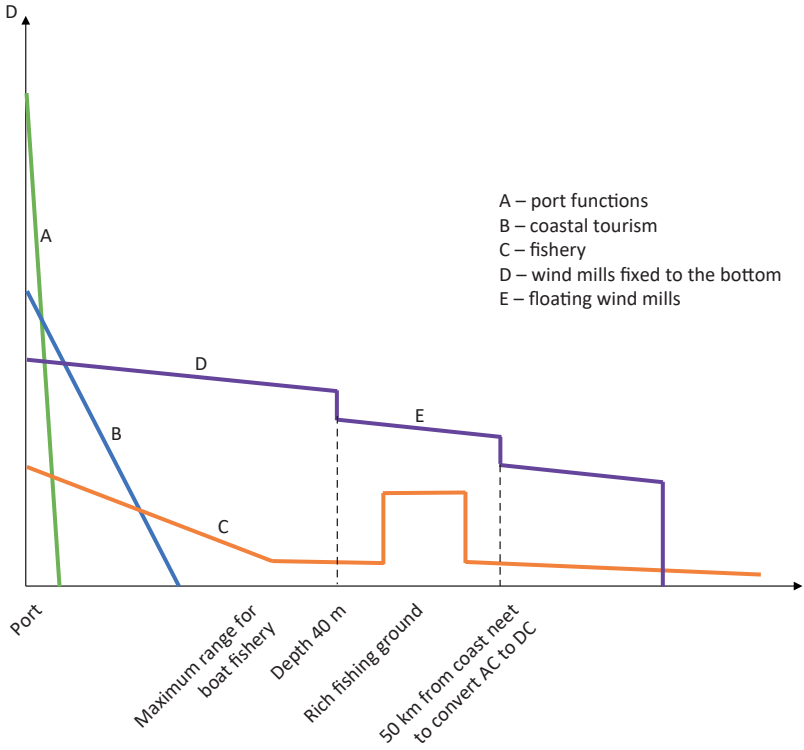

Figure 1. Hypothetical pattern of spatial development at sea based on rent estimates in Poland

Source: elaboration by J. Witkowska based on Zaucha (2018a).

offshore mining. Finally, public administration can affect the magnitude of the rent, an issue to be discussed in the next subchapter.

Public rent at sea

The considerations in the previous subchapter are linked to the assumption that the market allocates a specified area to the most beneficial aspects, i.e. maximizing net benefits. However, as previously mentioned, ocean space and the resources it contains are textbook examples of market failure. For instance, Markowski and Drzazga (2015, p. 11) claim that, "in modern economy, all spatial dimensions along with the phenomenon of time as its fourth dimension, are becoming the subject of political intervention as a result of a lack of proper allocation market mechanisms (lack or in-operational markets)."

It was the fear of market failure while developing maritime space that resulted in the establishment of maritime spatial planning (MSP). This is the process of aggregating public preferences regarding maritime space development (Ehler et al. 2019) that cannot be revealed through the market because of various reasons,

mostly related to value judgements or the public nature of some investments. Indeed, the axiological layer plays an important role in developing maritime space since unspoiled seas and oceans have great value, one which is unrelated to their uses. As discussed above, this is mainly due to the ecosystem element of sea space; yet, it is also partially due to the emotional bond between people and the sea (Gee 2019). Therefore, maritime spatial planning generally aims at the sustainable development of seas and oceans (Zaucha 2019; Kyvelou 2017), paying equal attention to the societal, economic and ecological outcomes of this development (Sachs 2015). MSP offers some form of arbitrage between these aims that is in line with key societal values and concerns. Though a kind of universal agreement on this matter does exist (Saunders et al. 2016), the few differences that may arise concern the importance of the individual dimensions of sustainable development of maritime space. The European Commission is also explicitly in favour of this paradigm (EC 2014a, Article 5).

For instance, the Polish maritime spatial plan draft aims at:

- the sustainable development of blue economy, including inter alia resilience to climate change;
- enhancing national defence and security;
- ensuring coordination of relevant entities as well as ways of using the sea and coastal areas;
- increasing the share of blue economy in GDP and number of people employed in it;
- strengthening the position of Polish seaports, increasing the competitiveness of maritime transport and ensuring maritime safety;
- sparing use of maritime space, leaving room for the decisions of future generations (Zaucha 2018b).

Those neighbouring on the Polish sea, however, have followed different approaches. Swedish planning is much more environmentally-sensitive while, for Denmark, blue growth is the main concern.

MSP, as a rule, is complemented by other policies aiming to implement key societal values. Various forms of public intervention are discussed in Zaucha (2019), but they can either influence the spatial rent of businesses (e.g. subsidies, taxes) or make this rent obsolete and ineffectual (e.g. administrative decisions banning some economic activities).

A successful public intervention is instrumental in terms of securing maritime space for some functions of a public good, or of it being subject to substantial externalities, as well as it resulting in the accomplishment of some important values, such as:

- environment preservation (externalities, public good);
- landscape protection (public good);
- national defence (public good);
- underwater cultural heritage (externalities, public good);
- living organisms' welfare (common resources);
- basic scientific research (public good);
- sea left unused for future generations (inter-generational justice).

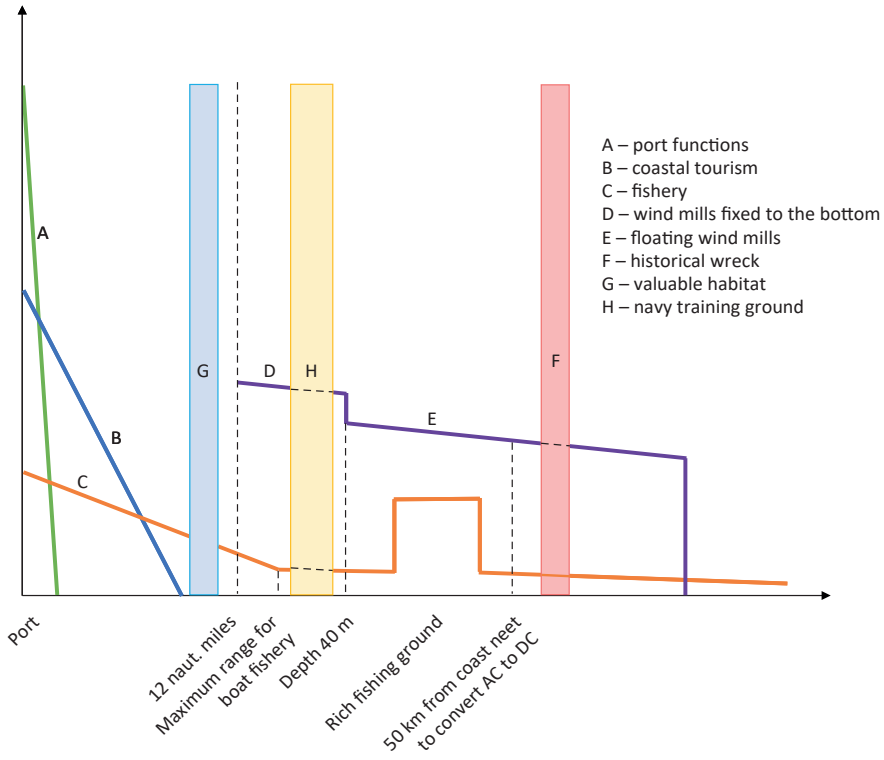

Figure 2. Hypothetical pattern of spatial development at sea with the influence of the public sector, based on rent estimates in Poland

Source: elaboration by Joanna Witkowska based on Zaucha (2018a).

In Poland, a prominent example of a public decision affecting maritime space development is the legal ban on building wind mill farms in territorial waters (i.e. up to 12 nautical miles from the baseline). The main reason behind the ban is to inhibit landscape pollution. However, in reality, the driving force behind the ban was the potential negative impact of wind mills on the revenues of the coastal tourism sector. Public decisions affect bid rents. Figure 2 assumes that regulations secure the protection of valuable habitats and historical wrecks, allocate space for navy training grounds and ban wind mills in territorial waters as well as subsidize energy transfer from wind farms to the coast. The assumption in Figure 2 is that, if some bans are imposed by the government, the "public" rent should be always higher than the rent perceived by businesses. However, there is no specific research evidence to support this assumption.

Large differences between private and public rent for a given sector might also prompt public authorities to act in order to incorporate the difference in the market price. Two possible methods of doing this are by using feed-in tariffs for marine renewable energy or by including the benefits of absorbing sediment nutrients (Kamińska et al. 2018) in the cost-and-benefit analysis of ports or other

fixed structure developments. The problem here is that both public and private rents are difficult to be computed in practice.

Computing maritime spatial rent in Poland

Blue economy is not one of the main drivers of Polish economy, even though it plays a significant role in the coastal belt that is inhabited by over 2 million people (Zaucha & Matczak 2015). According to the estimates of Brodzicki and Zaucha (2013), the six largest Polish maritime economic activities selected on the basis of a score calculated by combining gross value added and the number of people employed by the sector, are, in the order of their magnitude, the fish processing industry and fisheries, shipbuilding (excl. leisure boats) and ship repair, coastal tourism, water projects, short-sea shipping (incl. Ro-Ro) and yachting and marinas. Some of these activities, such as fish processing, shipbuilding and yacht building take place ashore, but others need maritime space. Marine activities with the greatest future potential (expert judgment) are offshore farms (offshore energy production) as well as yachting and marinas, both requiring marine space. For all the aforesaid key activities located at sea, (i) coastal tourism, (ii) ports, (iii) offshore wind energy, (iv) shipping, (v) fishery, an attempt to compute their respective private spatial rent was undertaken (Zaucha 2018a; Zaucha & Matczak 2018). This was successful only in the case of the fishery sector.

While private rent prevails in fisheries, public choice is imposed on it in various ways such as bans, quotas, and financial support from EU funds. The estimation of the rent was based on the information provided by the 2014 Annual Economic Report on the EU Fishing Fleet (STECF 2014), covering all EU countries and VMS (vessel monitoring systems) reports prepared in the Polish National Marine Fisheries Research Institute. The estimation was carried out for small and large vessels (i.e. with a length of over 12 m). The catches and fishing efforts of small vessels (days spent at sea) are calculated using the so-called fishers' squares (4,000 km^2),[7] while larger units, due to technical reasons, use much smaller VMS squares, with an area of approx. 18 km^2 (one fishers' square has 200 VMS squares).

Rent estimation required the attribution of costs and revenues of the sea space. The STECF and VMS reports contain information on the variable cost for each type of fishing fleet (segment of fishery) as well as the total fishing effort in the segment (number of days, hours or minutes of fishing), which allow calculating the average cost per unit of effort (day, hour) in each segment. The average cost of a square is the function of a given segment's fishing effort and that segment's average variable cost. In other words, fishing effort enables the spreading of a given segment's variable costs among fishers' or VMS statistical areas.

Similarly, the spatial revenue from fishing activities was calculated using the information, from the STEFC and VMS reports, on the total revenues (without

[7] The fishers' squares are related to ICES statistical squares with 1° longitude and 0.5° latitude (in Polish sea areas, it is from 3,495 to 3,628 km^2).

subsidies) of each fishing segment from fish landings, the total catches of this segment (which allows the calculation of revenues per one metric ton of fish caught) and the catches shown by a given segment in individual fishers' or VMS squares. The maximum value of revenue in 2014 was €326,000 or €1,059,000, for the VMS square and the fishers' square, respectively.

Spatial rent was computed as the difference of revenues and variable costs. Since fixed costs are not considered, this reflects only a rough estimate of genuine spatial rent. Assuming the 2014 average EUR/PLN exchange rate of 4.1852, the maximum rent level in the fishers' square in 2014 was PLN 217/km^2 , with PLN 26 743 / km^2 in the VMS square. It is important to note that these squares overlap and, therefore, rents should be added. The result for VMS squares is shown in Fig. 3.

For the other types of aforementioned economic activities, the calculation of rent was impossible. For coastal tourism, only the revenue was calculated while the costs could not be extracted. For port industry, only gross value added was obtained, which is not the same as net benefit. For offshore energy, only costs could be estimated while revenues remained unclear. Finally, for shipping, there was an issue with identifying the portion of net benefits accrued by the Polish ship industry, which should be attributed to the Polish maritime space, as well as with estimating net benefits of foreign ships using the Polish maritime space.

The key problems in calculating private maritime spatial rent were related to:

a) Problems with clear definitions of marine sectors. The maritime "blue" economy is absent from the public statistics of the EU. In the NACE classification, it is necessary to search as far as the fourth digit (which is not available in the public domain), while the need for the arbitrary assigning of the data for marine space still remains unsatisfied (e.g. the data on aquaculture cover both marine and fresh water aquaculture) − for details see ECORYS (2013).
b) Issues with the spatial attribution of data. NACE data has no explicit spatial reference. In the Polish case, only the REGON database (on registered firms) runs at the LAU2 level. The database, however, does not contain financial information and is not regularly updated.
c) Gaps in information on the net benefits of the marine industry. This information is not available in the public domain. While it can be purchased, the accuracy of the information is questionable. For instance, while the TEGIEL database on Polish enterprises contains financial information, it covers only legal persons that must report to the National Court Register (*Krajowy Rejestr Sądowy*). Moreover, such information is frequently attributed to the municipality in which the registered office is located and not to the one where the actual activity takes place in. As a result, the information on tourism indicated negative spatial rent for one of the largest Polish spa towns, raising doubts about the credibility of the results achieved.

There are additional and more significant problems related to the estimation of non-market benefits. In these cases, there are two alternatives: either simulate a non-existing market or trace the market's indirect outcomes, as they relate to the non-market benefits provided by maritime space. The first alternative can be

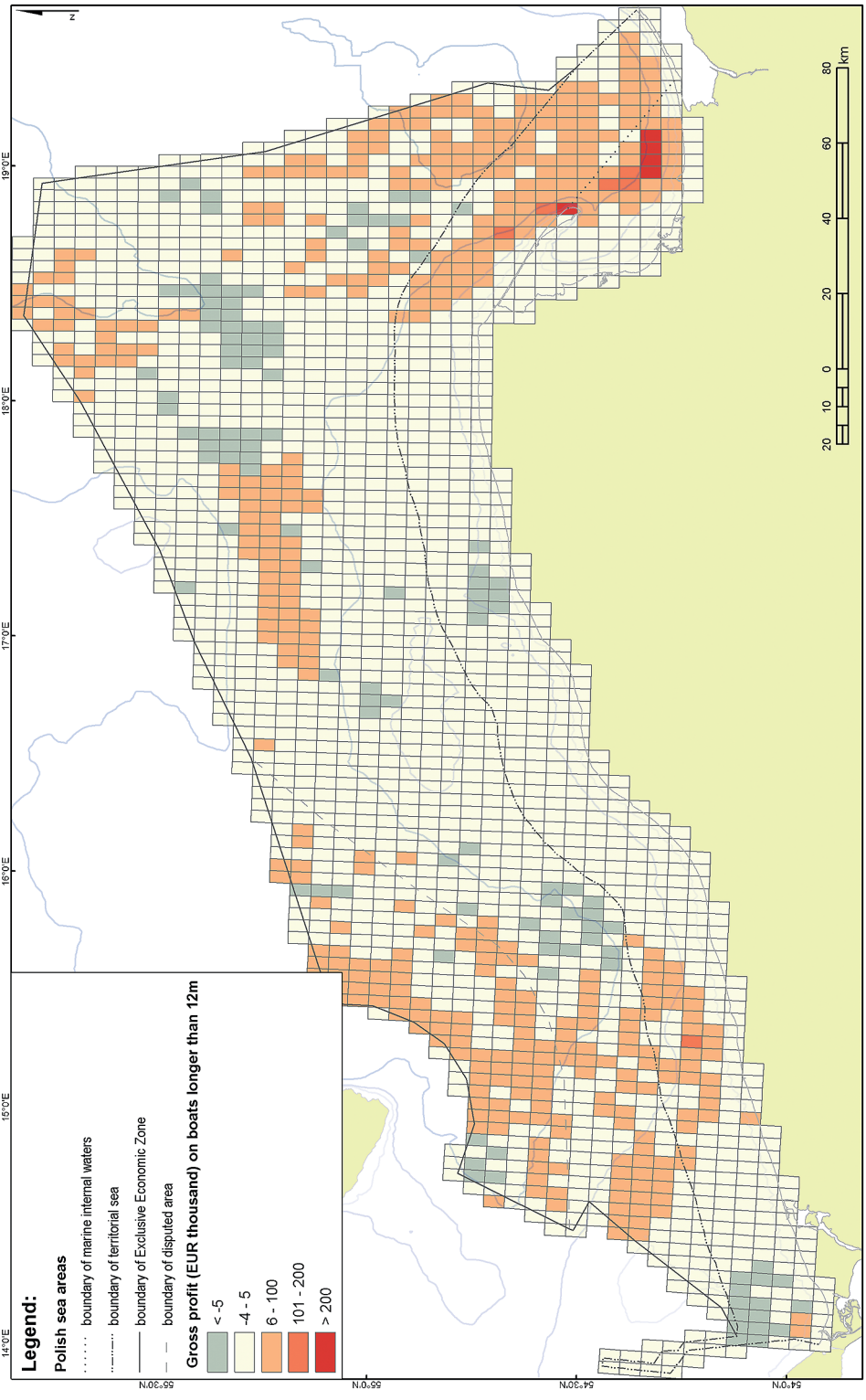

Figure 3. Spatial rent for fishery on boats longer than 12 m in 2014, in thousand EUR

Source: map prepared by Joanna Pardus based on calculations by Adam Mytlewski.

managed by stated preference approaches to the economic valuation of non-market goods and services, using such valuation methods as: Contingent Valuation, Choice Modelling and Group Valuation. The second approach seeks the economic value of benefits by indirectly revealing preferences, e.g. by observing the prices of other goods and services (e.g. surplus of the real estate price near the coast in comparison to the inland location-hedonic price method) or by measuring the costs of travel efforts to visit attractive coastal locations (e.g. national parks, etc.). For these methods, see Węsławski et al. (2006).

In the Polish context, such research has only recently seen some progress. Söderqvist & Hasselström (2008) have identified no other attempt of such a valuation prior to 2008 in Poland. Indeed, only a few successful attempts exist so far. The value of biodiversity (Zarzycki 2011; Ressurreição et al. 2012) and the cultural ecosystem services related to Baltic Sea food webs (Lewis et al. 2013) were assessed. In addition, the damage due to eutrophication or the monetary benefits of reducing eutrophication were estimated for the Polish sea areas as a part of a broader Baltic effort (Żylicz et al. 1995; Ahtiainen et al. 2012). In her recent research, Kamińska (2019) estimated the value of the ecosystem service of the sediments in the Gulf of Gdańsk for reducing nutrients (mainly nitrogen). She used the method of cost replacement and contingent valuation, and revealed that Polish society is not aware of the economic value of these types of services.

Table 1. State expenses on blue economy in the period 2012–2018

Year	State expenses on maritime (blue) economy	Share of state expenses on maritime (blue) economy in total expenses of state budget in %
2012	964,669	0.30
2013	667,127	0.21
2014	544,090	0.17
2015	463,246	0.14
2016	482,561	0.13
2017	434,786	0.12
2018	522,197	0.13

Source: Compilation by Adam Szczęch based on governmental data and reports on execution of the state budget.[8]

[8] Sprawozdanie z wykonania budżetu państwa za okres od 1 stycznia do 31 grudnia 2012 r. Omówienie, Rada Ministrów, Warsaw 2013, p. 68; Sprawozdanie z wykonania budżetu państwa za okres od 1 stycznia do 31 grudnia 2013 r. Omówienie, Rada Ministrów, Warsaw 2014, p. 65; Sprawozdanie z wykonania budżetu państwa za okres od 1 stycznia do 31 grudnia 2014 r. Omówienie, Rada Ministrów, Warsaw 2015, p. 73; Sprawozdanie z wykonania budżetu państwa za okres od 1 stycznia do 31 grudnia 2015 r. Omówienie, Rada Ministrów, Warsaw 2016, p. 81; Sprawozdanie z wykonania budżetu państwa za okres od 1 stycznia do 31 grudnia 2016 r. Omówienie, Rada Ministrów, Warsaw 2017, p. 84; Sprawozdanie z wykonania budżetu państwa za okres od 1 stycznia do 31 grudnia 2017 r. Omówienie, Rada Ministrów, Warsaw 2018, p. 83; Sprawozdanie z wykonania budżetu państwa za okres od 1 stycznia do 31 grudnia 2018 r. Omówienie, Rada Ministrów, Warsaw 2019, p. 80.

Although the monetary valuation of externalities related to economic activities on sea is not a popular method, a few examples do exist. For instance, Tegeback & Hasselström (2012) estimated the costs of oil spills from maritime transport in the Polish coast. They have considered direct costs (cleaning beaches), market costs (tourism, fisheries) and non-market costs (environmental costs). All of these efforts were pilot attempts of an ad hoc nature. This creates a significant problem for the valuation of public rent. Moreover, public authorities are not interested in such types of valuation. In fact, maritime economy attracts a limited amount of attention from the state. Despite important externalities and non-monetary benefits provided by marine space, the state subsidies to this branch of the economy have not exceeded 0.3% of the state budget in the recent years and have relatively dropped since 2012 (Table 1). This may indicate that the modelling of maritime space development will remain research-driven. Public authorities appear neither ready nor willing to intervene more seriously in this sphere.

Conclusions

Although the market plays a critical, though not exclusive, role in the development of maritime space, the latter cannot be fully understood without considering the impact of geopolitics, regulatory regimes and the differences between national policies. These are the influencing factors in determining the economic exploitation of maritime space, brought to the forefront by various public policies and, in particular, by MSP. In the Polish case, these interventions are primarily exercised through legal and regulatory channels, more so than by the use of market instruments (taxes, subsides). Two figures from this paper, based on the spatial rent concept which estimates utility for a specific public/private function, call for more complex conceptualizations of the economics of maritime space which would consider societal values, the power of stakeholders in pursuing their values and stakes, the correctness and transparency of the public choice process, regulatory capture, etc.

This complexity poses a veritable challenge to the accurate modelling of marine space. The typical economic approach (private rent) must be extended in order to take into consideration externalities and other non-market benefits delivered by maritime space. The range of these benefits are vast, from ecosystem services up to intrinsic values and benefits of enjoying power and control over other nations (broad security and defence issues). These benefits can be modelled by economics mainly by using e.g. stated preference approaches for the economic valuation of non-market goods and services and, quite frequently, revealed preference approaches may work, as well. However, the outcomes achieved thus far are far from perfect, the main issue being that many of the benefits delivered by marine space are either unknown by their potential consumers or taken for granted.

Thus, the critical areas of maritime space modelling in need of development are: (a) the consolidation of data on economic maritime use and their attribution to the maritime space, as it has been done in the case of fishery, (b) practising

various methods for estimating economic value of non-market benefits including externalities, (c) triggering cross-disciplinary scientific debate on mechanisms that further the development of maritime space.

As far as economics is concerned, it seems that there is a need for the merging of the more standard, mainstream economic approach with more updated and realistic public economics methods. For a more accurate prediction, the development of maritime space modelling must be confronted with the key parameters of the Social Welfare Function (Stiglitz 1986) and the power of stakeholders (Hassler et al. 2018). This cannot be accomplished through desk research but requires dynamic social debate. Modelling can provide a significant input to maritime territorial dialogue.

If maritime spatial economics succeeds in estimating the value of private and public rent, this information could function as a kind of boundary spanning object, encouraging a more evidence-based discussion regarding the policies that regulate the use of maritime space, particularly MSP. However, the problem is that this work has only begun fairly recently and, as such, its theoretical basis is weak and the necessary information is scarce, inaccurate or inexistent. This paper will hopefully trigger more rigorous debate on spatial rent as an instrument of public choice for the governance of maritime space.

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