Space Policy 65 (2023) 101555

Contents lists available at ScienceDirect

Space Policy

journal homepage: www.elsevier.com/locate/spacepol

Research Article

Asteroid Mining Tax as a Tool to Keep Peace in Outer Space

Pavel Semerád [a, b]

[a] Department of Accounting and Taxes, Sting University, Rasinova 103/2, 602 00 Brno, Czech Republic
[b] Department of Accounting and Taxes, Mendel University, Zemedelska 1665/1, 613 00 Brno, Czech Republic

ARTICLE INFO

Article history:
Received 12 May 2022
Received in revised form
12 May 2023
Accepted 16 May 2023
Available online 8 June 2023

Keywords:
Asteroid mining
Extra-terrestrials
Space colonisation
Space exploration
Space tax
Taxation

ABSTRACT

At first glance, taxing mining in outer space may seem like a marginal issue. However, based on the experience of taxation on Earth, it will be a prerequisite for ensuring peace in outer space.

The aim of this study is therefore to propose a way of taxing asteroid mining to eliminate economic inequalities between states on Earth and to reduce the future threat of space colonies and extra-terrestrials claiming asset-based benefits.

The study proposes the institution of a tax administrator to oversee taxation as appropriate. At the same time, a procedure has been proposed for determining the tax base using normal prices for specific commodities.

An important prerequisite for fair and sustainable taxation is the determination of the optimal tax rate. A progressive tax rate has been proposed that takes into account future developments in space mining. The proposal is divided into three stages to take into account potential collaboration with space colonies and possible clashes with alien civilizations.

1. Introduction

Humanity has dreamed of conquering and colonizing outer space since time immemorial [1–4]. These dreams began to come true in 1957 after the launch of Sputnik 1, the first artificial satellite on Earth [5,6]. This success of the then- Soviet Union, however, also launched the space race with the United States during the Cold War. The two states also competed with each other in outer space for primacy and power superiority [7–9]. Gradually, other states began to join these powers, incl. Canada, the People's Republic of China, European states (the European Space Agency – ESA), Japan, and Australia.

1.1. Extraction of minerals on Earth

If we look deeper into our history, we can see a parallel in the behavior of European states that have been discovering and gradually conquering other continents since the Middle Ages [10,11]. These European powers were mainly motivated by the expansion of new territories, increasing their political influence in the world, and the acquisition of mineral resources [12].

This status persists in Africa, for example, albeit in a less invasive form [13–15]. A more recent example is the People's Republic of China, a country that is investing money in industry and infrastructure in Africa [16], which is assumed to provide China with additional mineral resources in the future [17].

However, struggles over mineral resources also took place in other countries, e.g. in the Persian Gulf (1991–1992). Paradoxically, these military conflicts occur despite existing international conventions and efforts by governmental and non-governmental organizations to resolve matters peacefully. Similar behavior can be expected when there is mining activity in outer space [18].

Given the growing demand for minerals, it is very likely that humanity will eventually exhaust all safe deposits on Earth [19]. However, it is not possible to stop mining. If this were to happen, it would have an unimaginable impact on industrial development and economies around the world [20].

It can therefore be assumed that mining will take place at greater depths and in areas of extreme natural conditions [21–23]. However, this is going to have negative and irreversible impacts on the environment.

For this reason, it seems logical that humanity is drawing attention to potential mineral deposits in outer space [24–26]. For us, however, outer space will also be a source of land in addition to minerals. Because of the ever-increasing human population, the

E-mail address: pavel.semerad@atlas.cz.

https://doi.org/10.1016/j.spacepol.2023.101555
0265-9646/

colonization of outer space will be a necessary condition for our survival [27–29].

1.2. Extraction of minerals in outer space

Mankind has long been developing instruments and equipment to enable it to stay in outer space. It is therefore only a matter of time before we begin to exploit the full potential of outer space and import the extracted minerals to Earth [30]. However, this moment will bring along many legal and economic issues, as well as potential risks for the future [31]. That is another reason why humanity should be prepared for these issues and risks.

Since the mid-1960s, there has been a gradual evolution of the legal basis that is part of international treaties. The term *Space Law* thus represents the rules, principles, **private businesses,** and standards of international law governing outer space [32].

As '*Space Law addresses a variety of matters, such as, for example, the preservation of the space and Earth environment, liability for damages caused by space objects, the settlement of disputes, the rescue of astronauts, the sharing of information about potential dangers in outer space, the use of space-related technologies, and international cooperation*' [32], logically, the issue of taxation of space activities should be addressed, too.

The importance and relevance of taxation issues also lie in the fact that private companies become involved in space exploration and research as well [33,34]. The involvement of private companies in space activities helps advance our knowledge of outer space. On the other hand, space may also become another territory in which tax evasion, similar to that which we know from the taxation of terrestrial activities, could emerge over time. Examples could be undeclared imports of minerals, deliberate manipulation of the accompanying documents (inferior quality or mistaken identity of minerals could be reported due to lower taxation), or minerals becoming the subject of a transaction that, due to carousel fraud, would result in non-payment of VAT and the unjustified elicitation of excessive deductions.

For this reason, the taxation of minerals is a prerequisite for proper trade in minerals mined in outer space. In the early days of mineral extraction taxation, the application of the Model Tax Convention on Income and Capital could be considered, for example [35]. However, the problem is that in the context of space mining, other entities, such as space colonies and extraterrestrial civilizations, may be included among the beneficiaries of the benefits of mining. This article, therefore, defines the basic tax concepts (tax base and tax rate) and proposes a method for redistributing the benefit (tax).

1.3. Differences between countries

More and more countries are becoming involved in space activities. However, they differ in terms of their level of technology. The state of technology is influenced, among other things, by the level of investment in new technologies. The budgets of some of the space programs can be compared for reference: NASA 22.5 billion USD [36], ESA 6.49 billion EUR [37], Roscosmos 2.8 billion USD [38] and Space in Africa 0.5 billion USD [39].

In the absence of any rules on the taxation of space activities, the gap between developed and less developed countries would widen even more [40–42]. This could bring about wars in the future [43] since it would be easier and cheaper for poorer states to attack one that already extracts minerals in outer space than to fund their space programs.

Related to this are questions about how the minerals extracted from outer space will be used and whether countries will be willing to share them. Given that current mining on Earth is primarily about meeting demand in specific countries [44], it is hard to imagine that this would be any different from mining in outer space. In essence, this would discriminate against states that are not members of any space program, creating further inequalities and the potential threat of war.

To maintain neutrality of opinion, it is important to mention that states invest in their space program with funds that they generally receive from their tax residents. It is thus a matter of investment. States are in the position of investors who logically expect to profit from interest or other benefits related to space activities. It is for this reason that it is not appropriate to penalize these states for their rational behavior. Without it, potential mineral extraction would be nothing but a piece of science fiction literature.

1.4. The future of extraction in outer space

Let us suppose that the countries on Earth agree on the terms of the extraction and redistribution of minerals. Afterward, humanity starts mining operations on the nearest celestial bodies [45]. However, the resources will gradually be mined out, and it will be necessary to go deeper into outer space. At some point, we will reach a distance where it will no longer be possible to travel the distance between the celestial object and Earth without replenishing power for the spacecraft and its crew.

Thus, it will be necessary to establish base stations and stopover sites [46]. However, if there is no one to look after these places, then this replenishment of energy would be very difficult. For this reason, it will be necessary to establish and materially support space colonies that will live their own lives [47]. This cooperation will initially be mutually beneficial, as space colonies will be supplied with goods as spaceships travel from Earth to the extraction site.

But the longer space colonies live their own lives, the more they will evolve independently and perhaps begin to lose their relationship with Earth [48]. They will become independent places in outer space and begin to pursue their interests independently of Earth [49].

However, this independence may increase the risk of crime and loss of humanity [50]. In the future, we could be victims of space piracy and warfare. In extreme cases, Earth's security could be threatened as the most destructive weapons, including asteroids, could be used against it [51].

Yet there is a solution to avert these wars. The solution is to put a tax on mining activities since taxes have a redistributive and allocative function [52,53]. In a real-life situation, this means that taxes enable the redistribution of resources and profits between rich and poor (the redistributive function). At the same time, taxes can mitigate the effects of imperfect competition and market failure (allocative function).

1.5. Conflicts with extra-terrestrial civilizations

It is, however, not only in relation to space colonies that Earthlings may find themselves in similar conflicts. The possibility of an extraterrestrial civilization appearing in outer space cannot be ruled out [54,55]. Any collision with it could have fatal consequences for Earth [56]. It would not have to be the direct destruction of our planet. For aliens, it could be enough to win by introducing and spreading diseases that humanity could not counter. Hernán Cortés was similarly victorious in his conquest of the Aztec Empire [57].

The subject of the dispute could be compensation for damages for minerals extracted by humanity in areas that aliens would consider to be their sovereign territory. The question is whether or not, in a future division of the universe, they would or could

consider our solar system to be their sovereign territory. Rather, let us assume an adverse scenario for the sake of earthlings, and let us follow the accounting principle of prudence for the sake of greater security and our ability to meet our obligations even under adverse conditions. This means that it is better to calculate for lower returns, i.e., opportunities to use less of the extracted minerals for the benefit of planet Earth while assuming higher losses in the form of a higher rate of property compensation.

In the long run, this would still present astronomical values that would be impossible to satisfy by nature since the extracted raw materials would have already been consumed. Thus, the only possible substitute appears to be compensation in terms of value.

What such compensation might look like is the question, since earthly money has its value only on Earth. Other things and goods could be equally worthless to aliens. Moreover, due to inflation, the value of the compensation we would keep for these cases would decrease over time, while the value of the mineral resources would increase. Thus, humanity would not have enough resources to make a one-off compensation.

Many more such problems can be expected in the future. However, these introductory words are intended to show that the threats are real to some extent. So it is about inequality between states on Earth and war conflicts with space colonies and alien civilizations. Thus, there are essentially three groups that could lay claim to mineral ownership. Although these threats cannot be completely ruled out, it is possible to prepare for them and adapt mining conditions to them now.

Asteroids are the subject of investigation in this study because they will be among the first celestial bodies to be targeted for mining [58,59]. However, the experience we gain from asteroid mining can be modified for other celestial bodies. The second reason for selecting asteroids is the assumption that other planets and moons in the solar system will first undergo research related to the possibility of their settlement by artificial technology and humanity [60,61].

2. Material and methods

This study aims to propose a way of taxing asteroid mining to eliminate economic inequalities between states on Earth and to reduce the future threat of space colonies and alien civilizations claiming asset-based benefits.

The study aims to propose a form of taxation that will be acceptable to at least a supermajority of the countries on Earth, given their diversity and differing economic, historical, social and political developments. The article can therefore be considered a document combining an economical and philosophical approach, as intersections of civilizations and religions are also sought.

The main purpose of this article is to lay the groundwork for future taxation that will prevent war and that will redistribute the profits from asteroid mining fairly, especially in the long term, as it can be assumed that the first mining experiments will be conducted in peace under the guise of science and humanity. But when a massive form of extraction occurs, it can be envisaged that the desire to gain an advantage (e.g. in the form of profit or more minerals mined) will prevail at the expense of fair redistribution. If that were to happen, it could be the end of human civilization.

Technical literature on space mining and space exploration, mining on Earth, taxation of terrestrial activities, and religious writings thus became the basis for the present article. Through the analysis of these sources, potential scenarios and parallels to historical events that could occur in future space activities were sought.

The first part of the article presents the current state of the art and plans for asteroid mining. The second part focuses on the current extraction activity taking place on Earth. Mention was made not only of the current struggles over mineral resources but also of the history of the conquest of European colonies. Potential scenarios were derived that could be expected in future conflicts between Earthlings and space colonies' residents.

The third part of the article is based on the belief in the existence of extraterrestrial civilizations. Prediction is used to create a scenario of how the property benefits from mining should be settled peacefully.

The particular proposal to tax asteroid mining is based on humanity's experience with taxation on Earth. Reference is made to the tax fraud that takes place in the taxation of activities between countries on the planet. It specifically involves smuggling and carousel fraud that primarily affect indirect taxes. The aim is therefore to prevent these problems from recurring, as they would have an intergalactic overlap. At the same time, the issue of tax competition between states was addressed, and a suitable candidate for supervision and tax collection was proposed.

3. Taxing extraction of minerals on Earth

Taxing extraction and the activity of extracting the Earth's minerals as such are both important societal issues that must be addressed. At the same time, the experience from mining should help us set the rules for taxation in space.

Tilton lists three general arguments that are used to support higher taxes on mining [62]. The point is that (*i*) the wealth and fixed economic income belong to the host country's population; (*ii*) mining companies should compensate the state for the use of non-renewable resources; and (*iii*) the distribution of wealth itself is unfair, as very little of it is intended to support the economic development of the host country.

The first two arguments can be accepted and are difficult to dispute given the nature of the mining activity. Some states simply have rich deposits; other states are not so lucky. But if mining is already taking place somewhere, states should be entitled to compensation from mining companies for the exploitation of their territories and natural resources.

However, the major impact is in the redistribution of profits that do not go to mining-affected and poorer areas, e.g. rural regions [63]. This unfair redistribution leads to poorer areas experiencing tax evasion and illegal mining, as evidenced by satellite imagery [64].

Moreover, the fact that the economic benefits diminish as mining costs increase and the grade of ore at the site decreases cannot be ignored [65] and deeper drilling puts more pressure on the environment [66].

In the short term, mining can be an important source of revenue for public budgets. This will help the state (in the short term) raise its economic level. However, this activity must also be evaluated from a long-term perspective, and here pessimistic scenarios are more likely to be offered.

That is why countries should address their future as mining is underway or, even better, before the mining activity begins. They should be aware of how they will be able to maintain their economic level even when all the safe deposits in their territories have been extracted and mining has ceased. These countries will once again begin to slip into even greater poverty and, paradoxically, given the rising demand and prices for minerals, will not be able to afford them. This will enormously increase the disparity between rich (and still producing) countries and countries where mining has ceased.

Poorer countries will not be able to afford to invest in modern technologies that could help them reach mineral resources beyond the planet Earth. Their only option is to secure themselves during

the extraction process and build up sufficient reserves for the future. However, since these countries mostly license mining to private companies, the only way to ensure sufficient financial resources for investment is to increase the tax burden.

But as in the case of the Australian federal government, which sought to introduce a new tax on super-profits for mining companies, this is a very difficult task. The Australian government lost this fight in 2010 as the mining industry managed to convince large numbers of voters that this new tax would threaten investment, jobs, and growth [67,68].

Obviously, mining companies have significant political influence comparable to that of sovereign states. As the case of Finnish mining companies shows, they can evade their tax obligations very effectively, thanks to their dominant position, using tax loopholes and tax incentives offered by the states themselves [69].

These tax incentives are not ground-breaking news in the mining sector since we can observe them as early as the 1970s and 1980s [70]; they are part of agreements between private companies and states.

These cases just show how important it is to establish a sufficiently solid basis for taxing space mining. If the rules are not clearly set when commercial extraction starts, it will be politically difficult to counter the influence of the mining companies. They will thus take the lead and decide on future developments not only on planet Earth but also in the universe. This way, states and the public will lose absolute control and will only regulate the activities of these commercial giants to a limited extent. In the most pessimistic scenarios, this could turn open space into an official duty-free zone and a place where companies would not want to share their profits. In the short term, they might get away with it, but in the long term, it is unsustainable, and potential war conflicts could threaten the peace in the open space.

The aim of this article is not to attack future mining in space, whether by states or private companies. Indeed, it is clear that the states themselves recognize the importance of partnerships with the commercial sector and are trying to *facilitate a pro-growth environment for the developing commercial space industry by encouraging private sector investment* [71]. At the same time, they create stable and predictable regulatory conditions. These are intended to maintain control over commercial entities and, in turn, ensure predictable conditions for investment in the future. Although states are attempting to create space to benefit from mining, current space law does not directly regulate shared benefits [72].

4. Asteroid mining tax proposal

To formulate a proposal to tax asteroid mining, it is necessary to define the three basic pillars of the tax.

The first pillar is defining who will be responsible for overseeing the taxation of mining and into whose bank accounts taxpayers will pay the tax.

The second pillar is defining the form of taxation for asteroid mining. As a minimum, the procedure for calculating the tax base and the tax rate must be established.

The third pillar is the decision on how the tax collected will be distributed.

4.1. Pillar 1: Who will be responsible for the supervision and collection of the tax

Probably the most viable option would be for the United Nations, through the United Nations Office for Outer Space Affairs (UNOOSA), to take control of mining taxation. This body is already helping to define the foundations of outer space law and policies to be consistent with international conventions [73]. This makes it a suitable candidate who could be accepted by a majority of Member States.

As such, the review and inspection activities will be a very challenging task that will require fixed rules. However, if this task is carried out by a single international organization, it will be much more efficient and safer than if this power were given to individual states.

If taxation were left to individual states, there would be a risk that some of them would start to abuse their status as part of tax competition. Tax competition is specific in that the states compete with each other in terms of, e.g. tax rates, creating an imperfectly competitive environment [74].

Countries referred to as tax havens can be examples of such imperfect market environments. Tax haven countries are characterized by providing scope for aggressive tax planning [75]. In addition, especially in the past, they used to mask the true identity of taxpayers through bank secrecy [76] and have only cooperated to a limited extent with other jurisdictions [77].

However, the fact that companies and individuals could abuse tax havens to avoid taxation is still real. This is evidenced, for example, by the Panama Papers case, which involved, among others, 140 politicians from 50 countries [78].

If similar problems were to arise with the taxation of extra-terrestrial mining, this could cause disputes between states in the future since not only states that have properly taxed all imported minerals but also states that lack the technological equipment to extract them themselves could be involved in the dispute. They could feel that they are being robbed and claim the value of untaxed mineral resources. That is why control over the taxation of extra-terrestrial activities needs to be taken by a supranational organization.

Once mining is allowed by private entities, it is necessary to ensure full control over how they manage the mineral resources. Otherwise, they could be involved in other types of treachery on Earth, such as smuggling and carousel fraud.

Smuggling can be defined as the clandestine transportation of goods across national borders without the knowledge of customs authorities. As well, cases of deliberately incomplete or incorrect taxation can be referred to as smuggling. These can occur when goods are weighed, calculated, marked, or priced incorrectly, or only partially invoiced [79].

Smugglers use these methods to avoid paying customs duties and taxes. If we take into account the fact that tax competition between countries plays a role, goods tend to be smuggled from countries with a lower rate of excise duty to states with a higher rate. This leads to an unequal position for actors in the market, as honest sellers cannot compete with fraudsters in terms of price and margin [80].

Excise duties are not the only type of tax that fraudsters abuse to enrich themselves. There are also significant problems with value-added tax. Specifically, carousel fraud, in which tax exemptions are abused when goods are supplied to another member state [81]. The weak point is the self-assessment of the tax by the recipient of the taxable transaction. If it is a missing fraud trader, the entity, while it collects the tax from its customers, closes its business before the tax is due. The European Parliament estimates that EU countries will lose €164 billion in 2020 due to carousel fraud [82].

It follows from the above that mineral taxation must take place immediately once they have been imported to Earth. Delayed taxation could bring about the fraud we struggle with in Earth-related taxation.

The presence of UNOOSA officials on the spacecraft's board during transportation is the solution to this. These would thus carry out similar activities as customs officers. An alternative to this staff

could be special vessels/containers in which the cargo would be transported. These containers would be secured before shipment and would require biometric technology and an authentication system to be opened.

$$D = Q_{max} \times TR \quad (1)$$

where, D is a deposit, Q_{max} is the maximum allowable amount of minerals on a spacecraft, and TR is the tax rate.

At the same time, to eliminate possible "loss" of cargo during transport, the importing company must get a special import license. Such a license would be granted only if the security conditions are met and also after, *inter alia*, making a deposit (1). The amount of the deposit (D) would be set as the product of the maximum allowable quantity of minerals on the spacecraft's board (Q_{max}) and the tax rate set based on the minerals being transported (TR). The obligation to make a deposit before importing it to Earth could be replaced by a bank or government guarantee. The guarantee would be paid if the importing company failed to remit the mining tax to UNOOSA immediately after clearance.

4.2. Pillar 2: Taxation proposal

4.2.1. Setting the tax base

Commodities are usually taxed based on their physical and physical-technical characteristics, chemical composition, and nomenclature codes (description of selected products). It can therefore be assumed that the same practices and values will be transferred to outer space. The proposal, therefore, is to set the tax base (TB) as the normal price on Earth, as follows (2).

$$TB = (P_C \times Q_C) - C \quad (2)$$

where TB is the tax base, P_C is the average price of a commodity on Earth, and Q_C is the quantity of the commodity. C is the cost of achieving, maintaining, and securing taxable income.

Let the average price of the commodity traded on the commodity exchanges at the time of importation into the country be taken as the normal price (P_C). Since these are cases of extraterrestrial import, all world commodity exchanges must be taken into account to eliminate efforts to reduce the normal price through unfair local practices. To increase transparency and legal certainty, let the specific current value of P_C be publicly available on the UNOOSA web portal.

The second value that plays a part in the tax base is the quantity of a particular commodity (Q_C) expressed in customary Earth units.

The third significant item is the cost (C), which is incurred at the amount demonstrated. This includes, for example, investment costs (depreciation of technological equipment), transport costs (from the ground to the mining site and back), labor costs in the case of a human crew, or, as applicable, depreciation for robots and other pieces of automated equipment used for mining, material consumption, energy consumption, etc.

The claiming of the costs is fully following the Earth's income tax laws, where costs are deducted from taxable income (revenue) to the extent proven.

4.2.2. Optimal tax rate

Determining the optimal tax rate will be a politically challenging task, and it can be expected that all states will not unanimously agree on a single rate as there are cultural, historical, geopolitical, and social differences between countries. After all, differences in taxation do exist even in countries that together form economic and political unions and where tax harmonization initiatives are underway. An example is the setting of the standard rate of value-added tax in the European Union, where the only requirement is that the rate not be lower than 15% [83].

At the same time, tax theory must be taken into account when designing the rate. The basic premise is that the tax should not hinder technological progress. If too high, the tax rate could create barriers and resistance to further development and limit investments [84]. The Laffer curve can be used to explain this phenomenon. According to this theory, tax revenues initially rise with increasing rates, but after a certain point (the Laffer point), they begin to fall [85].

In addition, too high taxation could be an attraction for potential tax fraudsters since these take into account tax savings, the likelihood of detection, and the amount of penalty if detected [86–88]. Simply put, the greater the benefit they would gain through fraud, the greater the incentive it might be for them.

These problems must be eliminated since the introduction of additional control mechanisms may increase the administrative burden on taxpayers and increase costs for the tax administration, while the proposed tax rate should enable the collection of specific amounts without disproportionate costs, which is one of the prerequisites for a tax rate to be optimal [89].

Therefore, a requirement was set that the rate should be sustainable in the long term and that it should be fair to all entities that might require some future property benefit from the extraction activity then underway, i.e., all countries on Earth, space colonies, and potential alien civilizations. For this reason, the proposal is divided into three stages depending on the stage of exploration of outer space that the mining activity is part of.

The design of the optimal tax rate (TR) is inspired by the historical development of taxation in different cultures and parts of the Earth. The result is a tax rate of 10% on the normal price of the mineral on Earth (P_C).

$$AMT = TB \times TR \quad (3)$$

where, AMT is the asteroid mining tax, TB is the tax base, and TR is the tax rate.

The payment of a tenth of income has appeared several times in Earth's history and has a relatively long tradition. Tithes are mentioned, for example, in the Bible [90], in both the Old Testament and the New Testament (e.g. Gen 14:18-20; Gen 28:20-22; Mat 23:23). In the interpretation of the time, it was a payment of one-tenth of the agricultural produce to the priest, God, and the King [91]. As well, one-tenth of personal income was paid in Mesopotamia (esretu) and Egypt [92].

Also in the Islamic Order, we find the obligatory payment (zakat), which plays an important role in the spiritual and social life of Muslim society [93]. Its level depends on the specific conditions and varies from 2.5 to 20% [94]. One-tenth is paid from agricultural production. This payment is purifying by nature and serves as a form of aid to the poor.

The 10% rate is therefore not set at random. It is based on a historical exploration of the variety of cultures in the world that are united by religion. Religion is deeply ingrained in the minds of generations around the world. Although non-believers may disagree, even they, as well as their ancestors, were exposed to the extensive influence of religion. If we take into account the fact that the same element – 10% to be allocated for the benefit of gods or the ruler – appeared across different regions of the world, we can assume that such a rate could be accepted in most countries today.

One can, of course, argue over lower or higher taxation. For example, in the case of *Zakat*, Muslims also pay a 20% rate. But such a high rate would be difficult to enforce in countries with a predominance of the Christian religion. It is enough to take the example of the European Union countries, which are finding it

difficult to identify intersections on some issues within the framework of direct taxation. That is why only minimum rates are set, which can be adjusted individually by the Member States. Before the accession of the 10 new Member States in 2004, the newly acceding countries carved out exemptions from EU taxation to 'protect' their own markets. This example can therefore be used to demonstrate the difficulty of negotiating across the European continent alone. It can be assumed that negotiations across other continents would be much more complex.

To justify a 10% rate globally, let us assume that the number of believers in the two most widespread religions (Christianity population − approx. 2.2 billion [95] and Islamic population − approx. 2 billion [96]) exceeds 4 billion earthlings, which is more than half of the global population.

However, the 10% tax proposal still does not prevent the states from having the option of applying the standard form of taxation to mining companies, including income tax.

4.3. Pillar 3: How the tax collected will be distributed

Tithes and Zakat both serve to ensure peace and prosperity in this world [97]. We cannot neglect our future, either. It is precisely to achieve social justice and economic sustainability that mineral revenues must also be properly invested for the benefit of future generations [98].

It can be assumed that humanity will face the problem of how to redistribute the benefits of mining. According to what criteria would this redistribution take place? To find the answer, it is necessary to compare the current preparedness of individual countries. Only a small number of them would be able to start mining. These would be countries that have been involved in space activities for a long time, and even among them, there are significant differences in technological level. Other countries are putting any space-related activity on hold, for example, because they do not have sufficient funding for space research. If we apply the principle of 'first come, first serveed' not only for taxation but also in relation to benefits, less developed countries would never be able to catch up. The differences between countries would thus continue to widen.

In all seriousness and respect for humanity, it is, therefore, necessary that the benefit of extraction be redistributed to other countries, as the first country to extract would gain an uncompetitive advantage at the expense of others. The potential development of colonization and space exploration cannot be ignored either, although some scenarios may seem more like a script for a science fiction movie.

The taxation proposal has been split into three stages in the form of progressive taxation. Here, however, it is not a case of increasing the rate depending on income and quantity. The system of progressive taxation inmining is based on how many potential entities the collected tax will have to be distributed among.

4.3.1. Taxation stage 1: Independent mining by people of Earth

Space colonies are unlikely to be involved in mining initially. Therefore, in the first stage, they will not be considered tax beneficiaries. Moreover, it will be Earthlings who will work to establish the colonies and who will support them materially and financially. This can be seen as a form of future compensation.

Thus, before space colonies are added to those sharing the collected amount of tax, a tax rate of 10% is proposed to apply. The tax will be expressed in monetary units, and its subsequent redistribution will take place among the countries on Earth.

Fair redistribution will be made according to the following criteria: the total benefit, expressed in terms of the return from the taxed extraction, will be distributed per capita (the tax will be converted to human population and redistributed to each state according to the principle of residency). In this case, redistribution by citizenship/permanent residence alone cannot be used, as in some cases (e.g. cross-border commuters), a citizen may meet both criteria in more than one country at the same time. For this reason, the principle of residency is proposed.

Clearly, this is not an incentive- and merit-based approach, as countries that do not participate in extraction will be in a 'stowaway' position. But if we want to avoid wars from the outset, the extracting states have no choice but to share their benefits with others.

It is difficult to find justice in this area. This approach is close to collective ownership in principle, and it is indeed collective ownership in the long run (see the following proposals for redistribution between the planet Earth's population and colonies or compensation for extra-terrestrial civilizations, whatever is applicable).

While there will not be an increased share of the extraction and extraction-related costs for the states that will participate in the redistribution from this perspective, they will be able to deduct extraction-related costs from their tax bases. They will also benefit from ownership of the extracted minerals, whose use they will be able to decide for themselves. If they use the mineral resources for their own products, goods, or services, they will be able to pass on the resulting benefit to the final customer.

4.3.2. Taxation stage 2: Mining in cooperation with space colonies

The situation will change when space colonies become a prerequisite for logistics between the extraction site and Earth. In such a case, to compensate the claims of the space colonies, it is necessary to distribute part of the tax revenue in their favor.

This will make the tax rate increase to 20% in the second stage; the tax collected will be distributed to Earthlings and space colonies, the ratio being 10% to 10%. As Earth money is unlikely to be used for payment on space colonies, the proportion of the tax collected will be converted into a material equivalent in value. Redistribution on planet Earth will, again, take place as a per capita redistribution, while for colonies, the 10% will be redistributed in proportion to the number of colonies, as these may have different populations and it can be assumed that much of the traffic will be provided by robots.

4.3.3. Taxation stage 3: Mining outside our solar system

The more humanity advances deeper into outer space (even beyond our solar system), the more likely it is that other alien civilizations will lay claim to this territory. In that case, humanity must be prepared for claims for compensation from extra-terrestrials. This replacement will be essential to ensuring peace and security in outer space.

This way, the tax rate will be increased to 30% in the third stage; the tax collected will be distributed to Earthlings, space colonies, and alien civilizations, the ratio being 10% to 10% to 10%.

Although the idea of encountering extra-terrestrial civilizations may seem like a matter of science fiction, humanity must be prepared for this possibility. To maintain peace in the universe, the accounting principle of prudence must be applied. This principle is specific in that an entity prepares for anticipated losses, risks, and impairment of assets even though these events have not yet occurred or may never occur.

Preparing to meet and make contact with extra-terrestrial civilizations is a long-term activity for which humanity is also preparing by sending objects containing information about planet Earth into space [99,100]. In addition, the planet is also getting ready for its first moment of encounter [101].

The question remains, however, in what form to express the proposed 10% that will go to extra-terrestrial civilizations. In order not to lose value over time due to inflation, this should be in-kind compensation. Ideally, this part of the extracted minerals should remain in outer space and not be transported to Earth. However, these minerals will need to be collected and stored in a secure location to prevent their loss and degradation.

This activity of keeping mineral resources in outer space will bring additional costs related to mining, while, transportation costs will be reduced as minerals will not have to be transported from the extraction site to Earth.

At the same time, it can be assumed that by that time our civilization will be so technologically advanced that the points of keeping thus created can be secured so that nothing can be potentially stolen or degraded. The defense could be provided by remotely controlled security systems and robots. These points of accumulation should be under the administration of UNOOSA or any other successor organization in outer space.

It also raises the question of whether the space colonies should have already been sharing the cost of mining by then. This is especially true if they wish to continue to cooperate with Earthlings and not become separate entities extracting minerals in outer space. In that case, they should be taxed through a universal outer space mining tax, which would also benefit Earthlings and extra-terrestrial civilizations. To ensure long-term security and peace in outer space, taxation must have uniform rules for all.

5. Conclusion

The future mining of minerals in outer space raises many questions. One of them is the issue of taxation. On the face of it, this is a peripheral issue, but as our experience on Earth shows, it will be a prerequisite for securing peace in outer space since we are at risk of other groups claiming the benefits of the mining activities then underway. It can be assumed that in the first stage of mining, it may be the countries on Earth that have not participated in space exploration so far.

As humanity progresses deeper into the universe, a second group of legitimate beneficiaries of material benefits will emerge. These will be space colonies, which will become a prerequisite for the logistical support of mining. Stage 3 envisages extra-terrestrial civilizations becoming actors involved. They too can claim a share of the extraction made outside our solar system.

If we are unable to provide at least the minimum compensation to these groups, conflicts could arise that would have fatal consequences for humanity. The aim of this study was therefore to propose a way of taxing asteroid mining to eliminate economic inequalities between states on Earth and reduce the future threat of claiming asset-based benefits by space colonies and alien civilizations.

For these purposes, three necessary assumptions have been proposed to ensure future taxation. First, the asteroid mining tax should be administered by UNOOSA. As it is a multinational organization, this should eliminate attempts by some states to gain more benefits from mining through tax competition while eliminating the risk of tax fraud, which could cause significant losses on the tax collected.

For proper taxation, the procedure for calculating the asteroid mining tax (AMT) must be defined. The tax base is the normal price of the commodity on Earth (P_c) and its quantity (Q_c). This does not affect the possibility of claiming tax-deductible costs (C).

The proposed tax rate is at 10% and is progressive in nature. However, progressive taxation does not depend on the revenue or the quantity of minerals extracted but on the number of entities among which the tax should be distributed.

In the first stage, where space colonies will not yet be used, a rate of 10% is proposed. The collected tax will be distributed among the states on Earth according to principle the place of residence.

In the second stage, when space colonies will be part of the extraction activity, it is proposed to increase the tax rate to 20%. This tax will subsequently be distributed in the proportion of 10% to Earthlings and 10% to space colonies.

Stage 3 involves mining and potential encounters with extra-terrestrial civilizations outside our solar system. For these purposes, the tax rate will be increased to 30%. This tax will be distributed in the proportion of 10% to Earthlings, 10% to space colonies, and 10% to alien civilizations.

While in the case of space colonies, compensation will be paid in the form of material benefits, in the case of extra-terrestrial civilizations it is assumed that it will be an in-kind type. This in-kind compensation should be left directly at the extraction site so as not to increase transport costs to Earth. At the same time, however, it is assumed that this in-kind benefit will be secured by Earthlings against potential theft and devaluation.

Author statement

Pavel Semerád: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Roles/Writing - original draft; Writing - review & editing.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Acknowledgments

I would like to thank Martin Machay from Mendel University. It was from him that I first heard about asteroid mining. I am also grateful to my anonymous referees for their valuable feedback.

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