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Worlds of Risk: Science Fiction Economics

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Abstract

This article analyzes fundamental forms of economic risk in the unusual form of a science fiction narrative. This frame makes it possible to develop very explicit physical and environmental circumstances under which decision making and its consequences can be studied. We first cover risk arising from the actions of individuals. Here, the interactions of risk-avoiding and risk-seeking agents set the stage for stages of prosperity or crash. The second account deals with the tradeoff between growth and stability in the presence of external shocks. The last form of risk covered concerns resource extraction. Fundamental to all cases studied is the issue of rationality of choice. So, for example in the case of resource extraction, we study simple, smart, and optimal decisions. Further, we discuss a centralized analysis unit that distributes information on ways to improve decision making under risk. Such an arrangement in the tradition of behavioral economics clearly offers a less intrusive approach compared to the limiting of individual freedom by a central governing institution.

Keywords

Risk, Science Fiction and Economics

1. Introduction

It is rather by chance that the information which forms the core of this text has been retrieved. On March 26th, 2025, a string of information was received by the James-Webb Telescope bewildering scientists by its structural regularity and length. With the combined effort of the latest AI programs helping to piece together this string of information, it became clear that we had received a communication from an extraterrestrial intelligence. However, there is no evidence to suggest that this message received from space was intended to be communicated to us, the readers of planet earth. In fact, it was likely produced for communication and discussion in the society of planet Neptuna-58. This exoplanet in our solar system about five light-years away from Earth has only recently become the center of attention of astrophysicists searching for extra-terrestrial life.

One thing we know about this exoplanet is that it has surface water in the form of ice. The presence of ice was missed by the early surveys of Neptuna-58 because it appears on comparatively small lakes. What makes these lakes noteworthy is that they have the shape of perfect squares and appear to hold life. More astonishingly, we have now become aware that there is a society of intelligent beings harvesting this aquatic life. We shall henceforth refer to these beings or settlers as ice fishers and to their prey as fish. By using the term "fishers" instead of the more common expression "fishermen", we make clear that we have no information regarding gender and sexuality on Neptuna-58.

As will become clear from the further text, there are members of the same intelligent species as the ice fishers but with different occupations. The remarks presented here detail the activities of two additional communities of settlers: one of them collecting loaded particles and the other drilling for ore. As of now, there is sparse information on the hierarchy of these beings. Yet, the string of information that has reached us identifies a "Central Analysis Unit" as well as a "Central Council". While the former body describes and analyses conflicts and shortcomings in production decisions, the Central Council presumably has the means to allocate resources across different uses. Problems in decision making become clear when we study fishers whose life is made difficult by their physical environment and the interaction among clans of fishers. Concretely, in search of better catches in deeper waters, ice fishers venture far out on their lakes. This propensity leads them into dangerous rivalries with their neighbors with the possibility of ice breaks.

Beginning with the described conflicts encountered by the ice fishers, the text received offers recommendations offered by a Central Analysis Unit. Such reflections and suggestions are also given for the two further forms of production described here. The second sort of production on Neptuna-58 deals with the extraction of loaded particles from solar winds. The settlers described here are subject to a very different sort or risk. They have to manage an external challenge in the form of unpredictable solar storms. This brings into focus the tradeoff between the level and the stability of returns which illustrates the interplay between growth and economic cycles.

The third form of production concerns communities of settlers engaged in the extraction of ore from the ground. The task for these settlers is affected by the uncertainty concerning the location of the ore they seek to exploit. The information received documents the basic situation as well as two common strategies practiced for this decision problem. Again, the Central Analysis Unit offers perspectives and suggests improvements. These notes lead us to conclude that what we are reading here is a sort of policy document to be circulated for the purpose of improving the life of settlers on Neptuna-58.[1] To help the reader, we comple-

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[1] Given the likely use of the received information for internal use on Neptuna-58, it is not surprising that it does not provide a detailed account of further aspects of life on this planet. Notably, the manuscript is short on information pertaining to the biology of its life forms.

ment the received text with information that can only be inferred from the wider context. To make the manuscript more readable we blend such comments into the text. Similarly, we use figures that help to understand the basic motivations and dilemmas on this planet. These displays document the strategic dimensions of production on Neptuna-58. Decision making clearly is afflicted by forces and conflicts that appear familiar to us on planet Earth.

2. Of Ice and Fish

2.1. Basics

This is a general account of the life of settlers by our frozen lakes. The central topic concerns the ways of existence along these lakes. To begin with, this is a summary of obvious facts of subsistence of our ice fishers: our lakes are of a square shape and of equal size. They contain edible fish. The depth of lakes increases towards their center. Fish can be harvested by way of drilling holes into the ice and with appropriate tackle and bait. More fish caught means better living for ice fishers and more offspring. Settlers live in small communities, and each community or clan occupies just one side of a lake. Communities send out three fishers during any single period. Each community acts on its own. There exit strong obstacles to cooperation making communities highly territorial. Hence, there is no communication between communities. Clans consist of three active fishers and likely further inhabitants.[2]

The length of a single fishing period cannot be ascertained from the information received, so for simplicity we will refer to these periods as days. On any day, with four active clans, there will be 12 fishers on the lake. This generates the risk that is the focus of this chapter: too many drillings in too close a proximity leads to ice breaks. When the ice breaks, no catches are realized by any of the fishers on the lake. The mechanics of ice breaks are widely understood. If more than three ice fishers drill in too close a proximity, then the ice crashes.[3] **Figure 1** helps to understand the setting. The four quarters of the ice field are marked by diagonal lines which must not be trespassed on. They mark the territories of communities. To clarify and to give an example, the community harvesting the upper quarter of the lake can locate its fishers to drill fishing holes in any of the grey squares. The three specific slots chosen by a community do not have to be adjacent to each other.

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[2] There is no explanation given in the text as to causes of the obstacles to cooperation. Barriers to communication and cooperation could result from threats and hazards from other beings or from geological forces. Among the further inhabitants there could be offspring, as well as agents ready to replace fishers if needed. It is for now totally unclear whether there is a form of individuality or whether the behavior of all the fishers is determined by a central power within the community. Accordingly, the term 'fisher' should not be understood to necessarily mean the same as 'individual' in a terrestrial context.

[3] The text gives no hints of a visual sense being relevant on Neptuna-58. Thus, all figures appearing here are simply designed to clarify the information provided in the retrieved information.

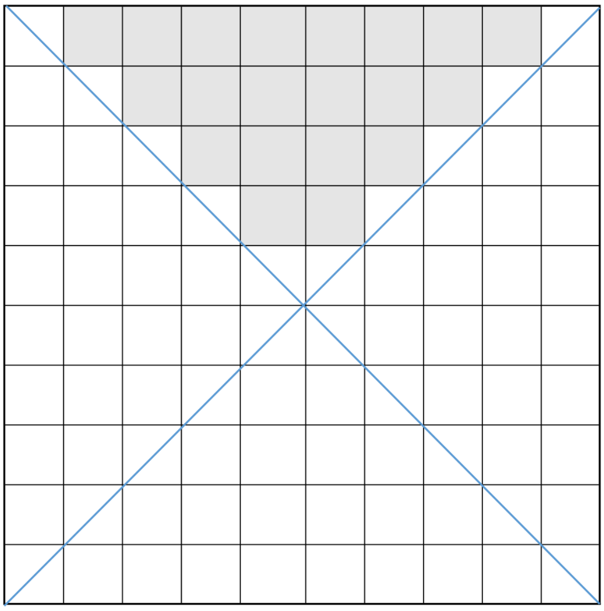


Figure 1. Territories and slots for ice fishers.

For an understanding of the key problems afflicting the communities of ice fishers it is important to know how the return in terms of fish increases the farther out on the lake the drilling of holes and fishing is done. In the domain right at the shoreline the return per fisher is two per period. In the next domain the return is three, in the third domain it is four, and in the fourth domain closest to the center of the lake it is five. The connection between the location on the lake and the density of fish becomes clearer with **Figure 2**.

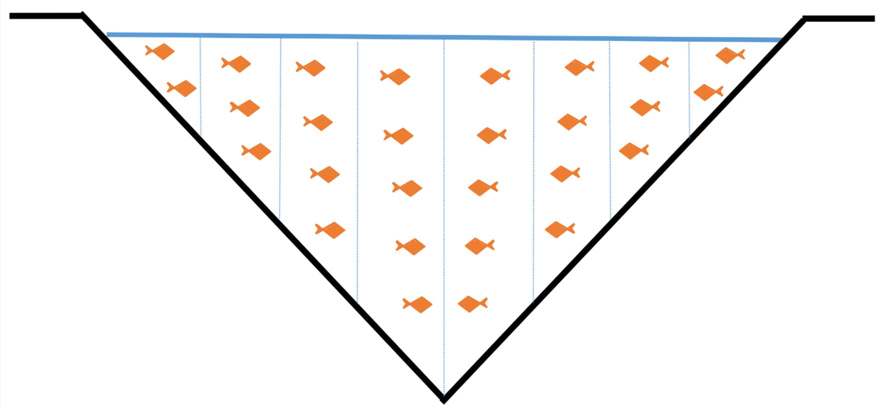


Figure 2. Fish density.

Importantly, the ice breaks when more than three fishers are placed in adjacent slots. Adjacent here means fields connected either along one side or at a corner. For a clearer understanding consider one concrete possibility for a crash to occur as displayed in **Figure 3**. Each community's fishers are identified by colored squares. In the case displayed the three fishers represented by yellow squares (left) and the one marked by a blue (top) square cause the break. This area of the lake where the break emanates is highlighted by a circle. Even though only the yellow and the blue fishers are causing the break, all communities are affected. In fact, all fishers come up empty in this period.

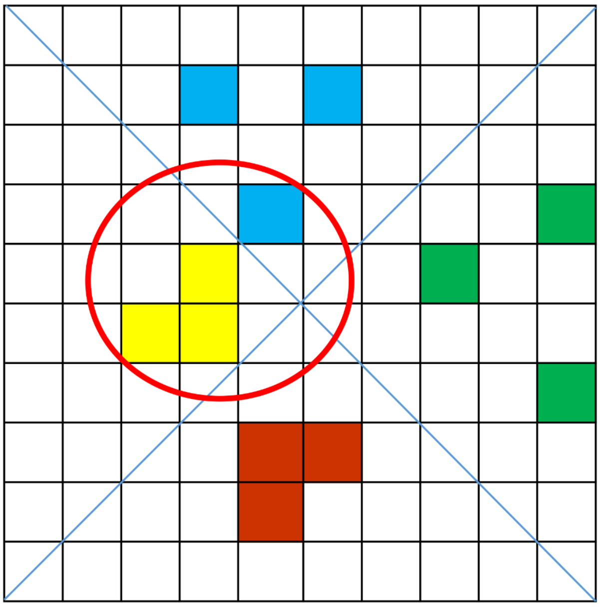


Figure 3. Emergence of an ice brake.

The ice break is displayed in **Figure 4** by black lines extending from the center of the crash into all four regions of the lake. Clearly, the green (right) and the red (bottom) communities who have not contributed to the ice brake are still caught in the crisis induced by two other clans. Accordingly, the consequences of an ice brake reach all fishers independently of their actions.

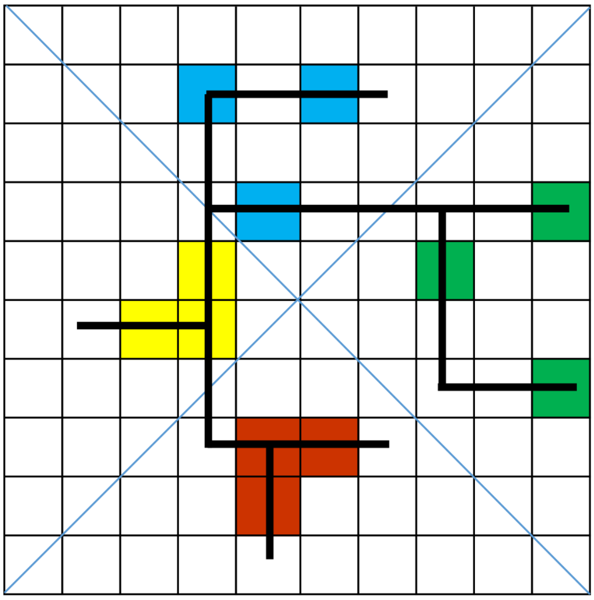


Figure 4. The extension of the ice brake.

2.2. Lakes of Modesty and Tranquility

Here, we start with strategies that avoid ice breaks altogether. Where these strategies prevail settlers live a tranquil life. Consider the first case which is called the lake of the fearful. On this lake all communities allocate fishers completely along the shoreline. This obviously never results in an ice break. **Figure 5** displays this situation. This setup generates catches of six fish for each community. Clearly, repeating this choice day after day leads to the same outcome with the ice always holding. Yet, there is a problem with this choice. The modest returns do not generate enough fish to allow a community to increase its population. In fact, over time starvation sets in.

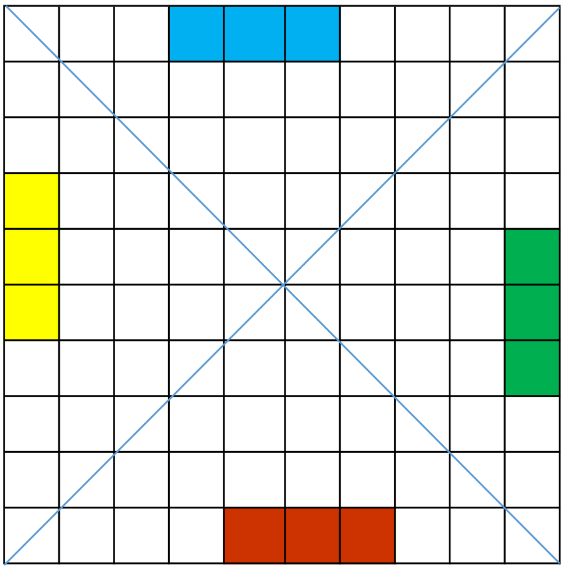


Figure 5. Lake of the fearful.

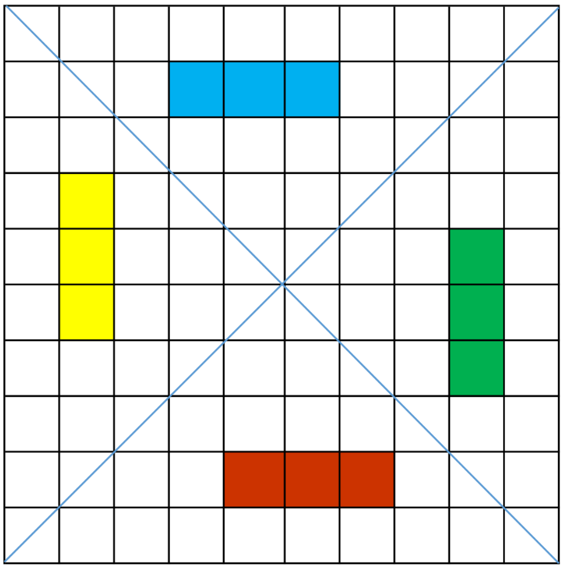


Figure 6. Lake of modest and safe returns.

Consider then a variation of the given example with a lake that also experiences no ice breaks. As before, the situation displayed in **Figure 6** shows a situation where every community is harvesting the same amount. Here, each community positions its fishers farther out on the lake but does not choose risky slots at the diagonal borders. The catch per community is now nine. This is a return sufficient to support the community and to allow it to grow. The section termed "Lakes of Conflicts and Crisis" will document how communities with the presently described strategy become exposed to risk once more than one community shifts to a different strategy.

2.3. Lakes of Ambition and Dominance

Consider now the situation when, starting from the situation first described, one community takes a more ambitious and riskier stance. This is the situation shown in **Figure 7**. Here, three out of four communities still follow a totally-risk avoiding strategy, but one community becomes more adventurous. Consider one (say the lower red) community choosing to go for the maximum possible catch. This is a clearly domineering strategy. It goes without ice break as long as neither the yellow (left) nor the green (right) communities follow suite. Yet, the perspective of increasing catches makes exactly this development likely.

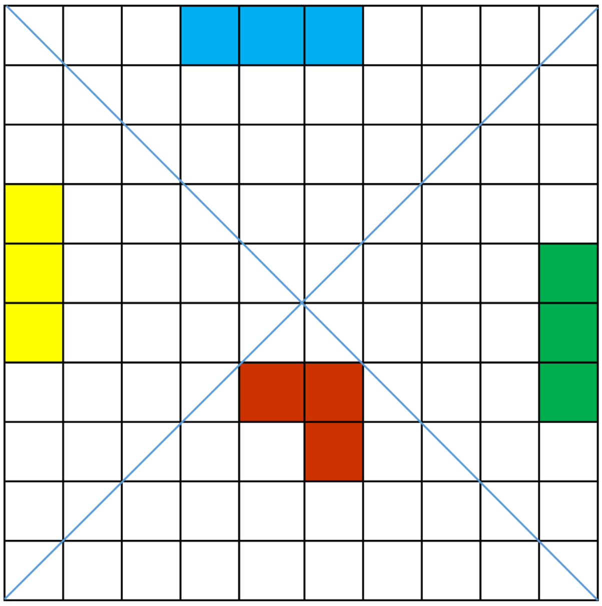


Figure 7. Lake with one dominant clan.

In just one conceivable constellation a second dominator can operate without the ice breaking. This is shown in **Figure 8**. Here, we directly go to the extreme case with two dominators on opposing sides of the lake and two less ambitious communities. The latter two clans now choose positions that yield the maximum possible for them given the dangers posed by the two dominating clans. We term the behavior of the former two clans risk-limiting. In this case each of the domineering communities catches 14 units of fish and the two less ambitious communities catch 12 units, respectively.

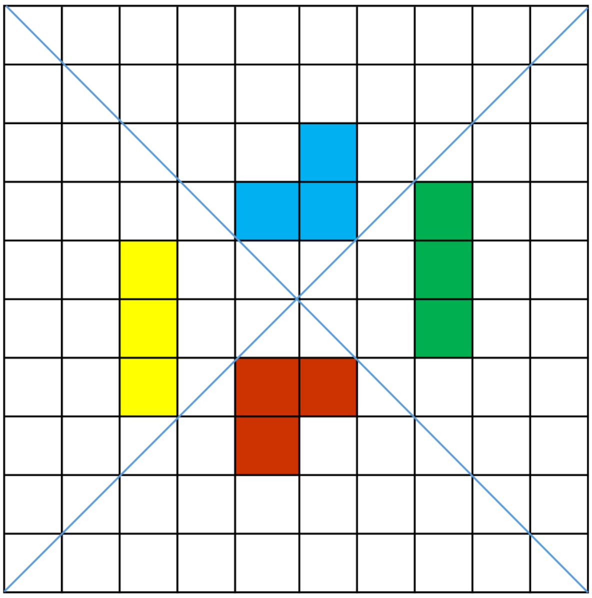


Figure 8. Lake with two dominant clans and two risk-limiting clans.

2.4. Lakes of Conflicts and Crises

The cases just described are helpful for understanding important threats to prosperity on our ice lakes. Unfortunately, our historical records document that situations of tranquility rarely continue for long. Sooner or later, some communities become more ambitious. With neighbors acting similarly, crashes become inevitable. As a result, everybody loses during such episodes of crisis. Now, the key question is what happens after a crash. How do communities react to crisis? Here are some notable variants: The worst outcomes are brought about by domineering communities who after a crash quickly go back to their risky strategy. If at least one adventurous community restricts its ambitions, this reckless behavior by one clan may pay out. In this case the dominators catch the maximum of 14 fish. More often, lakes with such communities experience frequent crashes and, on average, poor catches. Indeed, these situations typically lead to cycles of peace and crash.

A different outcome is feasible after a crash if communities still aiming for significant catches learn to behave less riskily. We do see some lakes where crashes are infrequent. On these lakes the typical reaction of fishers to a crisis is one of more restraint. Hence, a formerly domineering community may aim for a somewhat smaller level of catches. With such reasonable restraint we often observe productive outcomes under these conditions. Clearly, the key driver of instability is the perception in fishing communities with modest catches that more is possible. Crashes occur particularly often – but by no means exclusively – on lakes where nobody exactly knows who brought about this crisis. This happens where visibility is poor. Even a domineering group may not be the culprit when, e.g., two other groups aiming for a smaller return inadvertently drill too closely. This sort of strategic uncertainty adds to the challenges of fishing communities. Hence, even modesty is not a perfect guarantee for success and stability. It is on this background that our Central Analysis Unit has taken on the task of investigating key problems in order to propose possible solutions.

2.5. Analysis and Suggestions

The Central Analysis Unit has studied the situation of the ice fishers and proposes two possible approaches to the recurrent problem of crashes. Of particular concern is the dismal level of returns of communities that can occur even in the absence of crashes. To start, let us discuss a situation that generates the highest possible harvest at no risk. Here, all communities place their fishers as far to the center of the lake paying attention to not have any drillings adjacent within members of the same clan. Proceeding with these precautions it does not matter on which side the drillings are placed. A crash simply never occurs. An instance of this strategy is displayed in **Figure 9**.

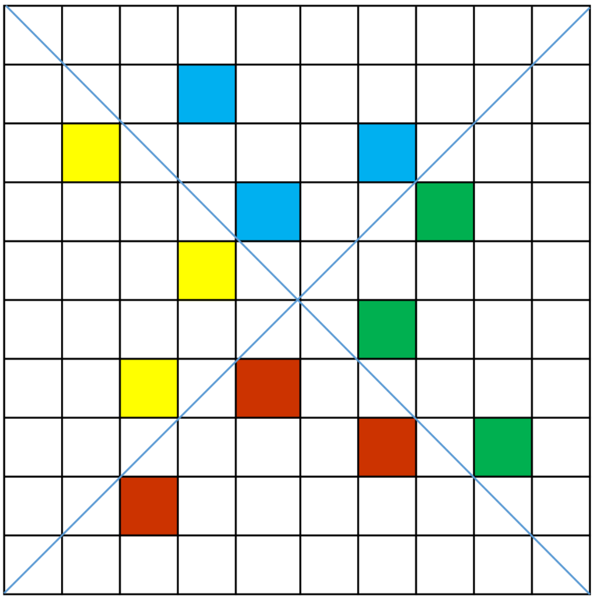


Figure 9. Lake with all clans following the safe strategy.

If all communities follow this strategy, it does not matter whether some communities place their fisher at the diagonal. Invariably, there are never more than two fishers from different communities that come to be adjacent to each other. This strategy gives a catch of 12 fish for each community and thus offers an excellent outcome to all clans on this lake. It is particularly relevant since it can be easily taught to communities.

The next possible strategy promises even more. We term this ideal situation the lake of peace and harmony. Look at the displays in **Figure 10** for variants of this approach. Apparently, there exists no better solution for placing fishers with every community harvesting the same number of fish. For sure, for this strategy it makes no difference whether the first or the second approach is realized. They both yield a harvest of 13 for each community.

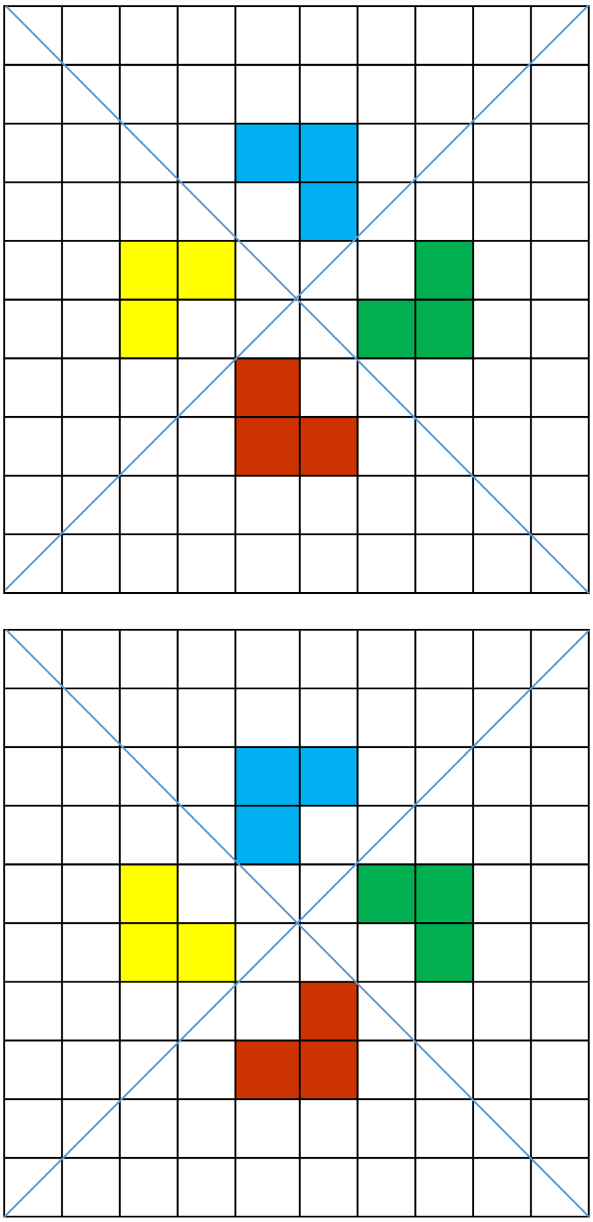


Figure 10. Lakes of peace and harmony.

So far, this approach has not been practiced on Neptuna-58. Thus, it would need to be taught to settlers. It is more challenging than the solution discussed before since four communities need to coordinate on one of the two variants just shown. They need to choose the same orientation of their three fishers. Either all choose the “∟” or the “˩” formation. Given the sign “∟” is prominent in our culture, it could be suggested to communities to place their fishers in just this constellation as shown in the first display.

3. Solar Winds and Loaded Particles

3.1. Basics

Our settlers in the valley of the solar winds face a special set of difficulties. Their task is to harvest as much of the loaded particles that flow through their valley. This solar stream strictly blows in one direction. The way to collect these energy-loaded particles is to put collector cubes in the way of their flow. Each settler community is initially given three such collectors, which they can position as they see fit. Here are the central aspects that define this task. Collectors placed on the ground collect one unit of particles. A collector placed on top of the first cube, i.e., on the second level, collects two units of particles and each collector placed on the third level collects three units. Beyond that level, collectors cannot be mounted. Technology allows particle collectors to be moved freely as long as they are on the ground. Collectors on the second and third level cannot be moved once anchored. Anchoring takes place as soon as the planned structure is finished and before the solar wind picks up. The mounting of collectors follows the following rules: a cube can only be mounted stepwise on top of another cube. The display of Figure 11 illustrates how this restriction guides the mounting of structures.

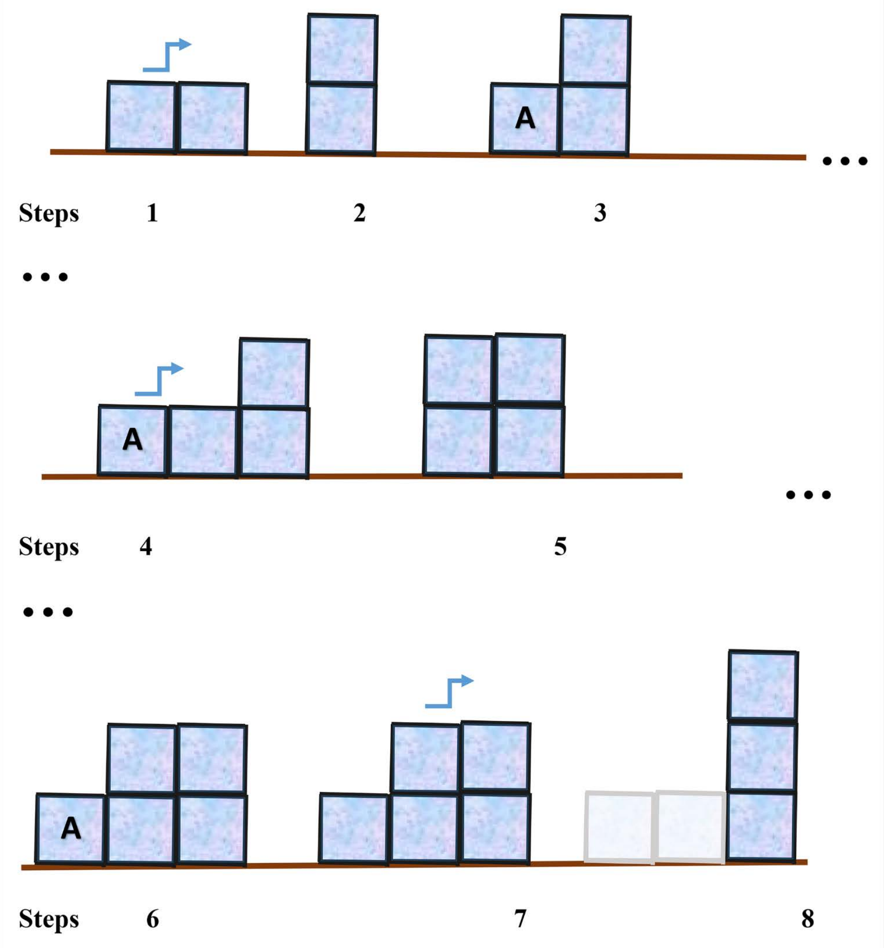


Figure 11. Mounting a tower of collector cubes.

A cube labeled with an "A" indicates that this cube is added in a given step of construction. As can be grasped from the display, the mounting of a three-storied tower of collectors proceeds in eight steps. Since the two remaining cubes on the ground can be moved away for further uses, this explains the construction of a tower of three levels. Clearly, given enough cubes available this structure can be extended to two or any number of similar towers.

3.2. Storms

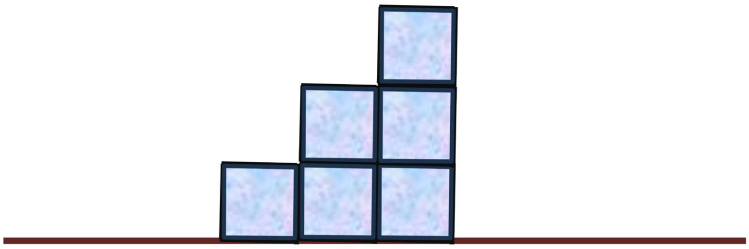
The collection of loaded particles by mounted structures of cubes is challenged by the random occurrence of storms. On average in one out of six seasons the solar wind turns into a storm. When this happens, the mounted structures are challenged. Except for cubes on the ground which are safe, cubes are destroyed when not stabilized by cubes placed directly on top. This means that a structure with a cube on the second level will be reduced to a structure of level one. A structure of three levels will be reduced to a structure of level two. Cubes that weather the storm still collect particles despite the stormy winds. The cubes that are destroyed collect nothing. Immediately after a storm the destroyed cubes are carried away.

3.3. Growth and Recession

Settlers that harvest more units of particles than the number of cubes they already have are given more cubes. For each full extra unit of particles, the Central Council delivers an extra cube. Settlers who place their initial three cubes on the ground gather three units of loaded particles and hence just subsist with no change over time. Storms will not affect their collection result. By contrast, settlers that decide to mount cubes start the first season with the structure shown in the top right of Figure 11. If the solar wind remains moderate in the first season, they gather four units of particles and accordingly receive an extra cube for the second season.

By contrast, if a solar storm hits during the first season, these settlers are thrown back to an endowment of only two cubes. If, given this setback, they mount a tower of two cubes for the second season they stand the chance to collect three units of particles and will be given an extra collector cube. This allows them to continue with possibilities of accumulation. If, however, a storm continues into the second period, these settlers are reduced to one cube and have no more options for change. We call this a poverty trap. Settlers experiencing this misfortune will not be able to recover.

If no solar storm hits in period one, settlers in period two are able to work with the structure shown on the right of the middle of Figure 11 since an additional cube is available in the second period. If things proceed undisturbed by storm, two more cubes are available for the third period bringing them to a total of six cubes. However, this does not yet allow the mounting of two towers of level three. Instead, in period three settlers have to operate with the structure shown in the display below. This structure generates ten units of particles leading to an additional allocation of four cubes for period four.



Provided no storm comes up in the following periods, accumulation continues. From here on, a community of settlers thus operating can further expand. In the absence of solar storms, this growth of collectors would approach a doubling of collectors and output in every period. Each tower of level three yielding three new cubes is just enough to build another similar tower. Yet, sooner or later, a solar storm sweeps through the valley. With the approach described the result will be roughly a halving of output during a storm. Just as an illustration, and assuming storms happen regularly every six seasons, the production of loaded particles will look as shown in Figure 12. Note that the vertical axis shows the natural logarithm of the units of loaded particles collected.

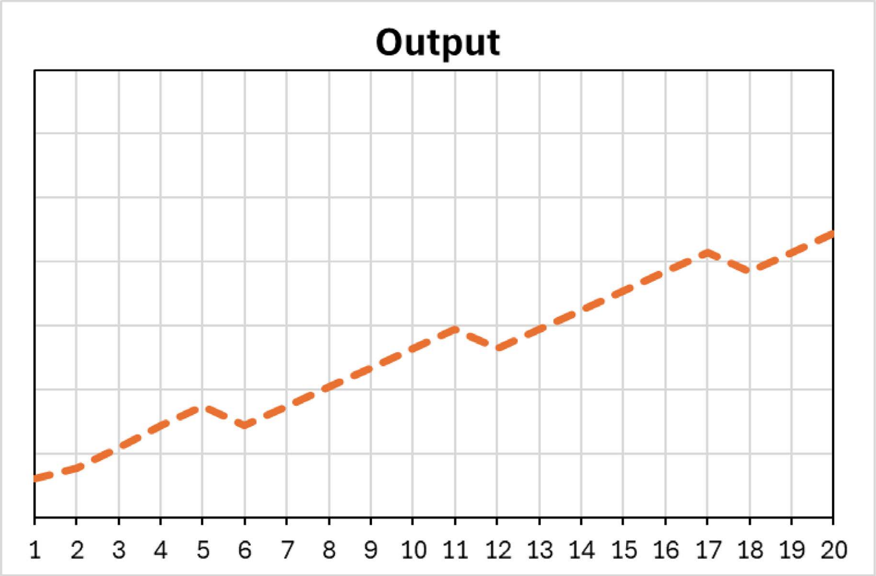


Figure 12. Output over time of particles collected.

3.4. Analysis and Suggestions

As with the situation of the ice fishers, a deeper study of the problem of collecting loaded particles suggests possibilities for improvements. Here, the recommendations by the Central Analysis Unit start with an important insight concerning the technology of collectors used. Research shows that the number of loaded particles collected is only determined by the surface area exposed to the solar winds. From this insight it follows that the cubes should not face the solar wind perpendicularly. Instead, they should be placed in such a way as to show maximum surface.

This means that they should be placed so that their diagonal is positioned rectangularly to the direction of the solar wind. Consider the display of this matter as seen from above in Figure 13. To the left we have the typically practiced positioning and to the right we see the optimized way of positioning.

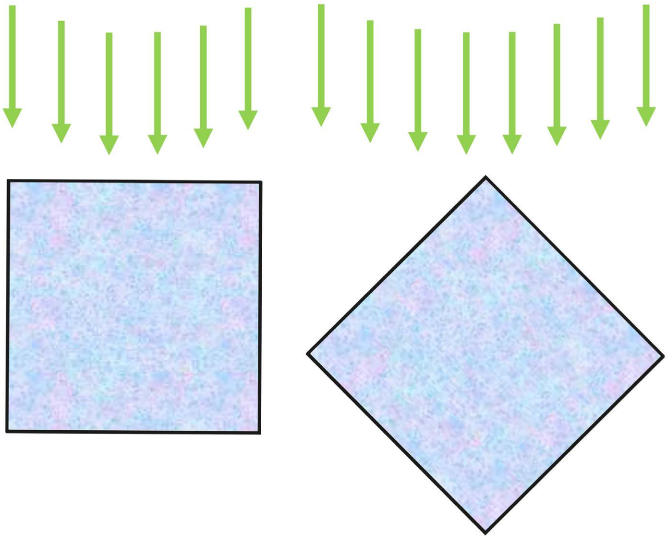


Figure 13. Collection of particles in standard and optimized ways.

If the side of the cube is one, then its diagonal is the square root of two which is 1.414. Hence, placing the cubes diagonally to the direction of the solar winds, as shown on the right-hand side, yields 41.4 percent more loaded particles. Starting the collection of particles with the initial endowment of three cubes could hence look as shown in Figure 14. This placement of the three cubes displayed generates 4.242 units of solar energy in the first season. This results in an additional cube for the second season. Note that with this plan there is no threat from a possible solar storm in period one.

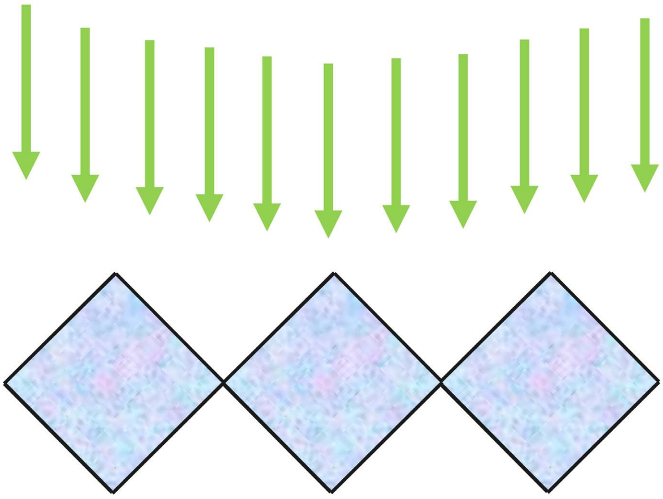


Figure 14. Initial positioning of collectors.

In the second season the site of four thus positioned cubes flatly on the ground generates 5.656 units of loaded particles and thus an additional 5th cube is available in the third period. In terms of collected particles output rises to 7.071 in period four which brings the count of cubes to seven in the fourth season. Clearly, from then on, the structure of cubes can be elevated to rise to level three. Each of these towers of three cubes placed on top of each other and set diagonally to the solar wind will now generate 8.485 units of loaded particles. The following **Figure 15** documents the course of the quantity of collected particles over time for the so far typical approach (denoted by P, for perpendicular) and the newly suggested approach (denoted by D, for diagonal). The new method of placing the cubes clearly dominates the method now typically practiced. The shortfall of the D-strategy at the beginning is well worth accepting as the cost of preventing the risk of a poverty trap.

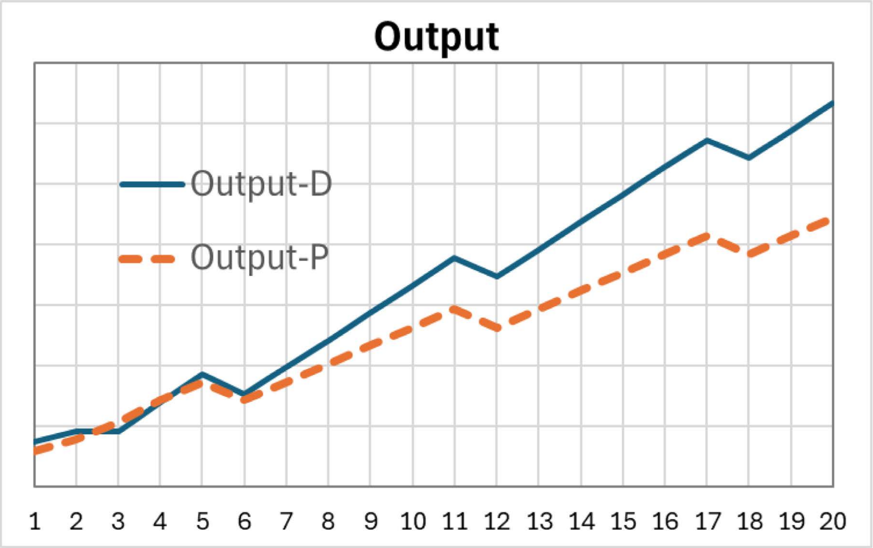


Figure 15. Output over time of particles collected under two strategies.

Yet, further research suggests an additional way to improve on the D-strategy. Tests have shown that there is a possibility of constructing the collector towers to make them fully resistant to solar storms. This final strategy will be termed diagonal and safe (DS). It consists of forming a wedge of diagonally placed cubes. This wedge structure shown in **Figure 16** withstands solar storms, even when three cubes are placed on top of each other. However, it is obvious that there is a downside to this approach when it comes to the output in terms of particles gathered. Three cubes positioned in the form of a wedge collect only two third of what the structure of three free-standing cubes is able to collect.

So how do the two new strategies proposed by the Central Analysis Unit compare? The DS strategy allows for a buildup of cubes preventing all possible losses from solar storms. As shown in **Figure 17** the resulting quantity of collected particles grows steadily. At no time will there be a setback. Yet, as the display also makes clear, under the D-strategy only the first realization of a solar storm in period 6 reduces output below the level of the DS-strategy. Already during the second occurrence of a recession in period 12 output from the D-strategy remains above the level from the DS strategy. So, there is a choice to be made between more output and more stable output.

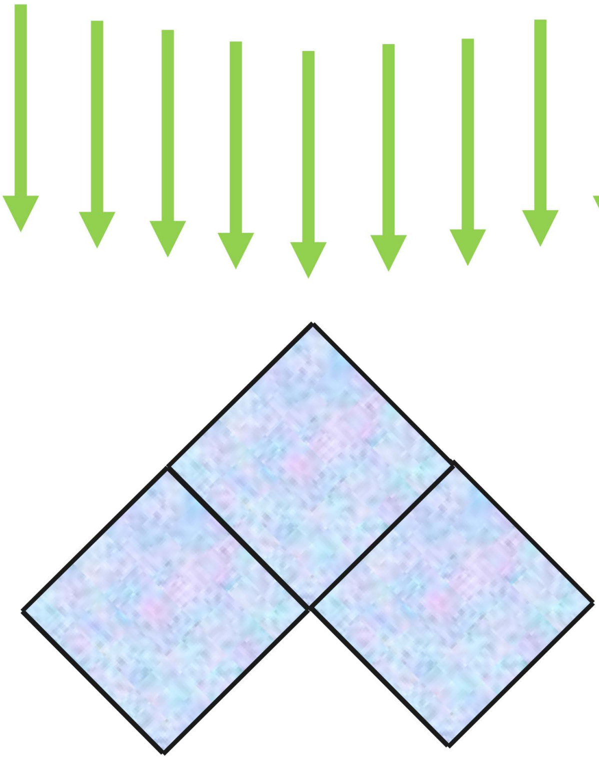


Figure 16. The wedge structure of collector cubes.

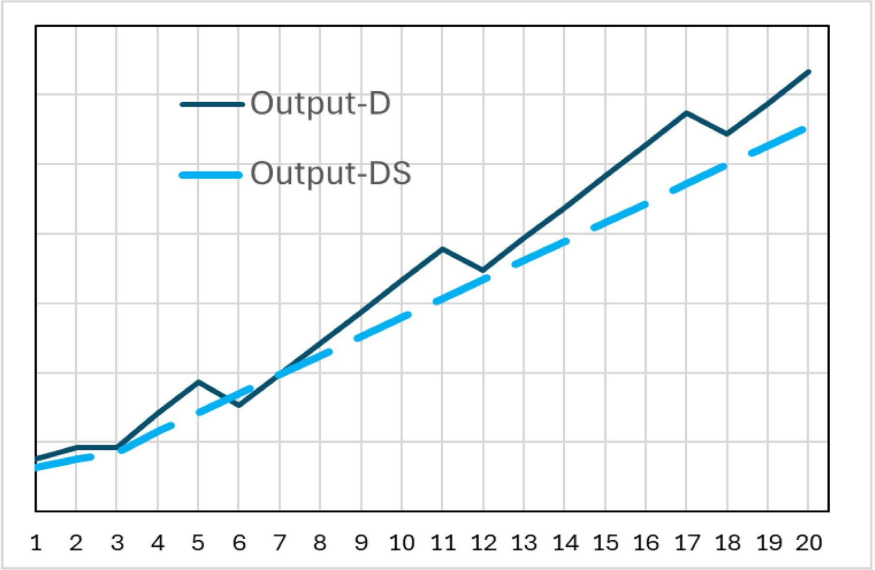


Figure 17. Output under strategies with and without setbacks.

4. Ore extraction

4.1. Basics

Here, we describe the situation of our settlers that drill for ore resources. The region of Neptuna-58 where the ore can be found shows clearly identifiable patches of surface where the resource is present underground. These patches are all of square size and equally large. They are the size of four units long and wide. Within each patch there is a subfield of two-by-two length in which ore is present. What makes the extraction of ore difficult is that with the parameters described there are nine different possibilities where the subfield with the ore can be situated. The ore is extracted by drilling. A patch can be drilled in four different places. More drills have the tendency of destabilizing the patch. Accordingly, in the best possible case all four drillings are successful and exhaust the total of the ore in a concrete patch. The following display gives a visualization of a patch and the possible positions of the ore field.

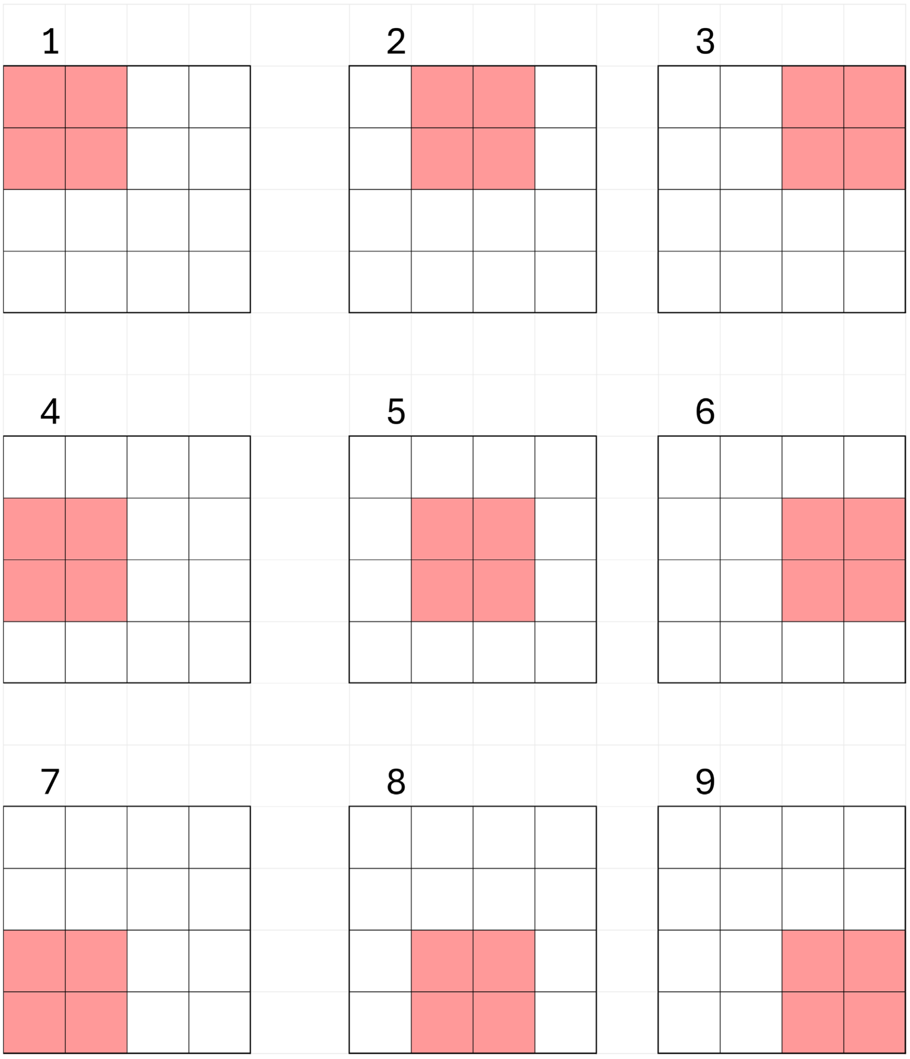


Figure 18. Possible positions of the ore field in a typical patch.

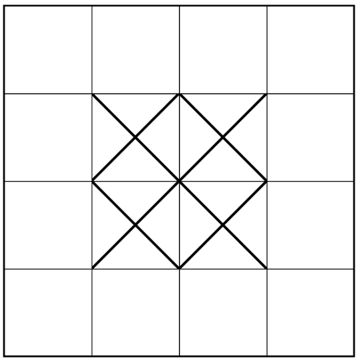
4.2. Simple Strategy

From surveys we know of the following two ways that our settlers proceed to search for the ore. Here we discuss the first of these strategies. With this approach the four drills are placed randomly in any of the 16 possible subfields. This strategy allows all drills to be placed at the same time. Experience informs us about the success of this approach. In fact, on average only one drilling in each patch thus explored yields a supply of ore. Clearly, there are instances where more is found, but there are also instances where nothing is found. Considering the previous display of **Figure 18**, the drilling of the four connected fields in the lower right corner of the patch could be an example of this strategy.

Going through the nine possibilities of where the ore resource may be located, we find, from top left to bottom right, the following numbers of success with this strategy: 0, 0, 0, 0, 1, 2, 0, 2, 4. This also indicates that there are five possible sets of drills with zero success. Further, in one out of nine cases there is just one productive drill, in two cases there are two successes, and in one case there is complete success with four positive findings. All nine of these possible locations are equally likely with probability 1/9. The multiplication of success rates with probabilities and summing up leads to 9/9, i.e., $0/9+0/9+0/9+1/9+2/9+0/9+2/9+4/9$, which adds to one. Hence, random drilling is a simple strategy but is yields on average only one success and in most cases (five out of nine) the drillers come up empty. If this happens, the potential of an ore patch is completely wasted.

4.3. Smart Strategy

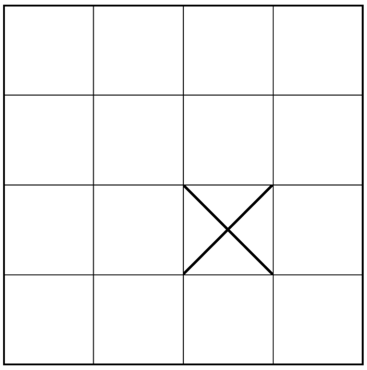
Under this approach drillers focus on the core fields within the patch. When the middle four subfields are covered with drills, the likely success rises substantially. This becomes clear when going through the nine cases shown before. Concretely, the positioning of the four drills as shown in the display below brings the following numbers of success depending on where the ore field is actually positioned. Again, referring to **Figure 18** with the nine possible positions of the ore this leads to the following instances of successful hits: 1, 2, 1, 2, 4, 2, 1, 2, 1. Weighting these outcomes with the probability of 1/9 generates an expected success of 16/9. Compared to the 9/9 of the random strategy discussed before, this is an improvement of almost 78 percent.



Note that the smart strategy not only yields a higher average of success than the random strategy. It further guarantees a minimal success from each patch thus explored. At the minimum, one subfield with ore is thus detected. Hence, with this approach it is not possible to completely waste the potential of a patch of ore resources.

4.4. Analysis and Suggestions

The Central Analysis Unit has documented the prevalence of the two described approaches among settlers. Upon a deeper review of the problem of ore drilling, the Central Analysis Unit asserts that even the smart strategy should be replaced because it can be substantially improved on. To begin, the newly suggested strategy is a sequential one. This means that with the new optimized approach drillers make one decision after the other depending on success or failure. The strategy outlined here has an important point in common with the smart strategy. Clearly, the central four subfields are the preferred range to set the initial drill. The four central possibilities are equally likely to contain ore, so it does not matter where to start. Consider the placement of the first drill as displayed below. This choice is either a success or a failure.



4.4.1. Initial Success

If this first choice for drilling is successful (in four of nine cases) there are only four sites left where the ore field could be situated. As shown in **Figure 19** these are the positions 5, 6, 8, and 9, respectively. The three positions on the top as well as the ones on the left can now be ruled out. They cannot be places where the ore field is located. This is identified by the greyish cover over these positions as shown in **Figure 19**.

So, continuing from here, after a first successful drill, there are again particularly promising options to proceed in the second step. They are identified by circles and squares (solid and dotted) in the display above. They lie to the left, right, top, or bottom of the first choice. The crossed field marks the site already and successfully drilled. Each of the marked options for a second possible drill will be successful in two out of four cases. Hence, there is a 50-50 chance of further success. Accordingly, one of these positions is chosen for the next drill. Take as an example the drill left to the already successful first drill as identified by the solid circle in Figure 19 and further identified in the display below.

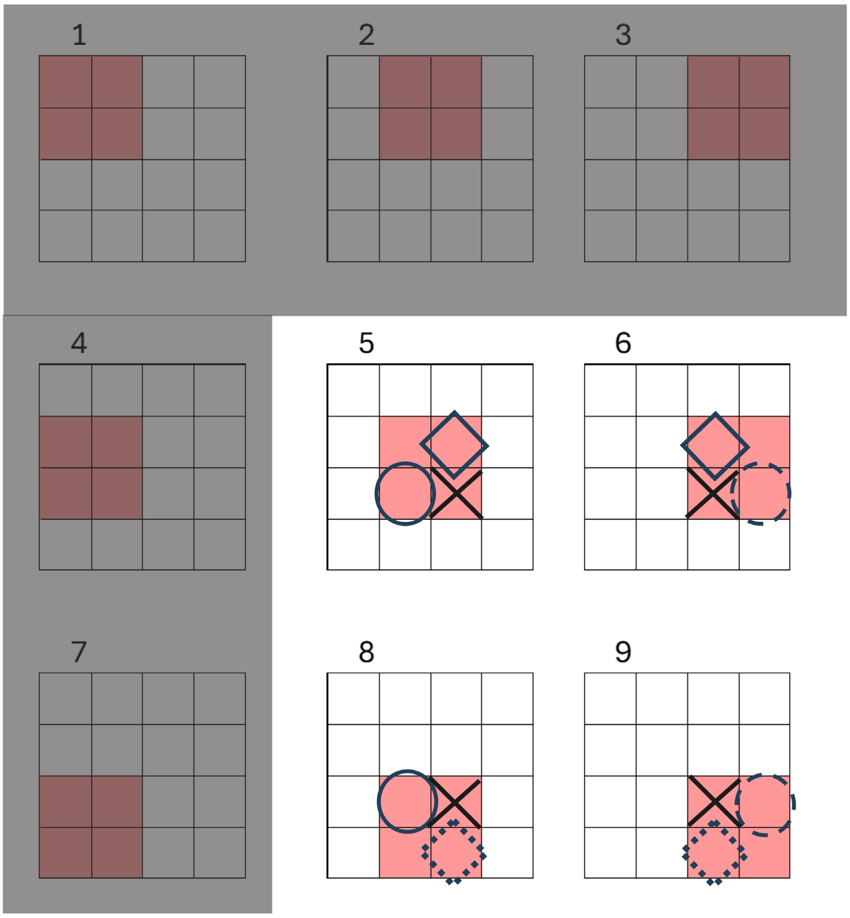
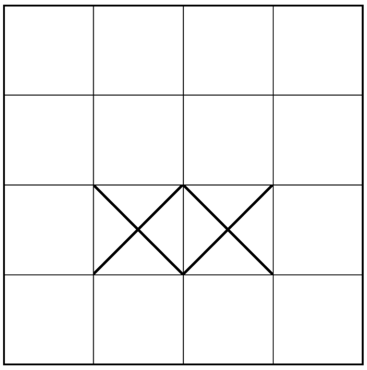


Figure 19. Remaining possible locations after initial success.



As indicated, this choice has a 50-50 chance of a further success. If this second choice is indeed successful, this only leaves the two positions 5 and 8 as possible location of the ore field. This is depicted in Figure 20. Hence, the third drill also has a 50-50 chance of success. In the case of a success in drill three, the fourth trial is a success for sure.

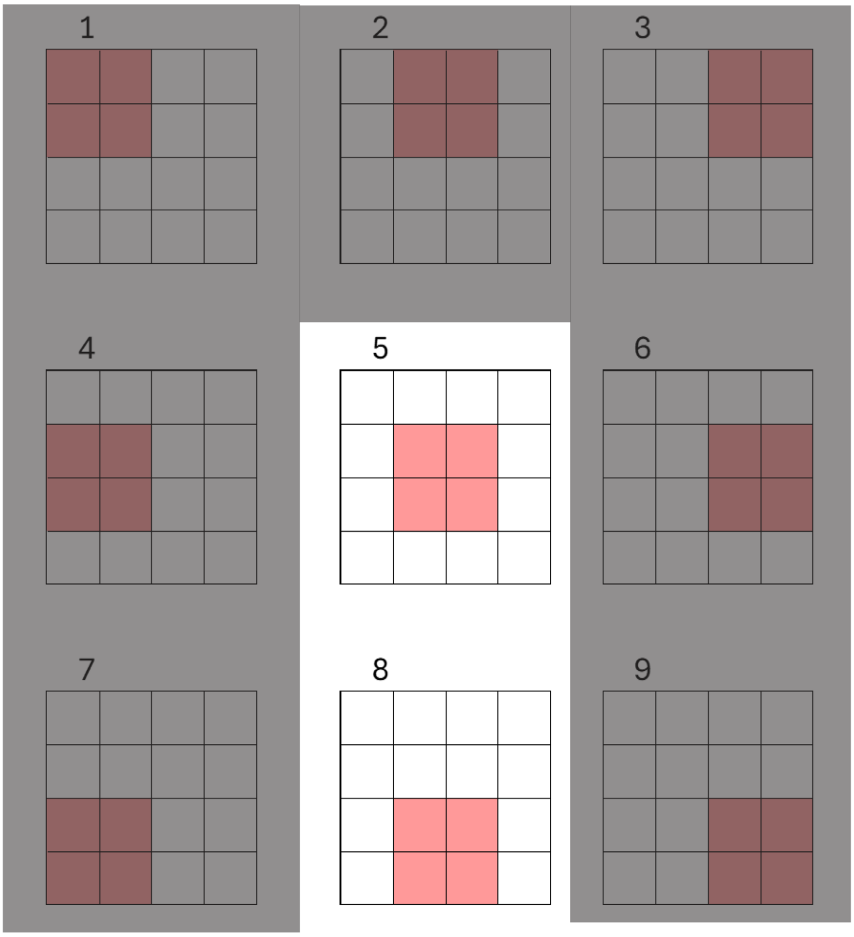


Figure 20. Remaining possible locations for third drill.

By contrast, if drill three is not successful, the last choice is obvious and hence cannot be a miss. The final choice then goes in the opposite direction (namely to the right of the initial drill) and will be a success for sure. Hence, we have Success-Success-Success-Success or Success-Success-Failure-Success. By contrast, what is there to be inferred when the second choice, after the success in the first exploration, is a failure? In this case the remaining possible positions of the ore field are positions 6 and 9 as shown in Figure 21. In this case we again have a 50-50 chance of success with the third drill. If it is successful, the final drill will also be a success. If, however, the third choice is a failure, then the final fourth choice will be a success for sure. This completes the branch of possibilities that starts with an initial success.

4.4.2. Initial Failure

Consider now the situation when the first choice is a failure. Then, there are five remaining positions of the ore field. This is presented in Figure 22. In this case, there is one concrete subfield (encircled) that offers the best position for the second drill. In three of the remaining five possible cases, this choice brings success.

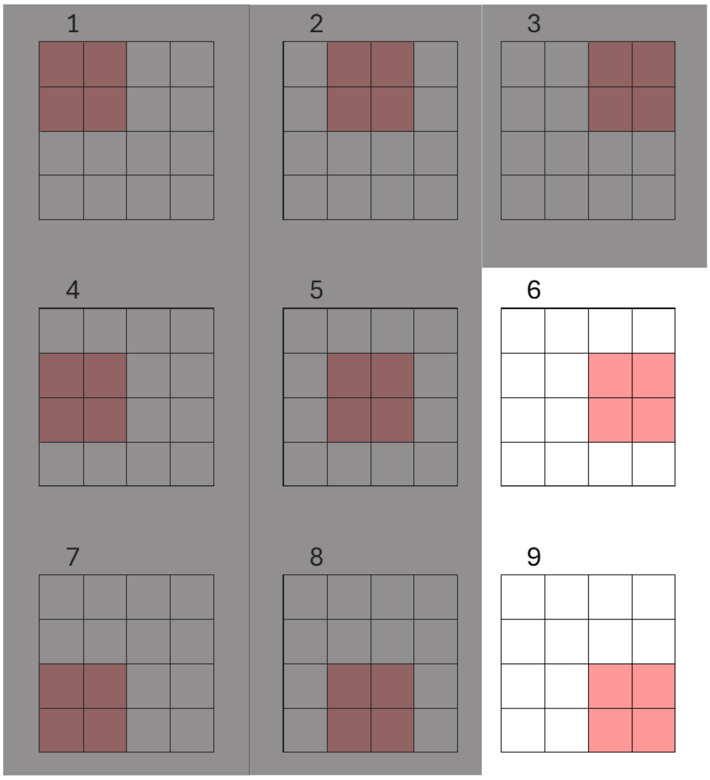


Figure 21. Remaining possible locations after sequence of success-failure drillings.

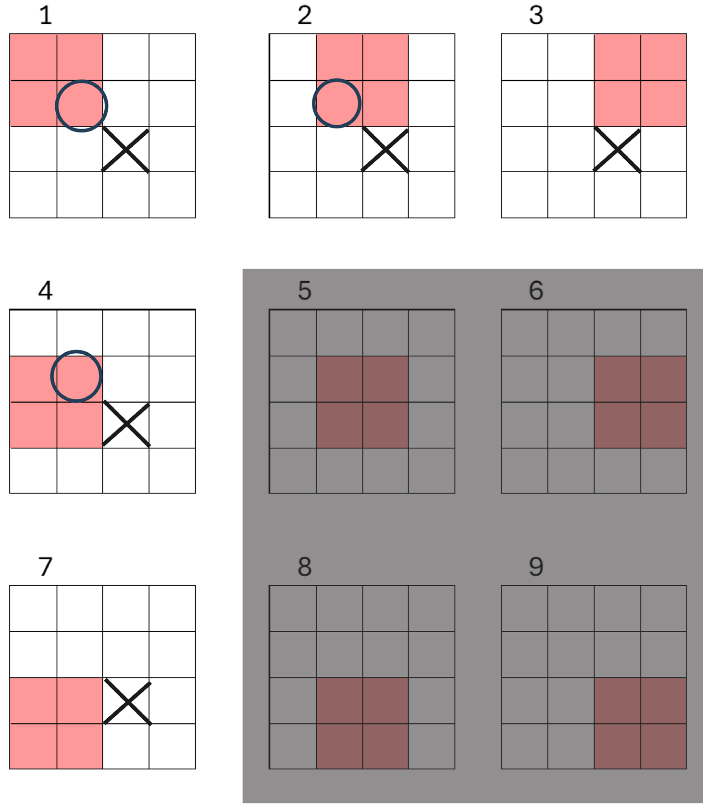


Figure 22. Remaining possible locations after initial failure.

Assume the circled position is chosen as the second position of the drilling. This is marked by the second cross in the display of **Figure 23**. From here on there are several more branches of choice. If the identified choice for the second drill indeed brings a positive outcome, this finding leaves the positions 1, 2, and 4 as possible sites of the ore field. Now the two newly circled choices (solid and dotted) have the highest chance of success in the next drill. They promise hits in two out of three cases.

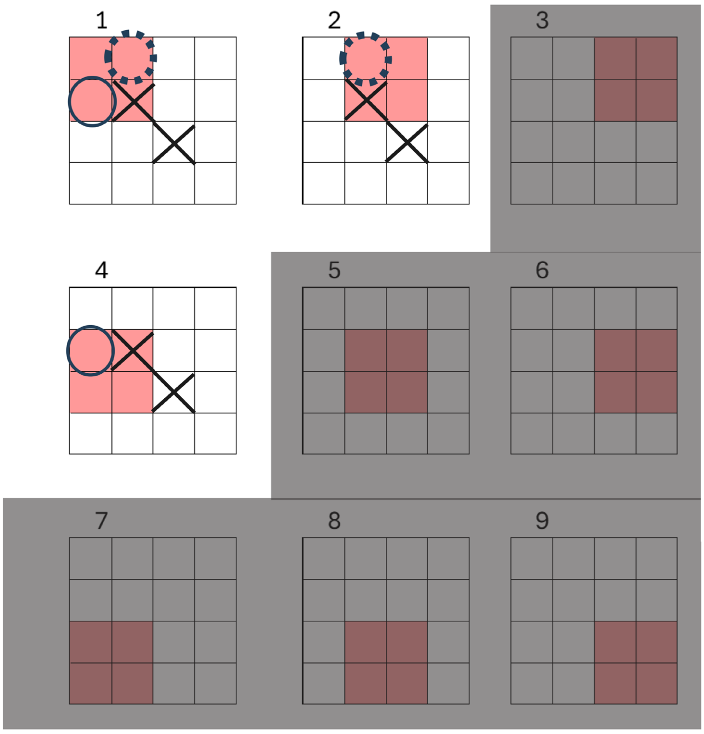
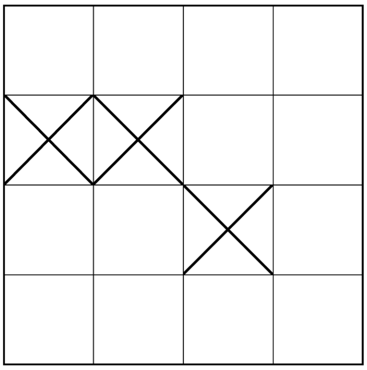


Figure 23. Remaining possible locations after initial failure.

Consider picking the position left to the successful second choice. The following display identifies the three drilling sites:



If this third choice is successful, the choice for the fourth drilling is a 50-50 chance because only the positions 1 and 4 are still viable. So, one of the subfields above or below the previously successful drilling is chosen. However, if the third drill is a failure, the last drill will be a success for sure since the ore field can now be clearly located as being in position 2. Coming to the last scenario: if the second choice is unsuccessful, this leaves only the two positions 3 and 7. With a 50-50 chance the third drill will be a success, and in any case the fourth drill will be successful.

This completes all possible branches of drilling with successes and failures. Figure 24 shows all the possible branches of exploration with the relevant probabilities. S stands for success, F stands for failures and the numbers given are probabilities. The newly developed strategy is clearly more successful than even the smart strategy. If settlers adopt this strategy, they will average 22/9 successful drills on each ore field explored. This result is found by going through the nine branches of the decision tree that yield successful drills of 4, 3, 3, 2, 3, 2, 2, 2, 1, respectively. Multiplying these numbers with the probabilities of these branches (which are all 1/9) gives 22/9 or 2.444. Hence, the new strategy offers an impressive improvement of 37.5 percent over the smart strategy.

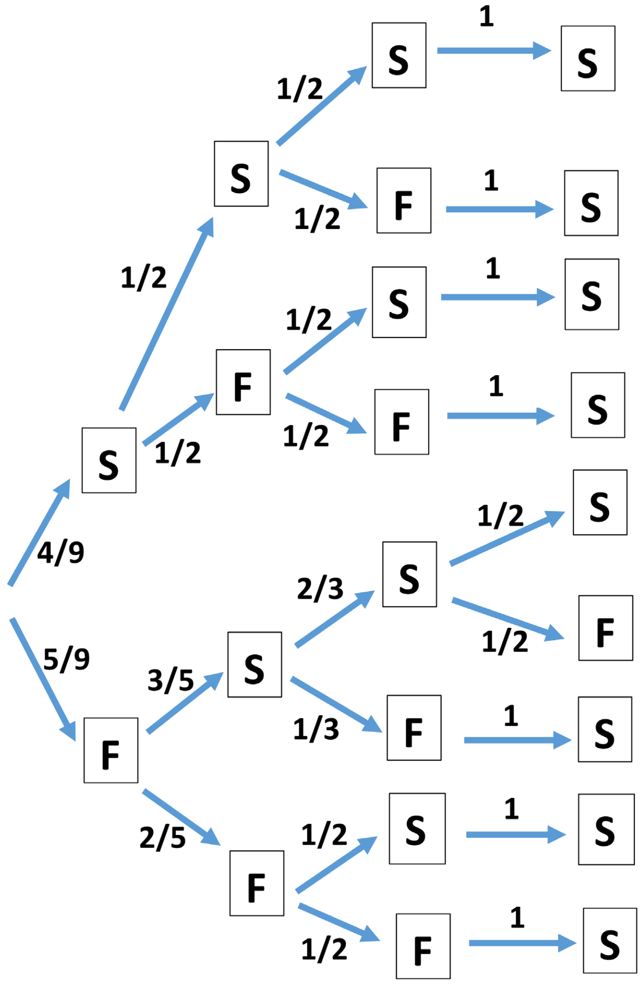


Figure 24. Decision tree for optimal strategy.

5. Discussion

This text offers only a glimpse at the economic life on Neptuna-58.[4] Nevertheless, it becomes clear that essential elements of economic logic apply as they pertain to our terrestrial situation. This starts with risk taking as a central element of many productive activities. All three forms of production described here are afflicted by elements of risk. For a start, the harvesting of fish from ice covered lakes indicates a situation where risk is determined by the interaction of actors' choices. While the physics of ice offers the background it is only the positioning of fishers on the lake that can bring about crashes. In the situation of ice fishers, we thus observe how the interaction of agents can lead to unintended bad consequences.

Now, just like on planet Earth, economic risk arises as a result of agents' urge to earn more, to aim for higher yields. The ice per se poses dangers, but it is the urge for higher returns that leads to the crash. Yet, restraint and modesty as traits are no guarantee against crisis and hardship. First, refraining from taking any risks leads to stagnation. Fishers sticking to the shore line make too little to support their communities. Further, and more troubling, even modest fishing clans cannot live in peace if they have overly ambitious and reckless neighbors. Hence, there invariably arises the danger of excessive risk taking. The conflicts that go with this can in principle and for some time be tamed by moderation, but escalation of risky behavior remains a constant threat.

Starting with the situation of the ice fishers and the propositions suggested by the Central Analysis Unit we appreciate the appeal to reason. The insights offered by the Central Analysis Unit may be sufficient to help societies to prosper. This differs from the possible stepping in of a central authority that takes over control of production processes. In this situation the provision of unbiased information and the appeal to rational behavior clearly offers the less intrusive approach. The collection of loaded particles in the valley of solar winds presents another central characteristic of economic life both on Neptuna-58 and on Earth. Here, we refer to the trade-off between growth and stability. The possibilities of positioning of collector cubes described as one variant by the Central Analysis Unit indeed offer a way for permanent improvement. They detail a way to accumulate more loaded particles without ever experiencing a backlash. However, accepting the possibility of crashes due to solar storms allows a path that generates a higher return. Hence, communities need to weigh how they choose to balance growth versus stability.

The example of ore extraction adds a final general point. First, we observe the difference between simple and smart solutions to a decision problem. Obviously,

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[4] As of now, we know nothing about possible additional forms and aspects of production on planet Neptuna-58. We are ignorant about how the capital goods used to drill and those applied to capturing loaded particles are produced. The whereabouts of the machinery used on the frozen lakes and ore patches remain a mystery. Also, there are no cues regarding the uses of loaded particles and ore. Furthermore, there are few cues as to how this planet's society is organized. The only indication here is that the mere existence of this text suggests a sort of hierarchy, with a central control supported by an analysis unit besides the periphery of producers. Obviously, there is only scant information regarding life in general, except for the fact that there seem to exist at least two species represented by the various settlers and the fish.

an extraction regime based on random sampling offers a feasible strategy. But then the smart strategy offers a very distinct improvement. It not only offers a higher return of extraction, but it reduces the possibility of total failure. Moreover, the smart strategy is still plain and simple. It does not need reflection and stepwise actions. In other words, it puts little pressure on the rationality of decision makers. Yet, the final suggestion made by the Central Analysis Unit provides an astoundingly superior way of managing the resources at hand. The sequential procedure of ore exploration promises a much higher return compared to the currently widely practiced strategies. With this approach the wastage of resources drops very markedly. Hence, reflection and rational behavior are clearly important allies for the conservation of the environment and of natural resources on Neptuna-58 as well as on Earth.

6. Epilogue

This essay takes some liberties with the scientific discourse. As most readers will notice, this is really a tour of some central forms of economic risk couched in the environment of a far-away planet. The format of science fiction as a tool for presenting mathematical and scientific speculations has quite a tradition. One of the classic contributions in the field is Abbot's (1884) "Flatland", which examines life in and perception of worlds with different numbers of dimensions. More recently, Fowler (2010) goes as far as claiming that mathematics itself is a branch of science fiction. In the field of economics, science fiction has its own tradition. Arguably, Marx's (1857-1858) discussion of machinery in his "Grundrisse" can be seen as an early form of economic science fiction (see Trott, 2018). Many contributions in the science fiction collection by Davies (2018) extend this social utopian approach to issues of production and distribution.

The study of economic risk also has a long history. In terms of formal analysis, it goes back at least to Bernoulli (1738). In the first part of the 20th century, key contributions came from Knight (1921) and Keynes (1936) which highlighted the central role of risk for entrepreneurs' activities and success and for a country's aggregate income, respectively. Important theoretical developments in the later part of the 20th century are summarized by Hirshleifer and Riley (1992). The topic at the core of our account is the concept of bounded rationality as introduced by Simon (1982). It emphasizes that economic outcomes are often suboptimal due to limitations of decision making. As such, this is one of the first behavioral economics contributions in a science fiction format.[5] One key message of our analysis is that the free provision of information and appeal to rational behavior should be pursued instead of limiting freedom through centralized decision making.

Acknowledgements

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[5] All three decision problems presented here can be studied experimentally. In fact, the described dilemmas of ice fishing clans are the subject of several experimental treatments in Rötheli (2017).

oss, Mathias Zurlinden, and Pierre-André Gericke have offered helpful remarks and suggestions. The author retains the original copyright of this work.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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