All for One and One (Space) for All

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Table of Contents

Introduction

The 20th century space race led to many discoveries in science and technology. The availability of space exploration created many opportunities for fortunate countries, but what about the percentage of countries that aren't economically stable enough to reproduce space exploration for their personal gain? The United Nations saw this worrisome outcome and decided to act before more excursions were held in space. Every nation signed a treaty that made sure any missions tied to outer space were carried out for the benefit of the world as a whole. This treaty was in favor of global equity and paved the path to many international space projects.

With the continuous advancement of technology and the constant curiosity of what lies outside the Earth's atmosphere, it is to no surprise that the ongoing search for resources has directed its gaze to outer space. Although the pitch-black night sky portrays space as an endless void, there is an abundance of natural "rock" formations called asteroids that roam around. Since there are a plethora of asteroids in space, it is easy to recognize why the idea of asteroid mining is a hot topic. Sending machines into space is not a cheap process; this leads to questioning the stability of many United Nation's policies. In this project, global equity will be defined by the use of mathematical modeling practices and the effects of asteroid mining on global equity. The policies that the United Nations could enact to keep global equity in check will also be proposed and analyzed.

Methodology

This analysis of the global future of asteroid mining begins first by defining the most important parameter to determine how the projects are funded and how the profits are managed. After the definition of global equity and its importance is established, different models will be developed and analyzed to see which model has the most favorable outcome in the eyes of the UN. There will be three models ranging from the most simple to a more complex model, all ideally aiming to achieve an equitable process for each individual. After each formula is created based on the assumptions and policies set by the UN excel will be used to analyze the data and perform the necessary calculations. Once the calculations are complete and the data is available for analysis, Tableau will be used to visually process the data. Since there are so many countries, treemaps will be used as they can easily show each country and their contributions in an easy to see manner. The results will then be discussed after each model has been properly analyzed and visualized.

Definition of Global Equity

The term equity arises from the deviation of access to certain opportunities and assets. It describes a way to combat inequality by finding creative methods to flatten the distribution of many disproportional practices. For global equity, the definition focuses on the disparity between countries. There are many ideas that alter the path to global equity, however it will be sufficient to implement three main sources that pertain to the development of global equity. These will be highlighted in the creation of a mathematical model that assigns a metric to global equity. The metric in question would act as a way to calculate the percentage of a country's contribution to global equity. Global equity can then be seen through the process of comparing each country's percentages.

Gross Domestic Product (G)

Gross Domestic Product (GDP) is the monetary value of all products and services being produced and or offered by a country. This is a great indicator for inequality in certain countries due to domestic-grown consumables and job opportunities directly relating to a country's GDP value. This would tie heavily into the process of asteroid mining since the resources gathered from asteroids could be allocated and used to increase a country's production increasing the GDP. GDP also acts as a way to put a value on a country's wealth. With that being said, there is no doubt a country's GDP should be implemented into the mathematical model of global equity in some way. The data for GDP will be represented in USD ($).

Happiness Score (H)

Happiness Score is a numerical approach to the rating of a population's happiness. This metric is calculated using many different ideas including the social support, average life expectancy, and perceptions of government corruption in a country **(Figure 1)**. This portion of the model highlights the disruption of global equity through discrimination and prejudice practices that can be found within many countries. Since the modeling task at hand correlates to asteroid mining under the assumption that the process would be financially worth the investment, the happiness score should represent global equity less than monetary metrics such as a country's GDP. Although the happiness score seems to be minuscule, it would be a mistake to leave out this data since global equity should not solely rely on a country's value.

Population (P)

Due to varying population sizes in different areas, it is reasonable to also include a country's population into the model as well. Population remains as a catalyst for many inequalities across the globe. An example would be recognizing that a particular country that has a small population will more than likely have a smaller GDP value due to the country having a smaller upper bound for resource laborers. There are many different scenarios that may harm or benefit global equity, however it would be foolish to not include population into the model. The main use for this data would be to calculate the GDP per capita, the total GDP divided by the country's population. That is GDP per capita would equivalently estimate the contribution any person would give toward their country's GDP value.

The Mathematical Model for Global Equity

Now that three variables have been recognized that affect global equity, it is now time to put the data to use. Since the question at hand revolves around resource gathering from asteroid mining, it should be said that the model for global equity should rely heavily on GDP. Ideally, the GDPs for all the countries to be in line with each other, however global equity should not be defined solely upon fairness between countries. Instead, it should be reasonably focused on the fairness between each person. This is why GDP per capita will be involved in the model for global equity. For clarity, the data provided will be centered around the year 2019. As an additional term to handle fairness in non-monetary cases, the model will incorporate a country's happiness score.

Variable Glossary

S	Sum of all equity values for each country
G(i)	The GDP value (in USD) of the i^{th} country
P(i)	The Population of the i^{th} country
H(i)	Happiness Score of the i^{th} country
E(i)	Equity percentage of the i^{th} country
C(i)	Contribution to global equity of the i^{th} country
M	Number of asteroid mining units
t	Time passed in months
R(i)	The i^{ith} countries current rank in terms of global equity
A	An asteroids country contribution price (Ranges between 5,000 and 16,000)
D	Distance from Earth to the asteroid being mined (Ranges between 200 and 900 miles)

Figure 1

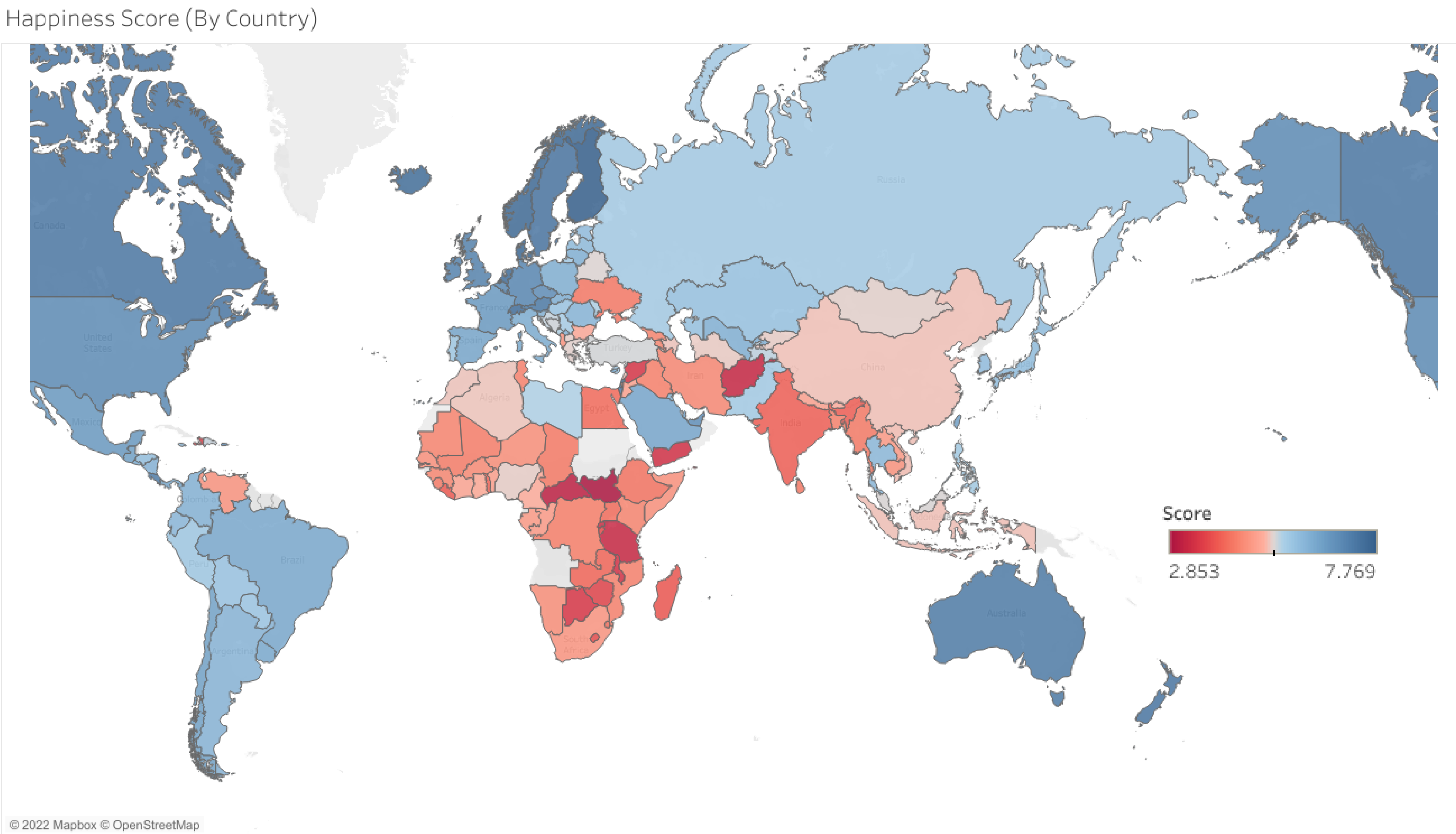
Happiness Score (By Country)
Score
2.853
7.769
© 2022 Mapbox © OpenStreetMap

Figure 2

Math Model Calculations

$$S = \sum_{i=1}^{n} \frac{G(i)H(i)}{P(i)}$$ - Formula 1

$$E(i) = \frac{G(i)H(i)}{P(i)S}$$ - Formula 2

$$C(i) = \frac{G(i)H(i)}{P(i)}$$ - Formula 3

Figure 3

With this model, it can be easy to track equity of all countries based on their percentage contribution to the sum. For example, if the United States had an outstanding percentage of the global sum because of asteroid mining privileges, it would be wise to tweak certain policies so that other countries can receive high percentages of the global sum. This example shows the model defined above could potentially aid in the overarching discussion of asteroid mining.

Asteroid Mining in the Future

The analysis of the question begins with the simplest and a realistic case in the current time, that the countries that have the highest percentage of the global equity will be able to start asteroid mining while the countries with less global equity cannot. For this situation a discrete dynamical system will be used to show how asteroid mining for those countries further skews their contribution to the total global equity percentage and why there needs to be certain policies put in place by the UN. The model will use the 20 countries with the highest global equity and evaluate how their growth affects the world. In this scenario there are the assumptions that: there is only one mining unit used per country (M = 1), a mining unit can only hold the resources from one asteroid, each mining unit makes a trip in one month (t = 1 represents one successful trip, in months), the value for C is only increasing for the countries that are mining, and there is a fixed increase in the contribution to global equity C, per mining unit M. Another assumption in this model is that each asteroid mined adds 10,000 to a country's contribution toward equity.

$$C(i)_{t+1} = C(i)_t + M(10000)$$

Formula 4

After using excel to obtain the new C values for the twenty countries that began asteroid mining they were then compared to the original values of the remaining countries. Using Tableau to visualize the data it is abundantly clear that the twenty countries that began mining have achieved a large advantage in terms of global equity contribution after 200 months of mining. In

Figure 4 and **Figure 5** the darker and larger the square the higher the E value of the country. It is clear from the difference between **Figure 4** and **Figure 5** that after mining without any policies in place the twenty countries have moved far past the point where the world can achieve a split of global equity percentage that is advantageous for each individual. This result leads to the first policy that the UN can enforce in order to limit one country's domination over another.

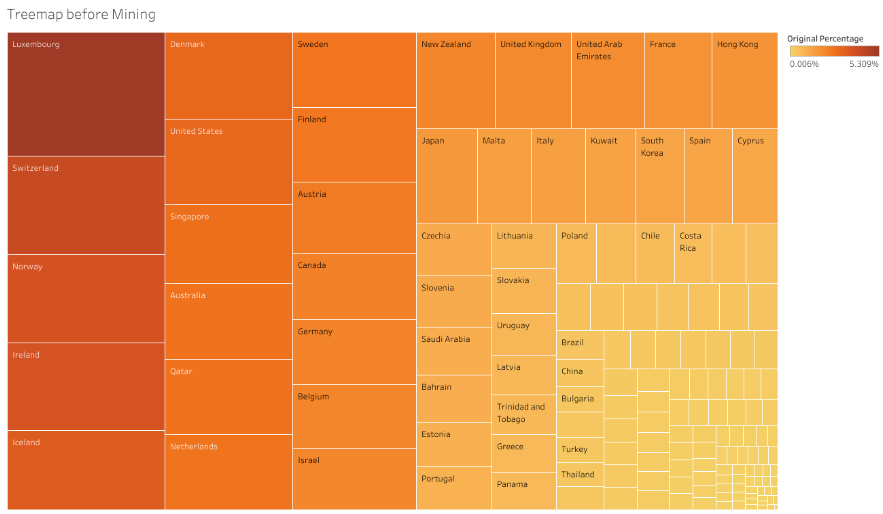

Figure 4

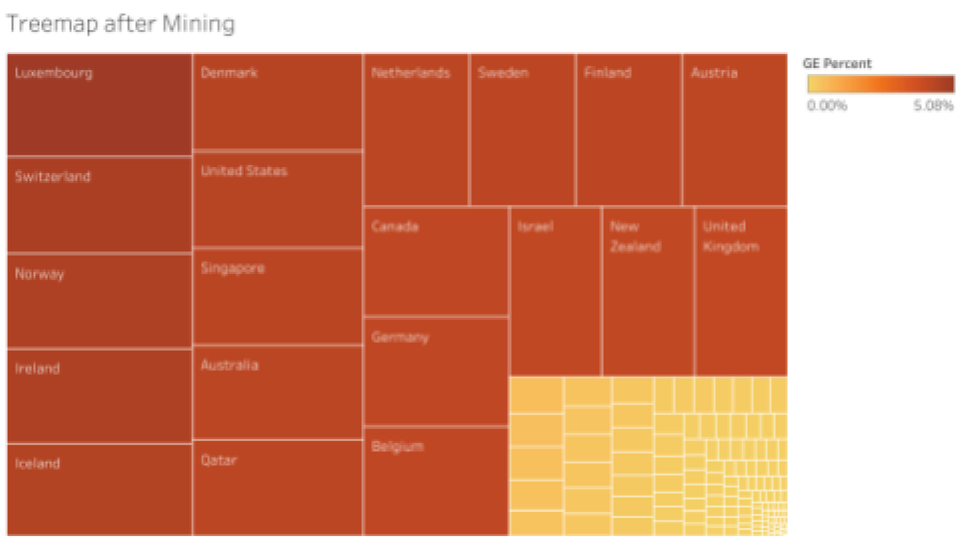

Figure 5

Policy One:

Each country will be given one mining unit, and if each country comes to an agreement to increase the amount of mining units, then all countries will only begin mining when the number of units is equal amongst all.

The enactment of *Policy One* by the UN is to assist those countries with a lower global equity contribution to begin their own asteroid mining operations. This policy also does not allow the countries with a disproportionate economic advantage over others to continue to achieve such an economic disparity. The overall goal of this policy is to allow each individual country to be able to execute their asteroid mining operations at the same capacity as every other country, which should facilitate the economic growth of the countries with a lower global equity percentage. This increase in economic growth should also lead to an increase in the population's happiness since more resources will be readily available, and so the global equity increases for the countries whose happiness levels are below average will be able to approach a global equality at an increased rate. All in all, the UN’s decision to enforce *Policy One* was made with the intent to give every country equal access to the resources they deserve.

Policy Two:

Each country will receive a unique percentage of the profit made by their mining units, with the percentage being directly proportional to the country’s ranking in terms of contribution to global equity. The remaining percentage of profits made will go to the UN to help fund more mining units and maintain global equity.

The next step in achieving global equity is the installment of *Policy Two*, which is developed to use asteroid mining to further push the disproportionate global equity as it stands to a fair state of equity for all countries. The goal of *Policy Two* is to provide a unique percentage of profit gain for each country based on their current contributions to global equity. This system, if put in place, will significantly benefit the countries with low contributions to the global equity, while putting a limit on the countries with high contributions to the global equity in order to achieve a global equity contribution in which each countries contribution is similar. The UN will be able to use the percentage profits of the larger contributors to global equity in order to purchase more mining units for all countries and thus expand the global profits, funding its own program for mining units as well as further decreasing the difference between the countries’ contributions to global equity. Overall, the use of *Policy Two* is to allow for the asteroid mining of all nations to be used to help better all of humankind.

With the UN implementing the use of *Policy One* and *Policy Two* a new model can be derived to represent how global equity will be affected for all countries as these policies are monitored and enforced. This equation of this updated model is as follows:

$$C(i)_{t+1} = C(i)_t + M(10000 * (\frac{R(i)}{149}))$$

Formula 5

For this equation M in **Formula 5** is still assumed to be 1 to further encourage an equitable mining process for each country. The unique coefficient that determines the amount of profit received for each country is its current rank divided by the total number of countries. Utilizing this model and simulating fifty months of global asteroid mining the result is shown in **Figure 6.**

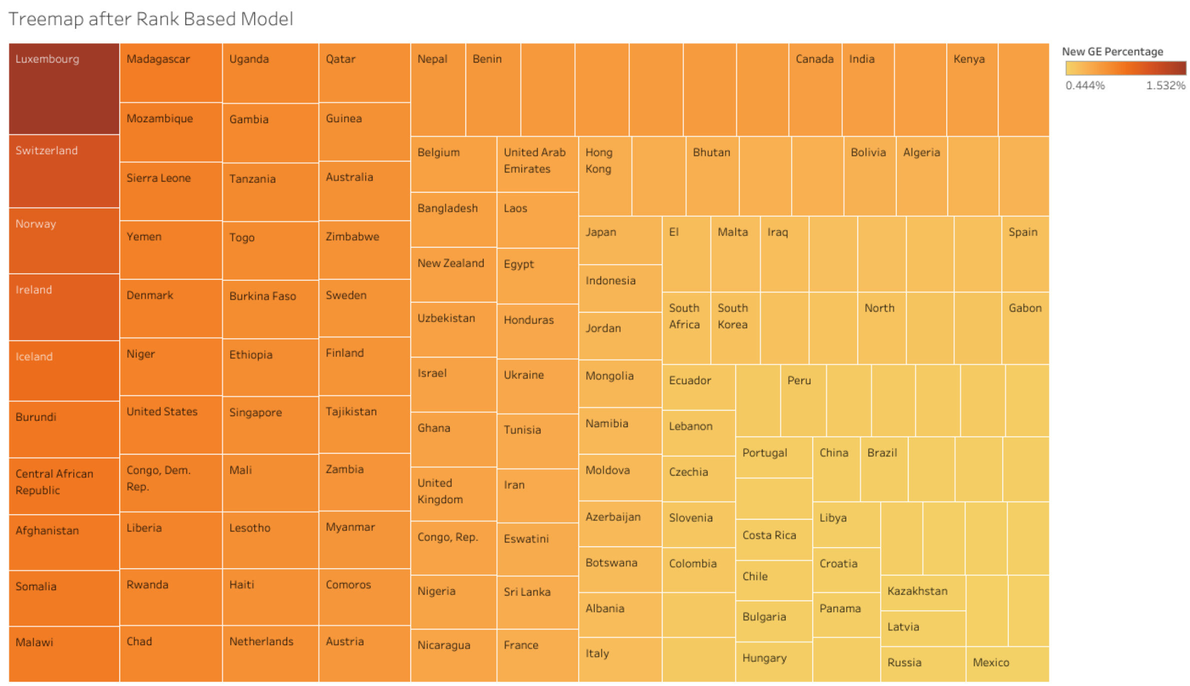

Figure 6

This model yielded fantastic results in increasing every country's global equity contribution and reducing the discrepancy from a difference of almost 5 percent between the most powerful country and the least powerful country to only a difference of about 1.1 percent as seen in the legends of Figure 4 and Figure 6. In fact, using excel to calculate the standard deviation between the original dataset and the rank based model there was a significant decrease, with the original model having a standard deviation of roughly .01 and the rank based model having a standard deviation of about .002. This change in the standard deviation shows how much closer the global equity contribution is between each country once **Formula 5** is implemented. Comparing this model to the first model, where each country's contribution to global equity was linear, this model is much more equitable and better satisfies what the UN is attempting to achieve. For example, the standard deviation derived from the model based on **Formula 4** was .014. This is higher than even the current difference before the global asteroid mining began and so this model proves worse than the ranked based model in terms of creating a more even distribution of contribution to global equity.

Although these results are fascinating and are on track with the UN's goal for global equity there are still some issues. Namely, there are countries that were ranked relatively well that quickly moved to the bottom of the rankings. In spite of this fact these countries still have a higher contribution total and percentage than those countries who had the same rank before the asteroid mining began. With the enforcement of *Policy Two* the percentage of profits that are added to the UN's global equity fund will be dispersed amongst the countries that need it most but this solution will hamper the ability to create more mining units and further increase the possible resource accumulation. To combat this issue the UN will administer a new policy as an addendum to the other policies that have already been passed, and attempt to create a new model to gain more information to better adapt their decisions in the future.

Policy Three:
*After a period of twelve months, each country and its rank will be assessed. After this assessment the countries will be reordered and their profits will be collected in line with the new ranking assigned. The collected profits will be utilized as stated in **Policy Two**.*

Simulation Asteroid Mining Practices

In reality, asteroids come in many shapes and sizes. The previous models highlighted above use a fixed number to represent the "cost" of the resources gathered from one asteroid. Due to varying sizes and disparity of resources found within an asteroid, it would be wise to engage the possibility of a model that contains the same randomness found in the rock's dimensions. Another problem to address is the differences between distances from each asteroid. For example, a mining mission that finds itself going to Saturn would cost more that a mission to an asteroid that is right next to planet Earth. This section will take these complexities into question to form a simulation model where the constraints of the mining mission are unknown.

It would be a great addition to keep the same assumptions made for the previous problems except now every country would only have access to one mining unit. The first new assumption for this model would be that the asteroid country contribution price ranges from 5,000 to 16,000. This means that the resources gathered from an asteroid would vary from mission to mission. The next assumption would be that the distance from Earth to the asteroid is between 200-900 miles away and a country's contribution cost for each mile would be 5 units. This will act as a cost for fuel and mining unit fortification since longer expeditions require more resources. The random intervals were specifically picked so that a country will always gain profit from each mining expedition. Instead of the use of a country's rank to decrease the amount of profit gained like the previous model, the model will now incorporate a sort of tax on the cost for each mission. This means that higher countries will have to pay more in order to send their mining units into space. The tax collected would go to the UN global fund stated in *Policy Two*.

$$C(i)_{t+1} = C(i)_t + \left(A - \frac{5D}{R(i)}\right)$$

Formula 6

After running the simulation for 50 months the results achieved are the best so far. It can be seen from **Figure 7** that the disparity of global equity contribution from each country is the least of any of the other models that have been run so far. It is also worth noting that the standard deviation of global equity percentage of this simulation model is 0.0015, which is the lowest of the three models. Besides this simulation having the lowest range of contribution percentage, the lowest contribution percentage as seen in the legend of **Figure 7** is also highest in this model. This exemplifies how adding the cost of travel as well as the variable profit benefits the countries with the lowest contribution. One last positive outcome of this model is how evenly dispersed the contribution percentage is amongst most of the countries, except those few who had a much higher contribution to begin with.

Although this simulation highlights the most realistic case of how asteroid mining could look in the future, it is not without flaws. That being said, this model is moving in the direction that the UN is seeking to achieve but there is more work and research that needs to be done to best address the issue of fair global equity contribution. As time passes and more information is revealed the UN can continue to update their policies to further improve mankind.

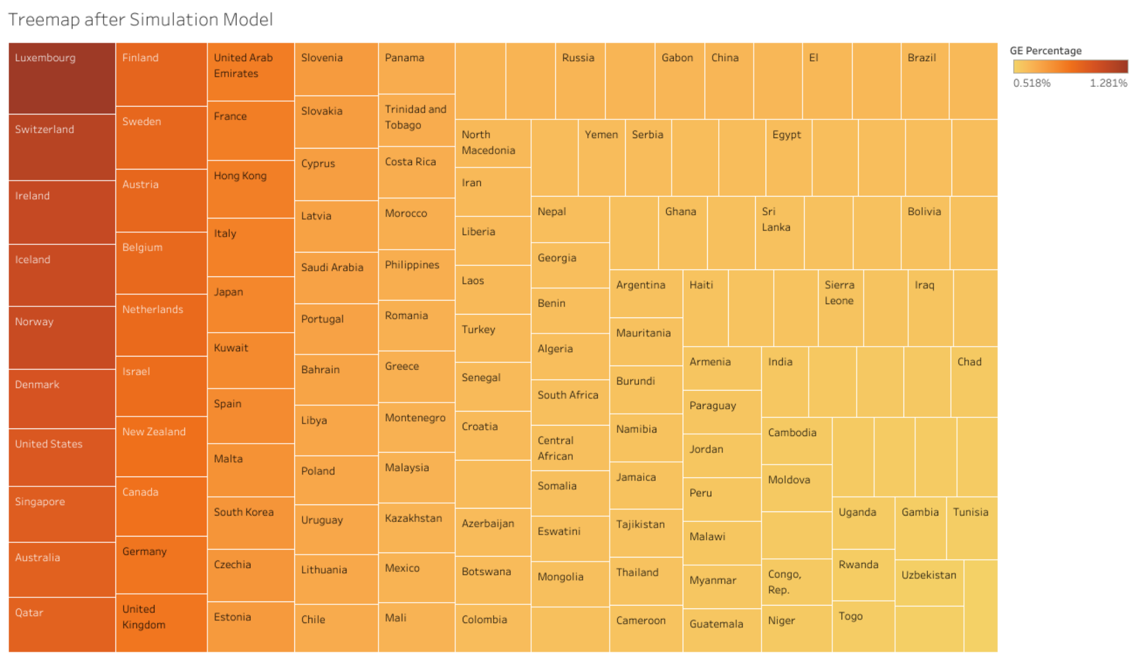

Figure 7

Conclusion

In human history, each century has its significant achievements and lasting impact for mankind. Asteroid mining will be an unprecedented milestone for humanity within this century and beyond. Not to mention the many advancements in technologies with the mined resources that will eventually make the global economy richer and efficient. That effect will benefit the mining operations with inventions and new technologies and processes of extracting materials, creating a positive feedback loop. Before humanity can embark on such an ambitious adventure, the United Nations should be at the forefront of this discussion, more importantly implementing policies that should give every country equal opportunity to have access to asteroid mining, regardless how large or small their economies are.

To prevent an increasing imbalance in the power of the most powerful countries the UN will put into place a number of policies each addressing different issues. The proposed policies are influenced by the UN's definition of global equity and data on each of the UN member's Gross Domestic Product (**GDP**), Happiness score (**H**), and Population (**P**). All of these policies are accompanied by formulas that we created and simulated to help us better understand how to propose a fair but equal balance of equity. Such as: all UN members should start with one mining unit and UN members can negotiate on increasing the amount of mining units for all its members (**Policy One**). Not only do these policies influence the amount of mining units that every nation should have, but what percentage of profit can each of the UN members get from their mining units. **Policy Two** solves this problem by having a rank-based system that is proportional to their contribution of global equity and as well as creating a system of sustaining this program by allocating a certain percentage of profits into a UN global equity fund to maintain global equity and fund more mining units. As time changes and UN members benefit from this program, every calendar-year, the UN proposed in **Policy Three** that all members should reassess their current ranks according to their contributions of global equity of that year and record and collect their profits and transfer some to the UN global equity fund.

Despite the fact that the possibility of asteroid mining is in the near future, these models and simulations allow the UN to begin proposing ideas that will ultimately benefit every individual on Earth. The policies proposed thus far are only the beginning of the UN's mission of achieving a world where global equity is truly equitable but have no doubt with time this goal will be a success. Asteroid mining is the future of the global economy and as such should be treated with the proper care and authority. There are many possible outcomes, a few of which are analyzed above, but under any circumstance this future is one small step for man and one giant leap for mankind!

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