

A Rawlsian Approach to Lunar Equity

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ABSTRACT

Any coming resource exploitation on the Moon must be governed somehow. This paper explores a synthesis: a “propertarian” approach to lunar equity moderated by market mechanisms and democratic processes. The philosophical starting point is John Rawls’s legal-philosophy approach of “Justice as Fairness.” A social order is fair, in his view, if it is guided by the principle of “the veil of ignorance”: what rules would we want to live under if we could not know the social position we would be born into? In particular (for this article) what political economy would we choose? The definition of property and its administration is key. The moon is subject to the Outer Space Treaty, which bans national appropriation, but does not clearly ban property rights in some form. Property rights in a form that can actually optimize benefits fairly for all humanity are, however, clearly within scope of lunar exploitation policy discussion. This paper proposes a number of global-benefit policies for the rights and responsibilities of those who may exploit lunar resources, including market mechanisms, tax policy, monetary policy, and democratic oversight on an intergovernmental agency that would implement and enforce these policies.

1. INTRODUCTION

Lunar exploitation has long been controversial. For much of that time, it has been largely a polemical contest between the partisans for the Moon Treaty, with its principle of “Common Heritage of Mankind,” against those who believe the moon should be an open frontier for capitalist exploitation as the optimal system for distributing the potential benefits. Until recent years, the debate has been academic. At this writing, however, we see multiple lunar missions concluded, in progress, and planned, with some commentators even framing the burst of activity as a new space race. The US-led Artemis lunar program is spurring activity in characterizing the lunar surface less with orbital missions and more with surface-contact missions. Most of these missions could be construed as mineral prospecting. Now, the questions of lunar exploitation are no longer quite so academic.

This paper explores a synthesis: a “propertarian” approach to lunar equity moderated by market mechanisms and democratic processes. The philosophical starting point is John Rawls’s general approach of justice as fairness. If a given resource is not yet owned, it offers opportunities for fair sharing of the benefits of exploiting it. If the strictures placed on exploitation make exploitation infeasible, however, they would be unfair to all: future welfare is foreclosed. In this case, the resources are those of the moon. Where is the policy balance point?

Decisions about fairness in the distribution of benefits from the moon are necessarily a matter of governance. Rawls concluded (in his *Justice as Fairness: A*

Restatement) that the only forms of government that satisfy his fairness requirements were property-owning democracy and liberal socialism. My proposal includes elements of both.

In outline, the actual governance mechanisms are as follows:

Market mechanisms

Equal shares for global equity in the stock of lunar development firms

Forward markets (roughly, futures markets) structured to dampen stock bubbles

Continuous auction of land leases including all mineral rights

Tax policy and regulation

Lunar land value taxes: Georgism

Lunar gravity emissions trading

Antitrust

Common ownership self-assessed tax (COST) for relevant intellectual property

Monetary policy: a “world currency” adapted to lunar commodities

Representative administration through sortition

If you did not understand much of that, I am not surprised. There are lots of great ideas from top-drawer economists and political thinkers, just waiting in the wings. None of them are utopian. Some have even been proven out on Earth. To be sure, this may seem more of a grab-bag of possibly utopian schemes than a global lunar governance architecture. I admit that its components are separable. A viable framework could emerge even from a subset of these elements. But I believe they would work better as a whole.

2. THE GLOBAL BACKGROUND: SAVAGE INEQUITY

Most nations in the world are developing nations. Most developing nations are postcolonial, with a history of exploitation of their resources by better-armed empires. This exploitation continues in our far-less-imperial but more competitive capitalist global economic order. Much of the current extraction is through channels provided by corrupt elites who merely adapted the exploitative practices of the now-departed colonists. Masters of newly independent nations have often reaped the rewards from the privilege of being corporate-entry gatekeepers under our current sovereignty norms, while underinvesting their winnings in the development of their own nations. If there is an irony here, besides “Meet the new boss, not too different from the old boss,” it is that these elites could probably be richer in absolute terms if they plowed their winnings back into development.

Instead, it seems that many of them relish being big frogs in small ponds.

While there is every reason to avoid extending this state of affairs to space in a Moon Treaty Implementation Agreement,¹ we also have every reason actively to enfranchise the world’s more economically beleaguered subjects and citizens in lunar development. Corrupt elites in the developing world are not the only political forces in their nations. There are reformers everywhere. What would empower them? What would embolden them? It will not be talk of space settlement. Even the developed world is economically far from enabling space settlement on a meaningful scale. There is neither an obvious business case nor a compelling state-interest public-good case for funding space settlement from government finances. But there could be a global egalitarian welfare case for enfranchising the great masses of the developing world in lunar resource exploitation.

The developing nations that could give a Moon Treaty Implementation Agreement enough UN votes are the last, best hope of passage of the Moon Treaty. Sadly, however, for the denizens of stinking Third World slums and farmers mired in rural poverty, their hopes and dreams are almost entirely ignored in talk of global space equity. Getting our planet to sustainability is key to those dreams. Lunar development could play a role in lifting them out of poverty and making life on Earth more sustainable. The question is how to generate this uplift in more direct and reliable ways than through unregulated markets and entrepreneurialism alone.

To put it all another way: it seems we are on the cusp of a paradigm shift in the dominant narratives about space. The transition is from what might be called mythic space, which is reflected in naming celestial bodies, robotic probes, and crewed spacecraft after Greco-Roman deities and European explorers, to a commodity cosmos, where the narratives are modeled less after compelling stories and more about speculative bottom lines; from tropes of heroic exploration to those of coldly calculated exploitation.

Yet this change is taking place in a world of increasing cognizance that Columbus—moved by some junk science of his era to believe the East Indies were not nearly as far as science already knew—embarked on a voyage for gold and spices only to turn to the very vicious slave trade. A world in which Magellan is better understood as an imperial schemer—indeed,

1 Cogently argued in D. O’Brien, “Is Outer Space a de Jure Common-Pool Resource?” *Space Review*, October 25, 2021, www.thespacereview.com/article/4270/1.

the man who killed him in what is now the Philippines, Lapu-Lapu, is a hero in that country. And in space development, it is a world that Ray Bradbury, facing the true difficulty of reaching his very mythic Mars, said was moving from romance to reality. In an era of resurgent nationalism, some fear that a New Age of Empires could also soon be upon us, fueled in part through lunar exploitation by the spacefaring superpowers.² Against a background of warfare flaring at the end of the post-Cold War “Unipolar Moment” of undisputed American economic hegemony, that fear may not be unfounded.

3. MARKET MECHANISMS

This section discusses market mechanisms for ensuring fairness in the equity of lunar enterprises. They are (1) equal shares (dividend income for all), (2) a bubble-dampening mechanism based on futures markets, and (3) auctions of lunar land leases. By themselves, they are not enough to ensure equity. Taxation and regulation is required for that. But the underlying economic engines that make taxation and regulation meaningful should be addressed at the outset.

3.1 Equal Shares for Global Equity in the Stock of Lunar Development Firms

John Roemer has proposed that everyone, at birth, should get options (“coupons”) for mutual funds that in turn, own shares in any of a number of private enterprises.³ At death, these shares would be returned to a common pool, for distribution to newborns when they come of age. The shares can be traded for other shares, but they cannot be sold. As such, they cannot be liquefied. But they can pay liquid dividends. Because an owner’s shares return to a common pool at death, those who have an initial growth-stock preference (i.e., foregoing dividends) can liquidate these growth-stock holdings into shares of dividend-paying value stocks that do pay regular and predictable dividends, for a nice retirement.

It has been called by the unlovely name “coupon socialism.” I prefer the title of a volume of essays that included Roemer’s essay plus commentary on it: Equal Shares. Roemer estimated a 10% welfare gain to societies adopting this structure for their financial markets.

In the case of a lunar implementation agreement,

mutual funds that invest in lunar ventures could be licensed under the agreement. These funds could allocate their share holdings in companies that meet the key criterion of attempting to profit from lunar exploitation.

A question arises: where does the capital for the lunar enterprises come from? There is an IMF facility called special drawing rights (SDRs)—interest-free loans. This form of money has almost become economically irrelevant. Poor countries do not get enough SDRs to matter to each individual country, while rich countries do not need SDRs. But it is money—around a trillion dollars in total.⁴ In aggregate, the amount that the poorer countries could pool is fairly large, for purposes of initial lunar development. For poor countries that suffer significant exchange-rate volatility, SDRs could offer some dividend-income stability as well.⁵

An implementation question arises with the promise of individual dividends for all: how should they be disbursed? Today’s near-ubiquity of mobile phones even in poor countries,⁶ combined with the various e-money channels seen in most of them, suggests that, with appropriate oversight, it is at least possible to make the payments very direct, even for the unbanked.⁷ Unfortunately, registering the entire population of Earth would be an enormous undertaking, if the choice is individual payments. Simply sending the aggregate payments to a nation’s government, on the other hand, faces the challenge of corruption in many developing nations—a thin trickle, or even nothing, could reach each citizen.

A possible approach may kill two birds with one stone. Experiments in just giving money away in poor countries have revealed that it is seldom spent for community benefit. One experiment with universal basic income in Kenya revealed that monthly transfers were spent on household food security, while lump-sum transfers resulted in longer-term investments

4 International Monetary Fund, “Questions and Answers on Special Drawing Right (SDR),” August 23, 2021, www.imf.org/en/About/FAQ/special-drawing-right.

5 See International Monetary Fund, “Enhancing International Monetary Stability—A role for the SDR?” January 7, 2011, www.imf.org/external/np/pp/eng/2011/010711.pdf.

6 E-money in East Africa was arguably made possible just through SMS, see, e.g., Murithi Mutiga, “Kenya’s Banking Revolution Lights a Fire,” *New York Times*, January 20, 2014, www.nytimes.com/2014/01/21/opinion/kenyas-banking-revolution-lights-a-fire.html.

7 M. C. Dobler, J. M. Garrido, D. J. Grolleman, T. Khiaon-arong, and J. Nolte, “E-Money: Prudential Supervision, Oversight, and User Protection,” December 14, 2021, Departmental Paper No 2021/027, International Monetary Fund. www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2021/12/13/E-Money-Prudential-Supervision-Oversight-and-User-Protection-464868.

2 D. O’Brien, “The Artemis Accords: Repeating the Mistakes of the Age of Exploration,” *Modern Diplomacy*, June 10, 2020, modern diplomacy.eu/2020/06/10/the-artemis-accords-repeating-the-mistakes-of-the-age-of-exploration/.

3 John E. Roemer, “A Future for Socialism,” *Theoria: A Journal of Social and Political Theory* 85 (1995): 17–46, bev.berkeley.edu/ipe/readings/A%20future%20for%20Socialism.pdf.

such as home improvements and the acquisition of productive assets like cows. There were measured effects on personal well-being, but no investment in public goods.⁸ This is perhaps symptomatic of an understandable general distrust in local government officials.

How to work around this? A system like participatory budgeting could earmark a portion of the dividend payments for investing in communitarian improvements, especially if optimized for fairness in allocation.⁹ This could provide incentives for participation, to bring all mandated dividend holders to light through community representation, while incubating healthier local government.

3.2 Forward Markets Structured to Dampen Stock Bubbles

As in many new areas of technology, proposed lunar enterprises will make extravagant claims and engage in questionable accounting practices¹⁰ in support of those claims. Indeed, some enterprises already do, despite being far from even getting off Earth, much less to the Moon. Lunar enterprises could be considered “story stocks”—overvalued for their novelty and their conversational value to the stockholder. As such, they will be bubble prone. A set of mutual funds divided between the retail stock market and lunar enterprises may do much to dampen this sort of economically inefficient behavior on its own. It may not entirely immunize the equal shares market from bubbles, however, depending on how the mutual funds brand and promote themselves. Irrationally exuberant rushes to growth stocks could effectively create bubbles, and leave the stocks at depressed prices before the bubbles pop—as bubbles always do.

It has been hypothesized by experimental economists that properly regulating a futures market can help to solve this problem.¹¹ These market mechanisms would allow the smart money to short stocks they see as bubbly; this could provide enough of a

market signal to dampen bubbles significantly.¹² A regulatory mandate for transparency in such short positions could help the mutual funds to keep their shareholders more rational.

So how does this square with Rawlsian “justice as fairness”? The benefit for developing world citizens is that they do not lose all effective equity through overinvestment in bubbles. After all, it is the musical-chairs nature of bubbles that somebody has to lose. And these developing-world investors are not smart money investors—many do not get educated past the fifth grade. *Caveat emptor* is not a fair principle when applied to the unjustly undereducated.

3.3 Continuous Auction of Land Leases Including all Mineral Rights

This one is simple: just divide the Moon into many small plots (perhaps with some multiple of the global population peak projection as divisor) and put mineral-rights leases up for bid. Would anyone buy them? There are companies offering novelty claims on lunar parcels.¹³ Clearly there is a market for what is now a useless piece of paper. Under some truly value-oriented scheme such as I propose here, however, the paper would not necessarily be useless, and thus could meet a much larger market.

Critics will naturally object that people earning as little \$1 per day cannot meaningfully participate in auctions of plots that have high speculative value today. These include patches of real estate that overlap the peaks of eternal light,¹⁴ or the permanently shadowed regions (PSRs) that are proven to contain theoretically useful volatiles.¹⁵ We might add the impact sites of asteroids that had a high fraction of platinum-group metals.¹⁶

12 Charles N. Noussair, Steven J. Tucker, and YiLong Xu. “A Futures Market Reduces Bubbles But Allows Greater Profit for More Sophisticated Traders.” SSRN Scholarly Paper, ID 2490326, Social Science Research Network, September 2 2014, doi.org/10.2139/ssrn.2490326.

13 Riddhi Kaushik, “Want to Invest in Real Estate? How Does the Moon Sound?” *Deccan Herald*, August 27, 2023, www.deccanherald.com/business/want-to-invest-in-real-estate-how-does-the-moon-sound-2662597.

14 Martin Elvis, Tony Milligan, and Alanna Krolikowski, “The Peaks of Eternal Light: A Near-Term Property Issue on the Moon,” *Space Policy* 38 (November 2016): 30–38. www.sciencedirect.com/science/article/abs/pii/S0265964616300194.

15 Though some of these regions are quite large, tens of kilometers across, proximity to a solar power source (“peaks of eternal light”) will likely determine actual market value.

16 These may be very localized in some cases. Modeling of high-angle impacts under 12 km/sec suggest that the central peaks of such craters consist significantly of the original impactor. See Z. Yue, B. C. Johnson, D. A. Minton, H. J. Melosh, K. Di, W. Hu, and Y. Liu, “Projectile Remnants in Central Peaks of Lunar Impact Craters,” *Nature Geoscience*, May 26, 2013, www.eaps.purdue.edu/minton/docs/Nature%20Geosci%202013%20Yue.pdf.

8 J. Haushofer and J. Shapiro, “The Short-term Impact of Unconditional Cash Transfers to the Poor: Experimental Evidence from Kenya,” *Quarterly Journal of Economics* 131, no. 4 (November 2016): 1973–2042. academic.oup.com/qje/article-abstract/131/4/1973/2468874.

9 A. Goel, A. K. Krishnaswamy, S. Sakshowong, and T. Aitumurto, “Knapsack Voting for Participatory Budgeting,” *ACM Transactions on Economics and Computation*, July 2019, arxiv.org/pdf/2009.06856.

10 Do not get me started on the EBITDA measure, which seems to have made a comeback in the bubbly late 2010s and early 2020s, after a rather blotchy post-Web bubble record of predicting success.

11 For a review, see economicprincipals.com/issues/2002.04.14/7.html.

I say: it does not matter. Remember, these leases would be auctioned off to firms whose stock is held by equal shares mutual funds in which these poor citizens have been granted shares. If there is a gold (or platinum) strike, any citizen who holds shares in a mutual fund that holds shares in the lucky mining firm should benefit, sooner or later, through dividend payments.

Auction design is a high art, so my “simple” is simplistic. But let us leave the exact design to seasoned (and space-interested) auction-system architects like Sam Dinkin. Auctions would confer rights to the winning bidder. What would be the concomitant responsibilities? For now, the problem of leaseholding firms squatting but not exploiting because of poor execution may be solved through a COST approach to taxing leases, as outlined below.

4. TAX POLICY AND REGULATION

This section proposes how taxes should be levied on firms and owners of lunar land. The first is Georgist taxation, which provides incentives for optimal use of resources, but with a twist: a continuous auction (COST). The second is arguably also a market mechanism: trade in lunar gravity emissions, as they affect Earth and orbital assets. The third is an interlock with the carbon-trading markets, and is thus also a kind of market mechanism. The fourth is plain old antitrust legislation, probably through treaty terms in a Moon Treaty Implementation agreement—there is considerable potential for monopolization on the moon. Finally, we apply the COST concept to patents for technologies specific to lunar development.

4.1 Lunar Land Value Taxes: Georgism

Henry George was a 19th-century reformer who proposed that taxation be based on the market value of land minus the value of its improvements. The value of improvements could be assessed by mandating disaster insurance on holders of land. In the early 20th century, Georgism was widely lauded by economists and political figures across the political system. George ran for mayor of New York on his taxation platform, placing second (beating out Theodore Roosevelt!), but losing to the Tammany Hall candidate. Both Roosevelt and George were perhaps victims of corrupt machine politics.

Despite early promise, however, Georgism never took hold, except in a few nations and regions. Why not? It is hardly market-unfriendly. Milton Friedman once called it the “least bad tax.”¹⁷ Friedman was not

anti-tax—he believed in representative government, which he knew cannot pluck money from trees, even if it could print too much money in some circumstances, too little in others.

Exactly why Georgism never succeeded has been diagnosed in different ways. From a Rawlsian perspective, it may be that one commentator in that debate has it right: “In essence George’s concept of economic justice was this: that human beings have an inalienable right to the product of their own labor.”¹⁸ That position will always face enemies. In this, George shared the view of Marx¹⁹ while he was at pains to deny that he was proposing socialism, but only trying to emphasize fairness in a different, non-Marxian plan of policy that preserved property-owning democracy.

Georgism has since been updated by Posner and Weyl²⁰ with an interesting wrinkle: optimize economic value with a continuous auction. As soon as someone posts a bid in escrow that is higher than the valuation the owner had put on the land (to calculate the property tax bill), the property right is transferred. The property rights go to the bidder, the amount in escrow goes to the former property owner, and the former owner is given a decent interval to vacate. It is called the *common ownership self-assessed tax (COST)*

How would the incentives work? For those who value their property more sentimentally (or lazily, or speculatively) than otherwise, and who can afford it, they will keep their holdings only by seeing their irrationality taxed. If, as Weyl and Posner assert, property is monopoly, the monopolists will eventually be taxed for impeding economically efficient uses of the land, which would be a substantial disincentive to continued holding. If their self-assessment is low compared to the speculative market value of the land, a shrewd buyer will bid and win, and most likely turn the land to more useful purposes at a profit high enough to more than cover the higher tax the winner would pay. One big gain from this scheme: it naturally helps to solve the free-rider problem in developing land whose owners are holding out for an exorbitant price: Eminent Domain becomes virtually obsolete.

There is an argument that such irrational attach-

view/articles/2017-11-28/why-economists-love-property-taxes-and-you-don-t.

18 J. F. Heavy, “Comments on Warren Samuel’s ‘Why the Georgist Movement Has Not Succeeded,’” *American Journal of Economics and Sociology* 62, no. 3 (June 2003): 593–99. cooperative-individualism.org/heavey-jerome_comments-on-warren-samuels-s-why-the-georgist-movement-has-not-succeeded-2003-jul.pdf.

19 ... who perhaps unfairly dismissed George as not understanding the theory of surplus value.

20 Eric A. Posner and Eric Glen Weyl, *Radical Markets: Uprooting Capitalism and Democracy for a Just Society* (Princeton, NJ: Princeton University Press, 2019).

17 Justin Fox, “Why Economists Love Property Taxes and You Don’t,” *Bloomberg*, November 28, 2017, www.bloomberg.com/

ments may make the whole idea unworkable.²¹ This strikes me as requiring perfection, which is so often the enemy of the good enough. The argument is based on interdependencies in the pricing of land—perceptions of value based on what is adjacent and nearby. When it comes to lunar land leases, however, the urban politicking seen around, e.g., “preserving the character of our neighborhood” is quite irrelevant: mining sites are not neighborhoods, and their valuations are based on cold risk-adjusted net-present-value calculations.

As applied to the moon presently, the market would probably be very illiquid, and the revenues low. But even if the price of most lunar plots is very low (say, \$1 per hectare), holdings in mutual funds that specialize in penny stocks, issued by more unlikely enterprises, could at least meet a market for “story stocks,” while the penny stock companies would be paying very little in tax. If applied to an area that could hold a small town, it would not be worth doing. But how many hectares has the Moon? At developing-world civil-servant salaries, this sort of taxation could support quite a few office workers for purposes of administering a Moon Treaty Implementation Agreement.

4.2 Lunar Gravity Emissions Trading

Economists both liberal and conservative agree that Pigovian taxes (i.e., taxing harms—“negative externalities” in EconSpeak—in proportion to the harm caused) are a fair and just form of taxation. A number of scholars have developed thinking on Pigovian taxes in a Rawlsian framework.²² Although Georgism gained popularity as a single tax movement, i.e., with the idea of land value taxes being a panacea for social injustice, George himself was uneasy about this, and more heterodox, agreeing with the idea of Pigovian taxes before they even had that name.²³

The idea that the moon has emissions may seem

strange, doubly so for the idea that it has emissions that could cause harm across such a wide vacuum gap from Earth. But the moon does have emissions: It reflects photons from the sun to Earth, and it has even more dramatic effects because of its gravitational field. There may be some way of accounting for harms and benefits from moon-reflected photons (e.g., accident liability for a bright moon as an “attractive nuisance” or even because of lack of moonlight where illumination would have saved lives or prevented accidental damage), but these are likely to be second-order effects compared to lunar gravity, which is where this section focuses. I will leave the benefits of lunar gravity emissions to later in this section. Let us look at harms.

Global warming proceeds apace. Sea levels are rising. This means that high-tide storm surges are becoming more damaging.²⁴ The potential for large-scale damage is hardly theoretical. For example, much of Jakarta is now below sea level because of drawdown of aquifers under the city. If the city’s storm defenses were breached, millions could be affected. Even insurance companies are taking threats like these seriously, looking at how they will affect their rates decades out.

On the basis of harms caused alone, the moon in itself, if severed from the other components of this proposal, would be a negative value proposition. Lunar landholders could be held liable for any added damage from high-tide storm surges. They would, after all, own a chunk of the Moon, from their lease boundaries on the surface and their mineral rights just below, all the way down to the moon’s core. Although the contribution of each leased portion may be a tiny fraction of the total, it is calculable. Who wants to buy shares in what is only a liability, not an asset?

Besides the more direct effects of the Moon’s gravity on catastrophic damage caused by global warming, the Moon contributes to warming over time by releasing GHGs on Earth. It has been found, for example, that tides increase the CO₂ releases from estuaries.²⁵

However, the GHG story on tides is not as simple as harms. Recent research shows that even slight increases in water depth in tide-zone shallows on Arctic coastlines can reduce methane emissions from sediments.²⁶

21 Lee Anne Fennel, “A Response to Eric A. Posner and E. Glen Weyl,” *University of Chicago Law School Review*, May 17, 2019, papers.ssrn.com/sol3/papers.cfm?abstract_id=3393205.

22 There is a split between “resource egalitarianism,” which for our case is arguably only vaguely codified in the Outer Space Treaty with idea of the moon as “the Common Heritage of Mankind,” versus “welfare egalitarianism,” which—by a stretch—perhaps even includes the erstwhile L5 Society: those who wanted an untrammeled market for the moon on the theory that it would unleash a cornucopia, making global inequality a non-issue. This may be a false dichotomy. At least one scholar suggests a near-synthesis. See Lily Batchelder, “Optimal Tax Theory as a Theory of Distributive Justice” (DRAFT), NYU School of Law, September 2019, www.law.nyu.edu/sites/default/files/Optimal%20Tax%20Theory%20as%20a%20Theory%20of%20Distributive%20Justice%20-%20Batchelder.pdf.

23 The idea that combining the two kinds of taxation would be fairer still is not new. See, e.g., Csaba László, “The Green Tax Revolution,” *Review of European Economic Policy* 56, no. 5 (2021), www.intereconomics.eu/contents/year/2021/number/5/article/the-green-tax-revolution.html.

24 Susmita Dasgupta, Benoit Laplante, Siobhan Murray, and David Wheeler, “Climate Change and the Future Impacts of Storm-Surge Disasters in Developing Countries,” Center for Global Development, Working Paper 182, September 2009, www.cgdev.org/sites/default/files/1422836_file_Future_Storm_Surge_Disasters_FINAL.pdf.

25 Mohammad Atif Khan, Sanjeev Kumar, Rajdeep Roy, Satya Prakash, Aneesh A. Lotliker, and Sanjiba Kumar Baliarsingh, “Effects of Tidal Cycle on Greenhouse Gases Emissions from a Tropical Estuary,” *Marine Pollution Bulletin* 180 (Apr 2023), www.sciencedirect.com/science/article/abs/pii/S0025326X23001649.

26 Nabil Sultan, Andreia Plaza-Faverola, Sunil Vadakkepuliambatta, Stefan Buenz, and Jochen Knies, “Impact of Tides and Sea-Level on Deep-Sea Arctic Methane Emissions,” *Nature Com-*

If the world adopts GHG emissions trading, owners of lunar mass should be on the hook to buy GHG emissions credits for the excess emissions their lunar mass causes. However, they could also earn carbon credits for reduced emissions.

A basis for Pigovian taxes based on lunar gravity emissions clearly exists. But we can go further, to emissions trading, because lunar gravity also offers benefits. The current tidal power base is estimated at over \$40 billion.²⁷ The operators of such power stations get a “free rider”/“public good” benefit now: nobody pays for the forces that generate tides. But what if they had to pay for the lunar gravity that provides them the potential-energy benefits? This could be a source of revenue for firms with lunar land-lease claims. Of course, it would fall on tidal power operators as a tax, and any tax will inhibit the activity taxed. But a serious global carbon market would improve the value proposition of tidal power, for how it can substitute for the burning of fossil fuels. The earning of carbon credits for turning tides to energy could more than cancel out the costs of paying for their ultimately off-world power source.

Of course, the moon has long been proposed as a source of clean energy. The dream of the L5 Society included not just settlement,²⁸ but also the vision of a cleaner Earth. In its vision, all heavy industry, not just power production, would eventually be moved off Earth. Well before that, the supposed value proposition would be space-based solar power (SBSP). Space colony settlement would (supposedly) be a natural outgrowth of the need for workers to construct SBSP, and of the need to fling materials off the Moon to build out SBSP. Alas, it did not happen, and the prospects remain dim under the status quo.

The environmentalist aspect of L5 was primarily focused on industrial pollution. In an era when the environmental movement came into its own, the L5 movement grew out of Gerard K. O’Neill’s question before a class at MIT: Is the surface of a planet the right place for an expanding industrial civilization? Although the threat of global warming seemed remote in the 1970s, O’Neill highlighted it later.²⁹

The Moon could still offer SBSP and reduce emissions. But could SBSP happen in time to make a dif-

ference, considering the present trajectory of climate change? In the late 1970s, it seemed possible. At this point, it is at best a late-20th-century move, too little too late.

How could lunar exploitation at a smaller scale help in the meantime? It is not all about the warming. Excess CO₂ (as the main problematic warming gas) shapes up as three threats to the developing world:

- **Warming**, and the consequences of more weather disasters and sea-level rise, which will hit the developing world far out of proportion to its past contribution to GHGs.
- **Ocean acidification**, sometimes called “global warming’s evil twin.” In so far as this disrupts ocean ecosystems, post-colonial nations with marine coastlines are likely to experience net damage to their food supply.
- **Malnutrition**: In fact it is evil triplets: more CO₂ causes reduced micronutrient density in crops that otherwise gain in carbohydrate content. Obesity as a symptom of malnutrition because of low micronutrient density in staple crops was first established in studies of diet in developing nations. As more poor people in these nations adopt diets closer to the standard American diet, the developing world may see a wave of Type II diabetes among other disabling conditions in age cohorts corresponding to later-life years that might otherwise be productive.³⁰

While I admit the following nearer-term uses of the moon are highly speculative, I think they should be explored.

Warming

The ability to fling materials off the Moon, cheaply, opens up the possibility of geoengineering a sunshade without needing much “geo” in the engineering.³¹ It could be done more cheaply than the \$1 trillion we can see in estimates that tend to be based on launching the key components from Earth.³² The Earth–Sun L1 point could be populated with continuously replenished fil-

munications 11 (2020): 5087, www.nature.com/articles/s41467-020-18899-3.

27 Giles Crosse, “Projects, Pipelines and Power: Around the World’s Tidal Projects,” *Power Technology*, January 10, 2023, www.power-technology.com/features/tidal-power-development-projects/?cf-view.

28 Which was perhaps only a political liability in their message—see Sen. William Proxmire’s “nutty fantasy” dismissal.

29 Gerard K. O’Neill, “The World’s Energy Future Belongs in Orbit,” *Trilogy*, Jan/Feb 1992, reprinted in the Space Studies Institute newsletter, 1992, ssi.org/reading/ssi-newsletter-archive/ssi-newsletters-1992-0506/.

30 L. H. Ziska, “Rising Carbon Dioxide and Global Nutrition: Evidence and Action Needed,” *Plants* (Basel) 11, no. 7 (April 2022): 1000, www.ncbi.nlm.nih.gov/pmc/articles/PMC9003137/.

31 “Fling” is not necessarily a mere figure of speech. For a proposed low-cost approach to feeding the constellation satellite market from the moon, see M. Turner, “A Rotating, Tapered, Balanced Sling Launcher on the Moon Made of Lunar Regolith Basalt Fiber,” 2018, *Astro* 2018, docs.google.com/document/d/16fFAHx-TOhwzMLulDfoD0ossUloAz0a9C6NrqbVG_jE/.

32 Cara Buckley, “Could a Giant Parasol in Outer Space Help Solve the Climate Crisis?” *New York Times*, February 2, 2024, www.nytimes.com/2024/02/02/climate/sun-shade-climate-geoengineering.html.

ters derived from lunar materials to reduce infrared, but pass other wavelengths. The business case? Earn virtual carbon credits.

Ocean Acidification

The Moon is rich in calcium. Flinging calcium carbonate from the moon into Earth's oceans could sop up excess CO₂, eventually sequestering it in the shells of shellfish and plankton.³³ The business case? Earn real carbon credits. One problem with this idea is that the moon is thought to be carbon-poor. However, there is tantalizing evidence from the LCROSS impact plume that carbon compounds make up around 7% of cold-trapped volatiles.³⁴ Though it appears that the early estimates of volatiles need to be reduced downward dramatically,³⁵ targeting parts of the ocean where acidification is ravaging ecosystems that poorer nations depend on for food may still be an effective approach.

Malnutrition

The developing-world micronutrient issue is more complicated, but it is possible that lunar mine tailings could be refined into mineral micronutrients and flung from the moon toward agricultural regions, at least to offset the effects of lower nutrient density in carbohydrate-rich crops until CO₂ levels can be reduced.

Considering today's inadequate measures to reduce GHG emissions, the Rawlsian "justice as fairness" view requires that we look at lunar exploitation not just for fair distribution of direct benefits, but also for fair distribution of harm reduction. The OST speaks of fairness not just in distribution of benefits, but also in the interests of States Parties.

4.3 Antitrust

The Moon may end up being unfortunately rich in "natural monopolies." In particular, the so-called peaks of eternal light could end up as oligopolies. But there are also artificial monopolies: Intellectual property provisions of a Moon Treaty Implementation Agreement may open loopholes that allow patent-holders effectively to monopolize key technologies, to the detriment of pricing lunar commodities fairly.

To be sure, monopolies are not always bad. The criteria of the US Department of Justice for antitrust is not

simply that the firm is a monopoly, but that it is monopolizing to the detriment of society.³⁶ This issue probably cannot be left entirely to the antitrust divisions of existing governments. (Certainly not to the governments that are little more than crony capitalist oligarchies to begin with.) Monopoly-prevention measures can sometimes strangle beneficial enterprise development, especially since success may depend on the fundamentally unpredictable: innovation. But such measures can also prevent a loss of general welfare in the name of profit for a tiny minority of monopoly stockholders.

Antitrust could be one of the few areas where an ounce of cure beats a pound of prevention, because industries can and do self-regulate, though mainly to deter government regulation. Even weak antitrust provisions established in an implementation agreement at the outset can spur self-regulation. Indeed, it appears that oligopolies, fearing government regulation, operate in "cooperation" on innovation, with extensive cross-licensing of innovations, whereas a monopoly, if allowed to charge what the market can bear, may not foster innovation quite as briskly.³⁷

The international legal aspect of this sort of monopoly prevention may be not only in establishing lunar exploitation patents as a specially protected class, but also in amending existing treaties through international institutions like the WTO and WIPO.

4.4 COST for Lunar-Exploitation Intellectual Property

Patent filings confer a monopoly on defensive rights—the right to incur public judicial-system costs. Except for possible capital/opportunity costs of paying for patent drafting and filing services, however, when a defense is not in progress, a patent incurs negligible ongoing costs to the holder. And this raises a nettlesome issue that has spurred some antitrust cases: patent pools. Are they good? Bad? A wash?

There are cases in which a patent pool's licensing terms can foster innovation, which is ordinarily a good thing. It has been noted, however, that some consortia accumulate enormous patent pools to intimidate smaller firms, even when much of the pool consists of in-

33 L. D. D. Harvey, "Mitigating the Atmospheric CO₂ Increase and Ocean Acidification by Adding Limestone Powder to Upwelling Regions," *Journal of Geophysical Research: Oceans*, April 2008, doi.org/10.1029/2007JC004373.

34 A. Colaprete et al., "Detection of Water in the LCROSS Ejecta Plume," *Science* 330 (2010): 463–468, www.academia.edu/25240043/Detection_of_Water_in_the_LCROSS_Ejecta_Plume.

35 N. Schörghofer and R. Rufu, "Past Extent of Lunar Permanently Shadowed Areas," *Science Advances* 9, no. 37, September 13, 2023, doi.org/10.1126/sciadv.adh4302.

36 In technology, a key case in the long and gradual softening of the Clayton and Sherman Acts was *United States v. Microsoft Corp.*, 1995 WL 505998 (D.D.C. 1995), in which Microsoft conceded and abandoned some anti-competitive practices but gained legitimacy on the basis that its de facto standard ratified its slogan of "freedom to innovate."

37 Welfare-enhancing monopoly—an idea tracing back as far as Joseph Schumpeter in 1942—is at least a theoretical possibility. See, e.g., M. R. Darby and L. G. Zuber, "Innovation, Competition and Welfare-Enhancing Monopoly," National Bureau of Economic Research, Working Paper No. 12094, March 2006, www.nber.org/system/files/working_papers/w12094/w12094.pdf.

defensible patents. Compared to the larger consortium members, the smaller firms attacked must spend a larger fraction of their revenue on proving that a patent they supposedly infringe is actually indefensible—for them, an enormous increase in IP transaction costs, which patent pools can otherwise reduce.

However, firm transaction costs are not the whole story. What we are concerned with here is fair global social welfare from lunar exploitation, which will presumably create markets for high-volume production of commodities. It appears that the welfare foregone in patent-monopoly pricing for commodities-processing inventions can be high.³⁸ This matters for inventions that reduce the cost of lunar commodities, including carbon credits as commodities in a global carbon trading system.

Monopolies are not ipso facto a bad thing. But stranded assets, underutilized assets, and overpriced commodities are not a good thing.

How can lunar technology development be market-optimized for general global welfare? I have proposed COST for ownership of lunar plots, to make sure that firms' control of the more valuable leases do not fall prey to poor business execution. Why not COST for space-oriented inventions, with the tax receipts going to pay for space technology capacity-building in developing nations? In acquiring a patent that may be relevant to lunar exploitation technology, firms would be required to post the minimum price at which they would automatically surrender it to bidders, and put that self-assessed value in escrow.

Unfortunately, developing nations face an uphill battle in affording to buy such intellectual property and in affording the expertise to exploit it. They operate in a neocolonial world order and under nation-state sovereignty norms. Under this world order, they have been left financially disadvantaged for acquiring (or developing) spaceworthy innovations. Any related expertise they do develop often suffers from brain drain—skills migrating to the richer nations. The few nations with low GDP per capita that have a significant space technology innovation base—chiefly, India and Ukraine—have benefited both by having large populations to offset the low tax base, and, at key points in their history, support from the USSR for launcher development. Then again, they are disadvantaged for securing rights to the innovations they do come up with anyway. Under nation-state sovereignty norms, there is no such thing

as a global patent—each nation has its own system.

A common heritage approach to lunar development technology would take these impediments into account, in two ways:

- (1) Establish a global space-technology patent system wherever it relates to lunar resource exploitation, with COST-based taxes levied on the patent holders.
- (2) Make purchasing power parity (PPP) a consideration in bidding for COST-controlled patents.

The first element ensures (if nothing else) a revenue stream for patent system administration. COST modeling and experimentation for land suggests that property tax rates as low as 2% provide enough of a market signal for the system to work. While all taxes inhibit the behavior that is being taxed, a tax rate below some threshold is negligible in the necessarily approximate task of planning an entrepreneurial venture, considering the many unknowns in such planning.

As for calibrating the bidding system with PPP for lunar-development COST patents, it helps to level the financial playing field. Poor nations tend to have lower costs of living—in many cases, much lower, even for relatively high earners such as technicians, engineers, and firm managers.³⁹ On a PPP basis, poor nations or coalitions thereof could more easily assemble the financial means to acquire a technology portfolio, along with its resulting COST-adjusted licensing revenue. This revenue could be plowed into lunar technology R&D in their own countries, even allowing them to license technology back to the former patent holder should it discover that it surrendered rights prematurely, and at tax costs that could fall below even what the former patent holder was paying.

5. MONETARY FRAMEWORK

This long section describes a monetary system based on lunar commodities for delivery, and how it could apply to a lunar economy in concert with the previous proposals.

Benjamin Graham's Storage and Stability

There have been a number of proposals for “space money,” from the very woolly⁴⁰ to the only-slightly-less-woo-

38 In particular, see pp.336–38 in M. Mattioli and R. P. Berges, “Measuring the Costs and Benefits of Patent Pools,” Indiana School of Law, www.repository.law.indiana.edu/facpub/2643. Cost increases of just a few percent may seem negligible, but when multiplied by the global population, the welfare costs could amount to trillions of dollars over the lifetimes of the relevant patents.

39 Sea Launch, a tie-up between Russian, Ukrainian, and American aerospace firms, relied heavily on Ukrainian workers aboard its oceangoing craft, thus saving on salaries for technical staff. Ukraine's median household income in 1999 was only around \$2,500 in USD terms, but much higher in PPP terms.

40 Armen Papazian, “Space Exploration and Money Mechanics: An Evolutionary Challenge,” SSRN Scholarly Paper, ID 2388010, Social

ly.⁴¹ For the most part, the promoters of these ideas are just looking for a way to print money, while ignoring the core issue for any monetary system: credibility. For general purposes of international space commerce, there is no great advantage in using one common reserve currency over another. Monetarily speaking, the IMF’s SDRs are proposed only because they offer a slightly greater degree of stability: they smooth out exchange-rate and inflation-rate fluctuations. The advantage is small, but one might as well use it. Politically speaking, SDRs do suggest an initial monetary reserve that smaller and poorer nations might draw upon, even if it amounted initially to bootstrap funding for an administrative framework.

Lunar exploitation for “raising all boats” implies credit expansion—increasing the supply of money available for investment, development, and marketing costs in exploiting the moon. One cannot justify credit expansion except on reasonable expectations of growth. The purpose of this paper is, of course, to foster political will along certain lines. Practical commercial feasibility, by contrast, depends on both financial market factors and technological innovation. Any “space money” must be justified as a financial innovation that can credibly repay those who trade currencies into it, in whatever terms they see as making the transaction worthwhile, whether it be in speculated appreciation against other currencies, or probable stability against them.

A bootstrap fund established with zero-interest SDRs (or an initial peg to them) would at least offer the enticement of relative stability, if not appreciation, even if this incentive is small. The question then becomes one of establishing credit beyond this initial pool. It is a difficult question given both the likelihood of a high risk premium for lunar ventures and the promise of only joint-stock dividend income from the successful ventures, rather than bond-issue coupon income.

A moon money peg to the SDR would not immunize the resulting currency against inflation. The SDR is based on a basket of common reserve currencies, all of which are managed with positive inflation targets by their respective central bankers. So one cannot even promise a long-term increase in purchasing power in acquiring moon money based on SDRs, except in the event of a very severe global recession: a deflationary spiral in all major reserve currencies.

However, there is a non-inflationary basis for a currency, proposed by Benjamin Graham, better known as the author of a touchstone work on value investing—

indeed, Warren Buffett was so grateful for Graham’s investing wisdom that he named one of his own sons Benjamin. Graham’s monetary ideas met with *theoretical approval*⁴² from some of the better minds at the Bretton Woods conference. In the post-World War II context, with its shattered economies among the developed nations, but also the national liberation of poorer countries, Graham was concerned that global development be fair to the poorer participants in any global currency regime.

The objections to Graham’s ideas were chiefly practical, partly political: the IT infrastructure required (then based on punched cards, not yet widely adopted) would have required considerable up-front investment across many industries. For fraud prevention, it would also have required central banks to employ many examiners to verify inventories. With modern internetworked supply-chain management and inventory management, however, the practical (IT-investment) objections would be negligible for our time, even if the audit function would still need to be sold in the political system.

Graham’s core concept was to base money on a basket of commodities slated for delivery—which represented the portion of an economy for which there was concretely established demand. To smooth out the business cycle, the government would step in—not as “lender of last resort,” but as “customer of last resort.” In the event of a slump, and thus cash squeezes and credit contractions that would otherwise trigger layoffs, firms could sell unsold inventory to the government, through “purchase-in-place” agreements that categorized the sold inventory as “for delivery.” Avoiding layoffs would support aggregate demand, including demand for commodities. As the panic contagion subsided and confidence returned among consumers and investors, the government would sell its share of inventory back to the firms holding the undelivered inventory.

Graham called this “a modern ever-normal granary,”⁴³ which suggests only the most basic kinds of commodities. In a world where DRAMs, advertising space on websites, and even vacant hotel rooms are treated by markets as commodities, his granary in fact permeates a great deal of the economy.

Where does lunar development fit in? Space development is often sold with the hyperventilation of “virtually infinite resources.” In practical terms, however, nothing is ever really a resource until it can be extracted economically. The Earth’s core is mostly iron, vastly

Science Research Network, November 11, 2012, papers.ssrn.com/abstract=2388010.

41 V. Beldav, “Blockchains and the Emerging Space Economy,” *Space Review*, October 10, 2016, www.thespacereview.com/article/3077/1.

42 L. J. Ussher, “Combining International Monetary Reform with Commodity Buffer Stocks: Keynes, Graham Kaldor”, April 7, 2011, www.ineteconomics.org/uploads/papers/BWpaper_USSHER_040811_EDIT.pdf.

43 Benjamin Graham, *Storage and Stability: A Modern Ever-normal Granary* (New York: McGraw Hill, 1937).

more than civilization has ever used, even that it can ever use, but this geological fact has no impact whatsoever on iron prices on the Earth's surface. Oil and gas companies sometimes restate reserves when an environmental regulation makes it impossible to pay future penalties on extraction with any remaining profit comparable to other opportunities, regardless of how large the prospected hydrocarbon reservoir is. An economy does not live on sheer mass alone.

Nevertheless, if space is "the province of all mankind," and our "common heritage," one can, for legal purposes, declare lunar resources inventory owned by the human race, located in a province from which it could theoretically be delivered and made available for sale. After all, there is little out there that could not be used for some purpose, in some speculative economy.

Would a civilization composed of thousands of space colonies orbiting the sun produce hobbyists who would like to terraform Venus, and who would thus eye the virtually inexhaustible hydrogen "resource" of Jupiter's atmosphere? Would they put a price on potential shipments of it? Could that pricing result in purchase-in-place agreements until the hydrogen could be scooped out of the atmosphere and shipped to Venus? Possibly. Ridiculous, of course. But not impossible.

Taking it down to Earth, however, we already derive a few kinds of resources from space, most of them now considered non-excludable public goods rather than commodities. A communications satellite could be considered a factory that takes delivery of solar photons on its PV panels and consumes them to produce value-added radio-spectrum photons. If Humanity, Inc., owns the sun, as well as the free space between the sun and the satellite, it could be considered "delivering" a "commodity," and it could bill the satellite operator for the deliveries.

If we viewed space assets such as satellites as firms in space, rather than being owned by firms on Earth, there is negligible trade of any kind between them right now. This is not to say it is impossible. For example, there is a constellation of satellites for what is called GPS radio occultation,⁴⁴ useful for weather monitoring and prediction. It makes money from a public good: it measures how the atmosphere distorts GPS signals and sells the information. Theoretically, GPS satellite operators could charge for this service.

To give another example: the operators of broadband satellite constellations could theoretically work together to meet the terms of service level agreements,

by charging each other for relay services whenever there is an outage in an individual network while another network can pick up the slack.⁴⁵ In both cases, however, there is little scope for inventory, except perhaps in satellite battery storage. Photons have energy and value, but they cannot be stored.

And yet, there are more possibilities. I have outlined how the Moon could be a source of both gravity-pollution taxes and gravity-delivery revenue. But the Moon matters for the space economy we already have in orbit. Satellites in GEO orbit require station-keeping fuel, because both the Sun and the Moon tend to pull them off course. At times during their orbits, however, the attractions are helpful in maintaining course. The gravitational forces are "pollution" for them at some points, "commodities" for consumption at other points. The balance of payments for the satellite operator will be negative, but they could still be payments. In the meantime, the mass of the Sun and the Moon can be considered "inventory" for "gravitons" not yet delivered to a given satellite operator, just as they can be considered "inventory" for a tidal-energy firm that is awaiting "delivery" of them to generate tidal power.

6. CONFLICT AND RESOLUTION: AN EXAMPLE

The political problems of implementation remain. I have suggested how an embryonic Earth-Moon economy might exist even today, based on the Moon as an existing resource, and (in the case of lunar gravity emissions trading) with climate change policy as the economic driver. Unfortunately, national sovereignty norms complicate this picture endlessly.

Satellite operators and tidal-power generators are businesses that operate subject to national jurisdictions. Nations must be persuaded that the treaty terms that put any burden on businesses within their jurisdictions more than repay the added costs to those industries. The nations' relevant industries will lobby against added costs, unless they can see net benefits. How does the administration of such a treaty make the policy case?

Even if the revenue that a given nation-state gains from such arrangements is expended in projects with multiplier effects, and can thus be rationalized in terms of general welfare, does it eventually (at least) result in increased demand or better profit margins for what the taxed firms offer? "Eventual" (not to speak of "speculative") gains is a weak argument, especially in so far as

44 J. R. Eyre, "An Introduction to GPS Radio Occultation and Its Use in Numerical Weather Prediction," Met Office, www.ecmwf.int/sites/default/files/elibrary/2008/9342-introduction-gps-radio-occultation-and-its-use-numerical-weather-prediction.pdf.

45 These sorts of agreements can be regularized in telecoms, in the form of private-sector tariffs. They can even be seen in commercial logistics, such as in overnight delivery, where firms like DHL and FedEx are sometimes seen relying on each other's services just to meet their commitments.

speculated demand depends on unpredictable lunar-exploitation innovations. There must be more—especially if increased demand means no marginal return (net of the policy's taxes) on the development of fixed capital to meet that demand. At best, firm growth, net of such taxes, could offer economies of scale not seen before. All else being equal, however, capital tends to flee to jurisdictions that are not under higher-tax treaty terms. If lobbyist shoe-leather does not repay effort, firms vote with their feet. How does one justify credit expansion for space expansion, through a monetary system, in terms of net benefit to firms involved in a space economy that has extended downward to the Earth?

The solution may be in the lunar equal shares market. Firms enrolled in that market will be engaged in R&D that, in many jurisdictions, is covered by tax credits. What if the treaty terms extended such credits to all cosignatories? Cosignatories could be required to offer new or additional tax credits to firms that invest profits into mutual funds in this notional stock market, while allowing dividends from that market to remain untaxed.

Admittedly, no single firm owned by a lunar equal shares mutual fund is a guaranteed proposition. Innovation is nothing if not unpredictable, else we would have gotten all possible innovation by now. But when a technology does take off, it attracts other innovators seeking cost-performance optimizations of it, yielding improvement rates that, at least for a time, can even be exponential in the early part of the classic s-curve of diffusion innovation.

Venture capitalists have been exploiting this fact for a long time, often on behalf of otherwise very risk-averse organizations such as state employee pension funds. Where many vaunted projections in startup pitches end up only drooping, a few others soar beyond anyone's dreams of avarice, while the bulk of the more predictable components of the venture capital portfolio stay fairly close to their projected tracks or are at least liquefiable without major loss. Over the entire venture capital portfolio, it averages out to a reasonable risk-adjusted return. Venture capital investments made during recessions, often to companies with only proofs of concept and prototypes, can be among the best performers later, during economic recovery. If a treaty-taxed firm opts to plow its windfall profits during a boom into a lunar equal shares market, the venture-oriented firms in the market may be generating acceptable dividend returns even during a bust, and these returns could be tax exempt.

If the tax treaty terms include mandates for R&D tax policy among the cosignatories, there is yet more scope for interlock with other components of the framework proposed here—in particular, the carbon-market

interlock. While the uses of the Moon for SBSP and geoen지니어ing remain very speculative and long-term, the development of space technologies with front-loaded spin-offs is a strategic class of investment for this framework. The developing world will suffer disproportionately from the effects of anthropogenic GHGs and may not benefit much from innovations meant to offset the effects. This inequity could be partially addressed by requiring a business case for lunar equal shares that puts emphasis on developing-world uses for technologies being incubated for lunar exploitation.

Let us be cautious here about likely returns. Much is made of spin-offs in the arguments for national space programs. In fact, the return on investment has been very inferior compared to private-sector investments in terrestrial technology. Even if one stripped out all the spending that did not yield any fortuitous spin-off technology, this would probably be the case. The reason is not hard to see: space is a very exotic environment (indeed, hardly reproducible on Earth even with expensive equipment) and what is useful in space is unlikely to be useful on Earth, except by chance.

Nevertheless, problems are also opportunities, and we are all effectively moving to another planet now: one that is likely to be 1.5°C hotter (or worse) before the century's end. Demand patterns will change in response to climate change, locally and globally. Much of the R&D for accommodating climate-change effects can be done at low expense in developing nations. Firms that are treaty taxed could be given special tax relief for allocating some fraction of their R&D budgets to technology development that relates, in demonstrable ways, not only to lunar development, but also to preserving health and lives in the developing world, as the effects of already-emitted GHGs inexorably set in.

7. A DEMOCRATIC MOON?

This short section discusses the problem of making the entire system outlined above more democratically accountable. In view of the complexities of policy, it makes sense to have informed voters. This would be a massive educational undertaking if it was one person one vote. While I have suggested how to nucleate the required registration democratically in my proposal for lunar equal shares dividend disbursement, the best solution for democratic policy evolution may be one that stretches back to Athens: selection of voters by lot, to create a sphere of deliberation in which lunar policy education becomes a manageably small task.

Sortition is a democratic mechanism based on the idea that a statistical sample of the population may stand in for one person one vote. This is a way to extend equal political rights to all global citizens, not just equal

financial stakes in the Moon. By combining it with a lottery, you create incentives for participation that the selected “citizen legislators” might otherwise choose to dodge. The amount awarded could perhaps be the median annual income, globally. Note that this would create great incentives for participation for people well below the median line—those who would be hurt most by global warming, for the most part, and who would be least likely to benefit by any trickle-down effect of purely private-enterprise exploitation of the Moon.

The approach should go beyond pro forma satisfaction of the Moon Treaty requirements for developing-world equity. One nettlesome question is exactly how? A not-unreasonable objection to sortition (by its critics in already well-functioning democracies) is that policy is hard, and not for the uneducated. The staffers of representatives do a lot of research, and lobbyists are not always wrong simply because they have axes to grind for their clients—they also play a role in rationally informing legislators’ opinions.

The answer here is, I believe, that my implementation proposal consists mainly of market mechanisms, and it is easy to underestimate the savvy of the poorly educated when it comes to markets. After all, many if not most families in the developing world work across sales counters, even when the counter is only the farm’s vegetable stand by the highway, or set in the street-facing vendor window on a small store in a city. A basic numeracy is all that is required. Beyond that, simulation games that illustrate the principles under which an agreement runs can, with enough repeated play, show both how it is working and how it is failing under current policy. Following such education, a deliberative process could begin, and a decision can be taken on policy changes by majority (or in certain cases, supermajority) vote.

The bigger problem is not education. It is corruption. Care should be taken to keep the identities of selected global citizens secret until they can be located, informed, and, with a consent not influenced by elite opinion (or veiled threats), accepted as lottery-paid participants. Since these pressures could extend to selectees’ families, a long-term guard of their security could be in order in some situations. In cases where a rogue nation keeps its subjects from accessing the process, it may be reasonable to select from immigrants and refugees from these countries.

Another common, and not-unreasonable, objection to sortition is that certain selectees will undoubtedly be ineligible through mental disability, infirmity, a credible record of antisocial behavior, or simply by not being old enough yet. Perhaps in these cases, the lottery award could be given away (to the community, in the case of criminals) and an-

other random selection of participants can be made.

8. CONCLUSION

“Anyone can agree that things should be fair,
and the world just. The way to get there
is *always* the real problem.”

—Kim Stanley Robinson, *Green Mars*, 1993

You have to start somewhere. To the extent that my proposals are oriented toward Rawls’s concept of property-owning democracy, they start with business. Business starts with the customer. If you want customers (voters) for a business-regulating policy, however, you need to find out who should benefit, and how. I have put a strong focus here on climate change as the international and intergenerational challenge for a more just world in the 21st century.

Let me admit that prospects seem to be worsening if anything. Nationalism is resurgent. We are apparently in a new Cold War, with flaring hotspots in the Middle East and southeast Europe, and with fossil-fuel powers very much in that mix. Culturally, people everywhere, rich and poor, seem increasingly in thrall to digital experiences. The placid dystopia of Bradbury’s *Fahrenheit 451*, in which citizens of the richer nations are hypnotized by immersive media, hearing of a resentful poorer world outside only by rumor, seems increasingly prophetic. There is more talk now of the threat of nuclear weapons use—where that novel concludes—than at any time I can remember since the Cuban Missile Crisis.

The global unity required to address global problems is very much at risk. But to quote Kim Stanley Robinson again, hope is a conscious choice. The triumph of hope over contemporary experience depends on keeping faith in ourselves as the dominant species on this beleaguered planet.

Let me also admit that my proposals undoubtedly raise more questions than they answer. I am far from having all the answers. I am merely hopeful that answers can come.

In this paper, where I apply the Rawlsian theory of justice to lunar administration, I have outlined how to make everyone on Earth a stockholder in the moon—without making it the only kind of stockholding. How to prevent bubbles in that market. How the property could be efficiently taxed, to fund lunar administration and enforcement. How the system of incentives and taxation could help to manage climate change and its effects on Earth. How to make the resulting economic system democratically accountable. And how to tie the finances of it all into a global monetary system that already exists, but also to a theory of monetary systems that does not depend on positive inflation targets, unlike

almost all others on Earth. It is, in short, administration of the moon by a global property-owning democracy with some "socialist" optimizations, specialized for the case of administering common heritage. If implemented, and successful, society could be a little richer and more sustainable. But the best pay-off may not be from the Moon. It may come from an awakening to the question: Why can't we run the whole world like this? It may come through how these ideas could be brought down to Earth, and make our planet a fairer place in space.

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