Scriptus, Part I:
The Case for Tokenized Research

Steven Yin*

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Abstract

Scientific discoveries have led to incredible progress in human conditions, and have the potential to continue drive tremendous improvement in quality of life for humanity in the future. However, there is a growing sense that scientific progress is stagnating. The sources of such stagnation can be broadly categorized into three types: lack of funding, misallocation of research effort, and increased science friction. In this paper, we present Scriptus, a blockchain based, decentralized crowdfunding mechanism whose core features revolve around tokenized research papers, i.e. research outputs represented as Non-Fungible-Tokens. We argue that Scriptus can strengthen the research community by improving on all three problems mentioned above, which will subsequently lead to faster scientific progress.

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1 Introduction

Scientific discoveries are perhaps the greatest drivers of human progress. The discovery of electricity, the inventions of fertilizer, vaccines, computers, and internet have all fundamentally changed the way we live, and improved human welfare on a massive scale. However, there is a growing sense that scientific progress is stagnating. Many view the innovations from the past two decades to be less significant than those from early and mid 1900s [11]. Indeed, few scientific and technological projects come even close to that of the Apollo program in terms of their ability to excite and inspire the general public. More pressingly, it is also widely believed that we are in the middle of a narrow window of time for mitigating existential crises such as climate change and AI risk[6, 14]. It is therefore crucial that we eliminate the sources of the scientific stagnation we are facing as soon as possible, and provide all the support that the research communities need in the next 20-50 years.

*e-mail: steven@scriptus.app

Although measuring scientific progress is a difficult and ill-defined task, we argue that there are three main issues that are contributing to the stagnation we see today. The first one is lack of funding. More specifically, we argue that science currently faces a liquidity problem:

> The *future* wealth that humanity will accumulate as a result of scientific progress in the *present* cannot be used to fund the research efforts *today*.

For example, suppose there is a new solar panel technology that requires 1 million dollars to research and develop, but can eventually generate a billion dollars worth of value once developed. If we can use that future wealth *today*, then we can easily afford the research cost required to develop that technology. Such misalignment in time between supply and demand represents significant missed funding opportunities for the research community.

The second source of stagnation comes from misallocation of research funding and research effort. Due to the tremendous pressure to publish that a typical researcher faces, many are consciously or subconsciously choosing their research focus based on how easy it is to receive funding, or publish a paper in that area. While this is not always a bad thing – if the community as a whole values impactful work, then this is the exact incentive structure we want – we argue that the current research funding infrastructure fails to incentivize researchers to work on the most important and impactful societal problems.

Lastly, increased friction in doing research has also contributed to the slowing down of scientific progress. As science projects get more and more complex, researchers take longer time to acquire highly specialized knowledge before being able to contribute to the field. At the same time, the number of research papers that are published each year is growing rapidly, further forcing researchers to narrow their focus in order to keep up with the progress of the field. As researchers group into more and more fractional communities, communications between fields decrease: ideas are rediscovered, wheels are reinvented, and efforts are duplicated. To make matters worse, there is little incentive for researchers to reverse this process: since reviewers of their papers are likely from the same field, trying to make the papers easily accessible to non-experts only make the papers appear non-standard, and make the researchers themselves look "new to the field", which in most cases hurts their chances of getting accepted. All of these phenomenons contribute to the increased friction in scientific research. Some of this effect might be inevitable: as our collective knowledge increases, there simply is more to learn before one can start contributing to the frontier of knowledge. However there is much room for improvement. For one, we believe that are ways to make good ideas more easily discovered.

In this paper, we outline our vision for a new decentralized funding mechanism that can potentially address all of the problems mentioned above. It represents a radical departure from the existing research infrastructure and crucially relies on Non-Fungible-Tokens (NFTs) to function. We name it: Scritpus. Since such funding mechanism is relatively new, it lacks direct empirical evidence for its' efficacy. However, we believe that ambitious experimentation like this is required to achieve the scientific speed up that we need.

Organization The discussion will be high level and free of technical details. The remainder of the paper is organized as follows. In Section 2, we describe our vision for Scriptus, and how different participants in the market will interact with the system. In Sections 3, 4 and 5 we explain how Scriptus addresses each of the three main issues we identified above.

2 Scriptus

Our vision for Scriptus can be roughly divided into two parts: 1) a marketplace for research as collectible art, and 2) a governance mechanism for allocating research funding.

2.1 Scriptus Marketplace

The core idea of Scriptus marketplace is that research output will be represented as fractional NFTs. When a researcher finishes a paper, they can "mint" an NFT that presents that paper on a blockchain. The use of fractional NFTs makes it possible for papers with multiple authors to share ownership of a paper. Once the paper is minted, the authors have full control of their shares of the paper. For example, a paper with four authors can be represented by an NFT with 1000 shares (a token with maximum supply of 1000), each author can be allocated an initial share of

250 tokens each (the exact amount can be specified at the time it is minted). The owners of these tokens can then list them for sale on the Scriptus marketplace. The specific sales mechanism can vary depending the specific implementation. Second price auction, posted price, are all possible options[1]. When a token is sold, money is directly transferred from the buyer's wallet to the seller's. In particular, during the primary sale (the first time a minted token is sold), the money is transferred from the buyer to the researcher. The researcher can then take the funding generated through the sale of his research tokens to fund their future research projects. The finer details of the sales process (e.g. royalties), and their implications, are beyond the scope of our discussion.

One commonly asked question about Scriptus marketplace is "What is the researcher losing when selling their research NFTs"? The answer depends on the exact implementation, but in the short term, we expect the answer to be nothing. The simplest way to implement a research marketplace would be to attach no legal rights to the research NFTs. The buyer is simply acquiring the digital ownership of the NFT, not the idea or the intellectual property behind the paper that it represents. A good analogy for this would be purchasing the physical manuscript of a scientist. When people collect manuscripts of famous scientists, the buyer does not acquire the ownership of the *idea* or the patents of the invention. The buyer is simply acquiring the physical object that is the manuscript. Of course, representing patents and intellectual properties as NFTs also has a huge potential in revolutionizing the legacy industry of technology patents. However, it is our opinion that a system without such legal bindings will be able to achieve the fastest and the most widespread adoption.

Value proposition for researchers From the researcher's perspective, minting a paper as an NFT accomplishes the same goal as uploading it onto one of the traditional "web2" pre-print websites such as `arxiv.org`, and `ssrn.com`, which is to make their research easily accessible. Note that even though the tokens have well defined "owners", the *content* of the research is always freely accessible. Different from traditional pre-print services however, Scriptus allows researchers to attract additional research funding through the sale of their research NFTs. This is similar to research crowdfunding, except here we do not require the researchers to perform any other steps beyond what they already do: uploading their paper to a website.

Value proposition for buyers There are roughly three types of buyers. The first group are people who have intrinsic value for supporting research. They have an opinion on which research fields are important, and want to support researchers working in those areas. Anyone who donate to non-profit organizations that support scientific research would fall under this category. The difference between donating to a science non-profit vs using Scriptus is that in the case of Scriptus, close to 100% of the money you spend directly goes into the researchers' pockets[2]. When you donate to a science non-profit organization, 10-20% of your donation is used to support the day to day administrative tasks of the organization[5]. Note that this figure is from some of the largest and most efficient non-profit organizations that deploy millions of capital per year. Smaller operations tend to have even higher administrative costs in percentage terms. In short, for people who purely want to support research, Scriptus offers the most direct and efficient way to fund scientists.

There are also people value and appreciate research as a form of art. Good research papers require an incredible amount of ingenuity and creativity, just like good art works do. Since research collection market does not currently exist, barring the very small exceptions of people who collect physical manuscripts of Einstein for example, it is hard to validate the size of such research collection market. However it is not hard to imagine that these are people who would be willing to collect research as a way to express their support for science. Just as people collect paintings to signal their taste in art, people can collect research NFTs to signal their taste in research. It is true that for certain fields of research, the population who can appreciate the beauty in papers from that area is relatively small. But the same can be said for art: not everyone understands all forms of art from all periods. It is also true that research NFTs are purely digital, whereas, many art forms are physical. But the value in collecting art does not lie in the physical utility that it provides, but rather in its' ability to express self identity. In a world where our social life is increasingly digital, expressing self-identity in a digital way will only become more prevalent.

[1] Although certain mechanisms are likely more easily implemented on a blockchain than others. For example sealed bid auctions are much trickier to implement than a simple posted price auction on existing popular blockchain ecosystems.

[2] A very small portion is spent on gas-fees and fees potentially charged by the marketplace

The last group of people who would participate in the marketplace is traders. These are people who like to speculate on the future value of different research NFTs. For example, suppose you come across a paper that solves an important open question, but for various reasons is clearly overlooked by the majority of the research community. You can purchase its' research NFT at a low value, and either wait for the rest of the market to recognize its' value. Once people have come around to understand its' impact, you can sell the research NFT for a profit. Unlike the previous two groups of buyers, traders do no intend to hold onto the research NFT for long periods of time. However, they serve important functions in the marketplace, including liquidity provision and price discovery. We will explore their role in the marketplace in more details in Section 3 and Section 5.

2.2 Scriptus Governance

Suppose a donor really cares about climate research but he does not have the bandwidth to look into specific research projects that need funding. He can deposit his fund into a pool specifically focused on climate research. This pool is be controlled by a smart contract on a blockchain, and the deployment of the funds will be governed by a governance mechanism. For example, users who are active on the platform can accrue non-transferrable "governance tokens". These token holders can then vote on different way to deploy the funds held by the smart contract. The design and analysis of such governance mechanisms deserve a separate treatment. Therefore, in Part I of the whitepaper, we focus solely on the Scriptus marketplace, and defer the detailed design and analysis of the Scriptus governance mechanism to part II of our whitepaper[3].

3 Longer Term Liquidity Provision for Science Funding

3.1 Liquidity Provision in Public and Private Markets

In many industries, companies face the following challenge when first starting out. The company has a great founder and a great idea, and if company can successfully develop the product, then there will be many customers in the future who will be happily paying for its' service. However, the founder needs the capital *now* in order to hire employees to build out the product first.

In the startup world, this is essentially a solved problem. In many of the major economies, there exists a very mature venture capital ecosystem, where Venture Capital(VC) firms supply the company with the initial capital that it needs in order to develop the product. In return, VC firms are allocated shares in the company, so that when it does become profitable, the investor's share of the company will be worth many multiples of the initial investment, and the investor is compensated for taking on the risk of investing in the company before there is any customer.

At its' core, the above problem is the issue of the buyer (i.e. the customers) and the seller (i.e. the company) arriving at different times. The company would love to take the money from future customers now, so that it can use the money to build the product first. However, because future customers are in the future, such transaction is not possible without a middleman, which in this case is the VC funds[4].

Such misalignment in time between buyer and seller is also observed in the stock market. Unless both buyer and seller arrive at the marketplace at the same time, one of them has to wait. Unsurprisingly, there is also a very mature solution to this. Market makers (MM) are market participants who stand ready to trade against both buyers and sellers, so that they can always trade immediately without having to wait. To make the example concrete, suppose the fair price for a stock is $100. Seller A arrives at the stock market, and the MM offers to buy the stock at $99.99. Person A takes the money and can do other things with it immediately (e.g. buying a car, a house, paying for tuition). A short while later, buyer B arrives and buys the stock from MM for 100.01. Both participants were able to trade immediately at a price that is very close to the fair value, and the MM made $0.02 for providing "liquidity".

In a sense, the role that VC plays in the early days of a startup is that of a liquidity provider. The seller (startup) arrived at the market before the buyer (the customer) showed up. An investor agrees to buy from (invest in) the company before the customer arrives. When the customers do

[3]To be released.

[4]This is not entirely accurate, as some companies do try to sell the product before it is ready, i.e. presale. But it is not widely used, probably because it only works for certain types of products.

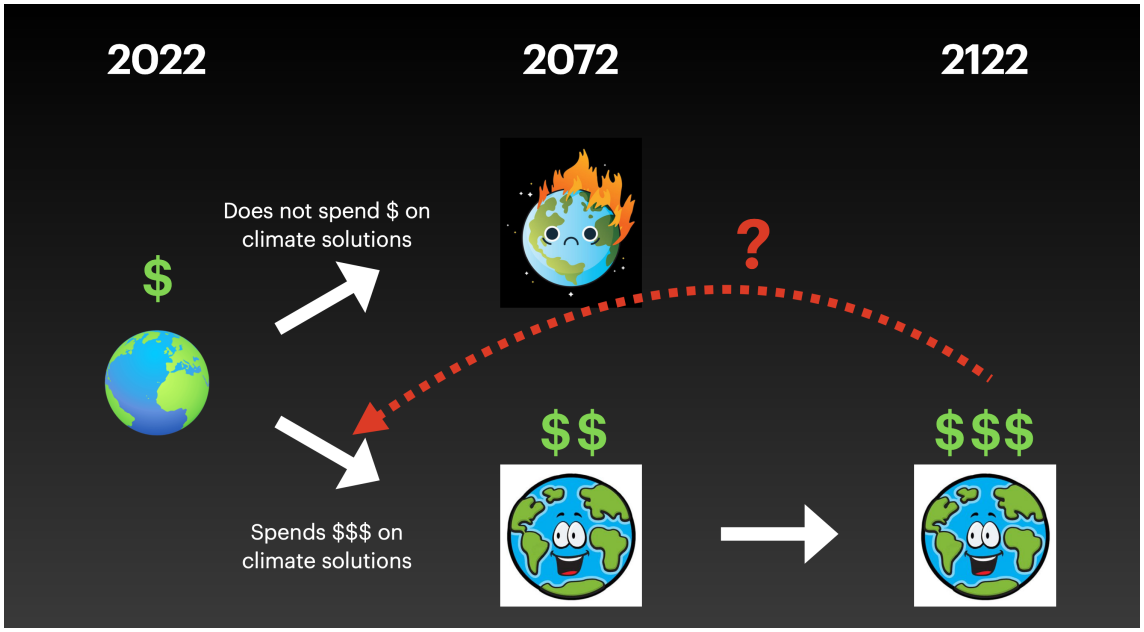


Figure 1: A thought experiment on the two possible futures of humanity.

finally arrive, the investor "exists" by selling the shares to the customers. The difference here is that the life cycle of these trades are measured in years, instead of seconds.

3.2 Liquidity Provision for Research

Research funding faces the same liquidity problem. A good research project can generate a large amount of value in the future, but requires research funding today in order to make that future a reality. Note that by "generating value in the future", we do not mean in the literal sense of financial return on investment, since the benefit that scientific progress brings to society cannot be reduced to "revenue" the same way for profit corporations do. To illustrate this, consider the following somewhat extreme thought experiment, also illustrated in Figure 1. We are in year 2022 and there are two possible futures. The top path is when we do not invest enough money on researching climate mitigation solutions, and climate change gets out of control and humanity goes extinct by year 2072. The other possibility is that we invest heavily on researching climate solutions, and we are able to avoid the climate catastrophe, and humanity continues to accumulate wealth for the centuries to come. This wealth can be in the form of bigger government budgets in the future, more disposable income amongst the general population, and more wealthy philanthropists, all of which would not have existed if we were on the top path of possible future. The key question is,

> Is it possible to take humanity's future wealth, and spend it on the urgent research that needs to be done today?

In this case, the seller (researchers) arrived first in the market, and the buyer (wealthy donors and bigger federal budgets in the future as a result of the research being done today) has not arrived. Can we take the VC playbook and apply it to research?

The reason why this problem has not been resolved affirmatively is surprisingly simple: bad accounting. Recall that in order for liquidity provision to be possible, there needs to be a well defined concept of *transfer of ownership*. In the case of VCs funding startups, ownership is represented in equity shares and are documented in the company's capitalization table. In the case of trading public stocks, ownership of shares is also clearly documented in the data bases operated by brokers and clearing houses. Unlike these for profit ventures however, science funding is much more unstructured. When someone donates to a non-profit organization, there is no meaningful way to transfer his "share" of the donation to someone else. Without the ability to transfer ownership, liquidity provision in science funding is not possible.

3.3 Retroactive Science Funding via Tokenized Research

So how does Non-Fungible-Tokens solve the above issue? This is best illustrated through another example,also given in Figure 2. We encourage the readers to read through the captions first.

In that example, we showed that it is possible for a donor who lives in year 2122 to donate to a research project that took place in year 2022. To make this possible, we crucially relied on using research tokens to represent the current effective donor of a particular research project. Note that even thought there was only one donor and one token in the example, it can be easily generalized to multiple tokens, and multiple final buyers. Recall in Section 2 we explained that there are roughly three categories of buyers: supporters, collectors, and traders. Supporters and collectors would typically be serving as the "final" buyer of a token, and traders are the one that facilitate the transactions between the researcher and the final buyer.

It is true that by the time the future buyer arrives in the system to fund a project, the project might have already been done. So why would donors want to fund the project, if it already exists? This idea is in fact not as radical as it might first seem, and is often referred to as retroactive funding, and has been implemented by projects like Optimism[10]. As explained in the previous subsection, whoever is currently holding the research token is effectively the donor for that project, and deserves the credit for the impact that the project has had on society. Therefore, donors who seek to maximize their impact with their money can do so not just via the traditional channel of funding future research, but also via *retroactively* funding the *past* research.

4 Incentivizing Impactful Research

Due to the competitive nature of the academic environment, many researchers (especially junior ones) are under immense pressure to publish. As a result, researchers' focus can be often influenced by funding sources. We argue that the existing major science funding sources are at best, inefficient at allocating funding and directing researchers' focus, and at worst, actively diverting researcher attention away from important societal issues, leading to inefficient allocation of research effort. We will dissect the issue by type of funding sources, and explain how Scriptus can improve upon the status quo.

Federal Funding

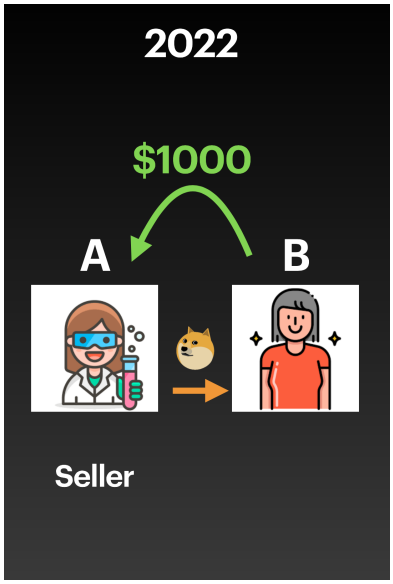
At least in the United States, federal funding remains the primary source of funding for many research areas. Federal science funding agencies such as National Science Foundation and Department of Energy receive funding from the federal budget, and are responsible for deploying the funds to different specific research projects. A typical process for a researcher to receive funding from one of these agencies is the following: one submits a proposal, which includes a research agenda, an explanation for why that research is important, and a summary of the applicant's existing research experience to demonstrate expertise in the proposed research area. This proposal is then reviewed first by a panel of 3-4 reviewers, and if deemed strong by the reviewers, goes through another 1 or 2 rounds of review by senior reviewers[5]. In theory, reviewers are experts in their respective fields and should be able to filter out the highest potential projects from all the applications. In reality however, many think that the federal funding system is broken.

First, many have noticed that the reviewing process is highly noisy: not only do the decisions have little correlation with eventual impact of the projects, the ratings among reviewers on the same grant proposal also have near zero correlation [8, 7, 12]. Additionally, scientists are often forced to bend their ideas towards directions that they think are more likely to be approved by the funding agency. Many report that they would change their research focus significantly if they had more freedom over the usage of their funding [17].

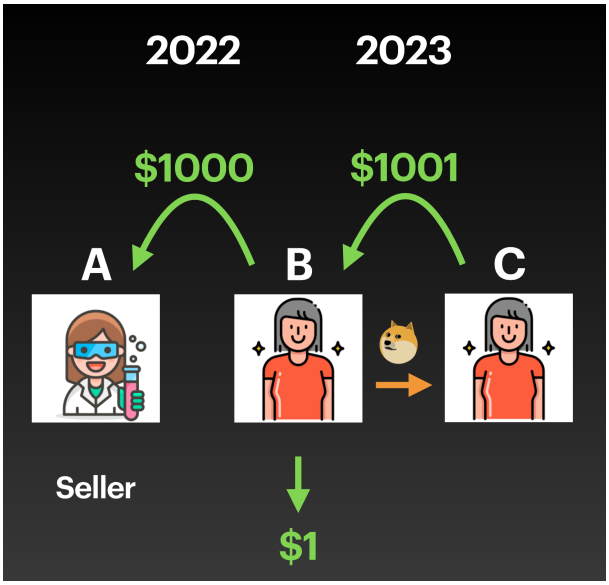
We believe that the key issue here is that there lacks a proper incentive structure for reviewers to perform high quality reviews. The process of selecting of reviewers is highly opaque[6]. Although we believe that those who self select to become a reviewer almost always have the best intentions, it is unclear how much effort the reviewers are really willing to put into reviewing highly technical and sometimes nuanced proposals, when they have full time jobs elsewhere.

[5]For an example, see `https://www.nsf.gov/bfa/dias/policy/merit_review/` for the review process of NSF.

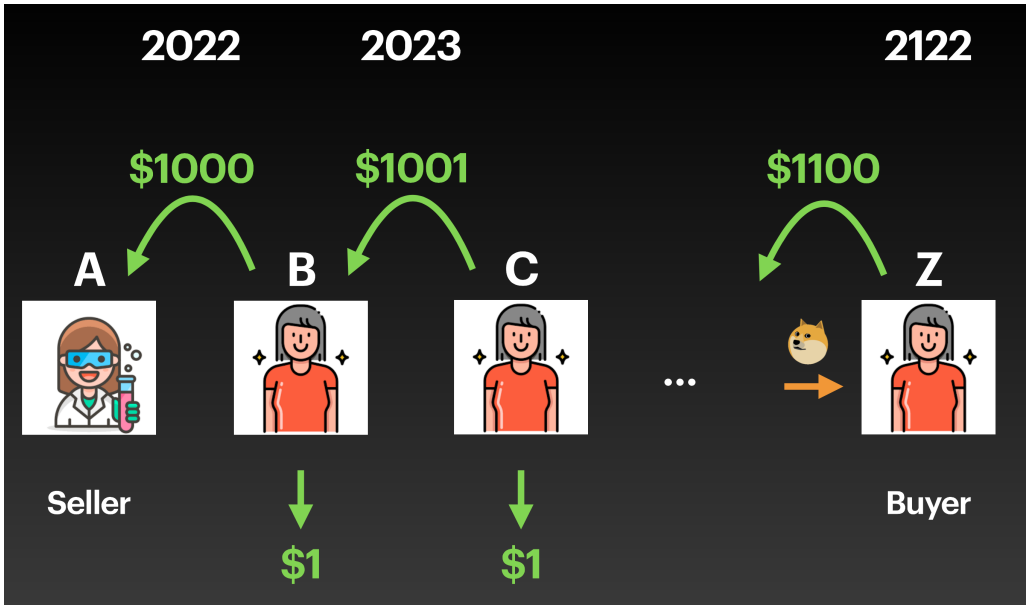
[6]For example, there does not seem to be an explicit list of criteria for selecting reviewers on the NSF website: `https://www.nsf.gov/bfa/dias/policy/merit_review/reviewer.jsp`.



(a) In the first period, B gives A $1000, who then takes the money and immediately starts working on her project. B is given a token that represents his support for A's project.



(b) One year later, C gives $1001 to B in return for the research token. At this point, effectively C gave A $1000 and B made $1 for facilitating this transaction. Note that A did not need to wait for the C to start working on her project, and the research token keeps track of the current "effective" donor of A's project.



(c) This process can continue until for example year 2122, and at the end of all of these transactions, Z has effectively given $1000 to A, and also paid $100 for making this transaction possible. Everyone else in between served as a liquidity provider, bridging the gap between A and the final donor Z who lived in the future (relative to A).

Figure 2: An example of how tokenized research can be used to facilitate long term liquidity provision for research funding.

Scriptus Marketplace alleviates the allocation inefficiency problem by providing a marketplace for the public to directly express their opinion on which research areas are important (recall that the marketplace is where people can directly support specific projects that they value). Topics that more people find to be important will naturally receive more funding, and researchers in those areas will be able to use the increased funding to purchase better equipments and hiring more assistants. To further maximize the impact of the Scriptus marketplace, we also need to implement a mechanism that allows people to delegate the decision power to others, allowing supports who do not have the capacity to evaluate individual research projects to support research *areas* that they value. To that end, the Scriptus Governance mechanism will provide a transparent allocation mechanism that allow participants with different expertise to all efficiently contribute to the system.

Industry Funding

Once the primary source of funding for many subject areas, federal funding's role in scientific research is being slowly eclipsed by the rise of industry funding. Many full time professors at academic institutions are also supported by grants from tech companies[2]. Some recent reports suggest that 84% Computer Science professors receive at least some industry funding [16], and over 75% of clinical trials are paid by private companies[18]. In areas such as Machine Learning, big tech companies such as Google, Microsoft, and Amazon have surpassed top academic institutions in terms of research output as measured by accepted papers at top ML conferences[3]. Although there have been very exciting research outputs from industry research, it is well known however, that industry research can be biased [13, 4]. Corporations tend to focus on research areas that either directly support their product development, or help upholding certain brand image. Industry funding pulls researchers from problems that the general public cares about, and push them towards problems that directly or indirectly help with maximizing corporate profit.

A decentralized crowdfunding platform such as Scriptus does not have intrinsic research agenda or any preference over one research area over the other. Every decision is made via an open governance mechanism. In particular, Scriptus allows the general public to participate in the scientific process, which has traditionally been opaque and limited to those in academia. By strengthening the connections between the general public and the research community, Scriptus will incentivize researchers to work on problems the the public cares the most about, and not those specific to profit seeking companies.

There are also some new initiatives (e.g. Arc Institute [1], New Science [15]) that try to directly address some of the issues we mentioned with federal and private industry funding sources. These experiments are very new, and have yet to proven themselves to be able to effectively address the issues mentioned above. We hope to see some of these experiments succeed.

5 Reducing Science Friction

Another key problem with the current research industry is that the friction in doing good research is increasing. We think of science friction as an umbrella term for many potential factors that slow down the exchange of ideas. For science to progress, researchers need to constantly communicate their new ideas to others and also absorb new ideas findings from others. Anything that makes this progress more difficult is contributing to science friction. We identify two key sources of friction below.

Low Signal to Noise Ratio One stems from the simple fact that the research community is growing, rapidly. Figure 3 shows that the number of submitted and accepted papers at NeurIPS, a major Computer Science conference, has been increasing at the rate of $30 - 50\%$ a year. The increasing number of papers that come out each year makes good ideas more difficult to discover, since there is simply more noisy that one has to filter through to get to the real progress. To make matters worse though, in an effort to boost one's chance of getting accepted at venues where the reviewing process is already highly random, people tend to congregate around the few ideas that are widely accepted to be valid, and shy away from ideas that are different and non-mainstream.

Siloing of communities No researcher is reasonably expected to improve their productivity at the same increasing rate that new papers come out, so their only recourse is to specialize. The

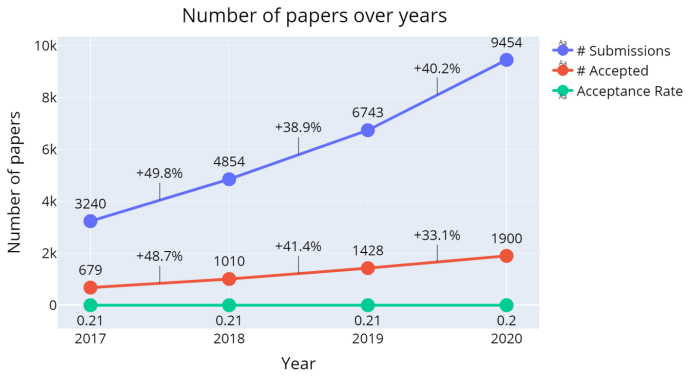


Figure 3: Publication statistics at NeurIPS from 2017 to 2020, taken from [9].

increase in specialization however, poses a different kind of inefficiency. As communities divide into more specialized groups, people tend to develop their own set of practices, assumptions, and expectations when it comes to communicating their results. As these practices diverge between groups, it becomes more difficult for researchers from different communities to communicate and share ideas. The review process at most conferences and journals implicitly encourages such siloing of communities, because reviewers are chosen to be experts from the same fields as the authors, and so authors have little incentive to present their papers in ways that make it easier for a broader audience to appreciate their work.

How does Scriptus address these issues? First of all, the marketplace for research tokens will naturally serve as a prediction market for research impact. As traders participate in the marketplace, they need to anticipate the likelihood that a future supporter or collector would be willing to purchase a certain research token. This future demand for research token will crucially depend on the impact that the research has had. In a traditional research publication venue, reviewers have little incentive to carefully evaluate ideas that might first appear unconventional. In the Scriptus marketplace however, those we are able to spot the undervalued ideas first will be financially rewarded. This creates strong incentives for every participant to seek out high potential ideas. As a result, if the marketplace is efficient enough, the price of the research tokens will naturally reflect the expected "impact" of that research project. Currently, without actually reading the paper, researchers have only 3 signals to evaluate a paper's quality: 1) the place it was published in, 2) the name of the authors, and 3) citation count. As explained before, 1 can be a very noisy signal, since reviewer quality tends to be low on average. 2 is highly biased against junior researchers. And 3 is a highly delayed signal. Having a prediction market for research impact can help researchers direct their focus on the most high potential ideas, making good ideas easier to discover and disseminate.

Additionally, since Scriptus opens up the reviewing process to not just 3-4 highly specialized reviewers, but rather the entire population, researchers are now incentivized to present their ideas in ways that can be easily accessible to a broader range of audiences. This makes it easier for good ideas to spread between different research communities, further reducing science friction.

6 Conclusion

We summarized what we view to be the three main sources of science stagnation, and described our vision for how Scriptus can address these issues by using blockchain and tokenized research to create 1) a mechanism for the public to provide liquidity for research funding, 2) a decentralized funding mechanisms that incentivizes high impact research, and 3) a prediction market for research impact that reduces science friction. Together, these three components will provide more funding for the research community, align researcher incentives better with the general public, and reduces the friction in doing good research, which in turn will lead to faster scientific progress. For more detailed and technical analysis of the designs of Scriptus, please checkout Part II of our whitepaper[7].

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