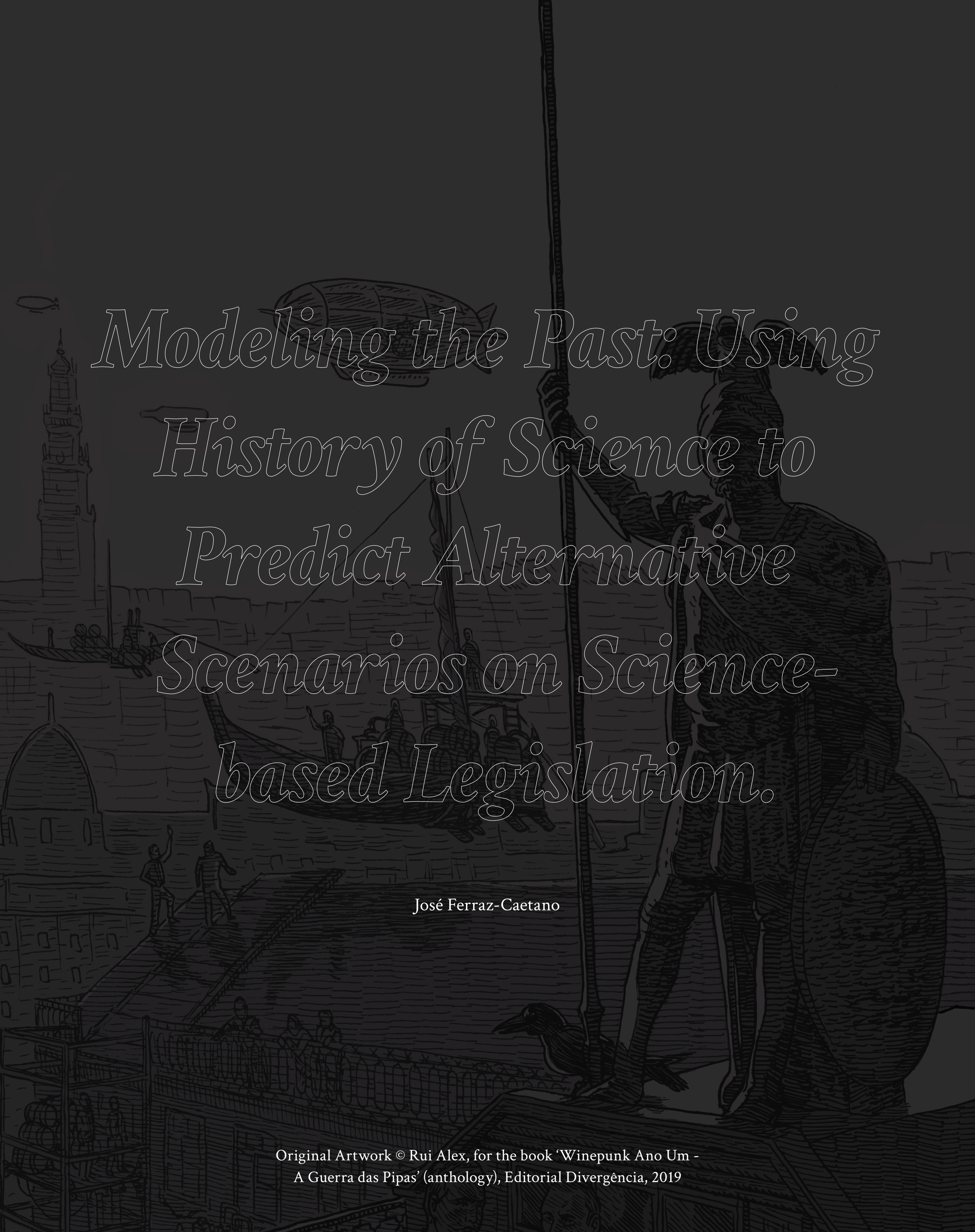

Modeling the Past: Using History of Science to Predict Alternative Scenarios on Science-based Legislation.

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Modeling the Past: Using History of Science to Predict Alternative Scenarios on Science-based Legislation

HYPOTHESIS HISTORIA PERIODICAL

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Abstract. In an ever-changing world, when we search for answers on our present challenges, it can be tricky to extrapolate past realities when concerning science-based issues. Climate change, public health or artificial intelligence embody issues on how scientific evidence is often challenged, as false beliefs could drive the design of public policies and legislation. Therefore, how can we foresee if science can tip the scales of political legislation? In this article, we outline how models of historical cases can be used to predict and understand how scientific evidence can influence the emergence (or fall-back) of science based-legislation. We also present frameworks on how to use past episodes of History of Science and Alternative History insights to build epistemic models, based on previous successful approaches on the spread of scientific misinformation. These models will help the accuracy of the design of eventual alternative realities, that can come insightful on present decision-making methodologies.

Keywords: History of Science, Epistemic Models, Science-based legislation, Alternative History

1. Introduction

The pursuit of scientific knowledge is not without downsides. Endless questions linger about how reality can be shaped by each technological achievement. It is not strange that scientists, and even the general public, dwell for guidance as to where must our endeavor move forward. Consider only biomolecular advances in genetic research and nanostructure inception [1, 2]. These scientific topics alone spun into so much versatile and distinct epistemological fields, that scientists cannot be the sole thinkers on the subject. Bioethical consequences, political ramifications, environment issues, all of them pose important questions on the why and how science efforts must be perused (and, at some point, regulated).

This is critical when we think about the major issues in our overdeveloped and inconsistent world. As this paper is written, several European governments issued another nationwide lockdown because of the SARS-CoV-2, coronavirus pandemic. It is safe to say that 2021's major political guidelines, around the world, will be shaped by increasing ongoing knowledge of the pandemic and, as such, scientists' inputs. Therefore, any preemptive glimpse on how scientific knowledge must be used to guide the inception of public policy is a valuable social asset. We have seen so much examples where scientific facts were cast aside in the making of important political regulations. Even today, despite having at our disposal an intricate arsenal of scientific data and information channels, it seems that policy makers still have issues on incorporating these outputs in their legislation. As such, it is of the utmost importance to build and characterize patterns of knowledge circulation, as they can provide answers as to why there is such an impedance on its assimilation.

If the History of Science can tell us something, is that this is not a recent problem [3]. Even as far back as the middle ages, we can encounter several miscues on the false appropriation of scientific knowledge as new legislation. Consider only the disinformation campaigns on science and medical achievements that were, for various reasons, undervalued due to pre-existing status and limitations, posed by human-made laws [4]. All of these examples, highlighted by historians, can pose as several episodes, cued as models, of a transversal issue in legislative history. However, these episodes can also be prompted through theorized events in Alternative History. By definition, Alternative History brings new episodes that harbor, cumulatively, a precise background divergence from established history; an outspoken historical change though divergence; as it also reflects on the implications of such a change. As such, we can design alternative episodes that diverge from written history, describing hypothetical scenarios that could happen alternatively to the considered timeline. This, in turn, allows to make a clear distinction between reality and alternative-based scenarios, reflecting on their consequences if they have happened.

But how can past events be connected with the design of alternative historical episodes? In fact, Alternative History can present itself as a pivotal research tool, since the analytical and multidisciplinary study of "what could have been" can clarify the reasons why it was not [5]. And what better way to predict possible outtakes of alternative history than looking back upon situational patterns in previous historical events. History, as commonly known, tends to repeat itself. But that is not an absolute certainty. There are many nuances that can shape the formation of future events, grasping from social to technological achievements. The key here is to carefully choose what to scope in previous events, and how to use the gathered information to help us precept the present and the future.

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In this work, we intend to explore the notion of creating epistemological models to understand the inception and enforcement of science-based legislation from scientific evidence. Can "fake-news" or scientific misinformation drive the design of legislation, successfully influencing, policy-makers, the public and even scientists? Is it possible to look back to the past, in order to predict how today's "fake-news" can undermine the credibility of current science-based legislation? To answer these questions, we present a three-part article. In the first section, we present an example of a computer-based epistemological model, which was successfully used in the characterization of the spread of scientific false-beliefs. We then reflect on how this model can incorporate History of Science and Alternative History tools, as to develop a novel model focussing of science-based legislation. In the second part of this work, we present an example on how to use these types of models on hypothetical alternative scenarios, as to give insights on the outcomes on present and future events, regarding the circulation of misinformation in science-based legislation. And finally, we outline an example for a predictive science-based legislation framework, discussing a model proposal and the importance of historical events, historical data and Alternative History.

2. Background

2.1 Agent-Based Models: An Epistemic Approach

As many philosophers of science point out, there are several models we can use to observe past events. Not taking them as a whole, but considering specific aspects of them [6]. One of the epistemic tools used is the establishment of Agent-Based Models (ABM). An important computational modelling strategy brought up in mid-twentieth century that presents a depiction of a macrosystem, populated by agents on a known grid [7]. In every step of the model, as time goes by, each agent, in contact with their neighbors, updates its actions according to the pre-established rules used to characterize this environment. Figure 1 depicts a proposed workflow on creating an ABM, outlining how Historical Scenarios and its elements can be combined to perform simulations using historical data.

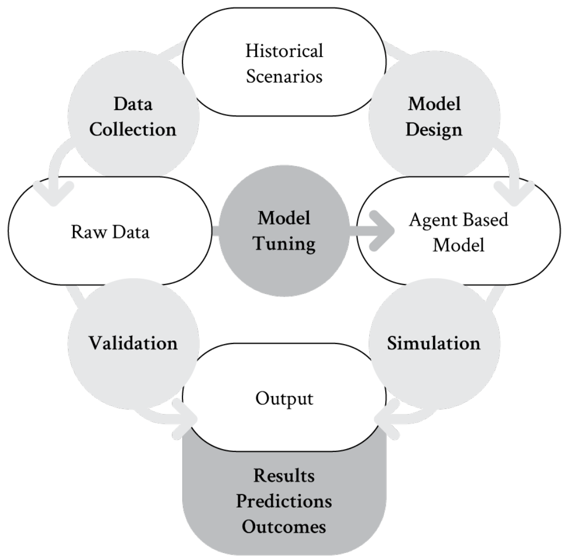

Figure 1. Outline of development of an Agent Based Model, highlighting the relationships between Historical Scenarios and its elements.

It is not on the scope of this article to develop in detail the characteristic of ABM. However, we will explore them with practical literature aspects of the models. A good example is the model made by philosophers of science to study the impact of scientific knowledge regarding the public perception of the consumption of tobacco cigarettes [8, 9]. In the early twentieth century, tobacco industries deemed strategies to mitigate the consequences of newfound scientific information, revealing that tobacco consumption is harmful to human health. There were strong indications that the strategy of the Tobacco Companies was

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biasing evidence to converge people into the incorrect belief that tobacco was not hazardous to health. An example of such evidence advertised to the public is portrayed in Figure 2 [10].

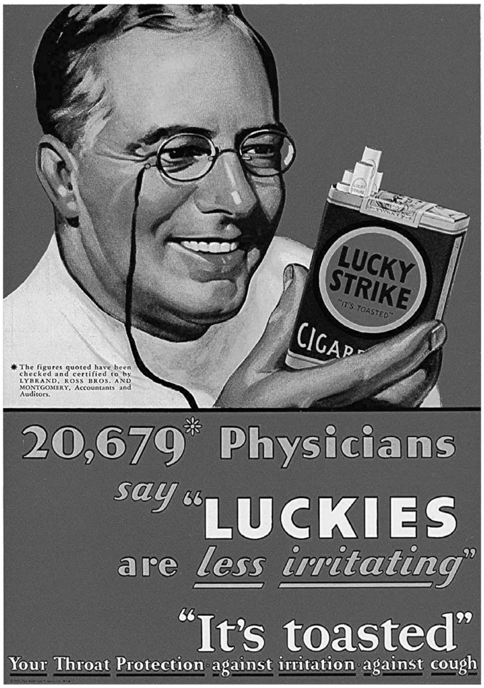

Figure 2. Advertisement for Lucky Strike ® cigarettes in the 1930s, depicting a physician asserting its benefits when compared to other brands [10].

But, however, a quantitative correlational evidence between these two was not presented until recently. In novel studies, historians of science made clear that there was a major casual factor in the delay of public perception of the relation of cigarettes and health hazardous conditions [4, 8]. In ephemerides, such as cancer, there was a significant chronological gap between medical evidence of the dangers of tobacco consumption and public awareness of this issue. Such strategies, must be analysed and considered with due cation, as the ones that have worked in the past are very likely to successes in an alternative future. Recent epistemological modelling frameworks on industrial propaganda have described, in detail, its effect in scientific communities and also on how scientific knowledge flows towards the general public [4, 8, 11].

What was described by these studies is that the strategies used by the tobacco industry had a major influence on public discernment. Using a group of agents as "propagandists", they vouched to bias policy makers into not incorporating recent scientific knowledge on tobacco consumption regulation. And even more interesting, is that it was made clear that the abundance of information, regardless of being right or wrong, and the way it is spread, it is regarded as a major contributor. Statistically, a propagandist can make its message more easily incorporated into public belief [8].

2.2 Agent-Based Models on History and Philosophy of Science

To realize how ABM can help us with describing alternative scenarios, it is important to understand the intricate relationships between science, its actors, and their regulations. To grasp the bigger picture painted by their interactions, some methods of philosophy of science can provide interesting tools for its interpretation. Some scientific epistemological models focus on the role played by scientific knowledge in the articulation between scientists, policy makers and the general public [11, 12]. It also helps to understand how science aided to shape important concepts and institutions through knowledge dissemination, and how they have moved between political, social and economic interests [13, 14].

Our take begins with a model introduced back in late twentieth-century by economists Bala and Goyal [15]. In their work, individuals in a community must choose either one of two theories to act on, based on the evidence they gather in their reality. This goes in a two-step process. First, individuals test one of the theories, and then share their output with the remaining members of the network. As the process spans out, individuals update their beliefs based on the common evidence assessed by the community, until the group identifies itself with one answer. The bridge between this economic-based theory and history and philosophy of science was shaped by Kevin Zollman, who theorized and proven the model's use towards the spread of scientific evidence [16, 17]. He stated that, considering each individual as a scientist, we can shape the model to give us insight on testing new hypothesis (hence, new knowledge). A network of distributed scientists with an established connection pattern is the baseline for the spread of knowledge between them. Each scientist can only perform two actions: either go with action A, a proven hypothesis, or go with action B, which is a new hypothesis less understood, uncertain if it's better that action A. Scientists' aim is to find out which of the actions is better towards their question, and then adopt it as scientific knowledge. In subsequent model simulations, each scientist has a different baseline of credence's, which represent different beliefs and backgrounds. In each simulation round, scientists get to observe the outcome of their choices and then update their beliefs according to the evidence they found. This is done so, because to better interpret scientific methods, it is expected that scientists test each theory several times. As such, the model simulations occur until all the scientists involved gather to believe in only one action.

Regarding the outline of the model explored above, we will now argue that it can be greatly expanded by the connection between ABM and Alternative History. Since we have mentioned the core value of Alternative History on designing alternative episodes and describing hypothetical scenarios, they are keenly aligned with the described model framework. For example, the model's action of "testing new hypothesis", embodies in itself alternative outcomes for a defined (historical) starting point. And those outcomes can provide newfound historical data, which in turn will aid the designing workflow of ABM, as described in Figure 1. To the best of our knowledge, this is the first time that the connection of Bala and Goyal, Zollman and Alternative History has been established.

3. Using Models on Alternative Scenarios

So how can we transpose this to describe a historical event? First, we would have to breakdown the episode in such a way, that we can devise its main outcome (or issue) though a model. And as such, that model must be populated by agents that can perform certain actions that may come in the result of a consequence. Recent philosophy of science studies have used this motto to model past historical events where scientific knowledge was on the brink [11, 13, 18]. And what they have done successfully is that they transposed a particular event and predicted alternative scenarios for what would be its future outcome. And what is more interesting, is that out of the infinite possible alternatives that the model would choose for a certain action, it usually chooses the one that would materialize in the future.

In this paper, we highlight our interest in how scientific knowledge moves through scientists, the public and policy makers, generating a new outline of science-based legislation. Considering the works based by philosophers of science, it is possible to build upon the frameworks by Bala, Goyal and Zollman. Using a basic model of scientists described by Zollman, it is possible to re-shape it, introducing our newly mentioned agents: the policy makers and the public. These new members have already their beliefs on scientific topics, but they do not test them and gather evidence by themselves [4]. Policy makers and the public only listen

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to some scientists in the network, but they do not influence them directly. However, policy makers by default are embedded to listen (at some degree) to the public in the matter of science-based decision, if they implicate their day-by-day lives. As such, the actions performed by the policy makers can be influenced by the credence of the public, if the hypothesis suggested by the scientists implies some sort of social impact.

As we discussed, the outcomes of scientific based legislation endeavors must harness the available knowledge on the description of the network between all the agents involved. Once described, we can then promote the design of a model that can be shaped according to any alternative scenario that we want to pose. It is our knowledge and characterization of the past that can help us articulate answers to alternative scenarios that can materialize themselves in a near future.

But what are the necessary steps to outline such a model based on historical moments? The first thing to be defined is the scenario we want to work with. This poses questions like "what is to be studied", by whom, and for what purpose. A historically based scenario is a specific situation where we devise a possible outcome from individual actions involved with scientific practice. It needs to have a heavily implied scientific activity component as to fit with the models we described. For example, we can name the influence of scientists in the making of a specific legislation, particularly on how they have persuaded policy makers (or not). Each situation can embody alternative futures, or counterfactual pasts, that can happen for a present-day or historical situation, posing questions that define our scenario's goals. Examples like this one are knowledge creation, its dissemination (among peers and public) and science communication and its networks. Expanding our knowledge on these issues can, pre-emptively, predict the success, or fallback, of certain legislation.

The other milestone to be defined is the agents and their network. History of Science gives us plenty of starting points: were scientists listened when health-hazard laws were taken in action? Has the communication of scientific feats and discoveries have been subverted in public knowledge? Take the current instance of COVID-19 vaccination: scientists have provenly produced evidence that vaccines are safe and effective. But science communication strategies seem to not pass along the message homogeneously. Discourse discrepancies and public opinions, especially on social media, point that on key issues, global health guidelines were not followed exclusively based on scientific evidence. As such, we define the scenarios as situations where we want to determine the influence of science and scientists in the making and enforcement of legislation, communication and other man-made systems of dissemination management. And such scenario definition can deeply benefit from the incorporation of Alternative History elements. By clarifying the reasons why past episodes happened in such a way, the outline on "what could have been" can be projected to our present or future timelines, when they present shared main topics and pivotal agents.

4. Predictive Science-based Legislation framework: A Model Proposal

Despite their insightful characteristics, ABM on scientific knowledge cannot, yet, provide any direct policy guidelines. However, such a framework, applied thoughtfully, can provide a better understanding of the many alternative scenarios that can come off from historical characterized events. In our proposed workflow back in Figure 1, we can see the connection between data from past historical events and simulations towards the prediction of a specific subject, when designing an ABM.

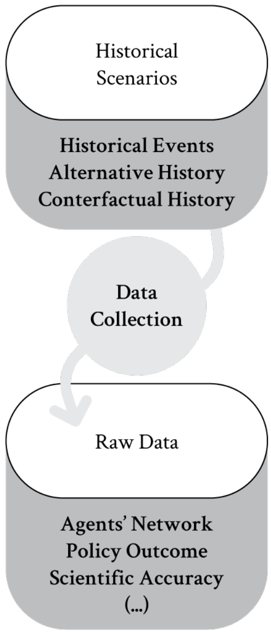

Figure 3. Outline of Data Collection workflow, extracting Raw Data form Historical Scenarios towards an ABM on science-policy guidelines.

In Figure 3, we zoom in on how Historical Scenarios and Raw "Historical" Data are connected. In order to collect the necessary elements for ABM model building, the Historical Scenario, in this case, involving science-based legislation, must be our primary concern. This aspect does not reduce itself just by looking for historical events that occurred in past and collect every piece of information on them. We must also bring to the equation elements from Alternative History and Counterfactual History. Exploring the reasons why a certain event did not occur in such a way (Alternative History) can provide equally valuable insights as just how it really happened (History). In fact, the "Raw Data" that we have to look for in these episodes, are the common denominator in each historical source. We are not talking about a quantitative way to describe each event. Instead, we focus on the factual elements that can be extracted from them. In Figure 3, we highlight some of the three major factors involved. Firstly, in the case of science-based policies, it can be the characterization of the network of agents present in the policy-making process. Who are they? What is their background? What are their political views? And also, were scientists involved? From which academia? Questioning the sources, is perhaps the greatest asset that an Historian of Science can provide, when describing the bonding elements on building an historical narrative.

All these questions give us more insight on the motivations behind law-makers' intent, forwarding to our second factor. What was the policy outcome? Was it well received by the general public? Did it achieve its purpose or did it fail and was retracted or modified? Looking back from Historical Events, it is easy to gather enough literature on these aspects. But it is also possible when discussing Alternative History events. If we know the outcome of a science-based policy that did not achieved its purpose, we can then explore the reasons why it did fail, when considering an Alternative Event in which the policy was successful. Since we are using real actors and real historical elements, we can organize this data and use it as input for our model.

And finally, our proposed third major element in data gathering is policy's scientific accuracy. It should provide information on the scientific foundation of the analyzed policy case, clarifying if the introduced legislation follows scientific consensus, or adopts guidelines from rogue theories, with or without empirical assessment. This is particularly interesting in studying early nineteenth and twentieth century food safety and drug legislation, as western societies witnessed a boom on science-based policy. Deliberate conflicts between policy makers, scientists, and corporations shaped the environment surrounding regulation efforts on public health, so often found on food-

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stuffs such as milk, wine or vinegar. And more interesting enough, is that we can witness these scenarios in present-day law-making. Like in the previously discussed cases of the Tobacco Industry and COVID-19 vaccination, it is not clear that policy making based on scientific knowledge is always well incorporated or disseminated. We can empirically categorize if a certain policy or regulation was successful, if we compare with the "gold-standard" of the topic, commonly assessed by a majority of peer-reviewed scientific literature. Although in some historical cases it may be hard to make such an evaluating endeavor, it really stresses the role of History and Historians of Science in studying these issues. Furthermore, having such data at our disposal, can also help us build a case for Alternative History scenarios, as we have discussed earlier. Characterization of "what could have been" in developing alternate chronologies, if sustained on a densified network of data collection, can readily help our modelling workflow, making the transition from historical research towards model building.

We stress, however, the ongoing research on the conversion of the collected data, as to carry out as input for computational models. ABM has come a long way in making the bridge between social sciences and computational modelling, but with the endeavor of deep-learning methods such as Machine Learning, several breakthroughs are expected in the following years. But bear in mind the potential outcomes for our proposed modelling. The ability to quantify the odds of eventual results for policy success (or failure) can have intricate social implications. For example, in the Tobacco Industry issue we have analysed, these models have predicted the way false beliefs spread in a community. This earlier knowledge, and subsequent public awareness, could have prevented the loss of countless lives to tobacco-related illnesses.

5. Conclusions

It is this clear that the intricate value of ABM modelling towards science-based policy comes mainly from the exploration of a well categorised network of agents and how they interact and interpret their knowledge. Scientists, general public and policy makers form an important community network, that exploring focal historical episodes can be expanded, proving additional depth in the understanding of these models. As such, the notion of epistemic landscapes can pave the way for the description of alternative policy scenarios, based on past historical examples [6, 19]. History of Science and Alternative History, as we have seen, can be great tools for developing these models, moulding them to shape present-day issues. And these insights, can shift bias and credence to a well-founded scientific theory. This takes us to the notion of "misinformation" and "fake-science", that will indeed move philosophy of science in the years to come.

The design of ABM models that we discussed, permits us to have a stronger inception of public opinion, rather than having just a sharable output. Particularly, when we talk about a densified network of agents, it must be considered that their relationships can outscore the performance and reception of the knowledge. For science-based legislation, there can be plenty of data and information that instead of leading to a clear policy disclosure, without proper context, can lead to scientific false beliefs. The act of sharing and propagating information can be even more risky that producing scientific results that contradict science theories.

The depiction of these models can be a valuable tool to predict alternative outcomes to a present-day issue starting point. In the case for science-based legislation, having established our network of agents, their relationships, and how they communicate with each other, we can have a thoughtful insight on the probability of alternative disclosures. Instead of theorising, what a specific type of science knowledge can have an impact of marked legislation, we can be able to quantify probabilities of occurrence of eventual outcomes that may be considered alternative. It is this versatility of ABM that, properly manipulated, can shine a revealing light on the materiality of an alternative scenario. Essentially, we are using a historical model to clarify an alternative event.

6. Round Table Insight

The article and subsequent topic discussion in the Round Table of the *2nd International Meeting of "What if?..." World History* (Porto, 2020), was fruitful on broadening the scope of Alternative History, towards ABM modelling. Major key issues on how to design and adapt past episodes of History of Science into ABM were discussed, as some of the suggestions were incorporated in the final article manuscript.

Some of the participants highlighted the difficulty of identifying the type of data that should be identified and collected from the selected historical events or Alternative History timelines. We then emphasized on the wide scope that this article brings to ABM modelling, stressing that each case can have specific data for characterizing its environment. Our presented work intends to serve as a primary guideline to help historians and philosophers of science to identify such data, as ABM modelling is a field of constant development.

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