**A soft-science view on a hard-science project**

Robin Kuipers (201854288)

Individual Essay, BF991 Research Philosophy

**Introduction:**

In this essay, I will attempt to outline how certain paradigms from (research) philosophy apply to the topic of my PhD research. How these paradigms relate to my personal worldview will also be discussed briefly.

**Research lay-out:**

My research topic and methods are different than most other research that takes place at the Strathclyde Business School. It’s quantitative research, as opposed to most other research done in this faculty, which is qualitative research.

The official title of my research is “Simulation and Optimisation of Offshore Renewable Energy Arrays for Minimal Life-Cycle Costs”, meaning the research aims to minimize costs of Offshore Renewable Energy Arrays, mostly windfarms in the North Sea. The Life-Cycle Costs can effectively be split in three phases; the installation, the maintenance and the deconstruction. The main methods I use for this research are simulation and optimisation; the goal is to mathematically model the schedule of an installation, maintenance and/or deconstruction project in such a way that solving the minimization-equation(s) can still be done in a reasonable time, and give a good result.

**Possible paradigms:**

It’s hard to imagine research of this kind in most of the philosophical paradigms discussed in the course. Within the world of mathematics there is the debate of mathematical realism; the question whether maths relates to “real” concepts and objects, or whether the concepts discussed in maths merely exist in the fictional, human-designed, system of maths. If the former is true it is very likely any other intelligent species in the universe (if they exist) will have the same mathematical system; they would also know what a triangle is, while if the latter is true other intelligent species might have completely different methods of making sense of the world, that are incompatible with our maths. However, both views agree that, within our maths, the statement “2+3=5” is objectively true. To clarify, an anti-realist would not say that statement is universally true, but that it is true within the context of mathematics, in the same way that the statement “Sherlock Holmes lives on 221B Baker Street in London” is not universally true, but is true in certain contexts (in this case the Sherlock Holmes books by Sir Arthur Conan Doyle). The distinction lies not in whether the statement is true, but whether it necessarily corresponds to something in the real world or not.

Hence, there are two ways to frame my research; the numbers and the reality. I could see it as a purely mathematical topic; my problem is a set of numbers and relations, for which I could (theoretically) write a perfect model encompassing all costs and processes with precise details and time-steps of mere seconds detailing what every crew member should do in every possible situation (taking into account delays, having a pre-calculated plan for every possible scenario). This would yield an unsolvable problem, since the number of variables would be absolutely enormous. The goal of the research would be to simplify this model to a point where it is solvable in reasonable time, and gives a schedule still strong (rather than optimal) in the original objective function. This way of looking at my research would have the realist and anti-realist agree that both the ontology and epistemology are objective; since it all exists within the context of maths and numbers, which are objective facts, and which we can know truth about. This would lend itself perfectly for a positivist philosophy.

The other way of looking at it takes more of the reality of the situation into account. Our goal is not to optimize this theoretical perfect mathematical system, our goal is to optimize the scheduling of a real life project which will actually happen. If we are planning for a specific project, the company executing the project will determine the restrictions and ultimate goal (for example maximise net value of the project, taking delayed returns of investment into account). However, in a realistic scenario after hearing these goals things can change, and we might have to adjust our model. For example, the costs of renting vessels might change, or due to changing company priorities the company might want profits faster and might put a deadline on when the first wind turbines are online and making profit, or it might change the discount rates of future spending and profit. Therefore the real goal of the research is to schedule this real project, even if the exact parameters of how to do that might change completely unexpectedly. If one would stay with the original parameters and design a schedule for that specific problem given at the start, and sticks with it even if the parameters of the actual project are changing, it would simply be an intellectual exercise without (direct) connection to the real world (and a researcher doing that would realistically lose the funding for the project).This unpredictable aspect of the project (where unpredictable does not simply mean the non-deterministic nature of the project) means the research cannot purely be seen as a mathematical endeavour. This in turn means that an anti-realist would see at least some degree of subjectivity in the research (because it is not entirely within the pure mathematical context), which could allow for a subjective epistemology, and even a subjective ontology.

Hence, while at first glance the philosophical paradigm of positivism seems like the only viable option for a quantitative research project like this, other paradigms could be considered.  In order to divert from a purely objective epistemology and ontology, we do however need to accept two things (that are disputable): We are mathematical anti-realists, and we adapt our research if the real-world aspects of it were to change.

**Critical Realism:**

If we accept these two things (for now), I would pose that critical realism is a fitting paradigm. A fundamental component of critical realism are the multiple levels of reality. This relates to different viewpoints depending on the context. Suppose we ask different scientists the question “What is humanity?” Each would answer depending on their own viewpoint. A physicist might answer that humanity is the collection of humans, where each human is simply an intricate set of atoms and molecules. If we would ask a biologist the same question they would still say that it is the collection of humans, but where each human is a set of metabolic processes. A psychologist might define each individual human as a collection of thoughts, memories, feelings and hopes. Finally, a sociologist might not even define humanity as the set of all humans, but as a thing it itself, as a human society has properties that do not stem from any of the particular humans, and is not just the sum of its parts. A critical realist would say that while all these scientists answered the same question in different ways, they are all right within their own viewpoint. And they are all equally right, it simply matters on the context which of these viewpoints you use. If you were to use the biologists explanation when answering a question about sociology you will get nowhere, and the same goes when you use the sociologists answer to answer a biology question.

This relates back to one of the things we previously accepted. When I wrote about different ways to view the research (as pure mathematics or as the scheduling of a real-world project), this fits within the different levels of reality the critical realist believes in. The researcher is both a scientist finding a strong ‘solution’ to this mathematical system, as well as a human who will adapt that mathematical system (or swap to a different system) when the real-world context of it would change (whether this is to continue being funded or because they want to produce practically applicable research), hence the researcher is maintaining two different viewpoints.

The other assumption, that of mathematical anti-realism, also fits well within the paradigm of critical realism, but in a slightly different way. When scientists are discussing the question “What is humanity?”, or when we’re thinking of different viewpoints on the project, we have differing viewpoints on the same reality. Ultimately, the same object is being discussed. In contrast, a critical realist who is also a mathematical anti-realist could say there is the real (the physical world) and the mathematical (imagined system), both are separate realities (not relating to the same object), and while results found through mathematics so far have always related to some real-world counterparts, this is not necessarily the case (since the laws of mathematics are not the laws of the real). This, however, is still compatible with critical realism, but we would not be certain that a solution which is good in our mathematical model is good in the real world; hence the epistemology is subjective.

**Personal views:**

Personally, however, I do not subscribe to mathematical anti-realism. In all my experiences with mathematics, which are fairly numerous as I have a Master Degree in Computing Science with a focus on Algorithm Design and Analysis, mathematics is an inherent feature of the universe. While the field is often seen as abstract and disconnected from reality, every aspect of mathematics follows from real-world observations. Mathematics started as a tool for daily life (from simple trading to geometry) and while it has developed far beyond that, I still see mathematics as a tool, just for sciences instead of daily life. So called Imaginary and Complex numbers seem abstract and unconnected to real-world phenomena, but they are used to explain concepts in physics, which by definition is the study of the real world. The position of anti-realism seems very susceptible to Occam's Razor; the simplest explanation is generally the right one. Either mathematics is an inherent feature of the universe, which would explain why questions worked out by mathematics have so far always corresponded to the real world, or it is some form of luck that this is the case, and there are questions out there where mathematics would provide the wrong answer (i.e. a circle where the ratio between the diameter and the circumference is not equal to pi). The latter explanation assumes that every single question worked out through mathematics so far is ‘luck’, which is an extremely big assumption. This does not mean I’m certain that we will never find something outside (our current understanding of) mathematics, but simply that I would be very surprised if this were to happen. And were it to happen, I think it is more likely that the related area of mathematics (and our understanding of it) could be adapted, rather than big parts of the field being actually wrong.

To me personally, the philosophical paradigm of critical realism seems to make a lot of sense. It takes a more practical and context-dependent approach than positivism, which always seemed very concrete and strict in its methods, thereby limiting itself in its reach. For my PhD project, looking at it through a mathematical realist lens, there does not seem to be much difference between critical realism and positivism. Critical realism says to use the tools and viewpoint that fits the question, for my research questions the tools and views of positivism fit. As for the second question I raised earlier, of whether to see the project as pure mathematics or not, I subscribe to the theory that it is not. I will create a mathematical model for the problem, and I will aim to find a strong solution to that model. If I find such a solution, I will expect it to work well in practice (if I made the model correctly). However, if during my work on this model the parameters of the problem change, I will try to adapt my model, since the final goal is to make the actual windfarm projects more cost-efficient. The entire reason I am motivated for this project is the mix of techniques (which are on a technical level I find interesting) and goals (since I think green energy is important).

**Conclusion:**

While at a glance positivism might seem like the only fitting paradigm for a mathematical project like this, there are plenty philosophical questions to ask regarding this research. Especially the question of mathematical realism is relevant. While I take a realist stance on that question, I do still subscribe to the philosophical paradigm of critical realism, which for this project is closely related to positivism.