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**Marginal damage and remedial responsibility: Revisiting the time
dimension of the Polluter Pays Principle**

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Introduction

Who is responsible for the damage caused by climate change? Difficult question, difficult answers. What is clear is that climate change is a pressing issue and, to deal with it, everyone has to contribute. To deal with it, every country has to contribute. However, not every country should contribute the same way. To attribute responsibility to each country the “Polluter Pays Principle” of climate distributive justice offers a solution. The principle suggests attributing responsibility based on amount of emissions produced and, therefore, based on the relative produced damage. The principle is very straightforward and logical. However, a question naturally arises: Are all emissions the same across time? This is a fundamental question because if some emissions are more or less blameworthy, this should inform the international distribution of responsibility. Then, PPP, in a way or another, has to deal with the time dimension of emissions. Indeed, for example, some would suggest that emissions that were produced by excusably ignorant states cannot have the same moral weight of subsequent emissions on behalf of aware states. If this is true, then the distribution of responsibility should change accordingly. This is the so called excusable ignorance objection that suggests that countries before a certain date were unaware of the effects of CO₂ emissions, and, therefore, should not be held responsible for emissions before such date. PPP has to deal with this type of objection to properly distribute responsibility. However, there must other ways to assess the nature of responsibility of polluting states over time. The attempt to engage with the temporal dimension of emissions in PPP, namely the so called excusable ignorance objection, is based on a binary understanding of responsibility. I will show how the debate about the moral weight of emissions over time needs to be expanded with a gradual and incremental understanding of remedial responsibility. Hence my research question: How should emissions produced at different points in time be evaluated? The moral evaluation of emissions across time should not only depend on the preconditions of harm at different times (were states aware or unaware?) but also on the *intensity of harm produced* at different times. This research question comes from empirical evidence that suggests that, with cumulative issues, such as climate change, the damage produced by a repeated action increases over time. To put it more simply, an emission of CO₂ today produces more damage than two years ago because it is added to an already existing pool of emissions in the atmosphere. Therefore, since climate change is a cumulative issue, we need to take into account the gradual increase of damage of CO₂ emissions for distributing responsibility. This thesis shows that the process of burden sharing in the fight against climate change, cannot ignore the temporal dimension of the damage of emissions, because of the cumulative nature of climate change. It shows that burden sharing practices based on PPP need to engage with the quantity of emissions as

well as their time-dependent quality (the extent to which they damage) without neglecting the role of moral bad luck, that an assessment of emissions based on time brings about. After having proved these theoretical elements, I will proceed investigating the implications of my normative findings for PPP in the last chapter. This is an intrinsically multidisciplinary paper: Normative conclusions are drawn also in accordance with some empirical knowledge that comes from environmental science and economics. Only a multidisciplinary approach can show the different nature of emissions over time to draw normative implications that are based on sound empirical evidence.

Chapter One: Literature Review: How is remedial responsibility attributed under PPP?

This section is dedicated to explore the Polluter Pays Principle (PPP), a principle of environmental distributive justice. After a definition of remedial responsibility I will proceed showcasing the most important academic debate about the moral evaluation of emissions in PPP justice frameworks, namely the debate about excusable ignorance. I will show how emissions are valued throughout time under PPP, within the excusable ignorance debate. Academic literature showcases there is an extensive debate about the moral evaluation of emissions based on knowledge of the harms. However, academia seems to lack a debate about the moral evaluation of emissions based on the different degrees of harm that states produce depending on the time they emit. For the purpose of this research, I will use states as the main duty bearers as they exist over time and, for this reason, they best capture the temporal dimension of damage I am investigating.

Let's however start from the beginning: What is distributive justice? Distributive justice is the realm of the fair allocation of resources, opportunities and wealth within a society and beyond. In the context of climate change, distributive justice refers to the just allocation of burdens among states, to engage in the fight against climate change. Allocating burdens means allocating different shares of duty to different actors. Caney (2017) suggests that "bearing the burdens of the fight against climate change" entails two different kinds of duty. The first one, the duty of mitigation, refers to the duty to cut down on activities that produce climate change and specifically emissions of CO₂ (p. 204). The second duty, the duty of adaptation, is the duty to devote resources to protect people from the impacts of climate change around the globe (p. 204). So, who should shoulder the mitigation and adaptation burdens and to what extent? Firstly, The "Beneficiary Pays Principle" (BPP) suggests that the states that should shoulder the biggest share of the burden are those states that benefitted the most from emissions of CO₂. BPP is based on the idea of burden-benefit

mirroring. Page (2012) suggests that states should shoulder burdens that are associated with climate change accordingly to the extent to which they have derived benefits from activities that have produced emissions (p. 310). Secondly, the “Ability to Pay Principle” (ATP) suggests that the biggest share of the burden should be shouldered by the wealthy states that are able to pay (Caney, 2010, p. 213). According to this approach, the duty of a state should increase in line with the state’s wealth (p. 213). Indeed, under ATP, actors contribute to mitigation and adaptation efforts based on their wealth, independently from the extent to which they polluted.

Finally, the “Polluter Pays Principle” (PPP) suggests that the actors that caused pollution have the responsibility to deal with the ensuing costs to others (Caney, 2010, p. 205). It follows from this principle that those who contribute to climate change should make amend for it by cutting back their emissions or by contributing to adaptation efforts, proportionally to the extent to which they have polluted. Tan (2023) says that under PPP, developed states have reparative duties to less developed states (p. 2). PPP encapsulate a straightforward philosophical reparative ideal: The agents who have caused injury have obligations to repair accordingly to the extent they damaged (Tan, 2023, p. 2). The main idea is that the countries that polluted the least (namely developing countries), should be compensated by the countries that polluted the most (namely developed countries) that are primarily responsible for the climate problem through their emissions of CO₂ over time (p. 2). Indeed, according to Page (2008), developed western countries are responsible for around 75% of the total emissions of CO₂ produced between 1750 and 2005 (p. 558).

Out of these three principles, this thesis focuses on, and tries to revise, the Polluter Pays Principle. PPP is the nowadays most used principle in international environmental treaties and conventions. This is true even though the historical version of it, the one that takes into consideration past emissions is, to a certain degree, still a matter of dispute. However, the PPP approach is used in the Framework Convention, the Kyoto protocol and the Paris Agreement (Posner & Weisbach, 2010, p. 81). Moreover, thanks to extensive work in the OECD in the past two decades, PPP has become a legal principle (Khan, 2015, p. 643). PPP is a well defined principle of EU law and it is endorsed in the EU environmental law regime after many years of negotiation (p. 643).

Distributive claims that arise from PPP are remedial claims, as they are about who has to pay (in terms of mitigation and adaptation efforts) for the damages caused by polluting activities. In this regard, Miller (2001) gives a definition of remedial responsibility. To be remedially responsible means having a special obligation to compensate for the harm produced by one’s actions (p. 455). To be remedially responsible means to owe a proportional compensation to whoever one has

harmful. Throughout this paper I will refer to the “degree of remedial responsibility” as the amount someone has to pay (in terms of adaptation and mitigation) to compensate for the caused damage.

How does PPP morally evaluate emissions over time?

In this section I will discuss how PPP engages with the moral evaluation of emissions over time and how this affects the international distribution of responsibility. Are all emissions the same across time? Are we responsible for all emissions across time? PPP engages with the time dimension of emissions and their moral weight over time through various debates. The most important academic debate about the moral evaluation of emissions across time, focuses on the degree of emitters’ awareness of the harms. Are excusably “ignorant states” responsible for production of emissions whose damage they were not aware of? There have been several theoretical and logical obstacles to assess the degree to which states should account for historical emissions and whether they are responsible for them or not. This is the debate around the so called “excusable ignorance” of polluting states. “Excusable ignorance” is an objection to the idea that states should be held responsible for emissions whose harms they were not aware of. The objection supports a moral evaluation of emissions across time based on knowledge, that has fundamental consequences for the distribution of responsibility amongst states.

Moellendorf (2022) claims that many states can say they were unaware of the harmful effects of their emissions before 1990, but no state can credibly claim the same after 1990 (p. 87). Indeed, 1990 is the year the IPCC published its first assessment report, warning about the effects of green house gas (GHG) emissions for climate change. This is the year the link between GHG emissions and the climate crisis is officially made. Two years later, in light of the 1990 assessment report, 154 nations signed the United Nations Framework Convention on Climate Change (UNFCCC), with the purpose of “preventing dangerous anthropogenic interference with Earth’s climate system”. For this reason, Singer (2002) suggests that, after 1990, ignorance about the harmful consequences of consumption of fossil fuels has become culpable (p. 34). This “knowledge benchmark date” has potentially the power to disregard or discount states’ emissions before 1990, in the name of their excusable ignorance. Excusable ignorance is a well known objection to the act of accounting for past emissions when deciding how to assign remedial responsibility, and subsequently, how burdens should be fairly shared among states. If emissions before 1990 are not to be accounted in the overall calculation of damage, then remedial responsibility sensibly decreases because a whole part of emissions would be disregarded.

Bell (2011) argues that the excusable ignorance argument is based on the idea that if an agent is excusably ignorant of the consequences of their actions, they should not be held liable for the costs that are associated with the consequences of their actions (p. 394). Excusable ignorance is an argument that has a lot of logical appeal and it is very present in common discourse. Some authors argue for strict liability of the costs for historic polluters, others for a more limited liability of the costs. For instance, Neumayer (2000) answers to the provocative question about whether emissions before 1990 could be rightfully ignored (p. 188). According to Neumayer (2000), past emission should not even be discounted, even if the emitters were ignorant about their effects. Indeed the developed western economies, the biggest polluters before 1990, have exploited in excess the absorptive capacity of nature to which every state across space and time has right to a share (p. 188). Moreover, Gardiner (2004) supports the idea of a strict liability for past emissions and consequential costs in four ways. Firstly, he suggests that ignorance cannot be excused from liability when the costs are above a particular threshold of harm, that, according to him, past emissions have definitely surpassed (p. 581). Secondly, Gardiner (2004) suggest that excusably ignorant, but casually responsible emitters, have to a duty to help the countries that are the most affected by their actions (for instance, developing states) (p. 582). Thirdly, excusably ignorant emitters should be held liable for the damage when they are wealthy enough to assist the most affected countries (p. 582). Finally, the excusably ignorant emitters should be held liable because their wealth is the consequence of the very activities that caused climate change (p. 582). Gardiner's (2004) ways to support strict liability for past emissions have a strong appeal because they have a solid logical base. In his opinion, polluters non-excusably produced harm, above a threshold of harm. For this reason, they should support countries that cannot help themselves with their own wealth, that is, as a matter of fact, the very consequence of their harmful actions. On the other side, Caney (2005) puts forward the idea of limited liability for historical emissions and their costs: When excusably ignorant emitters have benefitted from their emissions, they should be held liable for the costs of the emissions up to the value of the benefits (p. 209). Indeed, the costs the emitters are liable for, should not be higher than the benefits they gained from emission-generating activities. This is fair because otherwise, the costs historical emitters will engage in will not be mirrored by their gains (p. 209). For this reason, it is fair to say that, while Gardiner (2004) supports the historical version of PPP that takes into consideration historical emissions, Caney (2005) advocates for a PPP that has some similarities with BPP.

Research gap and rationale of the research

This literature review shows that there is an extensive debate about how to morally evaluate emissions across time and, therefore, how to attribute responsibility to different states. The debate is very heated because it informs to what extent different emissions need to be taken into account in the calculation of the overall damage, that subsequently informs the allocation of burdens, or better, the degree of remedial responsibility. The literature has focused a lot on the extent to which emissions before 1990 should be counted, discounted, disregarded and there are many answers to the excusable ignorance objection to PPP. Many scholars have responded to the well known objection assessing the nature of emissions before 1990, logically proving that emitters before this date should still be held remedially responsible for the damages, despite their ignorance.

Can the moral evaluation of emissions across time in PPP, however, only depend on lack of awareness of the harm? As shown later, empirical evidence suggests that the emissions in different years produce different amounts of damage because of their cumulative nature (Pearce, 2003, p. 363). A tonne of CO₂ in 1990 produces less damage than a tonne of CO₂ in 1991 because of the cumulative nature of greenhouse gases in the atmosphere. The damage of a tonne of CO₂ is not the same throughout history and time: The damage that a tonne of CO₂ produces depends on time.

Then, when evaluating emissions across time, should I also take into account the damage they caused, that depends on the time they were emitted? And why does time matter? In other words, while there is literature on the topic of evaluation of emissions across time on the basis of lack of awareness of the damage, the literature ignores a debate about the evaluation of emissions across time based on the increasing damage they cause. The literature seems to lack a more complex way of dealing with the time dimension of emissions in PPP. While there is a debate about how to account for emissions depending on the moral standing of the polluters that *dichotomously* varies *over time* (before and after 1990), there is no debate about how to account for emissions depending on the damage they produce, an element that *gradually* varies *over time* (every year a tonne of CO₂ produces more damage than the year before). To sum up, in the excusable ignorance debate, responsibility for a tonne of CO₂ is attributed in a binary way (you are either responsible or not because you are either aware or not) and based on how the preconditions of harm (awareness) vary over time. I suggest expanding the debate in a way that responsibility for an emission of CO₂ is also attributed gradually and based on how the intensity of harm varies over time (the later the emission the higher the damage).

Chapter 2: Argument: The time dimension of damage

In this chapter I will answer the research question, I will show why, with cumulative issues such as the greenhouse gases effect, actions at different times produce different damages, and how this should inform the process of attribution of different degrees of remedial responsibility. Indeed, I will firstly show why the degree of remedial responsibility should mirror the degree of harm produced, and secondly, how, for cumulative issues, this can only be done accounting for the time of emissions. To do so, I will firstly showcase the empirical evidence of the increasing damage caused by CO₂, to then engage with the normative implications of such evidence through an illustrative analogy about hunters.

To assess the degree of responsibility, the excusable objection assessed the *precondition* of harm, whether states were aware or not of the damage they were producing. However, the degree of remedial responsibility also needs to be assessed based on the *intensity* of harm, the degree of damage produced: More damaging actions bring about higher degrees of responsibility. This is also part of the rationale of PPP. In other words, the degree of responsibility attributed to different actors can be based on the conditions *before* the harm is produced, but the conditions *after* the harm is produced also need to be taken into account. Indeed, Coates (2022) suggests that there are different degrees of moral responsibility also depending on the extent of the produced harm (p. 2). If Barbara steals 20 euros while Gianluca steals 200 euros from Marco, then one can assert that both actions are blameworthy, but Gianluca's action is more blameworthy (p. 2). Marco needs to be compensated for the 220 euros he lost and, in this compensation process, Gianluca should play a bigger role than Barbara. Indeed, Gianluca has a higher degree of responsibility compared to Barbara towards Marco and Gianluca's remedial responsibility will be higher because the damage he produced is higher. So how does PPP account for this? Today, the countries that are considered to be having the highest degree of remedial responsibility, are the ones that emitted the most in terms of tonnes of CO₂. This is based on the idea that some countries, having started to emit earlier than others, produced more damages. For this reason, to distribute remedial responsibility, classical historical PPP calculates the amount of tonnes of CO₂ for every country from 1750 (assuming it overcomes the excusable ignorance objection). However, and this is very important, because of the *cumulative nature* of CO₂ emissions and their damage, an international distribution of remedial responsibilities purely based on the quantity of emissions, that doesn't take into account the time they were emitted, is flawed. PPP's classical way of calculating damage and subsequently attributing responsibility, is not in line with Coates' (2022) moral assumption that to assess the degree of responsibility one also has to look at the degree of damage produced.

CO2 emissions: A cumulative issue

Climate change is a cumulative issue. Indeed, increasing concentrations of CO₂ in the atmosphere, gradually trap some of the heat that is radiated by the planet, raising its temperatures and shifting its equilibrium (Singh & Singh, 2015, p 95). It is a cumulative issue because damage results from the gradual build up and accumulation of emissions over time. Climate change is a cumulative issue because increasing quantities of CO₂ in the atmosphere have increasingly severe impacts on the planet and its inhabitants.

The social cost of carbon (SCC) is an estimate of the monetary value of world wide damage caused by CO₂ emissions (Pearce, 2003, p. 363). More specifically, the estimate shows the monetary value of global damage done by emitting one tonne of CO₂ (p. 363). In a sense, the social cost of carbon evaluates the marginal damage of CO₂: The monetary damage that emitting *one additional unit of CO₂* produces for the whole planet. This estimate is calculated through the combination of data coming from different studies that quantify the impact of climate change. These impacts are monetised in order to quantify their relative harm to human society on a single numerical scale (Scovronick et al., 2019, pp. 642-643). SCC is an adequate measure to assess whether one tonne of CO₂ today and one tonne of CO₂ in the past, bring about the same damage in economic terms. Spoiler: They don't. The cumulative nature of CO₂, that remains in the atmosphere for several centuries after it is emitted, makes damage a function of cumulated stock, so one extra tonne released in the future will have a higher associated damage than an extra tonne released now (p. 363). Damage is a function of (depends on) quantity of emissions and time of emissions. Indeed, the marginal damage of CO₂ can be fully expected to rise in the future (p. 363). An extra tonne of CO₂ tomorrow will have a higher associated damage than one extra tonne released today because it will add to an already existing and ever increasing pool of CO₂ emissions in the atmosphere. Liu and Feng (2018) sampling the data of 41 world regions that include 165 countries, obtain an analytical overview of global flows of CO₂ emissions and they suggest that the cost of emission is increasing over time (p. 1433). The authors normatively assert that since reducing emissions will become more costly in the future because of accumulation, it is necessary to accelerate mitigation efforts before costs increase and reach an unsustainable point (pp. 1447-1448).

Moreover, many studies have shown that every additional unit of CO₂ in the atmosphere leads to approximately the same global increase in temperatures (Matthews et al., 2018, p.1). The transient climate response to cumulative emission of carbon dioxide (TCRE) is an index that shows how much the global temperature changes for every tonne of CO₂ emitted. Every tonne of CO₂ contributes to an equal increase in the global temperature. Indeed, current studies show that every

trillion tonnes of CO₂ emitted in the atmosphere, global temperature increases between 0.8 and 2.4 degree Celsius (p. 2). Does this mean that all emissions across time produce the same damage? Not at all. Indeed, a sound analysis of this data also takes into consideration the constant increase in the temperature of the planet due to the accumulation of past emissions. Different temperatures lead to different damages as there are already varying amounts of CO₂ present in the atmosphere. For every tonne of CO₂ emitted in the atmosphere, what is relevant from a world-temperature-perspective, is how the emission increases the *current* (already increasing) temperature. To sum up, it is true that every tonne of CO₂ has a similar impact on the temperature level, but that increase in temperature, needs to be added up to previous increases in temperature brought about by past emissions. Whereas each ton of CO₂ contributes similarly to global warming, climate damages increase more than proportionally with the temperature increase (Rickels et al., p. 742).

To conclude, scientific environmental evidence shows two relevant facts. Firstly, a tonne of CO₂ today produces higher damage than yesterday. Secondly, even though every tonne of CO₂ across time consistently produces the same increase in global temperature, any additional tonne of CO₂ increases the current-already-increasing global temperature reaching higher and higher levels of damage. In short, the later the emission, the greater the damage, because of the cumulation of emissions in the atmosphere.

Hunting deers

I suggest that these empirical evidence has a normative implication: Namely that the increasing marginal damage of CO₂ emissions should be mirrored by an increasing remedial responsibility to contribute to mitigation and adaptation efforts. I can now argue that PPP's way of attributing responsibility based on the intensity of the harm solely looking at the quantity of emissions is flawed. It is flawed because it doesn't take into account the time-dependent *quality* of emissions. The time a tonne of CO₂ was released in the atmosphere should be taken into account when attributing responsibility. This is true because, for remedial purposes, a damage equal to 1 needs to be accounted differently from a damage equal to 1+n. It follows, and this is very important, that historical emissions and recent emissions produced different damages and, as such, they should be accounted differently in the division of remedial responsibilities amongst states. The damage of a certain amount of tonnes of CO₂ is to be contextualised in a time dimension. For this reason, I argue that the distribution of remedial responsibility of the states should take into account the time

emissions were released in the atmosphere. Let me show this by making an analogy about how, the cumulative nature of pollution, has an effect on remedial responsibility.

Pietro is a hunter and he goes hunting an endangered species of deers in a national park. When he starts hunting, the park has a population of 100 deers. The more he hunts, the less deers remain in the park. The more he hunts, the smaller the chance deers have to meet and breed. Assume that the killing of an endangered-species of deer is harmful, and that the survival of the herd should be preserved as substantially and intrinsically valuable. It follows that Pietro's actions of killing a deer is harmful and, from that, it follows responsibility. The action of killing a second deer brings about a greater degree of responsibility because two deers is more than one. However, killing a second deer would also hold a slightly greater damage, because the mating chances of the deer herd slightly decrease. This is the reason why hunting is a cumulative issue as much as climate change. It follows that the higher the number of killings, the higher the degree of damage: Pietro's actions become increasingly more harmful as the the number of killed deers increases over time. This example shows how later killings are more harmful because of the cumulative nature of the damage caused by hunting practices. Indeed, assume that Pietro kills 10 deers, bringing the members of the herd from 100 to 90. Then assume that Marcello, another hunter, one day brings the number of the members of the herd from 20 to 10. Marcello's action is undeniably more harmful than Pietro's first killings (as he made the breeding chances significantly smaller and smaller), even though they both just killed ten deers alone. Finally, if Francesco's hunting practices bring the number of the herd from 10 to 0, his actions are even more harmful than Marcello's, even though they both just killed ten animals alone. As a consequence, Pietro, Marcello and Francesco, should not only be held remedially responsible for the mere amount of deers they killed, but they should *also* be held remedially responsible for the herd's decreasing breeding chances that their respective killings of deers over time have contributed to. They should also be held remedially responsible for the different damage they caused at different times. Only focusing on the quantity of killed deers to attribute remedial responsibility would be flawed, as we saw that killing ten deers at different times, produces different damages that should be mirrored by different remedial duties.

However, let me now add another element that makes the puzzle even more challenging. Focusing solely on the quality of the killings, on the time-dependent degree of harm caused to the breeding chances of the herd, would *also* be a flawed approach. It would be a flawed approach because it would not take into consideration that some people engaged in harmful activities before than others and that the higher levels of damage that Francesco brings about, are a consequence of the cumulation of previous actions that produced lower but increasing damages. Indeed, Francesco

is a victim of bad luck, he started hunting when the levels of harm were already high (not because of him) and that resulted in his actions being fatally more harmful than the Pietro's and Marcello's.

What does this example show us? The same reasoning of the analogy can be applied to polluting practices. If we want to seriously assess the degree of remedial responsibility based on the damage produced like Coates (2022) suggests, then looking at the amount of emissions of CO₂ is not enough. This is because we also have to consider their time-dependent quality. Therefore, to assess remedial responsibility we have to take into account the quantity as well as the quality of emissions. This comes from Coates' (2002) idea that the degree of remedial responsibility also has to mirror the degree of produced harm. If we agree that the degree of remedial responsibility has to mirror the degree of damage produced, then, to fully assess the degree of damage, for cumulative issues, we need to account for the time dimension of damage production. However, this normative intuition brings about some problems. Indeed, we need to seriously take into account that certain actors started engaging in damaging activities later in time. It follows that the reason why their actions result in greater damage is because other actors, outside of them, produced damage before them. Indeed, Marcello's and Francesco's actions are undeniably more harmful than Pietro's, but is it all their fault? Should Marcello's and Francesco's degree of remedial responsibility change accordingly? At the end of the day, the reason why Marcello's and Francesco's actions became more harmful is because Pietro, before them, has already contributed to harm. This problem is what is defined by Hartman (2019), the problem of "moral luck". Moral luck occurs when factors that are beyond an actors's control, affect the level of blameworthiness or praiseworthiness of their actions (p. 3179). For this reason, a proper way of attributing different degrees of remedial responsibility has to take into account the moral luck of the latecomers as well (in the case of climate change, latecomers are developing states). A serious redistribution of the burdens in cumulative settings, takes into account that states produce more damage later in time also because other states, or they themselves, have started producing damage before.

Thus, how do we attribute responsibility in this example based on the observation of the produced damage? To establish that, we have to look at 1) who killed more deers (quantity), 2) who killed deers later in time (quality), and also take into account that, 3) who killed deers later in time produced higher damage because someone before them already killed some (moral bad luck).

Chapter 3: Implications: What should PPP look like?

I will now analyse the implications of the argument about gradually increasing remedial duties over time for PPP. Throughout this thesis I have come to many different conclusions and now

it is time to pick up the threads. In particular, there are three elements that need to be taken into account. Firstly, I have answered the research question and I have shown how a proper distribution of degrees of remedial responsibility, needs to take into account the quantity as well as the quality of emissions. Secondly, I have showcased that latecomers should not be disadvantaged because the high degree of damage they produce today, depends on the damage that was produced by others in the past. Finally, at the beginning of the thesis, I said that the debate about excusable ignorance needed to be combined with my debate about the intensity of the damage. Therefore, a reflection about a possible combination of these debates is now necessary.

Quantity and quality

The previous chapter has shown us that a fair distribution of degrees of remedial responsibility over time should depend on the quantity as well as the quality of emissions. Therefore, how should a Polluter Pays Principle that seriously takes into account the relationship between time and damage look? How can the historical PPP take into account not only the total amount of tonnes of CO₂ produced by every country throughout history, but also the time they were produced? To account for the quality of emissions, one needs to engage with the social cost of carbon (SCC) because it is the measure that tells us how much damage one emission produces at different times. The social cost of carbon, is an indicator of the moral evaluation of emissions because it indicates what damage an emission brings about. The social cost of carbon measures the damage produced by emissions at different times, and, consequently, engaging with this metric represents a means to properly account for the time-dependent quality of emissions.

There are some possible ways of revisiting PPP with a contextualisation of damage in time. For instance, Rickels et al (2023) produce a measure called “Climate Wealth Borrowing” (CWB). Its calculation is really complex and it falls out of the scope of this normative research. However, we can analyse its rationale as a possible way to take into account the time-contextualisation of damage. What is the CWB measure? CWB is the current value of climate damages caused by all historical CO₂ emissions (p. 742). In other words, CWB measures the present global wealth that a country needs to compensate for the climate damages caused by its emission path (emissions amounts from 1950 till 2018). How does the measure take into account the time-dependent quality of emissions? It makes use of the Social Cost of Carbon for the calculation of the damage. Again, the SCC consists in the marginal damage of CO₂ emissions: How much damage (in monetary terms) one tonne of CO₂ produces for the planet. Rickels et al.(2023) note that, over time, the

current-value of SCC increases, reflecting increasing marginal costs, like suggested above by Pearce (2003). They showcase that every year the value of the SCC is higher. Therefore, when, for example, they calculate the damage produced by Italy in 2015, they take the global value of SCC in 2015 into account as well as the total amount of emissions produced by Italy in 2015. When they calculate the damage produced by Italy in 2016, they take into account the higher global value of SCC in 2016 as well as the total amount of emissions produced by Italy in 2016. At the end, summing up all of the years, they obtain the total damage produced by Italy from 1950 until 2018. This damage, in monetary terms, is then compared to the damage produced by other countries and it shows who has the highest remedial responsibility in monetary terms. They also offer a per-capita version of this measure that suggests to what extent each individual, from different countries, has produced damage from 1950 until today in monetary terms.

To sum up, we have shown in the previous chapter that, to assess the level of responsibility, we have to assess the level of damage based on quantity and quality. The rationale of the CWB measure consists in one of the many possible ways to visualise a new version of PPP that contextualises damage in the time it is produced. For contextualising damage in its time dimension, a possible solution is to assess the extent of the damage through the SCC, as this measure indicates how much damage a tonne of CO₂ produces in different years.

What about latecomers?

At this point it is established that it is necessary to account for the time emissions were produced, but this might have serious implications for developing countries. Indeed, if later emissions are more and more damaging, developing countries, that started polluting later, might end up being held accountable for disproportional shares of remedial responsibility just because of bad luck and bad timing. This is the problem of moral luck. Let's make an example: Imagine country X, a developing country, starts emitting in 2023. By only looking at the quantity and quality of emissions, like it was done above with the CWB measure for instance, a very high degree of damage (and therefore responsibility) would be attributed to the emissions country X produces. This is because SCC is at its highest today, in 2023. Indeed, as SCC increases over time, the value of SCC in 2023 will be the highest ever scored. For this reason, when country X steps into the emission game, the damage X causes is higher than the damage X would have caused if X stepped into the game years before. This is because, when X started emitting, the value of SCC, was already high due to the accumulation of emissions, to which, however, X did not contribute to. To put it simple: If country X start polluting today, his emissions will already produce a high damage

because of the accumulation of emissions in the atmosphere which country X did not contribute to. For this reason, the remedial responsibility that country X has, cannot simply mirror the damage they produced: it would be unfair because many other countries in the past contributed to that damage.

What some researchers propose is a social discount rate, applicable only to developing countries, to account for their bad luck as late comers. This idea builds on Nordhaus's (1997) so called "growth discounting" (p. 317). Growth discounting revolves around the idea that it is appropriate for future richer generations to pay a larger share of mitigation and adaptation costs, the same way, high income people contribute a larger part of their income in taxes (p. 317). Based on levels of development, the current damage should be discounted so that developing countries will pay for the damage they cause in the future, when they will have more economic means. Assuming that developing countries will have more economic means in the future, their damages should be discounted today, to then be paid back in the future, when it will be easier to do so. In practice then, when we internationally attribute degrees of remedial responsibility, we should discount the damage and therefore the remedial responsibility of developing countries. This way, they will pay in the future, when they will be richer than now. The suggestion seems logical, sound and pragmatic.

I believe, however, that despite it seeming logical and temporarily efficient, it is a non-solution, it is rather a patch. It is just a way of delaying the problem and it incurs in several problems. Firstly, developing countries would have the right to delay their payment to better and more prosperous times, but they would still have to pay for higher degrees of damage they have not fully contributed to, in the future. A social discount rate on growth does not fully solve the problem of moral bad luck developing countries face. Indeed, it would just delay their payment for damages that are still higher because of CO₂ contributions that do not come from them. Secondly, the assumption that people will be richer in the future could practically be questioned on many levels. Will future generations actually be wealthier? What would happen to their duties in case of a recession?(Caney, 2014, p. 328). Thirdly, I believe that a social discount rate, would only produce a redistribution of burdens *within* developing states. Indeed, it would only redistribute burdens between the generations within developing countries: While current generations would have a discount of their remedial responsibility, this will need to be compensated by an increment in remedial responsibility of future generations. For this reason, a social discount rate would only consist in a temporary solution that accounts for the current economic impossibility or difficulty of developing countries to engage in mitigation or adaptation efforts. Further research is needed so assess how to attribute remedial responsibility based both on quantity and quality of emissions

without holding latecomers accountable for disproportional responsibility that derives from their moral bad luck.

The incorporation of excusable ignorance

In the literature review it was suggested that the debate about excusable ignorance was an important one. However, it was also suggested that a new debate was also needed: One about the evaluation of emissions based on the intensity of the damage they produce. How can we incorporate the conclusions of the excusable ignorance debate with the normative findings we reached? Many scholars agree that states before 1990 are still remedially responsible for the damages of their emissions, even though they were not aware of the harms. Including the excusable ignorance objection in the burden sharing debate based on time-dependent quality of the emissions, would be complicated, but not impossible. First of all, one needs to show that an actor that is aware is *more* remedially responsible than an actor that is not. The excusable ignorance objection questions whether polluters have less remedial responsibility when they lack awareness of the damage. However, now, one needs to assess whether, in *presence* of awareness, their actions are more blameworthy, whether they have higher degrees of remedial responsibility *after 1990*. A possible answer comes again from Coates (2022). Coates (2022) suggests that different degrees of responsibility can be attributed also depending on whether subjects meet some epistemic condition of responsibility (p. 13). The difference in agents' epistemic standings affects the degree to which those actors are more or less morally responsible for their actions (p. 13). Therefore, aware actors are more responsible for their actions than unaware ones. If one agrees to consider 1990 as the awareness threshold, then, states that pollute after 1990 have higher remedial responsibility than states before 1990. Once one proves that states after 1990 are more remedially responsible, a new increased (not increasing) level of remedial responsibility after 1990 needs to be taken into account. This layer of remedial responsibility based on awareness, does not increase over time like remedial responsibility based on damage, because awareness is dichotomous in nature (you either have it or you don't have it). So while remedial responsibility increases over time and gradually, from the point of view of the intensity of the damage, remedial responsibility, from the point of view of awareness, has increased only once (and never again) in 1990. This means finding a solution that accounts for an *una tantum* increase in remedial responsibility based on awareness and a gradual increase in remedial responsibility based on increasing marginal damages. Therefore, the time-contextualisation of emissions that is needed to assess the remedial responsibility of the states that produced them, would need to become *double faced*. A tonne would need to be contextualised in

time to assess the degree of damage it brought about because of the increasing marginal damage of emissions. However, it should also be contextualised in time to assess whether the states have more responsibility because they were aware of their actions. The normative rationale is clear, even though it is hard to visualise it in practice. Further research needs to be conducted about how, in practice, a gradual increase in remedial responsibility for increasing damage could be combined with a single increase in remedial responsibility because of awareness.

Finally, what has this final chapter shown? I showed how a possible way to contextualise emissions in their time dimension is to engage with the social cost of carbon, an indicator of the degree of the moral evaluation of emissions at different times. I showed a possible temporary solution to account for the moral bad luck of developing countries that my account of gradual responsibility, based on increasing marginal damage, brings about. Finally, I showed how, to incorporate the excusable ignorance objection in my debate, a double-faced time contextualisation is needed. Emissions need to be contextualised in time to assess the degree of produced damage and also the awareness of the polluting states to then draw conclusions about their overall degree of remedial responsibility. Finally, further research is needed to investigate the role of discount rate and its efficacy as well as the practical implications of a double-faced time contextualisation of emissions.

Conclusion

From ignorance to deers, from remedial responsibility to bad luck, what has this paper shown? This thesis has explored the realm of environmental distributive justice and specifically how the Polluter Pays Principle should be revised. The thesis focuses on how to fairly distribute remedial duties amongst states under PPP, based on the amount of damage they produce. There is a debate about how to dichotomously evaluate remedial responsibility based on knowledge, but there is no debate about how to gradually evaluate remedial responsibility based on the intensity of the damage. Coates (2022) suggests that the degree of responsibility can be determined by various elements (including the epistemic standing of the actor), but also on the degree of damage produced. A moral evaluation of emissions cannot prescind from an analysis of the degree of produced damage. An assessment of remedial responsibility based on the intensity of the damage requires an agreement about how damage comes about. Empirical evidence suggests that higher degrees of damage are brought about both by higher quantity of emissions as well as emissions later in time. Such empirical evidence has normative implications. Namely, if one wants to engage in a debate about the attribution of remedial responsibility based on the intensity of the damage, the time

dimension of emissions must be taken into account. Therefore, when attributing responsibility based on the intensity of the damage, one will need to take into account the quantity as well as the time-dependent quality of emissions. This finding has important implications. Firstly, how does a PPP that account for quantity and quality of emissions look? A possible answer comes from the Climate Wealth Borrowing measure that incorporates the Social Cost of Carbon as an indicator of higher degrees of damage over time and, consequently, higher remedial responsibility over time. Secondly, my findings could bring about negative implications for developing countries because of their moral bad luck. Indeed their remedial responsibility will be higher because they started polluting later in time, producing higher damages, because of other countries' accumulation of emissions. A possible, but temporary, solution could be identified in growth discount rates. Finally, the combination of the excusable ignorance objection with the assessment of responsibility based on the intensity of damage and therefore time, requires a double faced approach. Emissions need to be temporally contextualised to assess the degree of damage they bring about as well as the awareness of the countries to then attribute remedial responsibility overall. To conclude, this thesis shows a more complex way of dealing with the time dimension of PPP for burden sharing practices. It shows that, when morally assessing emissions, their time contextualisation, affecting the degree of produced damage, should be taken into account. The time an emission is produced is a fundamental determinant of the moral evaluation of the emission and it should inform how we internationally distribute mitigation and adaptation burdens.

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