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Stoicism and the Tragedy of the Commons*

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Abstract

This paper revisits the Tragedy of the Commons - a Pareto-dominated overuse of a common resource - through the lenses of Stoicism, and, in particular, of the Stoic discipline of desires, according to which one should wish for nothing that is not under one's control. When the Stoic discipline of desires is modelled as a requirement of indifference between outcomes differing only on things out of control, Stoic agents are shown not to overuse the common resource. Alternatively, when the Stoic discipline of desires requires indifference between best outcomes under each circumstance, the Nash equilibrium, if it exists, cannot be Pareto-dominated. Depending on how the Stoic discipline of desires is formalized, a recentring of agents towards things under their control either allows them to avoid overusing the commons, or makes the use of commons not "tragic".

Keywords: Tragedy of the Commons, Stoicism, rationality, common resource game, land overuse.

JEL classification codes: Q24, D62, D91, Z1.

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1 Introduction

Following Harding's (1968) pioneer work, economists and social scientists have paid substantial attention to the Tragedy of the Commons, which refers to a generic problem of coordination of agents using a common resource (i.e., a resource for which property rights are not defined).¹ When using a common resource, agents do not perfectly internalize the negative impact of their decisions on other agents, which leads to an overuse of the resource. The basic example is the use of a common parcel of land by shepherds. Under standard economic rationality, shepherds choose to let graze a number of animals on the common piece of land without internalizing the effect of their land use on the output of other shepherds. This leads to land congestion, a Pareto-inefficient outcome.

Economists working on ethical preferences have shown that the Tragedy of the Commons is not a fatality, but is caused by a particular conception of rationality, that is, the standard conception of economic rationality. To illustrate this, let us consider another kind of rationality, Kantian rationality. Following Kant's (1785) categorical imperative - that is, always behave according to a maxim that you want to see respected as a universal law -, Laffont (1975) and Roemer (2010, 2015, 2019) formalized Kantian rationality as a tendency to choose the best *generalizable acts*, that is, the best acts in the hypothetical case where *all* agents would adopt these acts. Studying a common pool resource game, Curry and Roemer (2012) showed that agents adopting Kantian rationality overcome the Tragedy of the Commons. The intuition is that Kantian rationality makes agents choose the best act if all agents were playing symmetrically, which leads them to choose the socially optimal use of land. Thus land congestion emerges only under some forms of rationality, but not all of them.²

Kantian rationality allows agents to overcome the Tragedy of the Commons by imposing a kind of "decentering" of the agent: instead of focusing on the best strategy for himself - the strategies of other players being taken as given -, the Kantian agent focuses on the best strategy for himself *provided this strategy is generalized to all agents*. This task of "generalizing" or "universalizing" possible acts is central to Kantian rationality: this universalization procedure amounts to adopting another, broader perspective on the decision to be made, beyond the mere point of view of the agent himself. As a consequence, Kantian rationality assigns no value to deviating, since deviation consists of being the "exception", which is the definition of "injustice" according to Kant.

But is such a universalization procedure *the only way* to overcome the Tragedy of the Commons? In other words, is the "decentering" of the agent the unique way of getting out of coordination problems?

¹On the experimental study of the Tragedy of the Commons through common pool resource games, see Walker and Gardner (1992), Ostrom et al (1994), Keser and Gardner (1999), Ostrom et al (2002) and Apesteguia (2006). Other papers on common pool resource games include Sethi and Somanathan (1996) and Noailly et al (2007, 2009).

²On interactions between Kantian and Nash agents in common pool resource games, see Curry and Roemer (2012), Long (2016), Grafton et al (2017), Roemer (2019) and Bezin and Ponthiere (2019).

At first glance, it is tempting to answer: Yes. The intuition goes as follows. The Tragedy of the Commons occurs because agents do not internalize the effects of their acts on other agents. This lack of internalization of external effects being at the core of the problem, it is tempting to believe that any solution to the Tragedy of the Commons must involve some extra internalization of the effects of one's acts on other agents. Hence a "decentering" of the agent would be necessary to avoid the overuse of the commons.

However, as we will show in this paper, the correct answer is: No. The "decentering" of the person is not necessary to be able to overcome the Tragedy of the Commons. *It is possible to avoid the Tragedy of the Commons by the opposite movement: a "recentering" of the person towards herself.*

This result, which may look paradoxical at first glance, is obtained by the exploration of another form of rationality: Stoic rationality. Developed by philosophers such as Epictetus, Seneca and Marcus Aurelius, Stoicism is a philosophical doctrine that recommends a particular conception of the "good life" defined as "a life in accordance with Nature", that is, a life in conformity with the position and status of the person in the Universe. Whereas there are various ways to define "a life in accordance with Nature", the philosopher Pierre Hadot proposed, in various writings (Hadot 1978, 2001), to interpret Stoicism as a threefold discipline of the "interior discourse": first, a discipline of judgements (i.e., describing things as they are); second, a discipline of desires (i.e., wishing for nothing that is not under one's control); third, a discipline of acts (i.e., regarding things that are under our control, choose to act for the Common Good).

In order to examine the implications of Stoicism for the Tragedy of the Commons, it is necessary to first "translate" it into the language of microeconomics. For that purpose, we will follow here the recent work of Ponthiere (2024), who argued that the Stoic discipline of desires can be modelled as a requirement of extension of the symmetric factor of the preference relation beyond its boundaries under standard preferences. This *extension of the indifference relation* can take two forms: the I1 account requires indifference between all outcomes that differ only on circumstances; the I2 account requires indifference between all outcomes that are the best under each prevailing circumstances.³

The present paper shows that, if agents adopt the Stoic discipline of desires, and wish for nothing that is not under their control, two cases can arise, depending on how the Stoic discipline of desires is formalized. Either agents escape from the Tragedy of the Commons by avoiding the overuse of the commons (under the I1 account of the Stoic discipline of desires), or the Nash equilibrium, if it exists, cannot be Pareto-dominated, so that the use of the commons is not a Tragedy (under the I2 account). *A "recentering" of agents towards things under their control either allows agents to overcome the overuse of commons (under the I1 account of the Stoic discipline of desires), or makes the use of commons not tragic (under the I2 account of the Stoic discipline of desires).*

The present paper is related to several branches of the literature. First, it is related to the economic literature on ethical preferences. Following Harsanyi

³See Ponthiere (2024) on the implications of these accounts for the structure of preferences.

(1953, 1955, 1976, 1982), economists have "translated" moral precepts from philosophers into the language of economics, through the concept of ethical or moral preferences. In Harsanyi's works, moral preferences took the form of preferences on hypothetical equiprobable lotteries defined on all societal positions, in line with Smith's (1756) impartial observer. Later on, Laffont (1975) and Roemer (2010, 2015, 2019) formalized Kant's categorical imperative (Kant 1785) in terms of preferences on generalizable acts. Whereas these economic approaches to ethical preferences relied on philosophies of the Enlightenment, there is *a priori* no reason to ignore older doctrines. Our paper complements the literature on ethical preferences by taking as a basis an Ancient philosophy, Stoicism, in line with a recent study by Ponthiere (2024), who examined how the Stoic discipline of desires can be formalized into the language of microeconomics. Second, this paper is related to the literature on the Tragedy of the Commons (Harding 1968) and on its study by means of common pool resource games (see Walker and Gardner 1992, Ostrom et al 1994, Keser and Gardner 1999, Ostrom et al 2002, Curry and Roemer 2012). Our contribution consists in exploring how agents satisfying the Stoic discipline of desires play the common pool resource game. Its main contribution is to show that the Tragedy of the Commons can not only be overcome by a kind of "decentering" of the person (as under Kantian morality), but, also, by a kind of "recentering" of the person (modelled as the I1 account of the Stoic discipline of desires).

The paper is organized as follows. Section 2 provides a short presentation of Stoicism. Section 3 explains how the Stoic discipline of desires can be interpreted as requiring an extension of the indifference relation, and studies two ways of extending the indifference relation (the I1 and the I2 accounts). Section 4 presents the common pool resource game. Section 5 studies the outcome of the game under standard economic rationality. Section 6 revisits the Tragedy of the Commons through the lenses of the I1 account and the I2 account of the Stoic discipline of desires. Section 7 concludes.

2 Stoicism

Pioneered by Greek philosophers Zeno of Citium, Chrysippus and Cleanthe, Stoicism is one of the four major philosophical schools in Ancient Greece, together with Platonism, Aristotelianism and Epicureanism. That philosophical school has crossed centuries, thanks to the transcriptions of lectures given by Epictetus (the *Manual*), and, also, thanks to the writings of Roman philosophers who were much influenced by Stoicism, such as Seneca and Marcus Aurelius.⁴

In a nutshell, Stoic philosophers were defending a particular "art of living", which consisted in living a life in accordance with Nature. As stressed by Hadot (1995), Ancient philosophical doctrines such as Stoicism should not be inter-

⁴As stressed by Hadot (1995), many writings of Stoic philosophers have been lost over time. For instance, although the Stoic philosopher Chrysippus wrote about 700 treatises, none of these could reach us. These treatises are only known through indirect references and quotations by other philosophers (see Hadot, 1995, p. 151).

preted as coherent systems of thought, but, rather, as some kind of practical knowledge aimed at guiding citizens in their everyday life.

Stoicism admits several facets, which are not simple to synthesize. Based on his reading and interpretations of Stoic philosophers (mainly Epictetus and Marcus Aurelius), the XXth century philosopher Pierre Hadot proposed to synthesize Stoicism as a threefold discipline of thought (Hadot 1978, 2001):

- the discipline of *judgements* (that is, a physical description of things "as they are");
- the discipline of *desires* (that is, one should wish for nothing that is not under one's control);
- the discipline of *acts* (that is, regarding things under one's control, one should act for the Common Good).

These disciplines are distinct, but related to each others through various channels. First of all, the domains of these disciplines are determined by the metaphysical representation of the world adopted by Stoic philosophers. That representation, which is often regarded as the major dogma of Stoicism, states that the world can be partitioned in two classes of things: on the one hand, things that are under the control of the person; on the other hand, things that are not under her control (see Epictetus, *Manual*, I). According to that representation, the present self of the person is composed of three elements: her judgements, her desires/aversions, and her acts/willingness to act. Other things - such as the body of the person, her material wealth, other persons's acts, etc. - are external to the self. According to Epictetus (*Manual*, I):

Of things some are in our power, and others are not. In our power are opinion, movement towards a thing, desire, aversion, turning from a thing; and in a word, whatever are our acts. Not in our power are the body, property, reputation, offices (magisterial power), and in a word, whatever are not our own acts. And the things in our power are by nature free, not subject to restraint or hindrance; but the things not in our power are weak, slavish, subject to restraint, in the power of others.

Stoicism thus imposes a discipline concerning each element of the present self, each element under her control. These three disciplines are also related to each others in the sense that it is only if one describes things "as they are" that one can see which desires are good to pursue or not. Moreover, in order to know what one should do, it is necessary to first identify what one can do or not, based on the constraints of the context at hand. Let us briefly present these three disciplines of the interior discourse.

The Stoic discipline of judgements consists, in a nutshell, in describing things as they are. In other words, when looking at the world, persons should try to describe these things in purely physical terms, without adding extra concerns,

norms or value judgements. The discipline of judgements requires thus first to adopt a correct delimitation of the self of the person (see above). But beyond that, it requires to try to avoid being "polluted", in one's judgements, by norms or values. The discipline of judgements is a key component of Stoicism. As stressed by Epictetus, judgements and opinions are often what make persons suffer, even when there is objectively no reason for that (*Manual*, X):

Men are disturbed not by the things which happen, but by the opinions about the things; for example, death is nothing terrible, for if it were it would have seemed so to Socrates; for the opinion about death that it is terrible, is the terrible thing.

According to Stoicism, once persons are successful in describing things (including themselves) as these things are, they are on a good path to be successful in desiring and acting in an appropriate way, that is, in a way that is in conformity with Nature.

The Stoic discipline of desires is often summarized as a requirement of "indifference to indifferent things". That discipline requires that the person wishes for nothing that is not under her control, and, rather, focuses her desires and aversions only on things that depend on her. This is explained in Epictetus's *Manual*, II:

Remember that desire contains in it the profession (hope) of obtaining that which you desire; and the profession (hope) in aversion (turning from a thing) is that you will not fall into that which you attempt to avoid; and he who fails in his desire is unfortunate; and he who falls into that which he would avoid is unhappy. If then you attempt to avoid only the things contrary to nature which are within your power you will not be involved in any of the things which you would avoid. But if you attempt to avoid disease, or death, or poverty, you will be unhappy. Take away then aversion from all things which are not in our power, and transfer it to the things contrary to nature which are in our power. But destroy desire completely for the present. For if you desire anything which is not in our power, you must be unfortunate; but of the things in our power, and which it would be good to desire, nothing yet is before you. But employ only the power of moving towards an object and retiring from it; and these powers indeed only slightly and with exceptions and with remission.

The discipline of desires is a key requirement to reach the Stoic conception of a "good life", defined as a life of happiness (because the person is not frustrated by unsatisfied desires for external things), of freedom (because the person is free from these desires) and of autonomy (because the person is the master of what she desires).⁵ Otherwise, if the person is not able to wish for nothing that is

⁵The discipline of desires is also illustrated by Epictetus's metaphor of the child who wants to take lots of fruits from a pot, but cannot take his hand out of the pot. The morality is: one should desire less, to be able to satisfy one's desires (Epictetus, *Dialogues*, book III, 16).

not under her control, she will remain the slave of her (unsatisfied) desires.⁶

Finally, the Stoic discipline of acts concerns all things that are under the control of the person. According to the Stoic discipline of acts, persons should, for these things, always act in line with the Common Good, that is, in such a way as to promote the values of the City. The intuition behind this discipline lies in the idea of living a life in accordance with one's position in the Universe. A person is just an infinitely small part of a big whole, the Cosmos. The behavior of that person is in line with the Cosmos only if she acts in such a way as to best serve the whole to which she belongs. Otherwise, if the person acts egoistically, she behaves like a foot that would walk one its own, independently from the remaining of the body (see Marcus Aurelius, *Thoughts for Oneself*, book IV, 29). Thus the Stoic discipline of acts requires that each person makes the best use of her skills and talents to serve the society. This implies to best occupy one's positions and roles, within one's family and the society as a whole. Only a person respecting the discipline of acts can live a life in accordance with what she is, a small part of a bigger whole.⁷

One should note that the Stoic disciplines of desires and acts have a crucial corollary regarding the definition of a "good life": *the Good is reduced to the Moral Good*. This means that, under the Stoic disciplines of desires and acts, the only thing that can make a life good consists of the acts that the person will choose to carry out so as to contribute to the Common Good. All things that are external to the person, including her material wealth, her health, the acts of other persons, etc., cannot make her life better or worse. Only the things that the person does can make her life good or bad.

3 Extending the indifference relation

Given all facets of Stoicism, it is not straightforward to provide a unique economic interpretation of Stoicism. However, as it is argued in Ponthiere (2024), it is possible to provide a - partial - economic account of Stoicism by focusing on the Stoic discipline of desires. One can interpret the Stoic discipline of desires - the "indifference to indifferent things" - as a requirement of *extending the symmetric factor of the preference relation beyond its boundaries under non-ethical preferences*. From that perspective, the Stoic discipline of desires recommends an extension of the indifference relation. The underlying intuition

⁶It should be stressed that the justification of the Stoic discipline of desires does not require a belief concerning God's existence. Indeed, two cases can arise. If Providence exists, and if the world is well ordered, humans should not like or dislike what God created, because it is not their role, and they should just be contemplating what God created. Alternatively, if God does not exist, and if the world is just chaos, humans should not let their happiness depend on chaotic forces. Thus, in both cases, it is reasonable to adopt the Stoic discipline of desires, and to be indifferent with respect to things not under our control.

⁷We find here an important distinction between Stoicism and Modern philosophical doctrines: Stoicism defines the "good life" in accordance with the place and the status of the person in the Cosmos, unlike Modern philosophies. Note that this distinction can also be found for other Ancient philosophies such as Epicureanism. On this key distinction between Ancient and Modern philosophies, see MacIntyre (1971).

is that Stoicism involves a discipline of desires, which does not recommend global indifference, but, only, a "recentering" of the person's desires/aversions on what is really under her control, other things being indifferent to her.

This economic interpretation of the Stoic discipline of desires is purely ordinal. This does not impose any requirement about the intensity of desires, or about the extent of joy (or frustration) in case of desire (un)satisfaction. That economic account of the Stoic discipline of desires only requires the person to be indifferent towards the things that are not under her control. But this extension of what we could call the "domain of indifference" does not inform us about the intensity of desire (un)satisfaction.

Note also that this requirement of extension of the domain of indifference is not equivalent to requiring ignorance of things that are not under one's control. Such an ignorance would contradict the Stoic discipline of judgements, which requires to describe things as they are, in physical terms (see above). From a Stoic perspective, the "good life" is not about ignoring facts or events, but consists instead of knowing these, while adopting the right attitude towards these, based on what the person consists of.

A simple way to account for the Stoic idea of "wishing for nothing that is not under one's control" consists of requiring that *a person is strictly indifferent between all outcomes that differ only on things that are not under her control*. This indifference account of the Stoic discipline of desires is in line with Epictetus (*Manual*, XXXII):

For if it is any of the things that are not in our power, it is absolutely necessary that it must be neither good nor bad.

If circumstances (i.e., things that are not under our control) are neither good nor bad for the person, it must be the case that the person is strictly indifferent between two outcomes that differ only on circumstances. This can be proved by *reductio ad absurdum*. Otherwise, if the person were not indifferent between outcomes differing only on circumstances, then it would be the case that the circumstances prevailing under a particular outcome, by contributing to make that outcome either better or worse than another outcome (similar on other aspects), would be either good or bad for the person. A contradiction would then be reached with the Stoic requirement that things outside one's control are neither good nor bad.⁸

Requiring that the person is indifferent between all outcomes that differ only on things not under her power has important consequences in game-theoretical contexts. Indeed, given that other persons's acts are, according to Epictetus, not under one's control (*Manual* I), it follows from the Stoic discipline of desires that a person should be strictly indifferent between all outcomes of the game that differ only regarding the other players's acts. The remaining of this paper will examine the corollaries of the Stoic discipline of desires in the particular context of the Tragedy of the Commons.

⁸In other words, if the person were not indifferent between outcomes that differ only on circumstances, this would mean that the person would assign "some differences" between circumstances. This would contradict the ideal of "indifference to indifferent things".

Note that this extension of the domain of indifference is not the only possible economic account of the Stoic discipline of desires. As argued in Ponthiere (2024), another possible extension of the symmetric factor of the preference relation consists of *requiring indifference between outcomes that are the best under the prevailing circumstances*. This alternative "translation" of the Stoic discipline of desires, called the I2 account, is in line with the handles metaphor proposed by Epictetus (each event admits a "good handle", by which it can be borne). See Epictetus (*Manual*, XLIII):

Everything has two handles, the one by which it may be borne, the other by which it may not. If your brother acts unjustly, do not lay hold of the act by that handle wherein he acts unjustly, for this is the handle which cannot be borne; but lay hold of the other, that he is your brother, that he was nurtured with you, and you will lay hold of the thing by that handle by which it can be borne.

From the perspective of the "handles" metaphor, what matters in life is not the circumstances that turn out to prevail, but, rather, what the person can make out of these circumstances. In other words, circumstances become neutral for the person as soon as the person makes the best out of these circumstances.

This idea is also present in the works of Marcus Aurelius, through the "bright fire" metaphor (*Thoughts on Myself*, IV, 1):

When the governing part is in its natural state, it can easily change and adapt itself to whatever occurs as the matter of its exercise. It is not fondly set upon any one sort of action. It goes about what seems preferable, with a proper reservation. And if any thing contrary be cast in, makes this also the matter of its proper exercise. As a fire, when it masters the things which fall on it, tho' they would have extinguished a small lamp: the bright fire quickly assimilates to itself and consumes what is thrown into it, and even thence increases its own strength.

This metaphor suggests that, from a Stoic perspective, the "good life" requires to be able to deal with all circumstances that may turn out to happen, and that the most important thing is not the prevailing circumstance, but to be the person who will make the best of it. When a person is like a bright fire, circumstances become neutral.

The I2 account of the Stoic discipline of desires has implications orthogonal to standard microeconomics, and is more in line with adaptive preferences (Elster 1983). As we will see, this account yields also different implications concerning the Tragedy of the Commons. To examine this, we need first to formalize the Tragedy of the Commons as a common pool resource game.

4 The model

The economy Consider a simple economy where each agent $i \in \{1, \dots, N\}$ produces an output y_i by means of land s_i and animals e_i , through the following production function:

$$y_i = F(e_i, s_i) \quad (1)$$

where $F(\cdot)$ is supposed to be homogeneous of degree 1.

The total surface of land is denoted by $S > 0$. For the sake of simplicity, land is supposed to be of homogeneous quality. In line with the literature on the Tragedy of the Commons, land is owned *collectively*: there is no well defined individual property right. Each agent i uses a fraction of the total piece of land that is proportional to the total number of animals used in the population. We thus have:

$$s_i = \frac{e_i}{E} S \quad (2)$$

where $E \equiv \sum_{j=1}^N e_j$ is the total number of animals in the economy.⁹

Normalizing S to 1, the output of agent i can be written as:

$$y_i = F\left(e_i, \frac{e_i}{E}\right) \quad (3)$$

Dividing all inputs by e_i , one can rewrite the output of agent i as:

$$y_i = \frac{e_i}{E} G(E) \quad (4)$$

where $G(E) \equiv EF\left(1, \frac{1}{E}\right)$. We have $G'(E) > 0$ and $G''(E) < 0$.

Suppose that the cost of each animal is c . Hence the output net of the production cost of using e_i animals is:

$$\tilde{y}_i = \frac{e_i}{E} G(E) - ce_i \quad (5)$$

Note that the net output for agent i is decreasing in the number of animals chosen by other agents. Indeed, deriving the net output with respect to E (while keeping e_i unchanged) yields:

$$\left. \frac{\partial \tilde{y}_i}{\partial E} \right|_{e_i = cst} = e_i \frac{G'(E)E - G(E)}{(E)^2} = \frac{e_i}{E} \left[G'(E) - \frac{G(E)}{E} \right] < 0 \quad (6)$$

The negative sign comes from the concavity of $G(E)$. Thus, when the other agents increase the number of animals, this reduces the net output for agent i . The reason is that the increase in the number of other agents's animals reduces the piece of land available for agent i 's own animals. Hence, the output is reduced for agent i , leading to a fall in the net output *ceteris paribus*.

⁹That assumption is standard in the literature (see Curry and Roemer 2012, Bezin and Ponthiere 2019).

The socially optimal number of animals Given the symmetry of all producers, the number of animals per agent that maximizes the net output for each agent is obtained by solving the following problem:

$$\max_{e_i} \frac{e_i}{Ne_i} G(Ne_i) - ce_i$$

The first-order condition (FOC) for an interior optimal number of animals is:

$$\frac{1}{N} G'(Ne_i) N - c = 0 \quad (7)$$

Thus the socially optimal number of animals e^* equalizes the marginal product of animals (left-hand-side (LHS) of the equation below) with the marginal cost of animals (right-hand-side (RHS) of the equation below):

$$G'(Ne^*) = c \quad (8)$$

Given that $G'(E)$ is decreasing in E , the socially optimal number of animals per agent is decreasing in the cost per animal c , and decreasing in the number of agents N sharing the piece of land.

5 Land use under standard economic rationality

Agents with standard economic rationality choose a number of animals while taking the number of animals chosen by other agents *as given*, that is, they play the "best reply" to other players's choices. Note that we assume, throughout this paper, that the production process, as well as the cost of animals, is common to all agents, and is also common knowledge among all agents.¹⁰

The problem is thus, for agent i :

$$\max_{e_i} \frac{e_i}{e_i + \sum_{j \neq i}^N e_j} G \left(e_i + \sum_{j \neq i}^N e_j \right) - ce_i$$

where the numbers of animals e_j of other agents $j \neq i$ are taken as given.

The solution to that problem is given by the FOC:

$$\begin{aligned} \left(\frac{\left(e_i + \sum_{j \neq i}^N e_j \right) - e_i}{\left(e_i + \sum_{j \neq i}^N e_j \right)^2} \right) G(E) + \frac{e_i}{e_i + \sum_{j \neq i}^N e_j} G'(E) - c &= 0 \\ \Leftrightarrow \left(\frac{\sum_{j \neq i}^N e_j}{(E)^2} \right) G(E) + \frac{e_i}{E} G'(E) - c &= 0 \quad (9) \end{aligned}$$

¹⁰Since all producers are the same, this assumption of common knowledge is weak. Things would be different if producers were differing in skills or if land were not of homogeneous quality.

Assuming that all agents act symmetrically, we thus obtain that each agent chooses a number of animals e^0 such that:

$$\frac{N-1}{N} \frac{G(Ne^0)}{Ne^0} + \frac{G'(Ne^0)}{N} = c \quad (10)$$

When N is very large, the second term on the LHS tends to 0, and the factor $\frac{N-1}{N}$ tends to 1, so that this expression can be approximated by the condition:

$$\frac{G(Ne^0)}{Ne^0} = c \quad (11)$$

Thus, in a decentralized economy, each standard economic agent chooses a number of animals that equalizes the output per animal (or average output) with the marginal cost of animal.

Note that, since $G(E)$ is increasing and concave, the average product always exceeds the marginal product, that is, $G'(E) < \frac{G(E)}{E}$ for a given E . Hence, in order to have the equality:

$$G'(Ne^*) = c = \frac{G(Ne^0)}{Ne^0} \quad (12)$$

it has to be the case that:

$$e^* < e^0 \quad (13)$$

that is, that the number of animals chosen by standard economic agents exceeds the number of animals that is socially optimal. There is thus land overuse, and congestion in terms of animals. This is the standard result of the Tragedy of the Commons. In the decentralized economy, the net output is lower than what is socially optimal, because of the (non internalized) congestion of land:

$$\tilde{y}^* > \tilde{y}^0 \quad (14)$$

Note that the outcome where all agents choose the socially optimal number of animals e^* is not a Nash equilibrium of the game. Indeed, when an agent i has to choose the best reply to all other $N-1$ agents playing e^* , the problem is:

$$\max_{e_i} \frac{e_i}{e_i + (N-1)e^*} G(e_i + (N-1)e^*) - ce_i$$

The solution to that problem is given by the FOC:

$$\left(\frac{(N-1)e^*}{(e_i + (N-1)e^*)^2} \right) G(E) + \frac{e_i}{e_i + (N-1)e^*} G'(E) - c = 0 \quad (15)$$

When N is large, the FOC collapses to:

$$\frac{G(e_i + (N-1)e^*)}{e_i + (N-1)e^*} = c \quad (16)$$

Hence, given the concavity of $G(\cdot)$, the best reply e_i to e^* must exceed e^* (for which $c = G'(Ne^*)$). Agents have an incentive to deviate from the social optimum under standard rationality, and to have more animals than e^* . Thus the outcome of the game where all agents choose the socially optimal number of animals e^* is not a Nash equilibrium. Proposition 1 summarizes our results.

Proposition 1 *Assume that the production process and cost of animals are common knowledge. Under standard economic rationality, the outcome where all agents choose the socially optimal number of animals e^* is not a Nash equilibrium. The (symmetric) Nash equilibrium involves all agents choosing a number of animals e^0 that exceeds e^* . Thus the Nash equilibrium involves lower net output per capita in comparison to the social optimum.*

Proof. See the developments above. ■

Proposition 1 states, within our framework, the classical result of the Tragedy of the Commons (Harding 1968). Under standard economic rationality, agents guided by their self-interest do not internalize the negative externalities of their use of land on the output of other agents, which leads to land congestion, and, *in fine*, to a Pareto-dominated outcome.

The problem being the non-internalization of externalities related to the use of a common parcel of land, one may believe that the only way to overcome the Tragedy of the Commons is through some form of internalization of externalities, through a "decentering" of the agent. The "decentering" of the agent proposed by Kantian morality (Laffont, 1975, Roemer, 2009, 2019) allows agents to overcome the Tragedy of the Commons (see Curry and Roemer 2012). However, as we will show in the next section, this is not the only manner to overcome the Tragedy of the Commons. The opposite movement, a "recentering" of the economic agent towards himself, can also achieve the same result.

6 Land use under Stoicism

This section examines how Stoic agents interact in the common pool resource game. For that purpose, we will proceed in two steps, and consider first an economy where the N agents satisfy the I1 account of the Stoic discipline of desires. Then, in a second stage, we will consider the economy when the N agents satisfy the I2 account of the Stoic discipline of desires.

The I1 account of the Stoic discipline of desires In order to examine how Stoic rationality affects the outcome of the common pool resource game under the I1 account of the Stoic discipline of desires, it is first important to underline that this discipline implies that *Stoic agents do not have any incentive to deviate from the social optimum*. To see why, it is important to remind the content of the Stoic discipline of desires ("indifference to indifferent things"). The I1 account of the Stoic discipline of desires requires that the agent i is *indifferent* between all outcomes that differ only on things not under his control.

Let us examine the consequences of this discipline in the context of choosing a number of animals to graze on a common piece of land.

True, the piece of land s_i to which agent i has access for his farming activities, as well as the total output he can obtain from raising a given number of animals, depend on the behavior of the $N - 1$ other agents (their numbers of animals). Indeed, the piece of land s_i used by agent i is equal to:

$$s_i = \frac{e_i}{e_i + \sum_{j \neq i}^N e_j} S$$

which is *decreasing* in the number of animals chosen by the $N - 1$ other agents (see above). Hence, the output that agent i can obtain from a number of animals e_i is decreasing in the number of animals chosen by the $N - 1$ other agents, because a lower s_i leads, *ceteris paribus*, to a lower net output \tilde{y}_i .

However, despite these differences, the Stoic discipline of desires (II account) requires that agent i is strictly *indifferent* between all outcomes of the game that differ only on things not under control, that is, on what other agents play. Thus, even though the output achieved by agent i is decreasing with the number of animals chosen by the $N - 1$ other shepherds, the Stoic discipline of desires requires that the agent goes beyond these variations in his material living conditions, to be fully focused on what is under his control. The intuition goes as follows. From a Stoic perspective, the Good is reduced to the Moral Good. The only thing that can make the life of agent i good consists of the choice of things that are under his control. In the present setting, the only thing that can make agent i better off or worse off is the number of animals that he chooses to raise, no matter what other agents decide. The $N - 1$ other agents may decide to raise a high number of animals. If agent i is a Stoic agent, this will not make his life better or worse. Only his output will be affected, but this should not matter for him because this is beyond his control.

Thus, from a Stoic perspective (II account), all outcomes of the game where agent i chooses the same number of animals e_i are regarded as equally good by agent i . We thus have *indifference* between the following outcomes of the game, represented as vectors of number of animals (e_i, e_j, \dots, e_N) , the first entry being the number of animals chosen by agent $i = 1$:

$$\begin{aligned} & (e^0, e^0, \dots, e^0) I_i (e^0, e^+, \dots, e^+) I_i (e^0, e^*, \dots, e^*) \\ & (e^+, e^0, \dots, e^0) I_i (e^+, e^+, \dots, e^+) I_i (e^+, e^*, \dots, e^*) \\ & (e^*, e^0, \dots, e^0) I_i (e^*, e^+, \dots, e^+) I_i (e^*, e^*, \dots, e^*) \end{aligned}$$

where I_i denotes a strict indifference relation for agent $i = 1$.

This extension of the indifference relation is dictated by the Stoic discipline of desires ("indifference to indifferent things"). This discipline requires the person to become, *ceteris paribus*, indifferent to what other agents do, even if their acts have some effects on the person's material living conditions. The intuition is that others's acts belong to others. A person should thus "make no difference" between outcomes differing only on others's acts.

We will now show that the I1 account of the Stoic discipline of desires implies that choosing the socially optimal number of animals e^* is the *dominant strategy* for each shepherd, and, hence, that (e^*, e^*, \dots, e^*) is the dominant strategy equilibrium of the game under Stoic rationality.

To prove this, let us focus on the choice of animals for agent i , who is, for simplicity of presentation, the first in the list of shepherds ($i = 1$). The choice of the socially optimal number of animals e^* is the dominant strategy for agent i when, for any vector (e^a, e^b, \dots, e^N) of animals chosen by the $N - 1$ other agents, we have:

$$(e^*, e^a, \dots, e^N) P_i (e^+, e^a, \dots, e^N)$$

for any $e^+ \neq e^*$.

The result that choosing e^* is the dominant strategy can be proved as follows.

Note first that the I1 account of the Stoic discipline of desires implies:

$$(e^*, e^a, \dots, e^N) I_i (e^*, e^*, \dots, e^*)$$

that is, agent i is indifferent between all vectors of animals where he chooses the socially optimal number of animals e^* . Remind that the material living conditions of agent i vary with the choice of animals by other shepherds (see above). But the requirement of "indifference to indifferent things" implies that this does not matter for the agent. A Stoic shepherd choosing e^* is equally well-off, no matter what the $N - 1$ other shepherds choose.

Note that, as in any Prisoner Dilemma (PD) game, it is common knowledge that the outcome of the game where all agents cooperate Pareto-dominates the outcome of the game where no one cooperates. From the perspective of agent i , we thus have:

$$(e^*, e^*, \dots, e^*) P_i (e^+, e^+, \dots, e^+)$$

Thus, the outcome where all shepherds choose the socially optimal number of animals is strictly better than any other outcome where all shepherds choose another (common) number of animals. This assumption is weak, and is present in all PD games. Moreover, this does not conflict with the Stoic discipline of desires, because it does not involve the same act for agent i .

Note also that the Stoic discipline of desires implies:

$$(e^+, e^+, \dots, e^+) I_i (e^+, e^a, \dots, e^N)$$

Hence, by transitivity, we can deduce from:

$$\begin{aligned} &(e^*, e^a, \dots, e^N) I_i (e^*, e^*, \dots, e^*) \\ &(e^*, e^*, \dots, e^*) P_i (e^+, e^+, \dots, e^+) \\ &(e^+, e^+, \dots, e^+) I_i (e^+, e^a, \dots, e^N) \end{aligned}$$

that:

$$(e^*, e^a, \dots, e^N) P_i (e^+, e^a, \dots, e^N)$$

for any $e^+ \neq e^*$. Thus choosing the socially optimal number of animals is the dominant strategy for any shepherd i .

Since choosing e^* is the dominant strategy for each shepherd i , the outcome (e^*, e^*, \dots, e^*) is the dominant strategy equilibrium under the I1 account of the Stoic discipline of desires. No Stoic shepherd has any incentive to deviate from the global cooperation outcome. Hence, the I1 account of the Stoic discipline of desires allows agents to escape from the Tragedy of the Commons.

Proposition 2 *Assume that the production process and the cost of animals are common knowledge. Under the I1 account of the Stoic discipline of desires, the outcome where all agents choose the socially optimal number of animals e^* is the dominant strategy equilibrium.*

Proof. See above. ■

The result stated in Proposition 2 is somewhat surprising. At first glance, it is hard to believe that Stoicism leads to overcome the Tragedy of the Commons. However, the extension of indifference required by the I1 account of the Stoic discipline of desires does allow agents to overcome the Tragedy of the Commons.

The intuition behind this result is that Stoicism implies a "recentering" of the agent towards himself: the only thing that makes his life good consists of his own acts, while indifference prevails regarding the acts of the $N - 1$ other agents (*ceteris paribus*). As long as the agent sticks to a given act, the acts of other players do not matter for him. But given that it is common knowledge that the outcome where all agents choose the socially optimal number of animals Pareto-dominates the one where all agents choose any other common number of animals, the extension of the indifference relation induced by the Stoic discipline of desires implies that choosing the socially optimal number of animals is the dominant strategy for the agent. The I1 account of the Stoic discipline of desires has killed out any incentive to deviate from the global cooperation outcome.

This result casts new light on the roots of the Tragedy of the Commons. The cause leading to the Tragedy is not individualism. The origin of the Tragedy of the Commons lies in information processing, and, in particular, in how individuals perceive a deviation from global cooperation. Under standard economic rationality, such a deviation, by leading, *ceteris paribus*, to an extra material payoff for the outlier, is regarded as desirable by the person. Kantian rationality condemns that attitude, because "being the exception" constitutes the definition of social injustice (Kant 1785). Stoicism condemns also that attitude, but on other grounds. Under the Stoic discipline of desires (I1 account), a deviation made by a single agent is, for him, *as bad as* the outcome where everyone defects, because others's acts should not matter for the person *ceteris paribus*. The self occupying the entire space of desires, nothing - neither material payoff gains, nor other persons's behaviors - can justify deviations from cooperation.

The I2 account of the Stoic discipline of desires Let us now examine an economy where all agents satisfy the I2 account of the Stoic discipline of desires, that is, where agents are indifferent between all outcomes of the game that are the best under the prevailing circumstances, in line with the "handles" metaphor or the "bright fire" metaphor (see *supra*).

If one denotes by $e^R(e^a, \dots, e^N)$ the best reply of a shepherd to other shepherds choosing a vector e^a, \dots, e^N of animals, the I2 account of the Stoic discipline of desires requires, for shepherd $i = 1$:

$$(e^R(e^a, \dots, e^N), e^a, \dots, e^N) I_i(e^R(e^{a'}, \dots, e^{N'}), e^{a'}, \dots, e^{N'})$$

for any two vectors of number of animals chosen by other shepherds (e^a, \dots, e^N) and $(e^{a'}, \dots, e^{N'})$. Thus the I2 account of the Stoic discipline of desires requires that shepherd i is indifferent between all his best replies to any combination of numbers of animals chosen by the $N - 1$ other shepherds. The intuition behind this indifference requirement is that, based on the "handles" metaphor and the "bright fire" metaphor, the only thing that matters for a person is *to do the best she can* under the prevailing circumstances (not under her control). It is harmony with circumstances that matters, and not circumstances *per se*.

Note that this indifference relation is due to applying a discipline of desires: indeed, from a purely material perspective, the situation of shepherd i varies strongly with the number of animals chosen by other shepherds, since the other shepherds's acts affect the piece of land available for shepherd i 's animals under the commonly shared piece of land (see *supra*).

This alternative account of the Stoic discipline of desires is more parsimonious than the I1 account, in the sense that it has fewer formal implications than the I1 account regarding the structure of preferences.¹¹ The smaller number of induced indifference relations - in comparison to the I1 account - does not allow us here to deduce the behavior adopted by each shepherd with certainty, unlike under the I1 account, where we could demonstrate that choosing the socially optimal number of animals e^* was the dominant strategy for each shepherd. Under the I2 account, one cannot draw precise conclusions about the behavior of each agent without adding some extra assumptions.

However, the I2 account has nonetheless some key implications concerning the Tragedy of the Commons. If one defines the Nash equilibrium of the game as the outcome of the game $(e^R(\cdot), e^R(\cdot), \dots, e^R(\cdot))$ where all shepherds play the best replies to any other shepherd's act (which are themselves the best reply to other shepherds's choices), we can show that, *under the I2 account of the Stoic discipline of desires, the Nash equilibrium of the game, if it exists, cannot be Pareto-dominated by any other outcome of the game.*

To prove this, let us first show that the Nash equilibrium $(e^R(\cdot), e^R(\cdot), \dots, e^R(\cdot))$ cannot be Pareto-dominated by the outcome (e^*, e^*, \dots, e^*) where all shepherds choose the socially optimal number of animals. The proof goes as follows.

From the perspective of, for instance, shepherd $i = 1$, the outcome where he plays the best reply to other shepherds choosing e^* is weakly better than the outcome where all shepherds choose e^* :

$$(e^R(e^*, \dots, e^*), e^*, \dots, e^*) R_i(e^*, e^*, \dots, e^*)$$

where R_i denotes the weak preference relation for shepherd i .

¹¹The extension of the indifference relation is here less significant, because it is restricted to outcomes that are the best under each set of choices for other shepherds.

By the I2 account of the Stoic discipline of desires, there is indifference with respect to the Nash equilibrium $(e^R(\cdot), e^R(\cdot), \dots, e^R(\cdot))$:

$$(e^R(e^*, \dots, e^*), e^*, \dots, e^*) I_i (e^R(\cdot), e^R(\cdot), \dots, e^R(\cdot))$$

because, in each case, shepherd i chooses the best reply to what other shepherds choose.

Hence, by transitivity, we obtain:

$$(e^R(\cdot), e^R(\cdot), \dots, e^R(\cdot)) R_i (e^*, e^*, \dots, e^*)$$

that is, the Nash equilibrium is weakly preferred, for shepherd i , to the outcome where all shepherds choose the socially optimal number of animals.

Similar preference relations prevail for all shepherds $i \neq 1$, and also if one replaces e^* by any $e^+ \neq e^*$. Moreover, the above rationale can be extended to cases where the $N - 1$ other shepherds do not play symmetrically. As a consequence, it follows that the Nash equilibrium of the game, if it exists, cannot be Pareto-dominated by any other outcome of the game under the I2 account of the Stoic discipline of desires.

Proposition 3 *Assume that the production process and the cost of animals are common knowledge. Under the I2 account of the Stoic discipline of desires, agents do not necessarily choose the socially optimal number of animals e^* . However, the Nash equilibrium of the game, if it exists, cannot be Pareto-dominated by any other outcome of the game.*

Proof. See above. ■

Proposition 3 suggests that the capacity of Stoic agents to overcome the Tragedy of the Commons varies with the particular microeconomic translation of the Stoic discipline of desires. Unlike under the I1 account (Proposition 2), Stoic agents do not necessarily choose cooperation (the socially optimal number of animals e^*) under the I2 account of the Stoic discipline of desires. As a consequence, the equilibrium of the game, if it exists, may involve an overuse of the common resource, unlike under I1, where the dominant-strategy equilibrium was (e^*, \dots, e^*) . Hence, concerning the existence of an overuse of the commons, the I2 account of the Stoic discipline of desires does not necessarily prevent the occurrence of the Tragedy of the Commons, unlike the I1 account.

However, Proposition 3 states that, even if land overuse can arise under the I2 account of the Stoic discipline of desires, this resulting outcome does not, in welfare terms, consist of a "Tragedy" for the agents. Indeed, Proposition 3 suggests that, under the I2 account, the Nash equilibrium of the game cannot be Pareto-dominated by another outcome of the game. The reason is that, from the perspective of the I2 account of the Stoic discipline of desires, the only thing that matters for agents is to make the best of prevailing circumstances. As long as each agent plays his best reply, the resulting outcome is not, for him, worse than any other outcome where he does not play his best reply. Thus, if the Stoic discipline of desires is formalized as the I2 account, the only thing that matters

for agents is to "make the best" of circumstances, so that the coordination problem arising from individual decision-making about a common resource - as well as the (possible) overuse of the commons - is not seen as "tragic" any more.

This result, which is at odds with the one obtained under the I1 account of the Stoic discipline of desires (where the Tragedy of the Commons was *really* overcome under Stoicism), can be understood once one reminds that *harmony to circumstances* is the only thing that matters under the I2 account of the Stoic discipline of desires. As a consequence, from the perspective of the I2 account, whether or not circumstances lead to an overuse of commons is anecdotal as long as the agent plays his best reply to other agents. This explains that the Nash equilibrium - which can be seen as a situation of harmony to circumstances - cannot be Pareto-dominated by another outcome under the I2 account of the Stoic discipline of desires.

In sum, whereas the I1 account of the Stoic discipline of desires makes the Tragedy of the Commons vanish by inducing agents to choose the socially optimal number of animals e^* (and thus avoid the overuse of the commons), the I2 account of the Stoic discipline of desires makes the Tragedy of the Commons vanish by making the (possible) overuse of the commons not "tragic". The implications of adopting Stoicism for the Tragedy of the Commons are thus shown to vary strongly with the precise microeconomic translation of the Stoic discipline of desires ("indifference to indifferent things").

7 Conclusions

The Tragedy of the Commons constitutes a major problem of our times: self-oriented agents tend to overuse commonly owned resources, which leads to a Pareto-dominated social outcome. This problem extends far beyond the case of land use studied in our theoretical framework, but includes also the common use of the Earth's ecosystem as a whole, and of biodiversity.

The literature dedicated to ethical preferences has recently shown that the Tragedy of the Commons is the output of standard economic rationality, but can be overcome by adopting other forms of rationality. The best illustration of this is given by Kantian rationality (Laffont, 1975, Roemer 2010, 2015, 2019): universalizing one's maxim, that is, considering acts in the hypothetical case where these acts would be generalized to the society as a whole, allows to escape from the Tragedy of the Commons. Kantian agents, by focussing only on generalizable acts, internalize the externalities associated to individual acts (see Curry and Roemer 2012). Thus the Tragedy of the Commons is here avoided by a process of "decentering" of economic agents ("universalize your maxim").

The present paper aims at complementing that literature, by showing that the Kantian "decentering" of the agent is not the only possible way out of the Tragedy of the Commons. Quite paradoxically, another way out of the Tragedy of the Commons consists of a "recentering" of the agent towards himself, through the Stoic discipline of desires requiring that the person concentrates her desires on things that are under her control, and wishes for nothing that is not under

her control.

The extent to which Stoicism can overcome the Tragedy of the Commons depends on the precise "translation" of the Stoic discipline of desires into the language of microeconomics. As we showed, if the "indifference to indifferent things" is formalized as an extension of the indifference relation to all outcomes that differ only on circumstances (I1 account), the Stoic discipline of desires makes all agents choose the socially optimal behavior, leading to global cooperation (no overuse of the common resource). However, if the Stoic discipline of desires is formalized as an extension of the indifference relation to all outcomes that are the best under each prevailing circumstances (I2 account), the Stoic discipline of desires does not necessarily prevent the overuse of the common resource, but makes this (possible) overuse not "tragic", since the Nash equilibrium, if it exists, is not Pareto-dominated by any other outcome of the game. Thus a "recentering" of agents towards things under their control either allows them to avoid the Tragedy of the Commons, or makes this not "tragic".

These results cast light on the *historicity* of the Tragedy of the Commons. Under the I1 account of the Stoic discipline of desires, the Tragedy of the Commons would never have occurred. Indeed, the "recentering" agents towards things under their power would make them avoid the overuse of the common resource. Alternatively, under the I2 account of the Stoic discipline of desires, the Tragedy of the Commons could occur, but would not be seen as tragic (since harmony to circumstances is then the only thing that matters). Thus, when the self occupies the entire space of desires, either cooperation emerges as a necessity (since nothing - neither material payoff gains, nor other persons's behaviors - can justify deviations from cooperation), or cooperation does not necessarily occur, but this yields consequences that are not seen as tragic.

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