Climate Change and Pandemics: On the Timing of Interventions to Preserve a Global Common*

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April 2020

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Abstract

We characterize timing choices in investments towards the conservation of a global common and derive implications for interventions to contain the spread of a contagious disease.

1 Introduction

The opportunity cost of irreversible investments under uncertainty includes the forgone value of the option to wait for new information before undertaking the investment (Weisbrod, 1964; McDonald and Siegel, 1986). Policy interventions aimed at preserving global commons typically involve some degree of irreversibility. Since the extent of the depletion of the global common and of the damages this may cause are not well understood ex ante, with new information being learnt as time goes by, delaying action has a

*This note grew out of exchanges between the authors and Herakles Polemarchakis while working on a joint project about dynamically incentive-compatible governance institutions. We are grateful to Richard Baldwin, Daniel Cardona Coll, Andreas Haufler, Marcus Miller and Dennis Novy for comments and suggestions.

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positive option value, which must be weighed against its potential costs – more severe damages from waiting and/or higher costs of future investments towards conservation.

However, when the benefits or costs from an irreversible investment are not fully internalized by individual decision-makers, the timing of decentralized investment choices can diverge from the timing that is collectively optimal: external benefits will lead to overly-cautious decisions (too much learning), while external costs will lead to overly-rushed decisions (too little learning). Thus, lack of cooperation over conservation measures in relation to a global common can result in excessive delay rather than (or in addition to) sub-optimal levels of intervention. Implications for global governance are self-evident. This conclusion follows from a straightforward application of standard solution concepts for non-cooperative games (Nash, 1951) to an option value problem. But while the concept of option value has been invoked in relation to the conservation of natural resources (e.g., Krutilla, 1967), the consequences of non-cooperative decision-making for the timing of investment, to the best of our knowledge, have not been highlighted before.

2 The timing of investment in a two-period commons problem

The investment timing problem we have outlined and the conclusions that follow from its analysis can be most easily illustrated by reference to a two-agent, two-period commons problem.

There are two decision-makers, each having to make an investment that can be carried out either at time $t = 0$ or at time $t = 1$. There are two states of the world, L and H. In state L, the value of investment is zero to both decision-makers. In state H, the private present value, evaluated at $t = 0$, of the investment to the investor is $v/2 \geq 1$ if the investment is carried out at $t = 0$ and is $\delta\rho v/2$ if it is carried out at $t = 1$, with $\delta < 1$ representing a discount factor, and with $\rho \leq 1$ reflecting an attenuation (beyond discounting) in the efficacy of investment if this is delayed. Benefits of the same size from the investment also accrue to the other decision-maker in state H, making the collective value of the investment equal to v and $\delta\rho v$ respectively in each of the two periods. In relation to both climate change and pandemics, the value of the investment would consist of a reduction in future damages that can result from current conservation measures; and the attenuation in the value of delayed investment, as reflected by $\rho \leq 1$, would correspond to the potential increase in the severity of damages from delaying action (higher terminal temperatures, higher prevalence of infections).

At $t = 0$ the two decision-makers hold a common belief, β, about the likelihood of state H occurring. At $t = 1$ the state of the world is fully revealed.

If the investment is carried out at $t = 0$, the cost of the investment (at $t = 0$) is unity; if it is carried out at $t = 1$, the cost (at $t = 1$) is $\gamma < 2$. In the discussion that follows, we assume that $\rho v/2 > \gamma$, which implies that if investment has not occurred at $t = 0$ and the state is revealed to be H at $t = 1$, investing at $t = 1$ is always individually optimal, i.e. there cannot be an outcome where investment never takes place. This assumption also implies $\rho v > 1$ and $v > \gamma$, i.e. if investment has not occurred at $t = 0$ and the state is revealed to be H at $t = 1$, investing at $t = 1$ is jointly optimal; and if $\beta = 1$ (at $t = 0$, investors know with certainty that the state is H), then investing at $t = 0$ is jointly optimal. This means that the only choice that we need to consider, from both a collective and an individual perspective, is whether investment should take place at $t = 0$ or at $t = 1$, rather than whether or not investment should take place at all.

Cooperative choice

Consider first the jointly optimal investment timing choice. The joint expected payoff (the payoff of a representative player) from joint investment at $t = 0$ is $\beta v - 1$, whereas the joint expected payoff, evaluated at $t = 0$, from waiting and investing at $t = 1$ if H is realized (which occurs with probability β) is $\delta\beta\,(\rho v - \gamma)$. Equating these two values, we can solve for a critical level of β above which it will be jointly optimal to act at $t = 0$ and below which it will be jointly optimal to delay:

$$\beta^C = \frac{1}{\delta\gamma + (1 - \delta\rho)v}. \tag{1}$$

This is decreasing in v, i.e. for a given investment cost, it will be optimal to act under a less precise prior the higher is the potential value, v, of the investment.

Decentralized choice

We next consider decentralized choices and derive conditions under which investment at $t = 0$ by both parties is a Nash Equilibrium. Let $a_t^i \in \{0, 1\}$ denote the investment choice by investor i at t. Under the assumption $\rho v/2 > 1$, each investor will always invest at $t = 1$ in state H if she has not invested at $t = 0$, implying $a_1^i = 1 - a_0^i$. Then the expected private payoff (evaluated at $t = 0$) to i from investing at $t = 0$ is

$$\mathrm{E}\Pi^i\left(a_0^i = 1,\, a_0^{-i}\right) = \beta\left(1 + a_0^{-i}\right)v/2 - 1 + \delta\beta\rho\left(1 - a_0^{-i}\right)v/2, \tag{2}$$

(with $-i$ denoting the other investor), and the expected private payoff from postponing the investment to $t = 1$ (while benefiting immediately from any investments made by the other party at $t = 0$) is

$$\mathrm{E}\Pi^i\left(a_0^i = 0,\, a_0^{-i}\right) = \beta\, a_0^{-i} v/2 + \delta\beta\left(\rho(2 - a_0^{-i})v/2 - \gamma\right). \tag{3}$$

Equating these two expressions, we can solve for a critical level of β above which investment at $t = 0$ by both parties is a Nash Equilibrium and below which it is not:

$$\beta^N = \frac{1}{\delta\gamma + (1 - \delta\rho)v/2}. \tag{4}$$

Thus, if $\beta \in (\beta^C, \beta^N)$, taking action at $t = 0$ is jointly optimal but the non-cooperative outcome involves postponement to $t = 1$: action will eventually take place (in the unfavorable realization), but it will happen too late, producing a lower ex-ante net return. Note that this can even occur for $\gamma = 1/\delta$, i.e. when the present value of the gross cost of investing at $t = 0$ is *less* than that of investing at $t = 1$.

Atomistic agents

The previous results have been derived for a game involving a finite number of players. This is the right setting for modelling situations where the decision-makers are institutional players, such as the governments of different sovereign countries. But a problem with the same structure could arise in an environment with a large number of atomistic players whose individual actions have negligible impact on other players – what could be described as a "competitive" environment with externalities. This would be the right setting to use when the investment choices that affect the global common are made by private-sector agents.

To see how the previous conclusions can carry over to such a setting, consider a unit mass of players, and let $a_t(i) \in \{0,1\}$ denote the investment choice of player $i \in [0,1]$, and suppose that the effect of all players' investment choices at t on player i's period-t payoff, gross of the cost of the investment, equals $\left(\omega a_t(i) + (1-\omega)\int_0^t a_t(j)\,dj\right) v$, with $\omega \in (0,1]$. Proceeding as before, we obtain an expression for β^C that coincides with (1), whereas the expression for β^N becomes

$$\beta^N = \frac{1}{\delta\gamma + (1-\delta\rho)\omega v}. \tag{5}$$

In order to bridge the gap between the privately optimal and socially optimal timing of investment, a central planner could in this case resort to a Pigouvian remedy that either taxes investment in the second period and/or subsidizes investment in the first period.

3 Discussion

Managing global commons requires global cooperation, not just about whether action should be taken to preserve them, but also about when it should be taken. Lack of cooperation can result in excessive delay, even when decision-makers share common beliefs. The delay may be a matter of months and years in the case of climate change or a matter of days and weeks in the case of pandemics, but the structure of the problem remains the same.

The events that unfolded in 2020 suggest that, although the costs of contagion within national borders may have eventually been accounted for reasonably well, with most countries introducing similar containment measures, this might all have happened too late in comparison with the timing that might have been deemed to be optimal if transboundary effects had also been accounted for. The consequence might have been an above-optimal global loss of life and above-optimal long-run impacts on the global economy. And although shutting down borders removes one of the components of the transboundary externality, other dimensions remain for which a coordinated effort would be called for – e.g. in relation to the adoption of consistent standards of measurement and testing, which could improve the understanding of the process of contagion and help anticipate and prevent further outbreaks.

Global cooperation requires global institutions. In a commons problem such as the one we have described, if valuations are (at least in part) private, then designing optimal, incentive-compatible global cooperation institutions would be especially challenging. Arguably, this is one of the key obstacles delaying progress in multilateral negotiations on climate; but in relation to epidemic contagion, it is difficult to see how costs and benefits could be fundamentally heterogeneous across different regions of the world. Our analysis, however, has left out any costs and benefits to decision-makers that relate to political motives and incentives. That is perhaps where an explanation for the failure to coordinate the response to the pandemic can be found.

While all efforts to build multilateral institutions for the governance of global climate have so far produced disappointing results, where epidemics are concerned there have been several instances of countries successfully cooperating – one of the first examples being the 1892 International Sanitary Convention for the control of cholera. As is the case for other supranational organizations, however, the WHO lacks the real powers that would be needed to force countries to take action. A concrete and manageable way forward could be for the WHO to start producing regularly updated rating scores for the epidemic risk conditions of individual countries (accounting both for current levels of contagion and for the readiness of countries to anticipate, contain and manage any new epidemics), much as global credit rating agencies do for sovereign debt. Not only could this induce countries to act more swiftly to contain future pandemics, but could also help restore confidence and speed up economic recovery in the post-lockdown phase.

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