

Global public good provision in emergency states: A model of (asymmetric) yardstick competition between rent-seeking governments

Giuseppe Di Liddo^{a,*}, Annalisa Vinella^b

^a University of Bari Aldo Moro, Department of Economics, Management and Business Law, Largo Abbazia Santa Scolastica 53, 70124, Bari, Italy

^b University of Bari Aldo Moro, Department of Economics and Finance, Largo Abbazia Santa Scolastica 53, 70124, Bari, Italy

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ABSTRACT

In a world with two countries, each governed by rent-seeking politicians, there are two strategies to manage an emergency (say, a pandemic) and provide some innovative (global) public good (say, a vaccination campaign) to citizens: (i) invest in adaptation of an existing technology into a suitable good and purchase it, if available, at a low price; (ii) do nothing and import the good, if available, at a higher price. With media insisting on cross-country performance comparisons, political incumbents running for a new mandate are forced into a yardstick competition mechanism through retrospective voters' electoral decisions. One would expect them to follow the same strategy. In fact, an equilibrium with strategy diversification arises when the probability of success and/or the net benefits of the investment are relatively high. This scenario is more likely to occur the more patient incumbents are. On the one hand, the investing incumbent is attracted by the prospect of enjoying important savings on good procurement and withdrawals on national export revenues; on the other, the non-investing incumbent focuses opportunistically on the present, as he foresees little to gain in the future. Our findings offer a partial explanation to why one can observe strategy diversification for management of emergencies (such as, the Covid-19 pandemic) in (otherwise) similar countries.

1. Introduction

In this paper, we investigate how purely rent-seeking governments decide what strategy to follow for managing an *emergency* (or *crisis*) that affects more countries at once, and requires providing some *innovative* (global) public good to citizens. During the Covid-19 pandemic episode, for instance, countries followed a variety of strategies to cope with the emergency and procure novel vaccines¹ [2]. Some countries preferred to stipulate asset purchase agreements and buy the vaccines available on the market, for a total amount of EUR 21 billion; others invested in research activities and supported the expansion of internal vaccine production capacity, for a total amount of EUR 9 billion [3]. Referring to the former as “strategy N” (for do Nothing) and to the latter as “strategy I” (for Invest), in this study we attempt to offer a partial explanation to why (otherwise) similar countries may choose to manage the same emergency in different manners.

In states of emergency, *elections* are seldom suspended, at least as far as democratic countries are concerned. For instance, in spite of the Covid-19 pandemic, in both 2020 and 2021 elections took place in all continents.² Actually, a state of emergency may even offer occasions for politicians to pursue their purposes more effectively. In consideration of this, our perspective is one of political economics. We explore the convenience of adopting strategy N or strategy I for rent-seeking politicians running for re-election in countries in an emergency state.

Although democratic processes unfold normally (or, at worst, with some delay), there is nonetheless one peculiarity that is associated with an emergency state, particularly when countries are interconnected, say, as the EU member states or the US sub-federal states. Voters are prone to compare politicians engaging in electoral contests, taking the public goods and services provided in each country as a benchmark for evaluation purposes. As a result, politicians running for re-election are

* Corresponding author.

E-mail addresses: giuseppe.diliddo@uniba.it (G. Di Liddo), annalisa.vinella@uniba.it (A. Vinella).

¹ On the occasion of the pandemic, the WHO, UN and other international organizations pushed for vaccination to be declared a global public good [1]. That would entail that, although vaccine doses are rival goods *per se*, vaccination should be made a (non-rival and non-excludable) “public good” in each country, hence a “global public good” once warranted in every country. This is the acceptance of global public good referred to in this study. Accordingly, whenever a vaccine is mentioned as an example in the text, that is to be intended, more broadly, as a vaccination campaign.

² The most prominent example is given by the US Presidential election on November 3rd, 2020. In Europe, countries like Slovakia, Croatia, Britain, Poland, Bulgaria, the Netherlands, Germany all had elections during the period 2020–21.

subject to *yardstick competition* (henceforth, YC). In general, mechanisms of this kind are at work with administrators of local jurisdictions, and do not concern state governments. However, emergencies and other policies that have an impact on the international community naturally bring huge media attention onto cross-country comparisons [4]. For instance, the advent of Covid-19 vaccination meant a moment of political competition on social media in which national political leaders made propaganda on the success of their public health campaign, mixing the tools of emphasis and appeal to emotion and true fact checking [5].³ This triggers an (unusual) yardstick effect on state-level political contests as well. In YC mechanisms, relatively good performance in the provision of public services is “rewarded” through a higher probability of the politician being confirmed in office; a relatively bad performance is “penalized” through a lower probability, instead. In this paper, the mechanism is applied to state governments that are supposed to provide a (global) public good resulting from research activities with some probability. For instance, a vaccine requires, first, submitting a previously developed technology to a costly adaptation process, and will only be available for use if there is a successful outcome. Given that governments must also provide other goods and services, one expects them to decide on the specific management of the emergency, depending on how costly research/adaptation activities are, how likely they are to be successful, and how beneficial they are expected to be. We investigate the possibility for political incumbents⁴ of making their choices opportunistically in order to influence the political contests and extract rents.

Setting and results. We construct a theoretical model representing two identical countries over a time horizon of two periods. In addition to naturally featuring the presence of a possible term limit, as is the case in several countries,⁵ this more importantly captures the fact that there are essentially two phases at political sight, *i.e.*, the unfolding and the overcoming of an emergency. In each country, as the emergency unfolds, the government either invests up-front to come up with a suitable good in a later stage (I) or decides to import it, if it becomes available (N). In the first period, a strategy is adopted and new elections take place. In the second period, if the innovative good is discovered, then it is available for cheap to investing countries, at a higher price to non-investing countries. An investing government will also obtain a quota of the revenues deriving from the exports of the good discovered in a national laboratory to a non-investing country. If no discovery has occurred, then the full cost of the emergency is borne everywhere. Each incumbent aims at extracting the highest attainable rent, taking into account the other incumbent's behaviour and the impact on the probability of re-election. As in Kotsogiannis and Schwager [6], voters are uninformed of the exact costs, risks and benefits associated with each of the two options, and do not observe the rent-seeking behaviour of the home incumbent. Hence, they assess his performance on the basis of the supplies of public services in both countries. An incumbent providing poorer services will see his country fare worse in this comparison, and his chances of re-election decrease. For political YC to be effective, it must be the case that the ratio between probabilities of re-election is exactly equal to the ratio between rents; YC is biased otherwise [7].

We first characterize the equilibrium payoffs of the incumbents for given management strategies. When the same strategy is followed in the two countries (be that *N* or *I*) YC leads to a symmetric equilibrium, in which incumbents set the same amount of expenditure, face the same probability of running a new mandate, and extract the same rent. Hence, YC is effective. By contrast, when different strategies are followed in the two countries, an asymmetric equilibrium arises, in which incumbents set different expenditure levels, and face different probabilities of re-election and rents. In particular, the ratio between probabilities differs from the ratio between rents, so that YC is biased, due to the different inter-temporal cash-flow profiles and degrees of riskiness associated with the two strategies.

Among the possible equilibria, we next identify the ones to actually arise under different circumstances, which are determined by three main features: the incumbents' (im)patience, the probability of success, and the net benefits of a successful investment. As long as the size of the investment is relatively small, both incumbents find it convenient to contribute to the adaptation activities in view of later benefits. By contrast, when the required investment is relatively high, both incumbents prefer to bear the full cost of the emergency, if re-elected, without making any up-front disbursement. Governments will also end up in a symmetric equilibrium, whether doing both nothing or investing both, when the investment is of some intermediate size and, in addition, the probability of success and/or the benefits are relatively low. That is a case where what really matters for incumbents is to be in the same situation, regardless of what exactly that situation is. On the opposite, differentiating strategies is the most profitable thing to do when the probability of success and/or the benefits are higher. Actually, under these circumstances, incumbents are able to weaken YC and extract higher rents by choosing, one, to invest up-front in the expectation of later cost saving and gain on exports; the other, to simply import the newly discovered good, which is anyway likely to be available on the international market. Importantly, this case is more likely to arise (*i.e.*, it arises for a wider range of values of the parameters) when governments are more patient and prone to take advantage of a strategic diversification through the two-period time horizon.

1.1. Related literature

The idea of political YC was first formalized by Besley and Case [8]. They designed a political economics model of tax-setting in a multi-jurisdictional world, which has been further investigated in several papers thereafter. Those models all capture the fact that, in each jurisdiction, voters can observe neither the cost of the services they receive nor the rent the administrator is able to extract during his mandate. Thus, to be able to decide whether or not to vote again for the incumbent in the next election, citizens compare their administrator with others, making reference to some observable index of performance like service quality (or quantity). This is based on the common assumption that there exist jurisdictions which are identical or “similar” and can thus be compared. The comparison forces incumbents into a competitive mechanism, in which each incumbent maximizes his own rent taking the others' behaviour into account and considering how it will affect the probability of re-election. As, to gain a new mandate, incumbents will attempt to make the government they lead well placed in the comparison with the other jurisdictions, YC attenuates the consequences of the informational gap between administrators and voters.

In more recent studies, attention has been devoted to the effects that disparities (as opposed to similarities) across jurisdictions may have on political YC. In a theoretical investigation, Allers [9] highlights that when jurisdictions differ in terms of revenue capacity and/or spending needs, administrators of “richer” jurisdictions can provide high-quality services, keeping the local tax burden low. Thus, they are likely to be re-elected, in spite of extracting high rents, and political YC is biased as a result of fiscal disparities.

³ As an example of the media interest in the diffusion of Covid-19 vaccinations across countries, see the following link to The New York Times: <https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html>. The cross-country comparisons therein proposed are emphasized by means of different colours and nuances indicating different degrees of vaccination in the population.

⁴ Throughout the text the words “incumbent” and “government” are used interchangeably to mean the politician currently in office at the lead of the country. The pronoun “he” is used accordingly (together with the adjective/pronoun “his”).

⁵ For instance, in North-America, a term limit is found in the US (two four-year terms for the President); in South-America, it is found in Argentina (two consecutive four-year terms for the President).

Still in a theoretical analysis, Di Liddo and Vinella [7] further consider disparities across jurisdictions that are due to the adoption of different governance forms of infrastructure projects, namely, traditional procurement and public–private partnership. Identifying conditions such that a regime with traditional procurement in one jurisdiction and public–private partnership in the other is likely to arise, the authors conclude that incumbents specialize in rent extraction through project governance differentiation, which hinders YC among otherwise identical jurisdictions. More generally, it emerges that the ways in which public projects are financed and developed may well serve strategic purposes in political contests.

In addition to administrators of local jurisdictions, also central governments are frequently benchmarked against each other, both in terms of the nature of the policy and its efficacy, as a political yardstick. This phenomenon is especially evident in a state of emergency. With regard to the Covid-19 pandemic, Besley and Dray [10] point out that the rapid escalation experienced in Italy likely influenced the approach of other western governments early on in the crisis. After undertaking an initial *laissez-faire* policy, other countries, like Sweden, made up their mind to turn to a late lockdown-style approach. More generally, this phenomenon is widely acknowledged in the vast political science literature regarding retrospective evaluations of government performance by citizens [11]. While evaluating government performance is a complex task, benchmarking theories of accountability argue that cross-national comparisons provide citizens with a useful and readily available heuristic. According to the empirical findings of Kayser and Peress [12], benchmarking across national borders helps voters to form a judgement about how well the government has performed. Further consistent with these findings, recent survey experimental studies have shown that benchmarked information on the economy substantively shifts citizens' support for the government [13]. In particular, as emphasized by Becher et al. [11], the media provide a necessary input for democratic accountability by diffusing benchmarked information that can serve as a heuristic for a broad segment of (unsophisticated) electorate [14,15]. For instance, if citizens learn that, during the Covid-19 pandemic, their country provided better social assistance and health-care services than a comparison country, then they should positively update their beliefs about the performance of their government in that occasion. Their beliefs will then inform their vote.

In this paper, we look at political rent-seeking incumbents choosing between two strategies for coping with an emergency and (possibly) providing a (global) public good to citizens as a part of that. Although the choice between two options facing two opportunistic political incumbents brings this study close to Di Liddo and Vinella [7], here we introduce two novel features. First, we consider two strategies that do not differ only in terms of inter-temporal disbursement profiles. Specifically, unlike in strategy N, in strategy I there is a later cost saving, but only with some probability, and there might also be some gain to extract from export revenues. In particular, we focus on an “innovative” good, which is the outcome of some adaptation process of an existing technology that might result in a failure (thus nullifying the usefulness of the investment) but also deliver an additional return from sales abroad (thus amplifying the usefulness of the investment). This introduces an element of risk, which is absent in previous analysis. Of course, the perspective of being exposed to this risk, together with the benefits it could bring about eventually, plays a critical role at shaping incumbents' decisions.

The second novelty is that, here, players are not local administrators but, rather, national governments (possibly) putting money into the activities of national companies. Although this might seem to be an innocent switch, it is actually important in the interplay between countries. Indeed, unlike a local administrator, a national government has the power to interdict exports, and could take advantage of that to draw from the company some of the return on international sales. This takes place through a negotiation between the government and the company on how to share the revenues from sales abroad, which

we model as a bargaining problem (see Fearon [16], Khalil et al. [17] for a similar approach). In so doing, we nest a cooperative game between government and company onto a non-cooperative game between governments.

1.2. Outline

The remainder of the paper is organized as follows. In Section 2 we describe the model. In Section 3 we characterize the possible non-cooperative equilibria of the game between rent-seeking incumbents, and the cooperative equilibrium of the bargaining game between government and firm in the presence of exports. In Section 4 we identify and discuss the non-cooperative equilibria that can actually be expected to arise. Section 5 offers some concluding remarks. Nontrivial mathematical derivations are relegated to an Appendix.

2. The model

We consider two identical countries, with identical voters and population, whose size is normalized to the unity. For simplicity, we assume that governing politicians can be in office for a maximum of two periods. In period 1, politicians run their first mandate, and some external shock, such as the outbreak of a pandemic, hits both countries. At the end of period 1, an election takes place for a new mandate to be run in period 2, in which management of the crisis may start contrasting the effects of the shock. Overall, the politicians' time horizon spans over full crisis and early recovery.

In country i an expenditure of $E_{it} \in [0, 1)$ is incurred to provide (national) public goods or services in period $t \in \{1, 2\}$. This can be viewed as a measure of the level (or quality) of the goods, with the minimum normalized to zero.⁶ Provision of public goods is funded with tax revenues. With the two countries being identical in any respect, they also have an equal revenue-raising capacity. The available amount of tax revenues is normalized to 1, for simplicity, in each period.

To cope with the emergency, in each country, a global public good v , such as a vaccination campaign against a new pathogen, could be provided in period 2. There is a probability of $p \in (0, 1]$ that a technology previously developed in the country will be adaptable for use to contrast the current emergency, conditional on investing an amount of capital of $K \in (0, 1)$ to fund adaptation and manufacturing activities. This investment cannot be funded by raising additional taxes as, in the short run (*i.e.*, in the early stage of the crisis), the government is pressed with managing the emergency and it is unfeasible to adopt fiscal reforms.⁷ One can think of p as resulting from public and private investments made in past decades,⁸ and of K as the minimum (binding) investment necessary for the concerned industry to run those additional activities. Thus, p and K are exogenous and independent of each other and, in each country, the ex-post probability of developing and commercializing a suitable novel good is equal to p if K is invested, and equal to zero otherwise. Henceforth, for shortness, we shall refer to p as the “probability of success” in an investing country.

⁶ A level (or quality) of services equal to zero indicates that only basic services are provided [18]; a strictly positive level indicates that more sophisticated services are provided.

⁷ For instance, in the first two phases of the Covid-19 pandemic (*i.e.*, acute overall disruption and early recovery — here respectively represented as period 1 and 2), governments all focused on such emergency policies as lump-sum subsidies and incentive measures, essentially [19]. It is only in the aftermath of the crisis that tax reforms and debt restructuring policies are being undertaken, as a remedy to public finances having weakened significantly to cope with the emergency needs [20].

⁸ Regarding the Covid-19 disease, this is the case of the m-RNA technology used to develop a vaccine against the virus causing it: its development began in 1963 with the discovery of the m-RNA [21].

Strategies. There are two alternatives available to each country. First, invest nothing in period 1 and, in period 2, either sustain the cost of the pandemic $C_N \in [0, 1]$ or purchase good v , if available, in the international market (strategy N). Second, invest K in period 1 and, in period 2, either purchase good v (if available) or sustain the cost C_N if not (strategy I). Thus, although investing entails that there is less to spend for provision of other public goods and services in period 1, that choice may nonetheless afford the government more slack in period 2, if the outcome is successful ultimately. The involved industry is a pool of as many national laboratories as investing countries. For instance, in the Covid-19 pandemic context, the multinational company *Moderna* cooperated with both the US *National Institute of Allergy and Infectious Diseases (NIAID)* and the Swiss biotechnology company *Lonza* for the supply of a new vaccine. A government putting money into the activity of the industry purchases good v at a price of $C_I \in [0, C_N]$, thus being granted a saving on the cost of the pandemic as a reward on that contribution. This entails that there are spillovers in cost savings if both countries invest. Spillovers are absent, instead, if one country does not invest. Indeed, a non-investing government purchases good v with no saving at the (higher) price of C_N ,⁹ provided that the investing government does not ban its exports.

Governments and national companies. A rent-seeking government may threaten the manufacturing company to ban exports of goods with a high technological content, unless he is granted a return on international sales.¹⁰ Regardless of whether this takes the form of export duties, licensing requirement fees, or bribes, the company is obviously prone to negotiate with the government and concede a share $\alpha \in (0, 1)$ of the revenues C_N in exchange for the export permission. On the other hand, it is plausible that a government is willing to negotiate on duties/fees, provided big high-tech manufacturers operating internationally are especially valuable for tax authorities [22]; but also, possibly, on bribes, depending on his degree of corruptibility [16]. Accordingly, we take α to be the outcome of cooperative bargaining between the company and the government.

Governments and voters. Each incumbent acts as a pure rent-seeker. In period 1 he attempts to maximize the expected rent he can obtain over the two-period time horizon. This requires taking into account that a second mandate, to be run in period 2, will be obtained only with some probability, which will depend on the voters' appreciation. To represent the voters' behaviour, we do not model preferences through a utility function, and only take preferences to be homogeneous between countries. In line with the literature on political YC [7,18], we assume that voters take a purely *retrospective* behaviour. In each country, they decide whether or not to vote again for the incumbent, being based on the outputs of the government decisions made in the two countries, which they can observe and compare.¹¹ Essentially, these outcomes are the levels of the public goods and services provided in period 1, as measured by E_{i1} and E_{j1} . Indeed, in period 1, voters are informed of

how the government has reacted to the emergency (I or N strategy) but they need to wait until after they will have observed outcomes to be able to form an assessment of the governments' performance (total costs of the crisis management). Hence, the particular choice of one or the other strategy is irrelevant to them.¹² Thus, in definitive, the probability of re-election depends only on E_{i1} and E_{j1} for either incumbent.

Probability of re-election. To represent the probability of re-election, we follow the *contest success function* (CSF) approach, in line with a number of existing studies on political YC and related topics [7,25–31]. This reduced-form, simple contest approach is convenient in that it permits to capture the basic relationship between voters' behaviour and rent-seekers' policy choices, yet, abstracting from the specific institutional setting and agents' preferences [32]. Adhering to this approach, we can thus represent the political contest without making any specific assumptions on national preferences, as we said. Formally, the CSF is given by

$$\rho_i(E_{i1}, E_{j1}) = \frac{E_{i1}}{E_{i1} + E_{j1}}, \quad \forall i \neq j \quad (1)$$

and has the two following properties. First, it is increasing and concave in the expenditure for services made in the own country, whereas it is decreasing in the expenditure made in the rival country. Second, the probability boils down to 1/2 when the incumbents behave exactly in the same manner in the two countries ($E_{i1} = E_{j1}$). Thus, under the yardstick mechanism, the incumbent who provides better services, which signal more effort, gains consensus; the other loses it.¹³ It is noteworthy that the level of services chosen in the first period does not represent a commitment as to how the incumbent would behave in period 2, if confirmed in office. One may thus wonder why voters would be based on previous expenditure choices when deciding whether or not to confirm the incumbent at the end of period 1. In fact, this is consistent with the real-world evidence, well-documented in a number of Political Science studies that retrospective voters tend to display a *myopic* attitude [34–38]. They make their electoral decisions being based on the observation of past behaviours, even if those behaviours are poorly indicative of future performances, simply because they find it difficult to form reliable forecasts about what a political challenger would do. Thus, rather than looking over the full duration of a government office, they prefer to stick to what they experienced prior to casting their ballot.¹⁴

Timing of the game. To summarize, in each country i , the game unfolds as follows. At the beginning of period 1, the government chooses whether or not to make an investment of K and sets a level of expenditure of E_{i1} . At the end of period 1, voters cast a vote in the poll and the

⁹ To be rigorous, purchase of the good is preferred by a non-investing government if it costs $C_N - \epsilon$, for some small $\epsilon > 0$, i.e. slightly less than the worst outside option. We avoid non-insightful complications and take $\epsilon = 0$ so that purchasing at C_N is weakly preferred to doing nothing.

¹⁰ For instance, during the Covid-19 pandemic, after initially supplying vaccines to a number of countries as the pharmaceutical powerhouse of the world, India banned exports of vaccines in spring 2021, imposing prioritization of domestic sales. Immediately thereafter, restrictions on exports of vaccines and critical raw materials needed for its production also appeared in the US and the EU. Of course, the official motivation for restricting exports was domestic supply shortage. However, the decision might not have been free from opportunistic considerations, such as the search of internal consensus by "placing the country first" and/or the prospect of extracting benefits from industry stakeholders.

¹¹ See Berry and Howell [23] for further insights on retrospective voting theory and related empirical analyses.

¹² This behaviour mirrors the argument, put forward by Allers [9], that YC is a simple tool used by unsophisticated voters, who typically do not have enough economic expertise to judge over such complex issues as the choice of complex healthcare policies. If voters were able to assess alternatives, then, plausibly, they would also be able to read budgets, estimate cost curves, and deduce rents. YC itself would become useless in that case. See also Cunha Marques and Berg [24] for similar arguments.

¹³ Neglecting term subscripts, a more general formulation of the CSF would be $\rho_i(E_i, E_j) = f_i(E_i) / (f_i(E_i) + f_j(E_j))$, where $f_i(\cdot)$ and $f_j(\cdot)$ are non-negative strictly increasing functions, and $s > 0$ is a constant term [33]. The advantage of working with the specification in (1) is that it ensures that the total amount of available rents over the two countries, does not depend on the effort exerted by the incumbent politicians, and remains fixed in all scenarios to be considered, so that the comparison between symmetric and asymmetric cases is more significant.

¹⁴ There is evidence that this attitude is typical, in particular, of US voters, who tend to view elections as a referendum on the past performance of a (possibly term-limited) officeholder. As the political scientist V.O. Key Jr. points out in his by now classic book "The Responsible Electorate", judging the performance of an incumbent in office represents a perfect opportunity for voters to claim responsibilities or reward merits.

Table 1
Summary of assumptions on strategy N and strategy I.

	Strategy N		Strategy I	
	Tax revenues	1	1	1
Period 1	Investment	0	K	
	Probability of success	0	$p > 0$	
Period 2	Strategy N		Strategy I	
			Other country: I	Other country: N
	Tax revenues	1	1	1
	Expected export revenues	-	0	$p\alpha C_N$
	Expected cost	C_N	$pC_I + (1-p)(pC_I + (1-p)C_N)$	$pC_I + (1-p)C_N$

incumbent is re-elected with a probability of ρ_i . Conditional on being confirmed in power, at the beginning of period 2, the government sets a level of expenditure of E_{i2} . Good v is discovered or it is not. In the former case, if an investment was made up-front, then the government sustains a procurement cost of C_I , and obtains a share of revenues of αC_N from exports (if any); if no investment was made up-front, then the government sustains a procurement cost of C_N . In the latter case, the cost of the pandemic C_N is sustained in each country. For clarity, assumptions on strategy N and strategy I (particularly, the deriving costs and revenues) are summarized in Table 1.

3. Characterization of the equilibria

Turning now to characterize the non-cooperative equilibria of the game between incumbents, we first consider the NN and II (symmetric) cases where both countries, respectively, do nothing or invest K . We next complete this part of the analysis with the description of the NI (mixed) case where countries adopt different strategies. We will conclude that YC is effective in those cases where the ratio between probabilities of re-election equals the ratio between expected rents, and that it is biased otherwise.

Before turning to the analysis, it is noteworthy that, as in Di Liddo and Vinella [7], because for any incumbent i the expected rent decreases with E_{i2} and the incumbent has no electoral concerns in period 2, it is easily anticipated that there will be no point in setting E_{i2} above the minimum at the beginning of period 2. Hence, the level of expenditure in the second period is zero in all scenarios and can be neglected in the analysis. With this, we can save on notation and drop the time subscript from the levels of expenditure so that, henceforth, E_i will denote the level of expenditure in period 1.

3.1. The NN and II (symmetric) cases

Suppose that strategy N is followed in both countries. The expected value of the rent of the incumbent in country i is given by

$$R_i(E_i, E_j) = 1 - E_i + \beta \frac{E_i}{E_i + E_j} (1 - C_N), \quad (2)$$

where $\beta \in (0, 1)$ is the discount factor. In period 1 the rent is given by the tax revenues (normalized to the unity) net of the expenditure in public services. In period 2 the rent (to be obtained only in case of re-election) includes the tax revenues net of the cost of the pandemic. The government in office in country i chooses the level of expenditure $E_i \in [0, 1]$ in such a way as to attain the highest expected rent.¹⁵ Obviously, if voters are myopic, then incumbents are motivated to care about their opinion only before running for a re-election, and are prone to shirk as any electoral concerns disappear. Particularly, incumbents are insensitive to neighbours' behaviour in their last term of office as,

¹⁵ The budget surplus can also be used to favour special interest groups (say, in the form of campaign contributions) in the hope of acquiring political support. Our model could easily be extended to allow for this kind of rent conversion (laundering). Thereby, the applicability of our analysis is wider than the formal representation seems to suggest.

with re-election being interdicted, interactions (hence, comparisons) with governments in other countries are reduced or vanish [18].

As countries are homogeneous in any respect, the equilibrium is found to be symmetric. Dropping subscripts, for simplicity, the equilibrium value of expenditure and the probability of re-election are, respectively, $E^{NN} = \beta \frac{1-C_N}{4}$ and $\rho^{NN} = \frac{1}{2}$. Accordingly, the expected rent is found to be

$$R^{NN} = 1 + \beta \frac{1 - C_N}{4}. \quad (3)$$

¹⁶ Unsurprisingly, YC is effective in the absence of disparities, with public services, probability of re-election, and expected rents being the same for the two incumbents (compare Di Liddo and Vinella [7]).

When strategy I is followed in both countries, there are two essential changes: in period 1, the rent is diminished by the investment K ; in period 2, the relevant (expected) cost is $C = pC_I + (1-p)(pC_I + (1-p)C_N)$ instead of C_N . Accordingly, the equilibrium value of expenditure and the probability of re-election are now, respectively, $E^{II} = \beta \frac{1-C}{4}$ and $\rho^{II} = \rho^{NN} = \frac{1}{2}$, and the expected rent is found to be

$$R^{II} = 1 - K + \beta \frac{1 - C}{4}. \quad (4)$$

Obviously, YC is still effective, and an increase in C_I and/or in C_N results in lower service levels and rents. More interestingly, because $\frac{\partial C}{\partial p} < 0$, not only the level of services but also the expected rent increase with the probability of success of the investment. That is, a raise in p benefits both citizens and incumbents.

3.2. The NI (mixed) case

Suppose that one government follows strategy N and the other strategy I. To avoid confusion, we will append the subscript N to indicate the former and the subscript I to indicate the latter, instead of the subscripts i and j previously used.

In country N the expected rent is as presented in (2), where here $i = N$ and $j = I$. Turning next to consider country I, for shortness, it is useful to denote $\bar{C} = pC_I + (1-p)C_N$ the expected cost in period 2, and $\Pi = p\alpha C_N$ the additional rent extracted by the (investing) government from the national company as a share of its export revenues. With this, the expected rent of incumbent I is formulated as follows:

$$R_I = 1 - K - E_I + \beta \frac{E_I}{E_I + E_N} (1 + \Pi - \bar{C}). \quad (5)$$

Comparing (5) with (2), it emerges that there is an important novel aspect to the asymmetric (NI) case relative to the symmetric (NN and

¹⁶ To be precise, the equilibrium value E^{NN} reported in the text is one of those that solve the best response function of incumbent i , namely, $E_i(E_j) = [\beta E_j (1 - C_N)]^{\frac{1}{2}} - E_j, \forall i, j \in \{N, I\}$, as deriving from maximization of (2) with respect to E_i . For completeness, it is worth mentioning that, as usual in this kind of problems, the set of equilibrium solutions includes also a corner solution such that both incumbents make no expenditure to provide public services ($E^{NN} = 0$) and take all that is available in the first period ($R^{NN} = 1$). However, in all considered cases, we neglect corner solutions in order to keep the analysis well focused on the sole interesting equilibria.

II) cases. Beside the investment K and the expected cost $\bar{C}$, which are reminiscent of Di Liddo and Vinella [7], here the expected return from exports Π represents an additional source of disparities in the profiles of revenues and costs of the two countries. In particular, Π depends on p and α , which will appear to be critical in terms of effectiveness of political YC.

Maximization of (2), taken for $i = N$ and $j = I$, with respect to E_N , as well as of (5) with respect to E_I ,¹⁷ permits to derive the levels of expenditure, hence the probabilities of re-election and the expected rents in the NI equilibrium. Values are now different for the two incumbents and given by:

$$E_N = \beta \frac{(1 + \Pi - \bar{C})(1 - C_N)^2}{(2 + \Pi - \bar{C} - C_N)^2} \quad (6a)$$

$$E_I = \beta \frac{(1 + \Pi - \bar{C})(1 - C_N)}{(2 + \Pi - \bar{C} - C_N)^2} \quad (6b)$$

and

$$\rho_N = \frac{1 - C_N}{2 + \Pi - \bar{C} - C_N} \quad (7a)$$

$$\rho_I = \frac{1 + \Pi - \bar{C}}{2 + \Pi - \bar{C} - C_N} \quad (7b)$$

and

$$R_N = 1 + \beta \frac{(1 - C_N)^3}{(2 + \Pi - \bar{C} - C_N)^2} \quad (8a)$$

$$R_I = 1 - K + \beta \frac{(1 + \Pi - \bar{C})^3}{(2 + \Pi - \bar{C} - C_N)^2}. \quad (8b)$$

As is evident from (7a) to (8b), the ratio between probabilities differs from the ratio between rents, so that political YC is biased when governments follow different strategies. One can verify, in particular, that p and α have both opposite effects on the expected rents:

$$\frac{\partial R_N}{\partial p} = -2\beta \frac{((1 + \alpha)C_N - C_I)(1 - C_N)^3}{(2 + \Pi - \bar{C} - C_N)^3} < 0 \quad (9a)$$

$$\frac{\partial R_I}{\partial p} = \beta \frac{((1 + \alpha)C_N - C_I)(4 + \Pi - \bar{C} - 3C_N)(1 + \Pi - \bar{C})^2}{(2 + \Pi - \bar{C} - C_N)^3} > 0 \quad (9b)$$

and

$$\frac{\partial R_N}{\partial \alpha} = -2\beta \frac{pC_N(1 - C_N)^3}{(2 + \Pi - \bar{C} - C_N)^3} < 0 \quad (10a)$$

$$\frac{\partial R_I}{\partial \alpha} = \beta \frac{pC_N(4 + \Pi - \bar{C} - 3C_N)(1 + \Pi - \bar{C})^2}{(2 + \Pi - \bar{C} - C_N)^3} > 0. \quad (10b)$$

Having established that the NI equilibrium values vary with the share α , it is useful to briefly mention how α could be determined in a negotiation between government and company. The export permission negotiation could be viewed as a Kalai-Smorodinsky bargaining problem [39] where α is the solution, based on the consideration that the Kalai-Smorodinsky Solution (KSS) is known to perform especially well when the focus is on single players (rather than groups). As shown in Appendix A, here the KSS is $\alpha = \frac{1}{2}$.¹⁸ Accordingly, we now turn to complete the analysis taking government I and the company to share equally the revenues from exports of good v .

¹⁷ The best response function of incumbent I is $E_I(E_N) = [\beta E_N(1 + \Pi - \bar{C})]^{\frac{1}{2}} - E_N$.

¹⁸ Technically speaking, in a negotiation between single players, the KSS performs better than any solution satisfying weak Pareto-optimality and anonymity; the Nash Bargaining Solution [40] is preferable as far as groups are concerned, instead [41]. However, if one were to consider the government and the company as groups of agents in our model, then the Nash Bargaining

4. What are the relevant equilibria?

Our ultimate goal is to identify a rationale for political incumbents, governing otherwise identical countries, to follow different strategies in the domestic management of a worldwide emergency. To that end, we need to establish what equilibria are actually relevant, among those previously characterized. This requires comparing the payoffs of the non-cooperative game (the expected rents), which vary depending on the parameters of the model, to identify conditions such that each of the equilibria could arise.

We report the rents in the payoff matrix of the game represented in Table 2. To make the comparisons between those rents more immediate, yet, without loss of generality, we set $C_I = 0$,¹⁹ in which case C_N can also be interpreted as the cost saving to an investing government – if good v is available – relative to a non-investing government. By comparing (8b) with (3), one finds that $R_I > R^{NN}$ if and only if

$$K < K_1 \equiv \beta \left(\frac{(1 - C_N + \frac{3}{2}pC_N)^3}{(2(1 - C_N) + \frac{3}{2}pC_N)^2} - \frac{1 - C_N}{4} \right). \quad (11)$$

Moreover, by comparing (8a) with (4), one further finds that $R_N > R^{II}$ if and only if

$$K > K_2 \equiv \beta \left(\frac{1 - (1 - p)^2 C_N}{4} - \frac{(1 - C_N)^3}{(2(1 - C_N) + \frac{3}{2}pC_N)^2} \right). \quad (12)$$

There are, thus, two (positive) thresholds of the investment, K_1 and K_2 ,²⁰ which depend on p , β , and C_N , and are such that the equilibrium of the game changes according to how great K is relative to them. Referring to the distance between K_1 and K_2 , we can establish that

$$\Delta K \equiv K_1 - K_2 = \beta \frac{pC_N(3p^2C_N + 8pC_N + 4p + 2C_N - 2)}{12pC_N + 16(1 - C_N)} \geq 0$$

$$\Leftrightarrow C_N \geq C^* \equiv \frac{2 - 4p}{2 + 8p + 3p^2}, \quad (13)$$

which clarifies that K_1 can lie either above or below K_2 , and neglecting cases where K exactly coincides with any of the thresholds, one identifies four possible situations:

1. $K > \max\{K_1, K_2\}$: none of the governments takes any initiative, and the equilibrium of the game is NN;
2. $K < \min\{K_1, K_2\}$: governments both contribute to the adaptation and manufacturing activities, and the equilibrium of the game is II;
3. $K_1 < K < K_2$ (for $C_N < C^*$): governments follow the same strategy, both strategies are sustainable, and the equilibrium of the game is either NN or II;
4. $K_2 < K < K_1$ (for $C_N > C^*$): governments follow different strategies, and the equilibrium of the game is NI.

Naturally, the NN equilibrium and the II equilibrium arise, respectively, when the required investment is relatively high (situation 1.) and when it is relatively low (situation 2.). This result is very intuitive: when investing is onerous, none of the incumbents affords it; when it is cheap, both of them do so. As long as the cost of the emergency is not too high ($C_N < C^*$), one of the NN and II equilibria (situation 3.) arises for values of K in between the previous ones ($K_1 < K < K_2$).

Solution, namely, the value of α maximizing the Nash product $\alpha(1 - \alpha)$, would yield the same outcome. For an extensive presentation of the literature on cooperative bargaining, see Peters [42], Muthoo [43].

¹⁹ Remark that, with this assumption, the expected cost of good v to an investing country remains strictly positive and smaller than C_N .

²⁰ The proofs that K_1 and K_2 are positive are respectively found in Appendices B.1 and B.2.

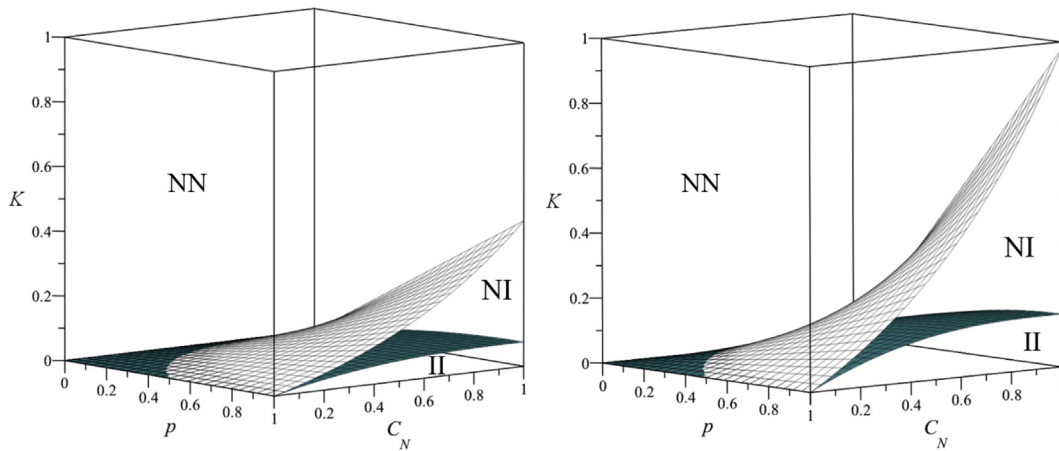


Fig. 1. NN, II and NI equilibria when $\beta = 0.3$ (left) and $\beta = 0.65$ (right).

Table 2
Payoff matrix.

		Incumbent j	
		N	I
Incumbent i	N	(R^{NN}, R^{NN})	(R_N, R_I)
	I	(R_I, R_N)	(R^{II}, R^{II})

Here, one possibility is that each of the governments believes that it is worthless to contribute to the adaptation and manufacturing endeavour, and will simply pay the full cost of the emergency, which is not prohibitively high. An alternative possibility is that both incumbents decide to contribute anyway. They bet on the discovery of a suitable innovative good in at least one of the countries, yet, with the idea that, should no discovery occur eventually, the missing benefit will not be especially high. In substance, given that the investment would be significant (though not huge) but little likely to yield a successful outcome, and that the outcome would be modest anyway, governments have an interest in either taking both part in a “club of investors” or abstaining both from any up-front initiative. In all these situations, with incumbents ending up in a symmetric equilibrium, the yardstick mechanism works, as in the classical literature on political YC *à la* [8].

The more interesting “mixed” case (situation 4.) arises when the investment takes “intermediate” values ($K_2 < K < K_1$), but C_N is sufficiently high ($C_N > C^*$) instead. In this case, incumbents take advantage of a strategy diversification, thus hindering YC, as in the more recent literature on political YC *à la* [9]. Noticing that C^* decreases with p , and $C^* < 0$ if $p > \frac{1}{2}$, one can conclude that NI equilibria are likely to arise for relatively high values of C_N and/or p . That is, in addition to the cost of the emergency, also the probability of success matters. Moreover, provided $\frac{\partial \Delta K}{\partial \beta} \geq 0$, the parameter β appears to have a scaling effect, which enlarges the set of “intermediate” values of K such that situation 4. is the relevant one. In other words, NI equilibria are more likely to arise the more patient incumbents are.

These results can be visualized graphically in Fig. 1, in which the two thresholds K_1 (the bright surface) and K_2 (the dark surface) are depicted for $\beta = 0.3$ (the graph to the left) and $\beta = 0.65$ (the graph to the right) to represent, respectively, impatient and patient incumbents. In the graphs, the regions of values of the parameters such that NN equilibria (situation 1.) and II equilibria (situation 2.) are sustainable, are those respectively placed *above* and *below* the two surfaces, with

the former region narrowing and the latter widening as β increases. NI equilibria are identified in the region lying *between* the two surfaces for sufficiently high values of p and/or C_N ; that region is wider for higher β .²¹

Whereas occurrence of symmetric equilibria is unsurprising, occurrence of NI equilibria looks little obvious and requires delving into it for interpretation. Let us first consider the impact of p and C_N . Government I is motivated to put money on the table up-front, although the other government is not contributing instead, because he can count on a sufficiently high probability of both developing the good in the national laboratory, hence enjoying a significant cost saving, and extracting an additional rent out of export revenues in the second period. One might wonder why government N does not invest in turn, in spite of p and/or C_N being relatively high. Precisely because the probability of success is high, it is likely that good v will be available through the sole contribution of government I. Thus, if also government N were to invest and a suitable good were discovered in a national laboratory, then that good would not be exported to country I, so that there is little hope for government N to gain on sales abroad. The impossibility of extracting an additional rent out of export revenues makes the investment less promising, in spite of the potential for a non-negligible saving. Therefore, the best way for incumbent N of raising his own rent is to avoid sustaining the investment cost up-front and grasp as much as possible before elections take place.

Let us next clarify how the scaling effect of β works. We said that NI equilibria arise because, by considering the overall time horizon, one incumbent (incumbent I) points to gaining in the future, the other (incumbent N) in the present. The choice of some incumbent to play strategy N in a mixed equilibrium does not stand as an expression of his specific degree of patience, as players are both – and equally – (im)patient. The decision to follow strategy N is that of an incumbent who focuses deliberately on the present, as he foresees little to gain in the future, given the decision of the other incumbent to invest instead. Thus, naturally, strategy N will be played more often, the more likely the other incumbent is to invest, which is precisely the case where more weight is attached to the future. This explains why the set of values of p and C_N such that a mixed equilibrium is sustainable is wider the more patient incumbents are.

²¹ The region with both NN and II equilibria (situation 3.), which is between the two surfaces for low values of p and C_N , is very thin and hardly visible, hence unlabelled.

5. Concluding remarks

In a multi-jurisdictional world, citizens have the possibility of comparing the public goods/services delivered in their own jurisdiction with those delivered in the others. These cross-jurisdictional comparisons can affect citizens' support for politicians in office and, as a consequence, governments' decisions, which thus interact (political YC). So far this interaction has been studied mainly in the context of federalism and decentralization, hence with reference to local jurisdictions, with the concerned policy variables being of a fiscal nature essentially (revenues and expenditures). In that – relatively simple – setting, it was established that the mechanism may be biased when jurisdictions display fiscal disparities that voters do not perceive correctly [9], and when different governance modes are adopted for the development of public projects [7].

In a broader context, in which national governments are involved, political YC is at work, particularly, during international emergencies [5]. In this study, we showed that the effectiveness of political YC may also be hindered when pure rent-seeking national governments adopt different solutions to react to an emergency that could be managed by providing some innovative (global) public good, such as a novel vaccine during a pandemic. We highlighted that the possible convenience of not doing the same thing rests on the circumstance that different solutions display, first, different inter-temporal profiles of both disbursements (invest or not up-front, purchase the good – if any – at a lower or higher price later on) and revenues (generated by the exports of the good, if any); second, different degrees of uncertainty (come up or not with a suitable innovative good). Unusual in models of political YC, strategy diversification translates into asymmetric re-election probabilities and (possibly higher) rents for opportunistic governments.

We found, specifically, that an equilibrium with differentiated strategies arises for intermediate levels of investment, provided that the probability of success and/or the benefits of a successful investment are sufficiently high. Furthermore, the range of levels of investment such that a mixed equilibrium is sustainable is wider when governments are more patient.

These findings suggest that when an equilibrium with strategy diversification is observed, one should expect an investing country to be one in which public finances are governed in a sufficiently virtuous manner so that it is possible to put some money on the table for funding adaptation and manufacturing activities without drawing on additional taxation; alternatively, there already exists a sufficiently deep background in research and know-how, representing the necessary foundation for a potentially useful discovery. Countries with these features are typically those in which an attentive budget management and sound research policies (including massive investments, when necessary) have been promoted systematically over time. However, when that same equilibrium is observed, there will also be a country in which, while conditions are equally favourable, a different strategy – with no investment being made – will be played for opportunistic purposes. This all points to the conclusion that, overall, being able (and willing) to fund a proper pattern of national investments in research may afford more and better strategies to (sufficiently patient) governments in hard times. Whether or not that background will be fruitfully activated will depend on how benevolent governing politicians are, especially when electoral concerns matter.

CRedit authorship contribution statement

Giuseppe Di Liddo: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization.
Annalisa Vinella: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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Appendix A. The Kalai–Smorodinsky solution

Let L denote the company and, as in the text, I the government of an investing country. In a negotiation between the two, the KSS is a combination of their respective revenue shares α and $1 - \alpha$ belonging to the Pareto frontier, which satisfies the following necessary condition:

$$\frac{\mu_I - d_I}{\mu_L - d_L} = \frac{U_I - d_I}{U_L - d_L}. \quad (14)$$

In (14), μ_z denotes the agreement utility, d_z the disagreement payoff, and U_z the Utopian payoff, where $z \in \{I, L\}$. The Utopian payoff is the maximum utility each party can attain, given that the other party receives at least its disagreement payoff [44]. As the “Utopia point” usually lies outside the set of feasible bargaining solutions, the parties may not simultaneously attain their maximum possible utilities. Disagreement payoffs are here both equal to zero, provided there are no exports (hence, no revenues to share) if no agreement is reached. Therefore, the Utopia point is such that $U_I = U_L = pC_N$, and the agreement payoffs are given by $\mu_I = \alpha pC_N$ and $\mu_L = (1 - \alpha)pC_N$. Replacing these values in (14), the bargaining solution is found to be such that $\alpha/(1 - \alpha) = 1$, from which $\alpha = 1/2$.

Appendix B. Proof of $K_1 > 0$ and $K_2 > 0$

B.1. Proof of $K_1 > 0$

Rewrite K_1 as

$$K_1 = \beta \left[\frac{3}{2} pC_N \frac{\left(1 - C_N + \frac{3}{2} pC_N\right)^2}{\left(2(1 - C_N) + \frac{3}{2} pC_N\right)^2} + (1 - C_N) \left(\frac{\left(1 - C_N + \frac{3}{2} pC_N\right)^2}{\left(2(1 - C_N) + \frac{3}{2} pC_N\right)^2} - \frac{1}{4} \right) \right].$$

The first term in the brackets is clearly positive. Hence, it suffices to show that so is the second term as well. We see that

$$\begin{aligned} & \frac{\left(1 - C_N + \frac{3}{2} pC_N\right)^2}{\left(2(1 - C_N) + \frac{3}{2} pC_N\right)^2} > \frac{1}{4} \\ \Leftrightarrow & (2(1 - C_N) + 3pC_N)^2 > \left(2(1 - C_N) + \frac{3}{2} pC_N\right)^2, \end{aligned}$$

which is true. Thus, overall, $K_1 > 0$.

B.2. Proof of $K_2 > 0$

We develop the expression in brackets in K_2 as follows:

$$\begin{aligned} & \frac{1 - (1-p)^2 C_N}{4} - \frac{(1-C_N)^3}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} \\ &= \frac{1 - (1+p^2-2p)C_N}{4} - \frac{(1-C_N)(1-C_N)^2}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} \\ &= \frac{1 - C_N - (p-2)pC_N}{4} - \frac{(1-C_N)(1-C_N)^2}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} \\ &= \frac{1 - C_N}{4} - \frac{(1-C_N)(1-C_N)^2}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} + \frac{2-p}{4}pC_N \\ &= (1-C_N) \left(\frac{1}{4} - \frac{(1-C_N)^2}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} \right) + \frac{2-p}{4}pC_N. \end{aligned}$$

To show that $K_2 > 0$ it suffices to show that $\frac{1}{4} - \frac{(1-C_N)^2}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} > 0$.

To that end, we rewrite

$$\begin{aligned} & \frac{1}{4} - \frac{(1-C_N)^2}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} \\ &= \frac{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2 - 4(1-C_N)^2}{4\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} \\ &= \frac{4(1-C_N)^2 + \frac{9}{4}p^2C_N^2 + 6pC_N(1-C_N) - 4(1-C_N)^2}{4\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2} \\ &= \frac{3}{4}pC_N \frac{2(1-C_N) + \frac{3}{2}pC_N}{\left(2(1-C_N) + \frac{3}{2}pC_N\right)^2}. \end{aligned}$$

This is clearly positive in the range of values of p and C_N . Hence, $K_2 > 0$.

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Giuseppe Di Liddo is Associate Professor of Public Finance and Public Economics at the University of Bari. During his Ph.D. in Public Economics and before starting the academic career he has been external consultant of the Italian Ministry of Economy and Finance - Department of Finance on issues related to local public finance and fiscal decentralization, and external consultant of the Italian Ministry of Economic Development on issues related to the monitoring and duration estimation of local public investments. In 2015 he has been awarded with the SIEP prize, intended for an outstanding unpublished paper, written by author(s) under the age of thirty-five, presented at the annual conference of the Italian Society of Public Economics (SIEP). His main research fields are fiscal decentralization, local taxation, and local economy, and market regulation, especially regarding the Energy and Health services sector.

Annalisa Vinella graduated in Economics and trade at the University of Bari, from which she also received her first Ph.D. in Economics, after a visiting experience at the University of York. She further obtained the Diploma in Microeconomics of Institutions, the DEA (M.Sc.) in Transport and Network Industrial Economics, the European Diploma (M.Phil.) in Advanced Quantitative Economics, and her second Ph.D. in Economics from Toulouse School of Economics. She was enrolled in the post-doctoral programme offered by the European University Institute as a Jean Monnet fellow at Florence School of Regulation. She has also been hosted as a Jemolo fellow by Nuffield College, University of Oxford. She participated in "The BRICS Multilateral Development Bank project" promoted by the G24 and GGGI. She is a CESifo affiliate, and a promoter of the Network on the Economics of Regulation and Institutions. She is also currently serving on the Board of Directors of the Italian Society of Public Economics.