Resource and Energy Economics 47 (2017) 56–71

Contents lists available at ScienceDirect

Resource and Energy Economics

journal homepage: www.elsevier.com/locate/ree

Promotion of cooperation when benefits come in the future: A water transfer case

Francisco Cabo[a,*], Mabel Tidball[b,1]

[a] IMUVa, Universidad de Valladolid, Spain
[b] INRA, UMR Lameta, Montpellier, France

ARTICLE INFO

Article history:
Received 11 March 2016
Accepted 1 December 2016
Available online 9 December 2016

JEL classification:
F18
C73

Keywords:
Cooperative differential game
Non-cooperative differential game
Imputation distribution procedure
Instantaneous side-payment
Time-consistent solution

ABSTRACT

This paper presents a two-regime differential game, with a first period in which two countries cooperate in a joint investment project to construct a specific infrastructure. This period ends when the infrastructure is finished, which serves to increase each player's welfare in a subsequent non-cooperative game played by the two countries thereafter. We define an imputation distribution procedure (IDP) to share the investment costs during cooperation according to each player' future benefits. We prove that the IDP is time consistent if at any time within the cooperative period each country's share on the surplus to go is equal to or converges towards the country's relative gains from the existence of the infrastructure (realized in the subsequent non-cooperative period). Furthermore, we obtain the instantaneous side-payment scheme which makes the IDP feasible. The mechanism is studied for a joint investment project to build a water canal to transfer water between a surplus and a deficit river basin.

1. Introduction

This paper proposes a time consistent distribution procedure to insure cooperation in a joint investment project between two countries or regions when the benefits will come when the infrastructure is finished. To situate the problem we refer to a particular application, the construction of a canal for water transfer. In this context our paper analyzes the dynamic cooperation between two countries or regions in order to build a canal which connects a donor river basin, with higher precipitation rates, and a recipient river basin, with greater water productivity. This joint investment program presents two main characteristics. First, cooperation does not lead to an immediate reward, but only after an initial period in which the two parts have to pay the costs of building the canal. Secondly, the delayed benefits of the cooperation are known by the cooperating agents and they are typically asymmetric. The efficiency gains linked to the flow of water from a surplus basin to a deficit basin with greater water productivity, can be realized thanks to the water market created by the water canal.

Some examples of already operative schemes or ongoing projects of water transfer can be found, usually within a specific country.[2] The Tagus-Segura Transfer Project in Spain, the Snowy River Scheme in Australia, the São Francisco Interlinking

* Corresponding author at: Dept. Economí a Aplicada (Matemáticas), Facultad de Ciencias Económicas y Empresariales, Universidad de Valladolid, Avda. Valle Esgueva, 6, 47011 Valladolid, Spain.

E-mail addresses: pcabo@eco.uva.es (F. Cabo), tidball@supagro.inra.fr (M. Tidball).

[1] Address: INRA, UMR 1135 LAMETA, F-34000 Montpellier, France.

[2] In some of these projects water is transferred from one river basin to another river, others transfer the water to dams in the mountains (for irrigation and to generate hydroelectricity), or towards a specific region for municipal water supply, industry and irrigation.

http://dx.doi.org/10.1016/j.reseneeco.2016.12.001
0928-7655/

Project in Brazil, the Olmos Transfer Project in Peru or the South-North Water Transfer Project in China. Some of these are ongoing projects, whose full implementation may take some decades, or even end-up as fail projects. These projects have been promoted by a central government. Much less frequent are the examples of water transfers between different countries, like the transfer from the Kosi river in Nepal to the Ganges in India and Bangladesh, or the Lesotho Highlands Water Project (drawn out by corruption) between Lesotho and South Africa (geographically condemned to get along with each other). This reflects the difficulties tied to the obliged cooperation between two governments who have to determine how to share the costs of the joint project, and how to distribute these costs along the often lengthy construction period. Maybe better examples of these difficulties are the failed projects, like the Rhone–Barcelona aqueduct proposed to supply the city of Barcelona in Spain with water from the Rhone river in France (see Lopes, 2008). We will focus on the economic aspects that help maintain the agreement to build the canal although, as pointed out by Lopes (2008), the obstacles to the transfer between countries are also political and institutional.

The bulk of the literature on river water management involving two regions/countries and non-cooperative game theory is on water-sharing under an upstream/downstream configuration (see, for example, Ambec and Ehlers, 2008; Bhaduri and Barbier, 2008; Ambec and Sprumont, 2002; Kilgour and Dinar, 1995, 2001). However, the problem of a water transfer between two river basins has some specificities not present in the upstream/downstream literature. The donor river basin must be characterized by a surplus of water inflows, and the recipient basin by a deficit. Given this asymmetry, water productivity is higher in the recipient. Two additional features are also present in most of the examples highlighted above. The recipient may have access to alternative sources of water, by investing in infrastructures which can help to increase the available water for the economy (examples could be desalination plants, projects to save water, to reduce pipeline leaking, or investment in recycling). The transfer brings environmental consequences mainly, but not exclusively, for the donor. If the relative cost of the alternative water supplies is low, and/or the magnitude of the environmental damages linked to the water transfer is high, then the inter-basin transfer would not be profitable.

For the particular example of the Tagus-Segura transfer, Ballestero (2004) presents a static demand-supply model, later extended to a dynamic setting in Cabo et al. (2014). The latter studies the interaction between a donor and a recipient region as a non-cooperative differential game, which defines the water market as a bilateral monopoly. It also includes the environmental damage in the donor region caused by the transfer, and the alternative water supplies available for the recipient. It is assumed nonetheless, that the infrastructure required to transfer the water between the two river basins is already operative.[3] Under this assumption the water market equilibrium is dynamically analyzed. By contrast, with a broader perspective, and particularly when the transfer involves governments from two different countries, we consider it important to address the previous coordination problem associated with the joint investment required to build the canal.

The central question in static cooperative game theory of how to distribute the gains from cooperation between the cooperating players, is extended by dynamic cooperative game theory to study the distribution of these gains not only among players but also over time. [4] In particular, how to distribute the surplus from cooperation over time to guarantee that no player has an incentive to deviate from cooperation, at any point in time (the cooperative payoffs to go surpass the non-cooperative payoffs to go at any time within cooperation). This concept is usually referred to as time consistency.[5] One widespread mechanism to guarantee the time consistency of the cooperative solution is to select a solution concept specifying each player's share of the total cooperative payoff, and define a payoff distribution procedure, as stated in Petrosjan (1997), to decompose the individual total payoff over time, in such a way that time consistency is preserved (see Zaccour, 2008 for a review). This mechanism constitutes the basis for implementing a time-consistent solution in this paper, although the literature provides other mechanisms.[6]

In our setting cooperation does not lead to immediate gains in payoffs. On the contrary, cooperation to invest in the construction of the canal, represents a costs for both players, maintained throughout the period of cooperation. In fact, the gains from the cooperation only start once the water starts to flow through the canal, and with it come the efficiency gains. But this is precisely the exact moment at which the joint investment cooperation halts. Therefore, the first question that must be addressed is how to share the "costs" of cooperation when its benefits will only materialize when the cooperation ceases to exist, and the two parts engage in a non-cooperative trade relationship in the water market. Thus, assuming that the aggregated (discounted) gains from the existence of the water canal surpasses the global economic and environmental costs of the joint investment project, our main research question is: how should the investment costs be shared between the two parts and distributed over time to guarantee the time consistency of the cooperate solution? That is, to guarantee that no player deviates from the cooperation and the canal is actually finished. We would like to stress that our model shares some similarities with the holdup problem analyzed in the literature (see, for example the dynamic formulation of this problem in Che and Sákovics, 2004). Both problems seek to maintain a joint investment project over time

[3] For this case study, 230 km network of canals, aqueducts and tunnels were built by the Spanish central government to transfer water from the Tagus basin in the center of Spain to the Segura basin in south-eastern Spain.

[4] For an upstream/downstream pollution problem, Jørgensen and Zaccour (2001) propose an instantaneous side-payment scheme to share the current surplus from an agreement to reduce downstream pollution.

[5] As stated in Zaccour (2008), it has been also called sustainability of cooperation, dynamic individual rationality, dynamic stability, durability of an agreement, or agreeable solution.

[6] Other mechanisms can be found in the literature, like the incentive strategies proposed by Ehtamo and Hämalä inen (1986, 1989, 1993), or the design of the cooperative agreement to satisfying the property of being at equilibrium (see, for example Rincón-Zapatero et al., 2000).