

Küçükmehtetoğlu, Mehmet; Büyükgöz, Ali

Conference Paper

Consensus Building Via Cooperative Game Theory In The Process Of Urban Redevelopment

53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Küçükmehtetoğlu, Mehmet; Büyükgöz, Ali (2013) : Consensus Building Via Cooperative Game Theory In The Process Of Urban Redevelopment, 53rd Congress of the European Regional Science Association: "Regional Integration: Europe, the Mediterranean and the World Economy", 27-31 August 2013, Palermo, Italy, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/123976>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

CONSENSUS BUILDING VIA COOPERATIVE GAME THEORY IN THE PROCESS OF URBAN REDEVELOPMENT

Mehmet KÜÇÜKMEHMETOĞLU
Ali BÜYÜKGÖZ

Department of City and Regional Planning, Gebze Institute of Technology,
Istanbul Cad. No:101, Gebze, 41400 Kocaeli, Turkey
mkucuk@gyte.edu.tr
abyukgoz@gyte.edu.tr

ABSTRACT

In Turkey, after the 1999 Gölcük Earthquake, urban redevelopment has been seen as a major solution for removal or rehabilitation of low quality urban settlements. Several laws and bylaws have been passed to this end. One of the major tasks of this transformation and/or redevelopment is to convince relevant parties to participate in the process. This process always needs either significant side-payments from the government, or land use change and/or density bonuses as much as to cover redevelopment costs in high-rent zones of urban land. This research utilizes the cooperative game theory concepts to achieve voluntary participation of property owners by satisfying their rational and reasonable requests from any forms of coalition. In this process, government as an outside institution is included as a central facilitator who has major public interest in solving low quality urban fabric problem with minimal/low-cost involvement of public funds. There are two types of government involvement: i) If the measurable benefits of coalition satisfy the parties, government may function only as a facilitator or coordinator, and may retain the extra benefits of coalition as a tax; ii) If the measurable benefits of coalition do not satisfy the parties, government may function as an external resource supplier to form a coalition. The obtained taxes, later, may be used in the necessary areas as subsidies to build stable coalitions. In the study, the cooperative game theory model utilizes the local governments' rezoning and density modification decisions favoring the financing of urban redevelopment, and sorts the involved parties' strategies. Game theory application results over a hypothetical case have shown that cooperative game theory is an efficient, effective, and rational tool to convince involved parties who may demand illogical and uneducated benefits from any form of coalition. The developed approach can be easily modified, improved, and used in any redevelopment projects.

Keywords:

C71 - Game Theory and Bargaining Theory

R30 - Real Estate Markets, Production Analysis, and Firm Location - General

R38 - Government Policy; Regulatory Policy

I. INTRODUCTION

Since the Second World War, Turkey has been facing a trend of rapid urbanization. Especially, during 1960-2000 period, this trend was overwhelming and has resulted in mostly informal and low quality housing and building stocks at the outskirts of major cities. After the 1999 Gölcük Earthquake, urban redevelopment has been seen as a major solution for the removal or rehabilitation of low quality urban settlements. Several laws and bylaws have been passed to this end. *One of the major tasks of this transformation and/or redevelopment is to convince relevant parties to participate into the process of change.* This process always needs either significant *side-payments from the government*, or *land use change and/or density bonuses* as much as to cover redevelopment costs in high-rent zones of urban land.

Many public projects require coalition among many parties to gain the benefits of economies of scale and common uses of infrastructure and public spaces. These gains are either from reducing costs or from deriving extra benefits. In the coalition building processes, some parties hold a more critical position than the others. If these parties are reluctant to join, they need to be encouraged by means of rational evaluation of their standings and if necessary rational side-payments. The cooperative game theory model used in this research proves to be a useful tool presenting such calculated information.

Urban redevelopment projects are very political and very complex in measuring the associated parties' desires and expectations. Almost always, it is highly probable that involved parties' benefit expectations i.e. allocation of values after redevelopment are far beyond the rational limits. This over expectation makes redevelopment projects infeasible and unrealistic. By using the cooperative game theoretic approach, the limits of parties' reasonable expectations can be methodologically presented.

II. LITERATURE

In the literature, Heaney & Dickinson (1982), Rogers (1993), Kucukmehmetoglu (2002 & 2009), Kucukmehmetoglu et al. (2010), Kucukmehmetoglu & Guldmann (2004), Wu & Whittington (2006), Tsang & Jim (2011) are the users of the cooperative game theory concepts in various allocation problems. Heaney & Dickinson (1982) focus on the cost apportionment techniques one of which is the core game. Rogers (1993) presents that core game can be used for various water resources allocation. Later, Kucukmehmetoglu (2002 & 2009), Kucukmehmetoglu et al. (2010), Kucukmehmetoglu & Guldmann (2004), and Wu & Whittington (2006) are the users of core game technique in the transboundary water resources allocation problems. Tsang & Jim (2011) are the users of the same methodology for the allocation of green-roof benefits among residents.

Heaney & Dickinson (1982) lists three types of cooperative games with respect to the characteristics of cooperation:

1. *The value game*, which maximizes the profit or revenue functions;
2. *The cost game*, which aims at minimizing the costs;
3. *The saving game*, which aims at reducing costs.

Cost games can be easily converted into value games by modifying inequalities. In this research Heaney & Dickinson's (1982) cost game is converted into a value game.

In details; let $x(i)$ be the benefit allocated to player i when all players cooperate, i.e., join the grand coalition, $b(i)$ be the benefit incurred by player i when he acts independently, i.e., out of the coalition, and $b(N)$ be the benefit incurred by the grand coalition. In order to make participation in the grand coalition advantageous to all players, the benefit of the participants' independent behaviors must not be greater than the benefit of their cooperative behaviors. The inequality (1), represents this condition, and Equation (2) states that the total benefit of the grand coalition is fully allocated among all the participants. These two relationships define all the feasible *imputations*.

$$x(i) \geq b(i) \quad \forall i \in N \quad (\text{individual rationality}) \quad (1)$$

$$\sum_{i \in N} x(i) = b(N) \quad (\text{allocation of benefit in the grand coalition}) \quad (2)$$

Next, consider a subset S of at least two players ($S \subset N$). Let $b(S)$ be the benefit of the subset S if it acts independently. Equation (3) states that the aggregate benefit of subset S when all its participants are in the grand coalition is greater than the benefit that the subset would incur when acting independently:

$$\sum_{i \in S} x(i) \geq b(S) \quad \forall S \subset N \quad (\text{sub-group rationality}) \quad (3)$$

All these equations define a solution set, named the core, over which all rational players agree to join the grand coalition. The higher the benefit of the grand coalition, the higher the probability of obtaining a non-empty core and achieving the grand coalition Kucukmehmetoglu (2002).

$$\sum_{i \in N} x(i) + Z = b(N) \quad (\text{allocation of benefit in the grand coalition with tax}) \quad (4)$$

Kucukmehmetoglu (2002 & 2009), Kucukmehmetoglu et al. (2010), Kucukmehmetoglu & Guldman (2004) introduced Z variable to these constraints. When it is maximized, the value and sign of Z presents three outcomes:

1. If Z has positive value, Z is the amount of tax can be derived from the grand coalition.
2. If Z has zero value, there exist a unique allocation vector in which all grand coalition participants have single allocation value.
3. If Z has negative value, Z is the amount of side payment (-tax) required to attain a unique grand coalition solution.

III. METHODOLOGY

In order to attain a high quality urban space by redeveloping the low quality urban fabric, the means of change is *the density bonuses approach* which provides space specific extra benefits to land lords. These extra benefits sometimes covers most of the development costs due to high rent value. While city government approving incremental density bonuses (extra floor area ratios for those who cooperating), it encourages the relevant parties act together for the success of redevelopment projects. It could be a small project affecting only a city block, but still involves many stakeholders depending on the size of the block and characteristics of the study area. The success of projects is based on how bonuses are derived and how the benefits are peacefully allocated to the relevant stakeholders. This research utilizes cooperative game theory concepts in order to i) evaluate the participants' reasonable level of requests, ii) to discover the critical players, iii) determine reasonable level of allocations and side payments, iv) to achieve voluntary participation of all parties. In this process, as an outside institution government is included as a central facilitator who has major *public interest* in solving low quality urban fabric problem with minimal/low-cost involvement of public funds. Even government may raise taxes to finance other projects requiring side payments.

In practice, *density and zoning bonuses* can be easily used to encourage the land/property owners especially in high rent segments of the urban land. In many instances, in high rent zones, the density bonuses are actualized by changes in floor area ratios (FAR). The higher density brings extra building spaces for land lords/owners and developers.

The developed approach evaluates the status of lot owners in the process of forming coalition in order to amalgamate their lots to reach higher property value, higher quality living environment (larger open spaces and public facilities), and larger building areas (FAR). Cooperative game theory is the tool used measuring the parties' possible strategies in various coalition formations.

There are three types of government involvement: i) Government may function only as a facilitator or coordinator without tax or subsidy involvement; ii) If the measurable benefits of

coalition satisfy the parties, government may function as a facilitator or coordinator, and may retain the extra benefits of coalition as a tax; iii) If the measurable benefits of coalition do not satisfy the parties, government may function as an external resource supplier to form a coalition. The obtained taxes, later, may be used in the necessary areas as subsidies to build stable coalitions. Besides city governments' rezoning and density modification capability and its use is another external involvement needs to be mentioned.

Tax Z and payments $x(i)$ to the grand coalition parties are estimated by the use of *Linear Programming Optimization Model* presented in Equations (5) and (6). The constraints of model are explicitly presented in Tables 2 and 3. It should be noted that, in all models, payoffs are measured in square meter floor area which could be converted into monetary value.

Maximize

$$F = Z \quad (5)$$

Subject to

$$\text{Equation (1), (2), and (4)} \quad (6)$$

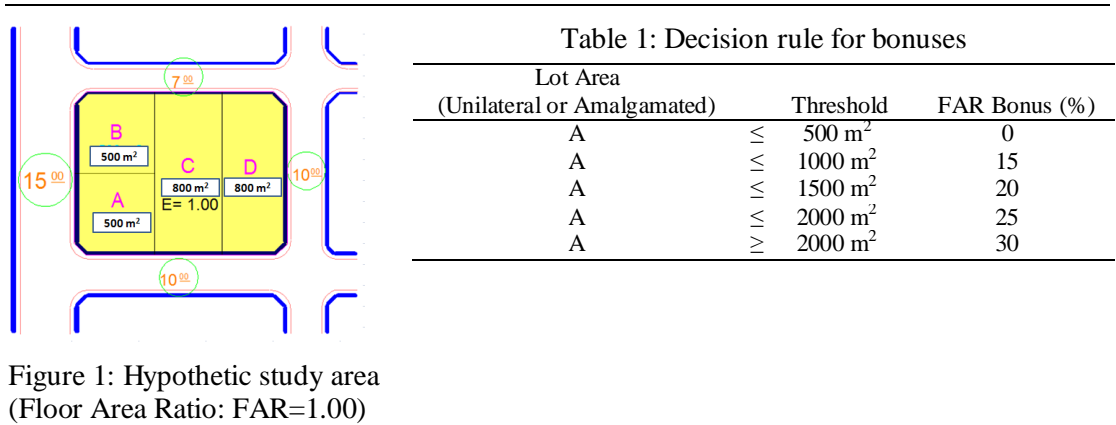


Figure 1: Hypothetic study area
(Floor Area Ratio: FAR=1.00)

Figure 1 illustrates a hypothetical building block and 4 lots (A, B, C, D) owned by 4 different land owners. We assume that all landlords behave rational. Current Floor Area Ratio (FAR) is 1.00 for this block. We assume that government has public interest in having this block developed in an integrated fashion, like a single lot, as opposed to each owner building in his/her lot. The government's gain will be increased quality and quantity of car-park and open spaces, therefore improved environmental quality. In order to achieve that, the government provides density bonuses with respect to the rules presented in Table 1. Density bonus means extra building space for use, rent, or sell in the high rent regions. To attain a density bonus at least two lots should have integrated development project. Integrated projects can be actualized only with adjacent lot(s). In other words, A and D cannot get into a common project unless C joins them. In the same way B and D cannot make a productive bilateral coalition. Here, the critical player is C and his participation generates productive results.

Table 2: Explicit presentation of Individual, Subgroup and Grand Coalition Strategies

Coalitions Strategies	Variables for Allocations	Payoff (m ²)	Behavior	Equation
Individual Behaviors Alone	X_A	\geq	$b(A)$	Eq. (1)
	X_B	\geq	$b(B)$	
	X_C	\geq	$b(C)$	
	X_D	\geq	$b(D)$	
Subgroup Behaviors Bilateral	$X_A + X_B$	\geq	$b(AB)$	Eq. (2)
	$X_A + X_C$	\geq	$b(AC)$	
	$X_A + X_D$	\geq	$b(AD)$	
	$X_B + X_C$	\geq	$b(BC)$	
	$X_B + X_D$	\geq	$b(BD)$	
Subgroup Behaviors Trilateral	$X_C + X_D$	\geq	$b(CD)$	Eq. (2)
	$X_A + X_B + X_C$	\geq	$b(ABC)$	
	$X_A + X_C + X_D$	\geq	$b(ACD)$	
	$X_A + X_B + X_D$	\geq	$b(ABD)$	
Grand Coalition	$X_B + X_C + X_D$	\geq	$b(BCD)$	Eq. (3)
	$X_A + X_B + X_C + X_D$	$=$	$b(ABCD)$	

Table 3: Explicit presentation of Grand Coalition and tax variable (Z)

Grand Coalition	$X_A + X_B + X_C + X_D + Z$	$=$	$b(ABCD)$	Eq. (4)
------------------------	-----------------------------	-----	-----------	---------

IV. MODEL APPLICATION AND RESULTS

Model application section consists of two subsections: In the *first* part, there is a benchmark model application. In the *second* part there are a series of sensitivity analysis.

Benchmark Model Application

Table 4 presents all forms of coalitions and their payoffs to the individuals, subgroups and grand coalition. These values later used in an optimization model (Equation 5-6) and the results are presented in the 6th scenario in Table 5b (*Core and Maximum Z Based Allocation*).

Preliminary results evaluating the various unilateral, bilateral, trilateral, and grand coalition strategies including the level of triggering thresholds and associated calculated bonuses are listed as follows:

- Unilateral A (500 m²) and B (500 m²) do not have any density bonus;
- Unilateral C (800 m²→800) and D (800 m²→) have 15% density bonuses (800x1.15 m² =920 m²);
- Bilateral AB (500+500=1000 m²) has only 15% density bonus (1000x1.15 m² =1150 m²);
- Bilateral AC (500+800=1300 m²) has only 20% density bonus (1300x1.20 m² =1560 m²);
- Bilateral BC (500+800=1300 m²) has only 20% density bonus (1300x1.20 m² =1560 m²);
- Bilateral AD (500+800=1300 m²) has only 15% density bonus only for D. Since lots are not contiguous there is no extra benefit of being in coalition (500 + 800x1.15 m² =1420 m²);
- Bilateral BD (500+800=1300 m²) has only 15% density bonus only for D. Since lots are not contiguous there is no extra benefit of being in coalition (500 + 800x1.15=1420 m²);
- Trilateral ABC (500+500+800=1800 m²) has 25% density bonus (1800x1.25=2250 m²);
- Trilateral ACD (500+800+800=2100 m²) has 25% density bonus (2100x1.30=2730 m²);
- Trilateral BCD (500+800+800=2100 m²) has 25% density bonus (2100x1.30=2730 m²);

- Trilateral ABD ($500+500+800=1800\text{ m}^2$) has two separate 15% density bonuses ($1000 \times 1.15 + 800 \times 1.15 = 1150 + 920 = 2070\text{ m}^2$) due to spatial separation of lot D from lots AB;
- Grand coalition ABCD ($500+500+800+800=2600\text{ m}^2$) triggers 30% bonus ($2600 \times 1.30=3380\text{ m}^2$).

In these analyses, it is clear that C is the critical partner, and his existence enables coalitions use higher multipliers. The red colored strategies in Table 4 presents that an exclusion of player C results in lowest payoffs in all forms of strategies regarding the block-wise total return. The *lowest* total payoff is being derived from the *sum of individual payoffs* (2840 m^2 floor area in Table 4), and the *highest* payoff is derived from *grand coalition* (3380 m^2 floor area in Table 4). The other two lowest payoffs are derived from the scenarios excluding player C from the coalitions. This also illustrates the critical importance of player C. Benchmark case is also presented in the 6th scenarios in bold in Table 5a-d. Optimization results for benchmark case also present the importance of player C that the highest square meter allocation (1100 m^2) is for this player. Positive Z value (75 m^2) shows the extra benefit derived out from the Grand Coalition.

Table 4: Benchmark case payoffs (m^2 floor area) to the all forms of strategies*

Strategies \ Coalitions	<i>b(a)</i>	<i>b(b)</i>	<i>b(c)</i>	<i>b(d)</i>	<i>b(ab)</i>	<i>b(ac)</i>	<i>b(ad)</i>	<i>b(bc)</i>	<i>b(bd)</i>	<i>b(cd)</i>	<i>b(abc)</i>	<i>b(acd)</i>	<i>b(abd)</i>	<i>b(bcd)</i>	<i>b(abcd)</i>	Total
Individual	500	500	920	920												2840
Individual & Bilateral		500	920	920	1150											2990
		500	920			1560										2980
		500		920			1420									2840
		500						1560								2980
Bilateral & Bilateral																3000
										2000						3150
						1560			1420							2980
							1420	1560								2980
Individual & Trilateral		500		920							2250					3170
			920									2730				3230
Grand (All)															3380	3380

* Triggering thresholds values comes from Table 2

Sensitivity Analyses

In the previous section, it has been seen that strategic location plays an important role. In order to illuminate the strategic site specific importance of C, a series of sensitivity analyses have been pursued. For the 1st scenario, though C's size is zero, its strategic location results in extra benefits (155 m^2) not because of lot size, but because of strategic location between A and D or B and D.

A series of scenarios designed regarding the following sets of rules:

- In all scenarios the total block area is held constant (2600 m^2);
- The size of lot C and D mutually altered that while the lot size of C increases, the size of lot D decreases. In this process, the sum of lot size C and D is always kept constant (1600 m^2);
- A 20% increment is selected to derive 11 different scenarios.

Table 5a identified as *Base Lot Size Scenarios* is prepared to show size scenarios; Table 5b identified as *Minimum Benefit Allocation* shows the least required party benefits from designed scenarios; Table 5c identified as *Core and Maximum Z Based Allocation* presents the existence of a core, and whether beneficial to establish a grand coalition, and the extra benefits (tax: Z) can be derived from that coalition; Table 5d identified as *Difference between Core and Minimum* displays the difference between minimal benefit and grand coalition benefits to show how beneficial to be in grand coalition after deriving tax benefits (Z) from grand coalition.

In all 11 scenarios, Z has positive value except one zero. This shows that parties may have more benefit as compared to their unilateral actions. Z is considered as tax, but use of Z is left to the government, which may choose to allocate this value to all participants with respect to a predefined rules. Shapley value can be a tool for that, also Heaney & Dickinson (1982) and Giglio & Wrightington (1972) proposes a series of allocation techniques in their researches.

Finally, Figures 2 and 3 is prepared to presents the strategic importance of location of C. In these figures Player C's returns are compared with the same size player D's returns. While preparing graphs the lot sizes are held the same for C and D, and returns with bonuses are comparatively observed.

Figure 3 presents the core game allocation (with maximized city tax: Z) to player C and D. The horizontal axis of the figure presents the square meter base lot area of C and D. Although the lot sizes of C and D are the same, their returns from core game are not the same. C always obtains higher returns. The difference comes from the intermediate locational position of the lot C as compared to lot D. The similar results are seen in Figure 4 which shows the difference between core allocation and minimum benefits. Again line for C shows that strategic location of C brings more core allocation as compared to the same size D lot.

Table 5: Sensitivity analyses considering the size of the lots (m² floor area)

a)	Scenario	Lot A	Lot B	Lot C	Lot D	Total	
Base Lot Size Scenarios	1	500	500	0	1600	2600	
	2	500	500	160	1440	2600	
	3	500	500	320	1280	2600	
	4	500	500	480	1120	2600	
	5	500	500	640	960	2600	
	6	500	500	800	800	2600	
	7	500	500	960	640	2600	
	8	500	500	1120	480	2600	
	9	500	500	1280	320	2600	
	10	500	500	1440	160	2600	
	11	500	500	1600	0	2600	
b)	Scenario	b(A)	b(B)	b(C)	b(D)	Total 1	
Minimum Benefit Allocation	1	500	500	0	2000	3000	
	2	500	500	160	1728	2888	
	3	500	500	320	1536	2856	
	4	500	500	480	1344	2824	
	5	500	500	736	1104	2840	
	6	500	500	920	920	2840	
	7	500	500	1104	736	2840	
	8	500	500	1344	480	2824	
	9	500	500	1536	320	2856	
	10	500	500	1728	160	2888	
	11	500	500	2000	0	3000	
c)	Scenario	Z	x(A)	x(B)	x(C)	x(D)	Total 2
Core and Maximum Z Based Allocation	1	75	575	575	155	2000	3380
	2	75	575	575	242	1913	3380
	3	75	575	575	434	1721	3380
	4	75	575	575	626	1529	3380
	5	75	575	575	900	1255	3380
	6	75	575	575	1100	1055	3380
	7	75	575	575	1300	855	3380
	8	75	575	575	1606	549	3380
	9	75	575	575	1814	341	3380
	10	48	548	602	2022	160	3380
	11	0	500	650	2230	0	3380
d)	Scenario	x(A)- b(A)	x(B)- b(B)	x(C)- b(C)	x(D)- b(D)	Total 1-Total 2	
Difference between Core and Minimum	1	75	75	155	0	380	
	2	75	75	82	185	492	
	3	75	75	114	185	524	
	4	75	75	146	185	556	
	5	75	75	164	151	540	
	6	75	75	180	135	540	
	7	75	75	196	119	540	
	8	75	75	262	69	556	
	9	75	75	278	21	524	
	10	48	102	294	0	492	
	11	0	150	230	0	380	

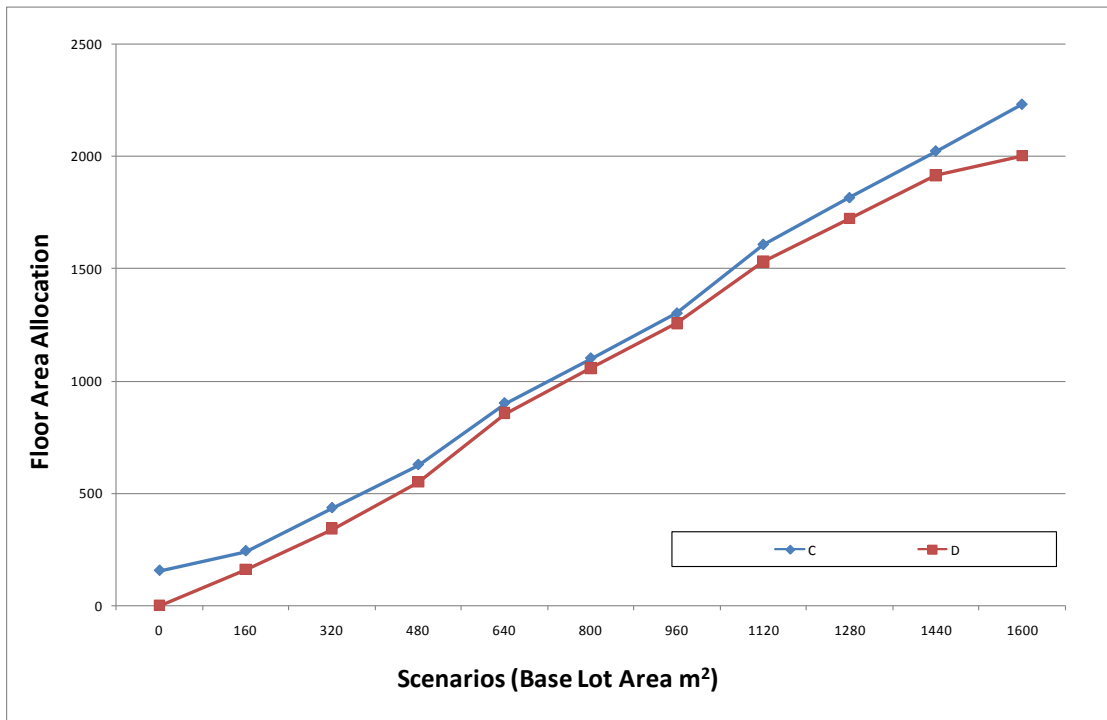


Figure 3: Core game allocation (m²) to the same size player C and D (Derived from Table 5c)

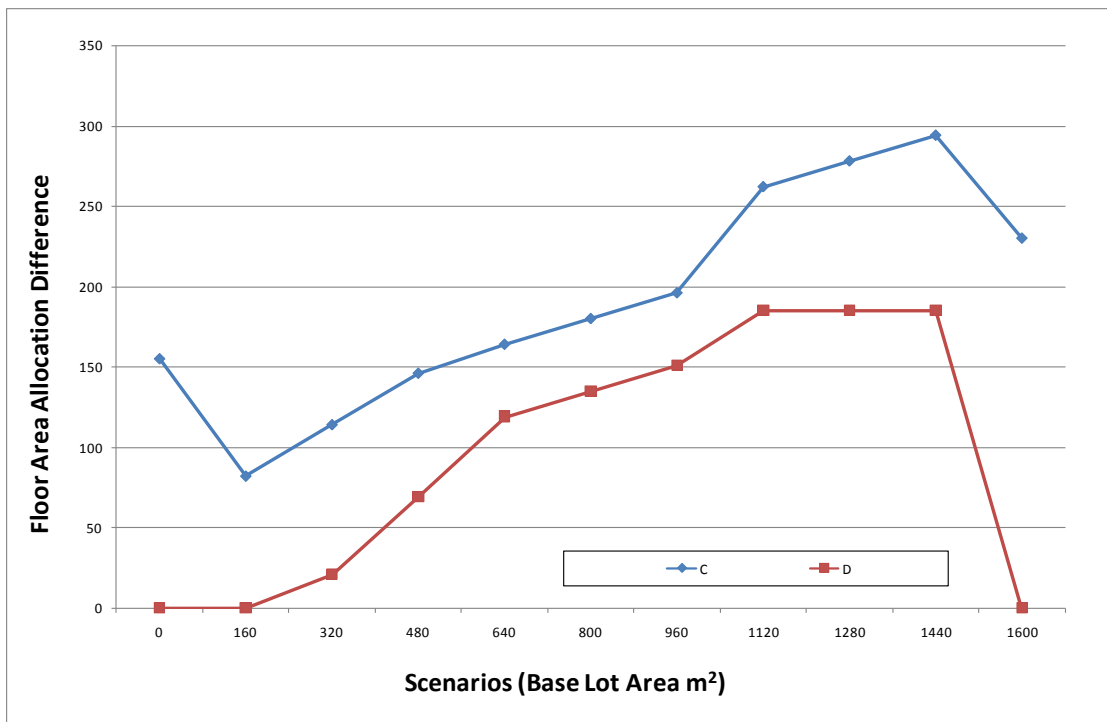


Figure 4: Difference between core game allocation and minimum benefit allocation (m²) to the same size player C and D (Derived from Table 5d)

V. CONCLUSION

Game theory application results over a hypothetical case have shown that cooperative game theory is an efficient, effective, and rational tool to convince involved parties who may demand illogical and uneducated gains from any form of coalition. The developed approach can be easily modified, improved, and used in any redevelopment projects.

Though a hypothetical case, scenarios clearly illustrates the significance of party strategies and their locational advantages. Strategic locations make difference and enables the parties extract additional benefits beyond their unilateral benefits.

The +Z shows that government may derive tax revenue to subsidize (-Z) some other projects requiring side payments. This empowers governments to improve urban public land by stimulating the parties with various bonuses. Because bonus rules are determined by city government and approved by city councils, they can be an efficient and effective tool for urban redevelopment policies especially for high rent zones.

VI. REFERENCES

- Giglio, R J. & Wrightington, R. (1972). Methods for Apportioning Costs among Participants in Regional Systems. *Water Resources Research*, 8(5), 1133-1144.
- Heaney, J. P. & Dickinson, R. E. (1982). Methods for Apportioning the Cost of a Water Resource Project. *Water Resources Research*, 18(3), 476-482.
- Kucukmehmetoglu, M., 2009. A game theoretic approach to assess the impacts of major investments on transboundary water resources: The case of the Euphrates and Tigris. *Water Resources Management*, 23(15): 3069-3099.
- Kucukmehmetoglu, M., Şen, Z., & Özger, M., (2010). Coalition possibility of riparian countries via game theory and fuzzy logic models. *Water Resour. Res.*, 46, W12528, doi:10.1029/2009WR008660.
- Kucukmehmetoglu, M. & Guldmann, J. M., (2004). International Water Resources Allocation and Conflicts The Case of the Euphrates and Tigris. *Environment and Planning A*, 36: 783-801.
- Kucukmehmetoglu, M., (2002). Water Resources Allocation and Conflicts – The Case of the Euphrates and the Tigris. *Dissertation*, The Ohio State University, Columbus, Ohio.
- Rogers, P., (1993). The Value of Cooperation in Resolving International River Basin Disputes. *Natural Resources Forum*, Mays: 117-131.
- Tsang, S. W. & Jim, C. Y. (2011). Game-theory approach for resident coalitions to allocate green-roof benefits. *Environment and Planning A*, 43: 363-377.
- Wu, X. & Whittington, D., (2006). Incentive Compatibility and Conflict Resolution in International River Basins: A Case Study of the Nile Basin. *Water Resources Research*, 42: 1-15.