Partial Takings and Project Induced Externalities

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Abstract

In many contexts, takings (of private property by the state) are partial, and generate externality for neighbouring properties. Yet, the literature on eminent domain has not adequately analysed the implications of externalities on the holdout problem and on the land use incentives of landowners. Only few studies have examined the idiosyncratic effects of partial takings. In this paper, we provide an analytical framework to model and study project-induced externalities in the context of partial takings. We find that if the spillover benefits are large enough, the government can collect a lumpsum payment and still induce efficient investment decisions by landowners. If the transfer payments are land-use dependent, the landowners invest less than what is efficient. In this case, investment can be efficient only if neither the asset is compensated for nor a payment for externality-induced benefits is collected. Use of the offsetting principle reduces the project costs for the exchequer, however, it causes agents to invest inefficiently. The offsetting principle based compensation does not eliminate the moral hazard on the part of the investors. We find conditions under which paying the "full current market value" of the property acquired can reduce the distortions away from efficient levels. By contrast, if compensation is calculated to achieve zero net loss for the property owner, the inefficiency of investments would be greater. We show that full compensation can reduce moral hazard.

Keywords: Eminent Domain, Partial Taking, Externalities, Moral Hazard, Holdout

JEL Classification: D62, H13, K11, H23

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1 Introduction

Traditionally, literature has justified the use of Eminent Domain by appealing to the problem of holdout (Miceli, 2011, Miceli & Segerson 2012, Cadigan, Schmitt, Shupp, & Swope, 2011). Holdouts can endanger the viability of projects that require land assembly. Market procurement of multiple, contiguous parcels can be made inefficient by landowners exercising disproportionately larger bargaining powers knowing that they can delay or deter the realisation of a project. In such cases, the State exercises Eminent Domain, its sovereign power to acquire private land for public purposes.

Mainstream literature has largely ignored the externalities associated with the use of Eminent Domain. The problem of assembly failure is more severe in cases where the project, post-development, exerts a positive externality on the neighbouring land. Portillo (2019) models this additional source of friction which arises from the landowner benefiting from her neighbours selling their properties, developer successfully aggregating land for the project, while her own parcel remains unsold. The prospect of benefitting from such post-development positive externalities can raise their reservation prices, threatening the completion of the project. In such cases, holdout is more acute, therefore, the use of Eminent Domain is more justified and often essential for the realisation of the project

Project-induced externalities – emerging post-development and on neighbouring properties, seem pervasive in nature. The impact of a land development project reaches beyond its physical boundaries, invariably affecting the general well-being of the neighbourhood. It is well-documented that properties neighbouring highways, metro-lines, parks, schools and other such infill development projects, fetch higher prices. Their development leads to a surge in neighbouring property values (Ooi & Le, 2013, Jud & Watts, 1981, Weigher & Zebst, 1973, Crompton, 2007). The fact that buyers are willing to pay higher prices for project-adjacent properties, indicates the presence of some beneficial spillover, one which they anticipate, recognise and would pay for. Studies also indicate that these externalities are not far spread out, but are contained in the immediate surroundings of the project. McDonald & Osuji (1995) study residential land values in the vicinity of a new transit line in Chicago and find that an increase of 17% *within one-half mile* can be attributed to construction of the line. Baornet & Chalermpong (2001) term it an "accessibility premium". They study the construction of toll roads in California and find a willingness to pay for it among home owners in the vicinity. Gibbons, Peng, & Tang (2019) find a price premium for living close to canals and waterway networks in Britain and a higher proportion of new-build sales within 100m of canals relative to elsewhere. Proximity to such projects can create externalities of both kinds. Studies have shown that housing societies in vicinity of newly developed highways, for example, face both accessibility premiums and increased levels of noise pollution. However, Levkovich et. al. (2015) find that the net effect of such developmental projects on housing prices is positive.

Such externalities are inherent to partial takings. Land acquisition wherein the State acquires a portion of the parcel rather than the entire private property, allowing the owner to retain the rest are termed "partial takings". They are peculiar in nature. The property is essentially sliced up and a project is undertaken on the part acquired. Positive externalities generated from a project are not far spread out and get manifested on the portion retained by the landowner. A portion of her property is acquired and developed, while the rest experiences a hike in its value due to its proximity to this development.

Partial takings are growing popular for linear projects like construction and extension of highways[3], metro-lines[4], flyovers, sea-walls along the beach [5] and laying down pipelines [6], garnering policy and academic interests (Bell & Parchomovsky, 2017; Russo, 2014; Rikon, 2023). They are preferable for the government, for one that they reduce the burden on the exchequer. The compensation award to be dispensed is smaller than if entire parcels had been acquired (Bell & Parchomovsky, 2017). In cases of partial takings, the owner is not completely displaced from her land. She might benefit from the project itself, and from the positive externality it would generate on the rest of her property. The prospect of enjoying a post-development externality increases the receptibility of the takings decision among acquisition-affected landowners. In case of total takings, this spillover benefit is manifested only for neighbouring unsold properties. Attempts by landowners to capitalise on anticipated benefits can raise transaction costs and threaten the completion of the project

[3]Ackerman A., Yanich N., (2000). "Just Compensation and the Framers Intent: a Constitutional Approach to Road Construction Damages in Partial Taking Cases". *University of Detroit Mercy Law Review*.

December 16, 2023. "Chandigarh: Owners flag concerns over partial acquisition of land for airport route". *Tribune India*

[4]July 09, 2019. "Namma Metro: Property owners in Kasturinagar seek full acquisition"*The Hindu.*

[5]See Russo (2014)

[6]Rikon, M., (2023). "The Partial Taking". *New York Law Journal*

(Portillo, 2019). This friction is reduced some extent when the anticipated benefits are to be enjoyed by acquisition-affected landowners themselves. The spread of benefits is, therefore, more equitable. The anticipation of the positive externality reduces her incentives to deter the realisation of the project, thus, reducing the intensity of holdout.

The literature on economic analysis of Eminent Domain is vast. Miceli & Segerson (2007) review it, focussing on the efficiency of takings decision (moral hazard on part of the government), definition and implication of "just" compensation, and the land use incentives of landowners who face a takings risk (moral hazard on part of the landowners). The issue of Eminent Domain takes a special character in cases of partial takings. The acquisition-affected property owner is also the one who experiences a project-induced positive externality on her remaining property. The prospect of such benefits reduces the reservation price of the acquisition-affected landowners offsetting the social and private costs of acquisition. Literature on eminent domain has not adequately analysed the implications of externalities on the problem of holdout or its impact on land use incentives of landowners. There are even fewer studies that formally examine the idiosyncrasies of partial takings.

In this paper, we propose an analytical framework that integrates the two and examines land use incentives of owners who make investment decisions under a threat of partial acquisition and in anticipation of spillover benefits. We find that land use incentives are significantly altered in such a setup. Externality generated from the project might even generate a surplus, which can be appropriated by the government while still maintaining incentives for efficient investments. Such mechanisms are being adopted in various contexts, where the surplus generated by infrastructure projects—often reflected in rising property values—is utilized to help fund the projects or offset development costs. One prominent example is Israel's "Metro Law," which is designed to secure a substantial portion of the funding for the planned metro system through appropriating a percentage of anticipated increases in property values near future metro stations. Specifically, Section 19 of the law imposes an "improvement" tax on property owners within an 800-meter radius of more than one hundred planned metro stations. This tax is applied upon the sale, construction, or redevelopment of properties in the affected area. Its primary purpose is to appropriate a portion of the projected rise in land values due to the proximity to new infrastructure, thereby redirecting a share of the generated surplus into the funding of the metro project. [7]

[7] January 13, 2023. "Developers protest a planned 75% tax on future property values to help fund metro".

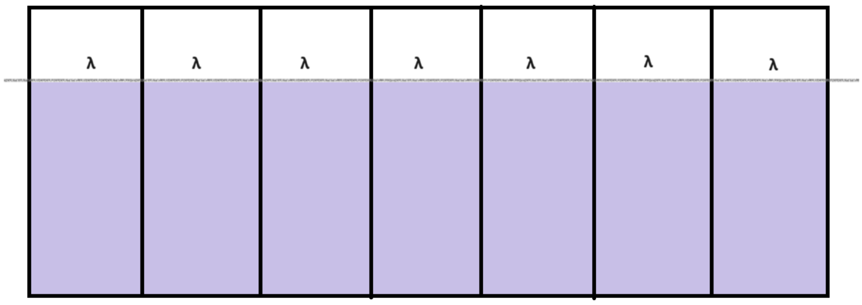
The peculiarities of partial takings and the associated externalities warrants a closer study. We build on the framework developed in Singh and Schafer (2018) and allow for the probability/risk of taking to depend on land-use. We examine the investment choices of landowners who face a possible partial acquisition of their land for a project. This project, once implemented, is expected to create a positive externality for the remaining portion of the land they retain. Landowners are uncertain of future conditions and investment decisions are made under a threat of partial taking, coupled with the anticipation of a positive externality.

Literature defines full compensation as the amount that equates private loss to zero. Usually (in the absence of externalities), this is the "full current market value" of the property acquired (Blume, Rubinfeld, & Shapiro, 1984). Miceli (2011) finds that when the takings decision does not depend on investment levels, full compensation can achieve efficiency of investments. Once project decision depends on the land-use, Singh & Schafer, (2018) find that under full compensation agents invest more than what is efficient. Once project-induced externalities are factored in, we can show that under certain conditions paying the "full current market value" of the portion acquired can reduce the distortions away from efficient levels. If compensation is calculated to achieve zero net loss for the property owner, the inefficiency of investments would be greater. If over-investment can hinder the realization of a project beneficial to the landowner, we find that in certain cases, a higher compensation can reduce moral hazard on her part.

In Section 2, we introduce a model featuring a benevolent government and private landowners whose parcels may be subject to partial takings. This section also outlines the government's decision-making process regarding takings. Section 3 explores the first-best solution. Section 4 examines various compensation schemes and their effects on landowners' investment decisions. In Section 5, we assume that the landowner values the project itself, independent of any externalities, and analyze how this influences their investment choices. Finally, Section 6 concludes.

Times of Israel. Acessed from link

January, 2023. "Petition against the metro law: "The apartment buyers will be forced to finance the huge project out of their own pockets", Ynet. Accessed from link



2 Basics of the Model

We consider a collection of n contiguous parcels of land in a neighbourhood owned by separate individuals. The neighbourhood might become the target of expropriation by the state for the development of a *linear* project, for example, the extension of a highway, metro line or an irrigation canal. For the construction of such a project, the state would require specific, contiguous portions of land from all parcels in the neighbourhood. Figure 1 showcases a simplified version of the scenario. In such a setup, holdout by owners precludes purchase of land through voluntary transactions. The conditions justify the use of Eminent Domain by the State.

Index i is used for an individual owner and her property $(i = 1, 2, ..., n)$. A landowner can make investments on her plot, denoted by x_i. All investments are sunk costs with no alternative use. Investments on the property increases its value. Let v_i denote the value of owner i's property. v_i is a function of the investment level x_i made by the owner i; $v_i = v_i(x_i)$. $v(.)$ is concave and increasing, $v'(.) > 0$ and $v''(.) < 0$. For simplicity, we assume the payoff function v_i to be same across the owners, $v_i(x_i) = v(x_i)$ for all $i = 1, 2, ..., n$. Further, we assume $v(0) > 0$; land is intrinsically valuable (even if no investments are made on it). Each owner makes investments on her property, x_i. Since the payoff function is concave, it is plausible to assume that no agent invests infinitely. We assume, $x_i \in [0, T] \subset \mathbb{R}$, where T is a large, positive real number. For simplicity, that investments are uniformly distributed across the property. [8] .

[8]Therefore, k portion of the parcel is valued at $kv(x_i)$, This assumption is made for the interest of simplicity and does not compromise on the generality of results.

At $t = 0$, the possible linear project, for which land might be acquired, and its expected size is made known. Owners choose investment levels at $t = 1$. At $t = 2$, the government takes a decision about the partial taking. All investments are sunk costs with no alternate use or value in secondary markets. If the government acquires λ portion of her property, the owner can enjoy no part of it. In such a case, $\lambda \sum_{i=1}^{n} v(x_i)$ is the direct social cost of taking. Upon completion of the project, only $(1-\lambda)$ portion is available for her use, and is physically attached to the newly developed project. Development projects exude a positive externality on neighbouring land, leading to a surge in their value. We capture the magnitude of this positive externality with α. Originally valued at $(1-\lambda)v(x_i)$, after the development of the project, and subsequent hike in value of project-adjacent properties, we assume that the portion retained by the owner is valued at $\alpha(1-\lambda)v(x_i)$, where $\alpha > 1$ [9].

Acquisition of land for development projects are justified by the public purpose they serve —social benefits they generate. Let β^S denote the net social benefit from a project (netting all *non-land* related costs).[10] Benefits generated from a project depend on the general economic conditions prevailing at the time of its construction. For instance, higher growth rates would, in general, imply more beneficial projects (Singh and Schafer, 2018). We assume θ denotes the general economic conditions prevailing at the time when takings decision is made[11]. Further, it is plausible to assume that physically larger projects would generate more benefits. For instance, a six lane highway would, in general, be more beneficial than a single lane road. Social benefits from a project, β^S, is, therefore, a function of θ, the general economic conditions, and λ, the proportion of each parcel acquired[12] —$\beta^S = \beta^S(\theta, \lambda)$ such that $\frac{\partial \beta^S(.)}{\partial \theta} > 0$ and $\frac{\partial \beta^S(.)}{\partial \lambda} > 0$.

At $t = 1$, when owners decide on the investment levels, θ is not known. Formally, at $t = 1$ θ is a random variable. It is known that $\theta \in [\underline{\theta}, \bar{\theta}]$ is distributed with $F(\theta)$ as its distribution function. Owners choose investment levels to maximise their expected profits.

At $t = 2$, value of θ is realised and becomes observable to all. Given the amount of investments made on land and the state of nature, the government decides whether to acquire

[9] Our model can be extended to cases where projects generate neagtive externalities on adjacent properties, leading to a decrease in their value. In such cases, $\alpha < 1$

[10] In accordance with literature, we assume that takings-affected landowners do not enjoy any part of these benefits (Singh and Schafer, 2018).

[11] more generally, θ is the state of nature influencing social value of the project

[12] a measure of the expected size of the project

land.

2.1 Project Appeal and Efficiency of Takings

Let $\pi^S(\theta,\ \mathbf{x})$ denote the net social welfare from the project. It can be calculated as the sum of the social benefits it generates and the net change in landowners' welfare [13] .

$$\pi^S(\theta,\mathbf{x}) = \beta^S(\theta;\lambda) + \alpha(1-\lambda)\sum_{i=1}^{n} v(x_i) - \sum_{i=1}^{n} v(x_i)$$

where $\mathbf{x} = (x_1, x_2, ..., x_n)$ denotes the investment profile.

The takings decision is socially efficient and hence, is carried out by a benevolent government if and only if the act increases the social welfare.

At $t = 2$, depending on the state of nature and the investment profile, $\pi^S \lesseqgtr 0$. The social desirability of the project depends on the state of nature, as well as the investment decisions taken at $t = 1$.

At $t = 2$, the takings decision requires the government to compare net social benefits, $\beta^S(\theta;\lambda)$ to net private costs $1 - \alpha(1-\lambda)\sum_{i=1}^{n} v(x_i)$. Given the investment profile, the benevolent government will pursue the partial taking if and only if the realised state of nature is such that $\pi^S > 0$, that is,

$$\beta^S(\theta;\lambda) + \{\alpha(1-\lambda) - 1\}\sum_{i=1}^{n} v(x_i) > 0$$

People value proximity to development projects. This is evident from the fact that properties adjacent to projects like highways, subways, schools or parks fetch higher prices in the market. Development of such projects leads to a surge in neighbouring property values, magnitude of which is captured in our model with the parameter α. At the same time, people place varying levels of importance/value to such proximity and are willing to pay varying premiums depending on the project type. The degree of surge in property values is, therefore, dependent on the type of project that comes up in the neighbourhood. Some

[13] $\pi^S(\theta,\ \mathbf{x})$ can also be thought of as the net social gains from the project: social cost of taking —the value of the portion acquired, which is completely lost for the owner, deducted from the sum of landowners' gains and the social benefits from the project. That is $\pi^S(\theta,\mathbf{x}) = \beta^S(\theta;\lambda) + \{\alpha(1-\lambda) - (1-\lambda)\}\sum_{i=1}^{n} v(x_i) - \lambda\sum_{i=1}^{n} v(x_i)$

like large scale transportation projects, for example, inter-city expressways [14], extensions of subway lines[15], and airports[16] often result in drastic property value increases in their neighbourhood. Similarly, large scale redevelopment or urban renewal projects can dramatically increase the attractiveness and value of surrounding properties[17]. In such cases, the positive externality generated for project-adjacent properties is substantial. For acquisition-affected landowners, the hike in the value of their remaining parcel might be substantial enough to completely offset their private cost of taking. Such projects are *highly lucrative* for the landowners (leaving them strictly better off). Formally, we term the project highly lucrative if $\alpha \geq \frac{1}{1-\lambda}$, project-induced positive externality is substantial enough to completely offset private costs of taking. Value of the portion she retains post-taking, $\alpha(1-\lambda)v(x_i)$, is greater than the value of her parcel pre-taking, $v(x_i)$. In such a case, the net social welfare is positive, $\pi^S > 0$, irrespective of the investment profile $\mathbf{x}$ or the realised state of nature, θ. Taking is always socially efficient and is certainly carried out by a benevolent government.

Proximity to other infill development projects like parks and green spaces, retail centres, office buildings, or niche establishments like museums or galleries, is also valued by potential buyers, and can enhance the neighbourhood appeal [18]. However, their impact on property prices, though positive, is generally more limited compared to larger infrastructural developments. In particular, the externality generated by these projects on adjacent properties, though positive, is of a smaller magnitude. Such projects are *moderately lucrative* to the buyer, and positive externality generated from them cannot completely offset her private costs of acquisition. Formally, if $\alpha < \frac{1}{1-\lambda}$, the acquisition-affected landowner incurs a net loss and change in social welfare post-taking, $\pi^S(\theta,x) \lesseqqgtr 0$.

[14]See Yen et. al. (2018)

August 26, 2024. *Housing prices up 83% along Dwarka Expressway; may rise further: Experts*. The Business Standard. Accessed from link

August 2024. *Delhi-Mumbai Expressway: A game changer for home buyers and investors* The Times of India. Accessed from link

[15]See Cervero & Duncan (2002), Bae et. al (2003)

February 26, 2024. *Impact of metro expansion on commercial property prices in Delhi-NCR*. The Financial Express. Accessed from link

[16]April 26, 2024.*Noida International Airport Boosts Real Estate Rates on Yamuna Expressway* The Business Standard. Accessed from link

[17]See Weicher, J. C., & Zeibst, R. H. (1973), Liang & Chen (2017)

[18]See Anderson & West (2006), Pivo & Fisher (2011), DiPasquale & Wheaton (1996)

Taking is socially desirable if and only if social benefits that it generates outweighs private costs of taking. Social desirability of taking depends on the state of nature at $t = 2$ and on the level of investments made. At $t = 2$, given investment profile $x = (x_1, x_2, ..., x_n)$, the government compares $\beta^S(\theta;\lambda)$ to the net private costs of taking, that is, $(1 - \alpha(1 - \lambda))\sum_{i=1}^{n} v(x_i)$. For projects that are moderately lucrative for the landowners, a benevolent government would carry out partial taking if and only if the state of nature θ is such that

$$\beta^S(\theta;\lambda) > (1 - \alpha(1 - \lambda))\sum_{i=1}^{n} v(x_i)$$

For moderately lucrative projects, takings decision is dependent on the realised state of nature at $t = 2$, and on the level of investments made on land. At $t = 1$, landowners take investment decisions under the threat of a partial taking and in anticipation of positive externality. They choose investment levels to maximise their expected gains. Probability of takings depends on investments made by owners. A taking occurs if and only if $\beta^S(\theta;\lambda) > (1 - \alpha(1 - \lambda))\sum_{i=1}^{n} v(x_i)$. Consider an increase in investment by some owner i. An increase in x_i, leads to an increase in $v(x_i)$ which in turn increases the opportunity cost of takings (which is equal to net private costs in our model). As the right hand side of the inequality goes up, the likelihood that taking would still be socially desirable decreases.

Given the size of the project, λ, and the externality it generates, α[19]; we assume $\hat{\theta}(x;\lambda,\alpha)$ equates net social benefits to net private costs, that is, equates the two sides of the inequality. Since social benefits, $\beta^S(\theta;\lambda)$ increase with bettering economic conditions, for values of θ larger than $\hat{\theta}$, benefits generated from the project would outweigh the opportunity costs of takings. Given the amount of investments made on land, takings is socially desirable if and only if the realised state of nature θ is larger than the cut off point of $\hat{\theta}$. A benevolent government exercises eminent domain if and only if $\theta \in (\hat{\theta}(x), \bar{\theta}]$. If some owner i increases her investments, opportunity costs of taking increases and the range of θ for which taking is socially efficient shrinks. In particular, the probability of taking is a decreasing function investments. The probability that taking is socially desirable can be expressed in terms of the distribution function of the random variable θ. That is, the probability that taking is socially desirable is $1 - F(\hat{\theta}(\mathbf{x}))$, where $\mathbf{x} = (x_1, x_2, ..., x_n)$. Going forward, we express it as a function of $(x_1, x_2, ..., x_n)$. The probability taking is socially desirable is $1 - F(x_1, x_2, ..., x_n)$

[19]We assume that α is exogneously given and is known to all. α can also be thought of as a function of θ. However, that does not qualitatively change our findings since $\hat{\theta}$ is already a function of α and λ

such that $\frac{\partial F(.)}{\partial x_i} > 0$.

3 The First-Best Solution

We start with the first-best solution for which we assume the landowners and the government take decisions as perfect agents of common good akin to a social planner.

3.1 Moderately Lucrative Projects

We start with projects that are moderately lucrative for the landowners and generate limited amount of positive externality on project-adjacent properties. Formally, we first consider the case where $\alpha < \frac{1}{1-\lambda}$. The takings decision is dependent on the amount of investments made at $t = 1$, and the realised state of nature at $t = 2$. Since taking is uncertain in such a case, at $t = 1$, the social planner chooses the investment level to maximise the expected social welfare, that is, Expected Gains to the Owners + Expected Social Gains from the Project - Sunk Costs of Investments. For an investment profile, $(x_1, x_2, ..., x_n)$ this can be written as:

$$F(x)\sum_{i=1}^{n} v(x_i) + (1 - F(x))\{B + \alpha(1-\lambda)\sum_{i=1}^{n} v(x_i)\} - \sum_{i=1}^{n} x_i$$

where,

$$B = E\left[\beta^S(\theta,\lambda)\middle|\beta^S(\theta,\lambda) > [1-\alpha(1-\lambda)]\sum_{i=1}^{n} v(x_i)\right]$$

B is the expected value of social benefits from takings conditional on takings being socially viable. The social planner will choose level of investments at $t = 1$ to maximise the above expression. Assuming concavity in x, the optimisation problem has a unique interior solution. Given the homogeneity of land parcels, the optimal investment will be identical across agents, that is, $(x_1^*, x_2^*, ..., x_n^*) = (x^*, ..., x^*)$, where x^* uniquely solves the following first-order condition:

$$\left\{F(x_i, x_{-i}^*) + \alpha(1-\lambda)[1 - F(x_i, x_{-i}^*)]\right\} v'(x_i) - 1 = 0 \qquad \text{(FB(1))}$$

The first-best solution in the case where the project is moderately lucrative ($\alpha < \frac{1}{1-\lambda}$) is characterised by probabilistic takings: acquisition is carried out if and only if θ crosses the threshold of $\hat{\theta}(x)$.

3.2 Highly Lucrative Projects

Projects that highly lucrative to the landowners generate a large enough externality to completely offset the opportunity costs of taking. Formally, in cases where $\alpha \geq \frac{1}{1-\lambda}$, the change social welfare is positive regardless of the investments made and the realised state of nature. At $t = 2$, taking is always socially efficient and is certainly carried out by a benevolent government.

When takings are certain, the post-taking social welfare generated by the investment profile $(x_1, x_2, ..., x_n)$ can be written as:

$$\alpha(1-\lambda)\sum_{i=1}^{n} v(x_i) + \beta^S(\theta, \lambda) - \sum_{i=1}^{n} x_i$$

At $t = 1$, the social planner chooses levels of investment, $(x_1, x_2, ..., x_n)$, to maximise the above expression. Assuming concavity in x, the optimisation problem has a unique interior solution. Given the homogeneity of land parcels, the optimal investment will be identical across agents, that is, $(x_1^*, x_2^*, ..., x_n^*) = (x^*, ..., x^*)$. x^* uniquely solves the first-order condition,

$$\alpha(1-\lambda)v'(x_i) - 1 = 0 \tag{FB(2)}$$

The first-best level of investments, in the case where the project is highly lucrative ($\alpha \geq \frac{1}{1-\lambda}$), is increasing in the magnitude of positive externality generated on the left-over parcel, α.

4 Cases of Compensation

Most democratic constitutions recognize the natural right of a person to be compensated for any loss or harm done and hence, mandate that a just compensation be paid for the public acquisition of private property. The quantum of this just compensation, justification and efficiency of takings have been topics of intense debate (Somin, 2015; Singh, 2012). Compensation awarded depends on existing land use, that is, on the amount of investment made on the parcel. Literature on the economic analysis of Eminent Domain has looked at the problem of moral hazard on the part of landowners whose investments are sunk costs and whose land faces possible expropriation. Land-use dependent compensation leads landowners to invest more than what is efficient in an attempt to solicit a higher compensation (Blume, Rubinfeld & Shapiro, 1984, Miceli & Segerson, 2007, Singh & Schaefer, 2018). Turnbull (2002) looks at the impact of a *threat* of regulatory takings on investment decisions made by landowners. They find that introduction of uncertainty in property rights due to a threat of taking (whether or not it actually occurs) causes agents to invest inefficiently.

We extend this discussion to our analysis. The neighbourhood faces a positive probability of becoming a target of partial acquisition by the state. The possible project is a linear one and, once developed, generates positive externality for adjacent properties. We study the problem of moral hazard on part of landowners who face a threat of partial takings of their properties and anticipate project-induced externalities on the portion of land not taken. The probability of takings is influenced by the level of investment made by the landowners. Project-induced externalities may generate a surplus. We investigate how the problem of moral hazard manifests differently depending on the compensation scheme employed and how calculation of the compensation adjusts to the peculiarities of partial takings.

4.1 The Offsetting Principle

The issue of compensation takes a special character in case of partial takings. The project on the acquired part generates a positive externality for the rest of the property. The acquisition-affected property owner loses a portion of her property while the rest hikes up in value. The quantum of compensation in such cases is usually calculated as the difference between the market value before and after the taking, which accounts for severance damages, if any (Palmore, 1967). If incidental benefits exist, under such a rule, they offset the compensation award.

The start of the offsetting principle can be chalked back to the early nineteenth century, to the "Railway Boom" in the U.S. The Pacific Railroad Acts of 1862 offered government incentives to development of the nation's rail line [20]. Large tracts of land were to be acquired and huge amount of compensation was to be paid. It is at this point that courts allowed for compensation to offset-ed by *all* benefits generated from the rail lines - that land acquired, as New York Supreme Court suggested, "could be entirely compensated in benefits". Compensation awards as low as $1 were paid to property owners before courts took cognisance and discussed creating a distinction between special and general benefits - benefits that can

[20]Landmark Acts", United States Senate, Retrieved from link

and cannot offset the compensation award[21].

A few jurisdictions draw such a distinction and allow for certain benefits to offset the compensation (Russo, 2014, Bell & Parchomovsky, 2017). General benefits are those which the landowner shares in common with the public. It is the “public purpose” which justifies the use of Eminent Domain. In our model, we capture it in the term β^S. What is called positive externalities in Economics, Law literature terms it “special benefits”. Special benefits are those “resulting from a public work which enhance the value of the land not taken because of their advantageous relation to the improvement” (Palmore, 1967). These are incidental spillovers to be enjoyed exclusively by the landowners. α captures the magnitude of the "special benefits" generated for landowners in our model.

Offsetting Principle Under Uncertainty

We first deal with projects that are moderately lucrative for the landowners. When positive externality generated by a project on the adjacent properties is limited, $\alpha < \frac{1}{1-\lambda}$, taking is uncertain and depends on the amount of investments made on land and the general economic conditions at $t = 2$. Offsetting principle allows for the "special benefits" to offset the compensation award. While the owner is compensated for the portion acquired, the surplus generated on the remaining property, due to project-induced positive externalities, is deducted from the compensation amount. Therefore, compensation would be $c_i = \lambda v(x_i) - \{\alpha(1-\lambda)v(x_i) - (1-\lambda)v(x_i)\} = v(x_i) - \alpha(1-\lambda)v(x_i)$ for all $i = 1, 2, ..., n$. Compensation calculated in such a way restores the landowner to her pre-takings level of utility[22]. This means the owner’s ex post payoff would be $v(x_i)$ regardless of whether the government carries out the partial takings.

The owner chooses her investment levels, x_i to maximise her post-compensation payoff minus the sunk costs of investments: $\{v(x_i) - x_i\}$. The privately optimum investment level will solve the following first order condition:

$$v'(x_i) = 1 \qquad \text{(FOC(OP))}$$

Let x_i^{OP} be the solution. Due to the assumption of homogeneity, the level of investments

[21] Russo, L., (2014)."From Railroads to Sand Dunes : An Examination of Offsetting Doctrine in Partial Takings". *Fordham Law Review, Vol. 83, Issue 3.*

[22] Similar to the differential method of compensation

will be the same across landowners, $x_i^{\text{OP}} = x^{\text{OP}}$. Comparison with the first-best first order condition (FB(1)) shows that $x^{\text{OP}} > x^*$.

Investment levels chosen will be greater than the first-best levels of investment. When the project is moderately lucrative and generates limited positive externality, takings are uncertain. Surplus generated is appropriated by offsetting the compensation award. This reduces the compensation amount but does not mitigate the issue of moral hazard. Landowners invest more than the efficient levels.

Proposition 1: *If $\alpha < \frac{1}{1-\lambda}$ (takings are uncertain), under the offsetting principle, landowners receive a compensation of $c_i(x_i) = v(x_i) - \alpha(1-\lambda)v(x_i)$. At this reduced amount, all surplus generated is appropriated, however, investments made, x^{OP} exceed the first-best levels of x^*. Landowners invest beyond efficient levels, the problem of moral hazard remains.*

When takings are uncertain (project is moderately lucrative and generates limited positive externalities), under the offsetting principle, any surplus generated by the project is appropriated, reducing the compensation award. However, this does not mitigate the issue of moral hazard. Landowners tend to invest beyond efficient levels, and the investment chosen will surpass the first-best investment levels.

Highly Lucrative Projects: Appropriation of Surplus

Projects that highly lucrative to the landowners generate a large enough externality to completely offset their private costs of taking. Formally, in cases where $\alpha \geq \frac{1}{1-\lambda}$, the hike in value of the portion of the parcel she retains exceeds her private cost of taking, that is, the value of the part that was acquired[23]. Consequently, the positive externality on adjacent properties completely offsets the opportunity costs of takings. Law literature terms such project-induced externalities which manifest in the increased value of the remaining land, "special benefits". The change social welfare is positive regardless of the investments made and the realised state of nature. At $t = 2$, taking is always socially efficient and is certainly carried out by a benevolent government.

[23] $\{\alpha(1-\lambda) - (1-\lambda)\}v(x_i) > \lambda v(x_i)$

The project-induced externality generates a surplus in such a case. The government can appropriate it by demanding a payment in lieu of the "special benefits", exclusively enjoyed by the acquisition-affected landowners. The appropriation of the surplus through such transfers allows for the internalisation of the externality and provides scope for additional funding of the development project. Such mechanisms are already being explored in various contexts, where the surplus generated by infrastructure projects, reflected in increased property values, is used to fund the projects or cover the costs of development. The most prominent example is that of the "Metro Law" of Israel, which is designed to secure a significant portion of the funding for the planned metro system from the anticipated increase in property values near future metro stations. Specifically, Section 19 of this law introduces an "improvement" tax on property owners within an 800-meter radius of over one hundred planned metro stations. Such a tax is imposed on the sale, construction, or urban renewal of properties within this designated area. Its primary purpose is to appropriate a share of the expected rise in land values due to the proximity to the new infrastructure, thereby channeling a portion of the generated surplus back into the funding of the metro project. This internalises the externality generated —those who benefit from the project's positive externalities contribute to its costs; and provides additional funding of such projects [24].

The government may want to appropriate some (or all) of the surplus generated. A transfer t_i is demanded from ith owner, for all $i = 1,2,3...,n$. Such transfers can be dependent on the level of investments made on land or be lump-sum in nature.

Investment-dependent Transfers

We first consider the case transfers are dependent on the investment level, $t_i = t(x_i)$ for all $i = 1,2,3...,n$. We suppose that the government appropriates γ fraction of the surplus generated from each landowner, that is, $t_i = \gamma\{\alpha(1-\lambda)v(x_i) - v(x_i)\}$ $(0 < \gamma \leq 1)$.

$\gamma = 1$ is the case where the government extracts all the surplus generated. In such a case, the owner is left with $v(x_i)$ regardless of whether eminent domain gets exercised.

[24]January 13, 2023. "Developers protest a planned 75% tax on future property values to help fund metro". Times of Israel. Acessed from link

January, 2023. "Petition against the metro law: "The apartment buyers will be forced to finance the huge project out of their own pockets", Ynet. Accessed from link

At $t = 2$, taking is always socially efficient and is certainly carried out by a benevolent government. At $t = 1$, the agent chooses level of investments, x_i, to maximise $\alpha(1-\lambda)v(x_i) - t(x_i) - x_i$ where $t(x_i) = \gamma\{\alpha(1-\lambda)v(x_i) - v(x_i)\}$.

The privately optimum investment level is the solution to the following first-order condition:

$$v'(x_i)\{\alpha(1-\lambda)(1-\gamma)+\gamma\} = 1$$

Let x_i^{t} be the solution. Clearly, the level of investment will be the same across owners and will be a function of γ, $x_i^t = x^t(\gamma)$, for all $i = 1,2,3...n$. Comparing the above first-order condition to equation FB(2), we get that $x^t(\gamma) < x^*$ for all $0 < \gamma \leq 1$. The individually optimal level of investment would be smaller than the first-best levels. Further, in the Appendix we show that $x^{\mathrm{t}}(\gamma)$ is decreasing is γ.

If the transfers are investment dependent, the individual optimal level of investments would be inefficiently low. As the fraction of the surplus that government tries to appropriate increases, investment moves further away from the efficient levels.

Proposition 2: *If $\alpha \geq \frac{1}{1-\lambda}$, then the landowner is strictly better off due to takings, as the post-taking value of her land exceeds its original value: $\alpha(1-\lambda)v(x_i) > v(x_i)$. If a payment is demanded in lieu of the special benefits and if such transfers are investment-dependent then individually optimal level of investment will be inefficiently low. If $t_i = t_i(x_i) = \gamma\{\alpha(1-\lambda)v(x_i) - v(x_i)\}$, where $0 \leq \gamma \leq 1$ is the the fraction of surplus appropriated, then $x^t(\gamma) < x^*$. Furthermore, $\frac{\partial x^t}{\partial \gamma} > 0$, investments are decreasing in the fraction of the surplus appropriated.*

When positive externality generated from the project is large enough, a payment can be demand in lieu of the special benefits. If such transfers are dependent on investment levels, the individually optimal level of investment will be inefficiently low. Furthermore, as the fraction of the surplus that the government seeks to appropriate increases, the level of investment deviates further from the efficient levels.

Lump-sum Transfers

We consider the case where the government collects a lump-sum transfer to appropriate the surplus generated. Suppose t_i is the payment that agent i has to make in lieu of the special benefits that she enjoys. At $t = 1$, the owners chooses level of investments, x_i to maximise $\alpha(1-\lambda)v(x_i) - t_i - x_i$. Individually optimal investment level solves the first order condition:

$$v'(x_i)\{1 - \alpha(1-\lambda)\} - 1 = 0$$

Let x_i^{t} solve the above condition. Comparing the above expression to the first order condition for the first-best (FB(2)), we get that $x_i^{\mathrm{t}} = x^*$. A lump-sum transfer, of any amount, leads to efficient levels of investment. The government can appropriate all surplus and still maintain incentives for efficient investments.

Proposition 3: *If $\alpha > \frac{1}{1-\lambda}$, then the landowner is strictly better off due to takings, as the post-taking value of her land exceeds its original value: $\alpha(1-\lambda)v(x_i) > v(x_i)$. If a payment is demanded in lieu of the special benefits and if such transfers are lump-sum in nature, then individually optimal level of investments equals the first-best level, $x_i^t = x^*$. Lump-sum transfers provide scope for external funding of the project while still maintaining incentives for efficient investments.*

When positive externality generated from the project is large enough, a payment can be demand in lieu of the special benefits. If such payments are lump-sum in nature, then any amount can induce efficiency of investments. Offsetting Principle in such a case, allows for appropriation of surplus, provides scope for external funding of the project while still maintaining incentives for efficient investments.

A special case of transfers independent of investment is the zero compensation case. When $t_i = 0$, individually optimal level of investment is efficient. In this case, no payment is collected for the special benefits the project generates and no compensation is paid for the portion of the land acquired.

Proposition 4: *A zero compensation, $t_i = 0$, that is, no payment is collected for the special benefits the project generates and no compensation is paid for the portion of the land ac-*

quired, leads to efficiency of investments.

A lump-sum transfer of any amount can lead to efficient investments. It is reasonable to expect that the transfer, t_i, is set so that the landowner is left with at least the same level of utility as she would have had, assuming first-best investment levels, if no taking had occurred. This condition is expressed as:

$$\alpha(1-\lambda)v(x^*) - t_i - x^* \geq v(x^*) - x^*$$

Thus, the maximum amount the government can charge for the special benefits generated by the project, while ensuring the landowner is no worse off, is given by:

$$t_i = \{\alpha(1-\lambda) - 1\}v(x^*)$$

At this transfer level, the government extracts the entire surplus created by the project while leaving the landowner with the same level of utility as if the taking had not occurred and she had made the efficient investment, x^*.

We conclude the analysis on the offsetting principle by noting that in situations where the project drastically increases the value of adjacent properties, as seen in the cases of subways, highways or airports, the offsetting principle provides scope for external funding of the projects by mandating contribution from landowners who benefits from it. If payments are independent of investments made on land, incentives for efficient investments can be preserved. If transfers are a function of level of investment then agents would invest inefficiently low to reduce the payment amount. For other projects with less drastic impact on neighbouring properties, the offsetting principle reduces the compensation amount but does not mitigate moral hazard. They invest more than what is efficient.

4.2 Full compensation

In this section, we consider the case wherein the acquisition affected landowner is fully compensated for the portion acquired. The positive externality generated for the rest of the property is an unaccounted benefit which doe not influence compensation. In such a case she is compensated $c_i(x_i) = \lambda v(x_i)$, equalling the value of the portion taken.

The case where projects are highly lucrative to owners and generate a massive hike in value for project adjacent properties, the full compensation case leads to predictable investment behaviour. Fully compensated and strictly better off post-taking, agents invest more than what is efficient to drive out their compensation amount. Formally, if $\alpha > \frac{1}{1-\lambda}$, takings are always socially efficient and are certainly carried out. At $t = 1$, investments are taken to maximise $\alpha(1-\lambda)v(x_i) + c_i(x_i) - x_i$. Individually optimal level of investment solves,

$$\{\alpha(1-\lambda) + \lambda\}v'(x_i) = 1$$

Comparing the above to the first-order condition of first-best (FB(2)), we get that investments under full compensation are more than the efficient levels.

For projects that generate limited externality, ones that moderately lucrative, takings are uncertain and depends on state of nature and level of investments made. If a compensation of $c_i = \lambda v(x_i)$ is paid to the landowners, takings leave them strictly better off. Their post taking payoff, $\alpha(1-\lambda)v(x_i) + c_i(x_i)$ is strictly larger than the value of their land before taking, $v(x_i)$. The positive externality generated is an added, unaccounted benefit.
At $t = 2$, takings decision is made depending on the state of nature and the level of investments made on land. The chances that takings would be carried out is decreasing in level of investments. At $t = 1$, the property owners choose the level of investments to maximise their expected payoffs, knowing that construction of the project under such a compensation scheme would leave them strictly better off and excess investments would dissuade the government from carrying it out. x_i is chosen to maximise

$$F(\hat{\theta}(x_i, x_{-i}))v(x_i) + [1 - F(\hat{\theta}(x_i, x_{-i}))]\{\alpha(1-\lambda)v(x_i) + \lambda v(x_i)\} - x_i$$

In the Appendix we show that the Nash equilibrium exists such a game exists and solves the first-order condition:

$$v'(x_i)\{F(\hat{\theta}(x_i, x_{-i}^{\text{FC}})) + [1 - F(\hat{\theta}(x_i, x_{-i}^{\text{FC}}))]\delta\} = 1 + (\delta - 1)F'(\hat{\theta}(x_i, x_{-i}^{\text{FC}}))v(x_i)$$

where $\delta = \alpha(1-\lambda)+\lambda > 1$.

Let x_i^{FC} solve the above expression. We draw a comparison between investments under full compensation to those made when positive externality offsets the compensation award. Note that full compensation of $\lambda v(x_i)$ is larger than the one paid under the offsetting principle $\alpha(1-\lambda)v(x_i) - v(x_i)$.

In the Appendix we show, that under certain conditions, allowing the externality to be an added, accounted benefit dissuades the owners from making excessive investments. In particular if takings decision is highly sensitive to individual investments, investments made under full compensation would be smaller than the ones made when offsetting principle is applied. The probability that takings are socially efficient and hence, are carried out is $(1-F(x))$. $F'(.) = \frac{\partial F(.)}{\partial x_i}$ is a measure of how sensitive it is to individual investment levels. If $F'(.)$ is large, in particular, if $F'() > \frac{1}{v(0)}$[25], an increase in agent $i's$ investment, significantly reduces chances of takings being carried out. Under full compensation, takings leave the landowners strictly better off. They are fully compensated for the portion acquired, and benefit from the development carried out on it. The rest of the property hikes up in value. The prospect of such benefits dissuades her from making excessive investments. On the other hand, if these benefits reduce the compensation amount, as is the case with offsetting principle, the incentive to promote the project is removed. In such cases, $x^{FC} < x^{OP}$

Proposition 5: *If takings decision is highly sensitive to individual level of investments, specifically, if* $\frac{\partial F(.)}{\partial x_i} > \frac{1}{v(0)}$, *and agents are compensated with the full market value of the property acquired, i.e.,* $c_i(x_i) = \lambda v(x_i)$, *the level of investment will be lower than those made under the offsetting principle where compensation is reduced to* $v(x_i) - \alpha(1-\lambda)v(x_i)$. $x^{FC} < x^{OP}$. *A larger compensation can reduce distortions away from efficient levels of investment.*

If takings decision is highly sensitive to individual level of investments, $F'(.)$ is large, investments made when agents are fully compensated for the portion acquired will be smaller than those made under offsetting principle. A larger compensation can, under certain conditions, reduce distortions away from efficient levels of investment.

[25] $v(0)$ is the intrinsic value of land. $v(0) > 0$, land is valuable even if no investments are made on it

On the other hand, consider a case where individual investment decisions have no bearing on the government's decision to exercise ED. This could be because the government's objectives are different from those of a social planner. The probability of taking, $F(.)$, depends on entirely other considerations the government has and does not depend on investments made ($F'(.) = \frac{\partial F(.)}{\partial x_i}$). In this case the owners can over-invest without dissuading the government from exercising eminent domain. For a larger amount of compensation being paid, under full compensation, they invest more than they would have under the offsetting principle and also more than the efficient levels.

5 Factoring in the General Benefits from the Project

Conventionally, the general benefits created from a project are not factored into landowner's investment decisions. In case of total takings, she is completely displaced from her property and, therefore, cannot enjoy the project. In the case of partial takings, the acquisition-affected landowner retains a part of the parcel and remains in the vicinity of the project. She remains on land, benefits from the positive externality that the project generates and might even the enjoy the project itself. For instance, the presence of a subway station in close proximity could significantly increase the value of her property while also offering enhanced travel convenience.

We suppose that the project is rivalrous, more the number of beneficiaries, lesser will each benefit from it. Let M $(M \geq n)$ be number of beneficiaries. Therefore, each landowner enjoys $\frac{1}{M}\beta^S(\theta, \lambda)$. This captures the idea that even though proximity to the subway station benefits the owner, the benefit drawn would smaller if the station becomes crowded, or if that benefit is to be shared among many.

We consider the case where the project is moderately lucrative, generates limited externality. Takings are uncertain and the decision depends on the amount of investments made on land and the state of nature at $t = 2$. It is interesting to see how investment decisions change if she has a reason to value the project itself. The chances of project's realisation decreases as her investment increases.

To see the impact of general benefits on her decisions, we suppose the offsetting principle is applied. She is compensated for the portion acquired and the surplus generated on the remaining property, due to project-induced positive externalities, is deducted from the compensation amount. A landowner is paid a compensation of $c_i = v(x_i) - \alpha(1-\lambda)v(x_i)$. At $t = 1$, the landowners choose the level of investments so as to maximise their expected benefits. If partial takings are carried out, and the project is undertaken, they enjoy $\frac{1}{M}$th part of $\beta^S(\theta,\lambda)$. Therefore, they choose x_i to maximise,

$$\pi_i = v(x_i) + [1 - F(\hat{\theta}(x_i, x_{-i}))]\frac{1}{M}\beta^S(\theta,\lambda) - x_i$$

The game is supermodular and hence, a Nash equilibrium exists.[26] x_i^{GB} solves the first order condition:

$$v'(x_i) - \frac{\partial F(x_i, x_{-i}^{\text{GB}})}{\partial x_i}\frac{1}{M}\beta^S(.) - 1 = 0$$

Comparing this to the first order condition in case of offsetting principle, it can be seen that investments made when general benefits are factored in to agent's decision making are smaller. Distortions away from the efficient levels will be smaller if general benefits are factored into agent's investment decisions. There is something to gain from the project and the probability that it will be undertaken reduces in the level of investments. If the undertaken project, in itself also benefits the acquisition-affected landowner, that is, if the landowner has reason to value the project itself (irrespective of the spill-over effects) then the incentive to over-invest reduces.

Proposition 6: *If general benefits, $\beta^S(\theta,\lambda)$, is taken into account in landowners' investment decisions then for the same compensation amount of $c_i(x_i) = \alpha(1-\lambda)v(x_i) - v(x_i)$, individually optimal level of investments would be smaller. Distortions from efficient investment levels are reduced when general benefits are taken into account.*

In this case, the landowner has something to gain from the project, and the probability of the project's realization decreases as investment levels increase. If the project itself benefits the acquisition-affected landowner—independent of any spillover effects—the incentive to over-invest reduces.

[26] $\frac{\partial^2 \pi_i}{\partial x_i \partial x_j} = -\frac{\partial^2 F(.)}{\partial x_j \partial x_i}\frac{1}{M}\beta^S(.) \geq 0$ and therefore the game is supermodular. $\frac{\partial^2 F(.)}{\partial x_j \partial x_i} = 0$ in the model. The rate at which probability of taking not being socially desirable changes with respect to ith agent's decisions is independent of jth agent's decisions.

6 Conclusion

The impact of development projects extends beyond their physical boundaries, generating externalities for neighboring properties. Existing literature has largely overlooked how these project-induced externalities affect holdout issues and the use of eminent domain. In certain scenarios, takings are partial and landowners retain a portion of their property, which experiences project-induced externalities. Partial takings are gaining traction, especially for linear development projects, such as highways and metro systems, and is attracting both policy and academic attention.

Despite the vast literature on eminent domain, the implications of externalities on the problem of holdout and its impact on the use of Eminent Domain remains relatively underexplored. There is a notable lack of formal analysis on the unique character of partial takings. This paper introduces an analytical framework to model and examine the impact of project-induced externalities on land use incentives within partial takings scenarios. Our findings indicate that land-use incentives are significantly altered. We find that if the spillover benefits are substantial, the government may collect a lump-sum payment and still encourage efficient investment decisions by landowners. However, if transfer payments are dependent on land use, landowners may invest less than what is efficient. Use of the offsetting principle reduces the project costs for the exchequer, however, it causes agents to invest inefficiently. Zero compensation: neither the partial asset acquired is compensated for nor payments for externality-induced benefits are collected; can achieve efficiency of investments. While the offsetting principle can reduce project costs for the government, it may lead to inefficient investments and does not fully address moral hazard issues. Under certain conditions, compensating the "full current market value" of the property can reduce distortions away from efficient levels. By contrast, compensation aimed at achieving zero net loss can exacerbate inefficiencies. Our analysis can be extended to cases where projects generated negative externalities on neighbouring properties.

Given the growing popularity of partial takings and their increasing traction in legal literature, a more nuanced economic analysis is warranted. As countries, such as Israel with its Metro Law, begin to tax properties neighboring development projects to fund such projects, a closer examination of the offsetting principle and its impact on land use incentives becomes imperative.

Appendix

Mathematical Appendix

A

We first introduce some formal notations. At $t = 2$, $\pi^S(\theta,\ \mathbf{x})$ denotes the change social welfare from the project. [27] .

$$\pi^S(\theta,\mathbf{x}) = \beta^S(\theta;\lambda) + \alpha(1-\lambda)\sum_{i=1}^{n} v(x_i) - \sum_{i=1}^{n} v(x_i)$$

where $\mathbf{x} = (x_1, x_2, ..., x_n)$ denotes the investment profile.
The takings decision is socially efficient and is carried out by a benevolent government if and only if $\pi^S(\theta,x) > 0$.

At $t = 2$, investments are already made on land. Given the investment profile x, the properties should be taken if and only if the state of nature θ is such that $\pi^S(\theta,x) > 0$, that is,

$$\beta^S(\theta;\lambda) + \{\alpha(1-\lambda) - 1\}\sum_{i=1}^{n} v(x_i) > 0$$

If $\alpha < \frac{1}{1-\lambda}$, at $t = 2$, depending on the state of nature and the investment profile, $\pi^S \lesseqgtr 0$. A taking occurs if and only if $\beta^S(\theta;\lambda) > (1-\alpha(1-\lambda))\sum_{i=1}^{n} v(x_i)$. Since $\beta^S(\theta;\lambda)$ is an increasing function of θ, the probability of an efficient taking can be expressed in terms of the distribution function for θ. Consider the equation,

$$\beta^S(\theta,\lambda) = (1-\alpha(1-\lambda))\sum_{i=1}^{n} v(x_i)$$

For a given investment profile x, let $\hat{\theta}(x)$ solve the above equation. At $\hat{\theta}(x)$ the change in social welfare due to the takings is 0. Since $\frac{\partial \beta^S(.)}{\partial \theta} > 0$, we have $\frac{\partial \pi^S(.)}{\partial \theta} > 0$. Therefore, for all $\theta > \hat{\theta}$, $\pi^S(\theta,x) > 0$. Given an investment profile, x, takings are socially efficient if and only if $\theta > \hat{\theta}(x)$. Therefore, probability that takings are socially efficient is $[1 - F(\hat{\theta}(x))]$. A benevolent government exercises eminent domain if and only if $\theta \in (\hat{\theta}(x), \bar{\theta}]$. Suppose,

[27] $\pi^S(\theta,\ \mathbf{x})$ can also be thought of as the net social gains from the project: social cost of taking —the value of the portion acquired, which is completely lost for the owner, deducted from the sum of landowners' gains and the social benefits from the project. That is $\pi^S(\theta,\mathbf{x}) = \beta^S(\theta;\lambda) + \{\alpha(1-\lambda) - (1-\lambda)\}\sum_{i=1}^{n} v(x_i) - \lambda\sum_{i=1}^{n} v(x_i)$

some agent i increases the investment made x_i made on her property. The net private costs of taking $((1-\alpha(1-\lambda))\sum_{i=1}^{n} v(x_i))$ increase. Since $\frac{\partial \beta^S(.)}{\partial \theta} > 0$ a higher $\hat{\theta}$ would mark the cutoff point or set $\pi^S = 0$. The range of states of nature for which taking is socially desirable shrinks as individual investments increase $(\frac{d\hat{\theta}(x;\lambda,\alpha)}{dx_i} > 0)$. The probability that taking is socially efficient and hence, carried out is decreasing in the amount of investments made.

The probability that taking is socially desirable is $1-F(\hat{\theta}(\mathbf{x}))$, where $\mathbf{x} = (x_1, x_2, ..., x_n)$. Going forward, we express it as a function of $(x_1, x_2, ..., x_n)$. The probability taking is socially desirable is $1-F(x_1, x_2, ..., x_n)$ such that $\frac{\partial F(.)}{\partial x_i} > 0$.

Now in the first-best scenario, at $t = 1$, socially optimal levels of individual investments x^* solve:

$$F(x)\sum_{i=1}^{n} v(x_i) + (1-F(x))\{B + \alpha(1-\lambda)\sum_{i=1}^{n} v(x_i)\} - \sum_{i=1}^{n} x_i$$

where,

$$B = E\left[\beta^S(\theta,\lambda)\middle|\beta^S(\theta,\lambda) > [1-\alpha(1-\lambda)]\sum_{i=1}^{n} v(x_i)\right]$$

which solves to

$$\max_{x_1,x_2,...,x_n} F(\hat{\theta}(x))\sum_{i=1}^{n} v(x_i) + \{1-F(\hat{\theta}(x))\}\alpha(1-\lambda)\sum_{i=1}^{n} v(x_i) + \int_{\hat{\theta}(x)}^{\bar{\theta}} \beta^S(\theta) f(\theta) d\theta - \sum_{i=1}^{n} x_i$$

Applying the Leibniz differentiation rule and replacing $\beta^S(\hat{\theta}(x)) = (1-\alpha(1-\lambda))\sum_{i=1}^{n} v(x_i)$, the first-order conditions reduce to:

$$\left[F(\hat{\theta}(x_i, x_{-i})) + \{1-F(\hat{\theta}(x_i, x_{-i}))\}\alpha(1-\lambda)\right] v'(x_i) = 1$$

Assuming concavity in x, the optimisation problem has a unique interior solution. Given homogeneity of land parcels, optimum investment choices would be identical across agents. Let $\mathbf{x}^* = (x_1^*, x_2^*, ..., x_n^*) = (x^*, x^*, ..., x^*)$ be the solution.
When $\alpha \geq \frac{1}{1-\lambda}$, the change social welfare is positive regardless of the investments made and the realised state of nature. At $t = 2$, taking is always socially efficient and is certainly carried out by a benevolent government.

When takings are certain, the post-taking social welfare generated by the investment profile $(x_1, x_2, ..., x_n)$ can be written as:

$$\alpha(1-\lambda)\sum_{i=1}^{n} v(x_i) + \beta^S(\theta,\lambda) - \sum_{i=1}^{n} x_i$$

At $t = 1$, the social planner chooses levels of investment, $(x_1, x_2, ..., x_n)$, to maximise the above expression. Assuming concavity in x, the optimisation problem has a unique interior solution. Given the homogeneity of land parcels, the optimal investment will be identical across agents, that is, $(x_1^*, x_2^*, ..., x_n^*) = (x^*, ..., x^*)$. x^* uniquely solves the first-order condition,

$$\alpha(1-\lambda)v'(x_i) - 1 = 0 \qquad \text{(FB(2))}$$

The first-best level of investments is increasing in α.

B

B.1 Proof of Proposition 1

When positive externality generated by a project on the adjacent properties is limited, $\alpha < \frac{1}{1-\lambda}$, taking is uncertain and depends on the amount of investments made on land and the general economic conditions at $t = 2$. Under Offsetting principle "special benefits" offset the compensation award. Compensation would be $c_i = \lambda v(x_i) - \{\alpha(1-\lambda)v(x_i) - (1-\lambda)v(x_i)\} = v(x_i) - \alpha(1-\lambda)v(x_i)$ for all $i = 1, 2, ..., n$.

The owner chooses her investment levels, x_i to maximise her post-compensation payoff minus the sunk costs of investments: $\{v(x_i) - x_i\}$. The privately optimum investment level will solve the following first order condition:

$$v'(x_i) = 1 \qquad \text{(FOC(OP))}$$

Let x_i^{OP} be the solution. Due to the assumption of homogeneity, the level of investments will be the same across landowners, $x_i^{\text{OP}} = x^{\text{OP}}$.

The first-best level of investments solve the first-order condition:

$$\left[F(\hat{\theta}(x_i, x_{-i})) + \{1 - F(\hat{\theta}(x_i, x_{-i}))\}\alpha(1-\lambda)\right]v'(x_i) = 1$$

Since $\alpha(1-\lambda) < 1$, $\{F(\hat{\theta}(x_i, x_{-i})) + \{1 - F(\hat{\theta}(x_i, x_{-i}))\}\alpha(1-\lambda)\} < 1$. $v''(x_i) < 0$ it implies that $x^{OP} > x^*$. Under uncertainty, the offsetting principle reduces the compensation award, but does not mitigate moral hazard on the part of the landowners.

B.2 Proof of Proposition 2

$t_i = t(x_i)$ for all $i = 1,2,3...,n$. We suppose that the government appropriates γ fraction of the surplus generated from each landowner, that is, $t_i = \gamma\{\alpha(1-\lambda)v(x_i) - v(x_i)\}$ $(0 < \gamma \leq 1)$.

At $t = 2$, taking is always socially efficient and is certainly carried out by a benevolent government. At $t = 1$, the agent chooses level of investments, x_i, to maximise $\alpha(1-\lambda)v(x_i) - t(x_i) - x_i$ where $t(x_i) = \gamma\{\alpha(1-\lambda)v(x_i) - v(x_i)\}$.

The privately optimum investment level is the solution to the following first-order condition:

$$v'(x_i)\{\alpha(1-\lambda)(1-\gamma)+\gamma\} = 1$$

This can be written as:

$$v'(x_i)\{\alpha(1-\lambda) - \gamma(\alpha(1-\lambda)-1)\} = 1$$

Let x_i^t be the solution. Clearly, the level of investment will be the same across owners and will be a function of γ, $x_i^t = x^t(\gamma)$, for all $i = 1,2,3...n$. The first-order condition for first-best levels of investment when $\alpha > \frac{1}{1-\lambda}$ is:

$$\{\alpha(1-\lambda)\}v'(x_i) = 1$$

Comparing the two, we get that $x^t(\gamma) < x^*$ for all $0 < \gamma \leq 1$.

Further, let $P(x) = \alpha(1-\lambda)v(x_i) - \gamma\{\alpha(1-\lambda)v(x_i) - v(x_i)\} - x_i$ be agent i's payoff. $\frac{\partial^2 P(x)}{\partial x_j \partial x_i} \geq 0$ for all $i, j = 1,2,...n$. That is, the game is supermodular, therefore, a Nash Equilibrium exists. $\frac{\partial^2 P(x)}{\partial \gamma \partial x_i} = -v'(x_i)\{\alpha(1-\lambda)-1\} < 0$. The game is supermodular and $\frac{\partial^2 P(x)}{\partial \gamma \partial x_i} < 0$, which implies that individually optimal level of investments will be decreasing in γ.

B.3 Proof of Proposition 5

We are consdering projects that generate limited externality, $\alpha < \frac{1}{1-\lambda}$. If a compensation of $c_i = \lambda v(x_i)$ is paid to the landowners, takings leave them strictly better off. Their post taking payoff, $\alpha(1-\lambda)v(x_i) + c_i(x_i)$ is strictly larger than the value of their land before taking, $v(x_i)$. The positive externality generated is an added, unaccounted benefit.

At $t = 1$, the property owners choose the level of investments to maximise their expected payoffs. x_i is chosen to maximise

$$F(\hat{\theta}(x_i,x_{-i}))v(x_i)+ [1-F(\hat{\theta}(x_i,x_{-i}))]\{\alpha(1-\lambda)v(x_i)+\lambda v(x_i)\}-x_i$$

Individually optimal level of investments solve the first-order condition:

$$v'(x_i)\{F(\hat{\theta}(x_i,x_{-i}))+[1-F(\hat{\theta}(x_i,x_{-i}))]\delta\} = 1+(\delta-1)F'(\hat{\theta}(x_i,x_{-i}))v(x_i)$$

where $\delta = \alpha(1-\lambda)+\lambda > 1$.

Comparing the above to the first-order condition for individually optimal level of investments under offsetting principle: $v'(x_i) = 1$

$$x_i^{OP} > x_i^{FC}$$
$$\longleftrightarrow \frac{1+(\delta-1)F'(\hat{\theta}(x_i,x_{-i}))v(x_i)}{\{F(\hat{\theta}(x_i,x_{-i}))+[1-F(\hat{\theta}(x_i,x_{-i}))]\delta\}} > 1$$
$$\longleftrightarrow F'(\hat{\theta}(x_i,x_{-i})) > \frac{\{F(\hat{\theta}(x_i,x_{-i}))+[1-F(\hat{\theta}(x_i,x_{-i}))]\delta\}-1}{(\delta-1)v(x_i)}$$

$$\longleftrightarrow F'(\hat{\theta}(x_i,x_{-i})) > \frac{\{[1-F(\hat{\theta}(x_i,x_{-i}))]\delta-[1-F(\hat{\theta}(x_i,x_{-i}))]\}-1}{(\delta-1)v(x_i)}$$

Since $\delta > 1$ this can be written as:

$$\longleftrightarrow F'(\hat{\theta}(x_i,x_{-i})) > \frac{[1-F(\hat{\theta}(x_i,x_{-i}))]}{v(x_i)}$$

Note that $[1-F(\hat{\theta}(x_i,x_{-i}))] < 1$ and $v(x_i) > v(0)$ where $v(0)$ is the intrinsic value of land even if no investments are made on it. The above expression can be simplified to

$$F'(\hat{\theta}(x_i,x_{-i})) > \frac{1}{v(0)} \longleftarrow x^{OP} > x^{FC}$$

We get that if $F'(.)$ is large enough, in particular, if $F'(\hat{\theta}(x_i,x_{-i})) > \frac{1}{v(0)}$, where $v(0)$ is the intrinsic value of land then $x_i^{OP} > x_i^{FC}$ that is, there's less investment when a compensation of $\lambda v(x_i)$ is paid than when a smaller compensation of $[1-\alpha(1-\lambda)]v(x_i)$ is made.

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