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A reflection on the trading of pollution rights via land use exchanges and controls: Coase Theorems, Coase's land use parable, and Schumpeterian innovations☆

Lawrence W.C. Lai[a,b,*], Frank Lorne[a,c], Stephen N.G. Davies[b]

[a] Ronald Coase Centre for Property Rights Research, University of Hong Kong, Hong Kong
[b] Department of Real Estate & Construction, University of Hong Kong, Hong Kong
[c] New York Institute of Technology-Vancouver, 1700-701W, Georgia St., Vancouver, B.C. V7Y 1K8, Canada

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ABSTRACT

This monograph attempts to connect various versions of the Coase Theorem to carbon trading as a means to help ameliorate global warming and manifests their relevance to designs of land-based environmental policies with reference to such established land use planning tools as zoning and the transfer of development rights. These land-based policies, which are in line with the received concept of "transfer of development rights", are demonstrably sustainable and they are easier to monitor physically than trading in greenhouse gas emissions. The discussion is in support of and articulates with the "land use, land-use change and forestry" (LULUCF) endeavours of the Kyoto Protocol and is timely, as global warming is a real environmental issue. The supposition that Coasian economics, under the spell of the false plan/market dichotomy in both the academic and the political arena, is inherently alien to sustainable development is wrong. The argument below involves four versions of Coase Theorem. Two were formulated by George Stigler based on Coase's "The Problem of Social Cost" (1960), a treatise against Arthur Pigou's concept of pollution. The remaining two are those that in *The Firm, the Market and the Law* Coase considered his actual theorems. The theorems are supportive of government planning rules including "transfer of development rights" (TDR) and land readjustment. Despite seeming to be restrictive quotas, they actually enable innovations that can promote sustainable development, as envisaged in Yu's Coasian-Schumpeterian model of creative destruction (Yu et al., 2000). Standard supply and demand graphs and examples are used to demonstrate the compatibility of our reasoning with standard neoclassical economic tools.

1. Introduction: zoning, taxation and trading pollution

Morgan (2018) described the dominant international and regional measures for tackling global climate change as a "techno-finance fix." While this fix now manifests itself mainly in the form of trading of "rights" to pollute, this monograph discusses what While (2008) called "policy commitment" and Cooke (2011) "eco-innovations". These are land-based approaches using key concepts such as the "transfer of development rights" (TDR) and "land readjustment", which are as old as modern town planning itself. Stressing new institutional design and technological innovations (Andersson & Moroni, 2014), the theoretical grounding of this article is radically traditional. It considers planning to be a *purposeful* present act for the good of people both today and in the future. "Spontaneity" in planning is possible, though that is an essentially path-dependent and constrained event rather than a purely accidental one.

In an era of rapid population and industrial growth, modern town planning emerged in the service of the state as a profession distinct from surveying, engineering and architecture. Its earliest concern was public health as a municipal scale (Burian & Edwards, 2002). Even before its interest expanded to encompass the vast rural hinterlands as country planning, its vision had been about the proper structuring of big human settlements. Today, in developed countries, what occasionally may hit news headlines drawing public attention are no longer stories about public planning of whole new or old big cities. Instead there are stories about specific, high value private *real estate projects*

☆ This paper is dedicated to the late Dr. Edward George Pryor, MBE, JP (1938-2018), who was responsible for the last rounds of strategic planning for colonial Hong Kong.

* Corresponding author at: Ronald Coase Centre for Property Rights Research, University of Hong Kong, Hong Kong.
E-mail addresses: wclai@hku.hk (L.W.C. Lai), florne@nyit.edu (F. Lorne), daiwaisi@hku.hk (S.N.G. Davies).

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inserted into existing urban cores or along their vague peripheries, having gone through or been delayed by lengthy and sometimes controversial planning approval procedures. In such a context any relationship between government planning and trans-national issues like global warming or oceanic pollution seems remote. A possible exception might be the many attempts that have been made locally by regulating use of water, use of fossil fuels etc. However, the very 'localness' here, with its implicit smallness of scale, seems remote from so planetary scale a challenge as 'global warming' and hence the connection seems seldom to be made. Carbon or pollution trading seems to be the only application of a market mechanism most people know about in relation to the issue.

This monograph argues, from the stance of Coasian economics, that government land use planning, as in its formative years, is not confined to *micro development control* of sites here and there but has a great potential to make a greater categorical contribution to the global environment. To begin our intellectual inquiry, there is a need to recollect first in this section the history of modern town planning in terms of zoning, taxation and trading pollution. This paves the way to an elaboration in Section 2 of the methodology of this monograph in terms of Coase's methodology; and in Section 3, the very important notion of Coasian bargaining in the Coasian tradition of inquiry into the market as an institution in Section 3. In that latter section, a contrast of this tradition that takes into account transaction costs with various forms of the Coase Theorem will be provided. This comparison is necessary to better position the main theoretical elements in this monograph, which are contained in Sections 4 and 5. The former offers a mode of Coasian exchange for achieving optimality in trading of rights generalizing Coase (1960) story of the conflict of interest between a cattle rancher and a crop farmer. Section 5 incorporates the factor of Schumpeterian innovations, which are considered important in help promoting sustainable development in this monograph. The reception of such innovations in the planning arena is depicted in Section 6, as the setting for a suggestion in Section 7 for further research into Coasian trading of greenhouse gases using conventional planning tools of zoning, i.e. transfer of development rights and land readjustment. Section 8 discusses various policy questions and the implications of the methods suggested for land use trading and its regulations. Section 9 recapitulates the rationale behind these methods as a way of freeing exchanges of rights/obligations regarding land properties from the confines of their spatial boundaries. The Conclusion, Section 10, then reviews the main arguments and implications of the monograph.

1.1. Zoning

As modern town planning had a strong public health foundation developed in the context of the urban squalor and rapid, uncontrolled growth of the Industrial Revolution, the approach taken by the government landuse planner was basically regulatory. If in retrospect extremely slowly, the planning was concretized in various forms of interventionist zoning that aimed at consolidating polluting uses in certain areas so their spillovers (externalities) on neighbours were confined. Zoning controls, as fiscal regulation of real property, were *spatial* in the sense that they had to be planimetrically represented on a zoning map. They were considered a viable, if not better, alternative to reliance on the common law to deal with public and private nuisance. A zone border may be imagined as a vertical screen, often reinforced by a buffer like a green belt, that shields one use from an incompatible use.

Note that zoning is not necessarily simply a method of government development control or regulation of development, which is the understanding of Coase (1960). It can well be a means by government to allocate initial property rights. (Lai, 1997; Webster & Lai, 2003). When zoning is defined generically as the *de jure* property boundary delineation by government (Lai, Davies, & Lorne, 2016), it is actually the foundation of the private property rights system for land resources, urban or rural.

1.2. Pigovian tax

Arthur Pigou's *The Economics of Welfare* (Pigou, 1921, 1932), the express target of Ronald Coase (1960), introduced taxation of the supplier in the product market as a means to tackle externalities and also as an extra-judicial solution. However, unlike zoning controls, this form of regulation is *a-spatial* in the sense that the direct object of control is a production unit or its level of output, not its location and surrounding physical context, which are taken as givens. There is thus no imaginary vertical screen actualized as a zone boundary, but a tax penalty that hits excessive market production wherever that may occur, and which Pigou argued caused an uncompensated loss to innocent third parties. The polluter in Pigou's articulation is a hypothetical factory[1] and the innocent parties those imaginary residents near the factory, who suffered from the aerial pollution by its smoke.[2] The economic interest of the parties to the market for the factory's products and that of the residents are in conflict. The former want production at a cost only of the actual primary and secondary factors of production employed. The latter wants the costs to include the externalities that impact on her/him.

1.3. Coasian exchange

Both zoning (in its narrow government development-control sense) and taxation of pollution, like litigation, involve government measures against the polluter, whose interest is deemed to be mutually exclusive to that of his victim. Coase (1960) introduced a revolutionary idea by inviting the policy maker to consider a win-win outcome in a scenario of pollution in a picturesque agricultural setting. He used an example, also hypothetical, of an apparently bilateral conflict of economic interest between a crop farmer[3] and a "cattle-raiser". Then he used numbers to demonstrate that an exchange of *de jure* interests, under some heroic conditions (notably zero cost of reaching an agreement and clearly delineated property rights, notably property boundaries), can internalise an externality, as a superior alternative to either litigation or Pigovian taxation. In place of a judge's verdict after a costly bilateral legal battle, the government planner's zonal screen imposed by edict, or a Pigovian fiscal tax that always incurs a loss, Coase proposes that a voluntary private settlement that maximises the joint value outputs of polluter and victim is theoretically welfare enhancing.

1.4. Coase Theorems and its critics

Many consider Coase's (1960) teaching in "The Problem of Social Cost", as formalized by Nobel laureate George Stigler into two Coase Theorems, too good to be true. Amongst other reasons for the scepticism, some other interesting ones are discussed below, this is notably due to unrealistic assumptions and wealth effects. Coase and his followers nonetheless maintained their stand (Coase, 1988a; Marciano, 2013). Critics do not appreciate that to reject a theory on grounds of invalid assumptions may commit the fallacy of denying the antecedent. Nor do they reckon that the power of these two Coase Theorems, basically tautological, lies exactly where and when the two assumptions do not hold: hence the choice of institutional design has a great (beneficial or adverse) effect on resource allocation and its efficiency. This is the so-called corollary of the Coase Theorem. As regards wealth effects due to the pattern of rights assignment, the best defence was offered by

[1] Pigou did not specify the nature of the factory.

[2] We can assume here that Pigou's example covered all sorts of negative externalities generated by a factory, with smoke being merely the most visibly manifest.

[3] In the economic literature, the crop was often taken to be wheat. Historically, wheat farming, as a more intensive mode of agriculture, displaced cattle ranching.

Coase (1988: pp.170–174). Accordingly, other than pointing out that his argument boils down again to the assumption of zero transaction costs, we shall let the matter rest.

1.4.1. The case of Coleman

Coleman (1984) has an interesting argument against Coase in terms of causality in relation to efficiency.[4]

It would seem that what Coleman is accusing Coase of is category confusion; namely of assuming that anything labelled a 'harm' is equivalent in nature (category). Coleman saw this as eliding the basis of state intervention on false premises. For if harm A is categorically different to harm B both actually and contextually (cows destroy corn, directly reduce the amount of corn available for consumption, and indirectly diminish the corn farmer's income; taxation does nothing to cows, does not directly reduce their numbers or the amount of meat available for consumption but directly diminishes the rancher's income and only, if he wishes to maintain his profit margin, indirectly affects cattle numbers, feed or available grazing land), then to leave the market to settle the matter is to open the door to asymmetries of power, etc.

A thought experiment is useful to put Coleman's legally sound and useful but non-Coasian analysis of causation in context. This is to see both the crop land and cattle range or both activities, as owned and managed by one person, as proposed by Lai and Yu (2003).

Before examining the one-person ownership scenario, we need to note that both activities are *spatially proximate* and share one important common social characteristic: both are uncontroversial decent ordinary businesses and each has an export market predicated on free trade and not coercion. The goods in both businesses are good AND tradable without moral or ethical concerns (like the usual examples of apples v. oranges in economic texts but unlike butter v. guns or human tissues/organs). [The presupposition that two physically close activities or goods are good AND tradable without moral issues will appear again in our discussion of Yu's model of sustainable development. The absence of coercion too is a point we shall visit soon.]

If both activities are separately owned by two persons, as in Coase's (1960) exposition, then each party's market can generate an externality that affects the yield of one's neighbour activity. The rightful direction of compensation payment would depend on how the law assigns rights among them.

At common law, the cattle farmer has no right to let his cattle roam over crop land. If the cattle does roam that way, the Pigovian description would be that the cattle market gives rise to a negative externality that affects the crop owner. The institutional options for the wrong doer, the cattle owner, is to either pay a one off damage and restrain his animals in compliance with a court order; to be barred from crop land under zoning control; or pay the wheat farmer a fee or rent as a matter of private settlement. Coasian analysis predicts that IF the transaction cost is zero, then neither the court nor the zoning option would be preferred by parties. Instead, both parties will adopt the last option. It is better than the court solution, because the settlement fee (which may be in the form of a rental contract for some wheat land for cattle roaming) can be greater than the damage. The damage being restricted by its basis based in the principle of restitution: the just restoring of the injured party to the pre-trespass situation.

But in our one common owner scenario, the concern is not whether any externality has arisen or how that harm can be mitigated or estopped but the joint income (wealth) maximisation of both activities. If both activities are situated at two well delineated and adjoining parcels of land then, in a poor crop market relative to the cattle market, the owner would allow cattle to roam in crop land. He would however restrain the cattle more when the crop market is more profitable. He has no concern about categories of harm or harm prevention.

One faint difficulty in our thought experiment is the Coasian condition of clearly *de jure* delineated boundaries. Within the single domain of a lone owner, whilst she/he may have a clear sense of where it is preferable from time to time to sow corn and where to graze cattle, this is not a "clearly delineated *de jure* boundary" established by a sound legal property rights regime. It is, rather, an entirely fungible and contingent allocation of land use *within* a single property *around* which a legal boundary obtains but within which (q.v. an Englishman's home is his castle[5]) there is no such legally backed setting out of firm but market negotiable boundary fences. Yet, if we assume that the owner is 'sovereign' over her/his own domain. And if we assume that she/he erects a cattle fence to protect the corn she/he is also growing. Then from the Walrasian viewpoint, the owner is making a market-equivalent decision as in the case of the rancher/farmer neighbours. Anyfence adjustment from time to time is made seamlessly to optimize output. The sole difference between this thought experimental case and the rancher/farmer situation is that our single proprietor can always choose to switch to monoculture. It follows that what matters in the Coase Theorem is resource allocation, not negotiation and in that sense the single-owner thought experiment illustrates well the zero transaction cost path to optimal resource allocation.

If a legal regime confers rights on the cattle to roam freely, then any attempt by the wheat farmer to restrain the cattle is in Pigovian terms a negative externality produced by the crop market. The analysis is just the same as in the case of common law, though payment would be from the crop farmer to the cattle owner.

In short, the Coase Theorem (Nos. 1 and 2) can be seen as operating in Coase's (1960) example of a cattle/crop conflict exactly as the scenario of unified ownership as outlined above. The message is that in the absence of transaction costs, then two neighbours enjoy an "angelic vision" and desire for the best interest of each other and their value preferences are identical: wealth maximization. That vision enables them to avoid all frictional issues of bargaining in a Walrasian fashion as above and by-pass the concerns of Coleman, who looks at the real world situations where people are actually different in mindsets and some may simply refuse to trade in given situations irrespective of economic incentive. *Refusal to trade* (say to sell land) even in face of obvious economic gain is part of the private property rights of an owner of property rigorously defended by Nobel laureate economist James Buchanan (Buchanan, 1993).

An aberration of the angelic vision referred to above in land use planning is sometimes used by government-led urban renewal agencies to expropriate private property on "Coasian" grounds, namely that the compensation to minority land owners is "good enough" and their "holding out" (blackmailing, an issue to which we shall swiftly turn) incur too great transaction costs in the process of maximising wealth.

[4] "Ronald Coase presents an alternative to the Pigovian approach which denies the necessity of both causation and taxation to efficiency. Indeed, Coase goes further than to deny the relevance of causation to the goal of efficiency; he denies the existence of nonreciprocal causal relations. His argument, which economists by and large take seriously but which they ought not to, is as follows. The rancher's cows cause the farmer a loss. But if the state restricts the rancher from raising cows because cows trample corn, it causes the rancher a loss. There is, then, a reciprocity in the causation of harm; either we cause the farmer harm by permitting the rancher's cows to graze or we cause the rancher harm by prohibiting his cows from trampling the corn. The central question is not which activity causes harm – they both do. The question is which harm (and how much of it) we should permit. Of course Coase is wrong. He treats the harm the rancher's cows cause the corn as if it were the same sort of harm the state does by reducing the level of the rancher's activity. Surely, whether the state interferes or not, cows destroy crops. That is the very plain sense in which causal relations are not reciprocal." (Coleman, 1984: p.655, underline authors')

[5] The most famous source for this is Sir Edmund Coke's 1604 judgment in Semayne's Case (5 Coke Rep. 91), "the house of every one is to him as his castle and fortress", though he seemed to be echoing an earlier, 1505, judgment in Norman French (Tri.14 Henry.7), "la maison d'un est à luy son castel" (the house of a man is to him his castle).

The right to not trade costs is definitely denied (Lai, 2014).

1.4.2. The case of guerra-pujol

Our interpretation of Coleman builds on the criticism of Guerra-Pujol (2012), who argued that Coase drew a false distinction between "blackmail incidental to a business relationship" (Coase, 1988b: p.658) and "ordinary blackmail." (Coase, 1988b: 675) It is a received view that the Coase Theorem is contractarian (Ault & Ekelund Jr., 1988) rather than game-theoretic and hence blackmailing should have no role to play in Coasian analysis. However, Coase himself was conscious of blackmailing as a common economic phenomenon.[6]

Though Guerra-Pujol (2012) did not refer to the cattle/crop example used by Coase, his argument is important for our discussion, especially as RonaldH. Coase (1988b) referred to "The Problem of Social Cost" (1960), which is at issue in this monograph. In particular, the example of the cattle ranger/crop farmer sounds like a bilateral monopoly scenario. Coase himself said:

> I explained (in Problem of Social Cost (Coase, 1960)), using the example of the cattle raiser and the crop farmer, that if the cattle raiser was liable for the damage brought about by his cattle, the crop farmer might plant crops which otherwise would not be profitable because the resulting crop damage would be such that the cattle raiser, to avoid having to pay for the damage, would be willing to pay the crop farmer not to plant these crops. However, if the situation were reversed and the cattle raiser were not liable for the damage brought about by his cattle, he might increase the size of his herd above what it would otherwise be, thereby increasing crop damage, in order to induce the crop farmer to pay him for agreeing to reduce the size of the herd. (Coase, 1988b: 657, brackets authors'.)

The problem of blackmailing in Coase's farming story, as Coase was aware, was in fact solved by Guerra-Pujol's own example of a bilateral monopoly, because the outcome always lies on the "contract curve" and is thus Paretian efficient. A further answer leans on the same zero transaction cost assumption, which, as we point out in relation to Coleman, reduces all persons to the same mindset and elevates them to perfect mutual knowledge: where there is no bargaining, how could there be any threat or blackmailing demand?

1.5. Coase Theorems and its components

The two Coase Theorems which Stigler abstracted from Coase's (1960) agricultural fable are called the "Invariant Theorem" (Coase Theorem No. 1) and the "Optimality Theorem" (Coase Theorem No. 2). The former can be expressed thus: Given zero *transaction cost* and clearly defined *property rights*, the *choice* of the ways in which rights and liabilities are assigned does not affect resource allocation. Rights and liabilities here are often simplified as "property rights" or "institutional designs" or "institutional arrangements" such as those pertaining to planning policy, law, market exchange, form of contract etc. Coase Theorem No. 2 may be summarised as: Given zero *transaction cost* and clearly defined *property rights*, resource allocation is always Paretian efficient. In other words, when transaction cost is zero and property rights are clearly defined, freedom of contract ensures an efficient economic outcome.

The terms "transaction costs", "property rights" and "choice" are pivotal in understanding Coase's ideas. Both transaction costs and property rights were novel concepts in economics as they were not of significance in the classical economics of Adam Smith or neo-classical economics of David Ricardo and others. The latter assumed that there was a well-established legal system that defined rights and duties, and that the market or economy functioned smoothly without any friction. In other words, property rights are taken for granted and transaction costs are assumed away. In Coasian economics, transaction costs can be defined as costs that cannot be captured by a neo-classical production function[7] and cover costs of transport, stressed by neo-classical economists, and information, negotiation, bargaining, contract formation and enforcement.

From another angle, one could argue is that there are two costs that cannot be captured by a neo-classical production function. These are transport and information. The latter, using a formal information theory approach, includes any system input that affects system output, hence negotiation, bargaining, contract formation and enforcement, a legal framework, an environmental context and knowledge about that. This angle not only significantly broadens possible transaction costs but also hints that full knowledge of all relevant transaction costs in any transaction may actually never be attainable.

A point of importance is that it is not entirely clear whether in Coase's parable, the cattle farm is an open range or closed range type. Yet, it is clear that Coase's story is about "straying cattle which destroy crops growing on neighbouring land" and the farms are "operating on neighbouring properties." (Coase, 1960, p.2) Furthermore, we must suppose there to be "no fencing between the properties". These details are sufficient to characterise the case as a land use conflict and are of use in our further theoretical exploration.

1.6. Pollution trading and the Coase Theorems

It is received knowledge that a market for pollution rights, as in the case of "carbon trading," is *theoretically* one for "Coasian (Coasean) bargaining" to help reduce greenhouse gases[8], given the latter to be taken as an externality that contributes to global warming (Choy & Ho, 2018). Such bargaining is generally and loosely treated as an application of the corollaries of the invariant or optimality versions of the Coase Theorem. This is deduced by Stigler from the above mentioned imaginary example of a land use conflict between two neighbouring farms. Arguably therefore, carbon trading is more efficient than for government bureaucrats to levy a Pigovian tax. This follows from the transaction costs of information incurred in ascertaining the "correct"

[6] "Professor Coase is simply trying to make a pragmatic point, that blackmail is so common and pervasive in the business world that there is little one can do to reduce the incidence of business blackmail. Indeed, one could argue that the costs of enforcing the law of blackmail in business relationships probably outweigh the gains. Instead, Coase draws an awkward distinction between "blackmail incidental to a business relationship" and "ordinary blackmail." That is Coase argues that blackmail should be punished in situations in which "[t]he victim has to deal with the blackmailer" and in which the blackmailer "causes real harm which reduces the value of production." The problem with Coase's analysis, however, is that these two conditions arise in all situations of bilateral monopoly. Thus, if "blackmail incidental to a business relationship" should not be illegal (and we agree with Coase that it should not be), then what is it about bona-fide or "ordinary" blackmail that is so horrible as to constitute a crime? Why are some forms of blackmail perfectly legitimate, while other forms constitute a crime?" (Guerra-Pujol, 2012: p.5)

[7] Cheung considers that they are costs that are absent from a "Robinson Crusoe world". Robinson Crusoe, however, is subject to less than perfect information.

[8] There is not much written about trading greenhouse gas emissions in general except carbon dioxide. Greenhouse gases include water vapor (H_2O), Carbon dioxide (CO_2), Carbon black, Methane (CH4), Perfluoromethane (CF_4, C_2F_6), Nitrous oxide (N_2O), Ozone (O_3), Chlorofluorocarbons (CFCs), Hydrofluorocarbons (incl. HCFCs and HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6), Nitrogen trifluoride (NF_3), Halogenated and Fluorinated ethers, Halocarbons, Mixtures of the above. As the good detail in https://www.whitecase.com/publications/insight/greenhouse-gas-emissions-trading-schemes-global-perspective indicates, almost all trading schemes deal only in CO_2, the rest seem generally to be covered by regulations but not to be traded. SO_2 trading in US started in 1990 but collapsed after 2005. (Fraas & Richardson, 2010)

tax rate at various times, although researchers have also disagreed over the effectiveness and ethics of such a carbon trade. It is admittedly hard to monitor compliance of players in urban trading with official caps but similar issues occur to a (Pigovian) carbon tax too. Any "emissions trading scheme" (ETS) traditionally has to rely on firms to report their emissions. Mis-reporting can result in over-/under-allocation and distort market prices, eventually giving room to opportunism. Gambling might occur but the crux is effective monitoring and regulation. There have been reported cases of cheating or mis-behaviour, particularly in early years of implementation. A strong regulator is needed here. (Lohmann, 2006). However, the EU ETSs for greenhouse gases have been operating for more than 10 years and the EU has fixed some of the problems already given modern automated monitoring systems.

But carbon emissions are different from land. They are invisible and pervasive, their impacts are widely dispersed and long-lasting, and there are substantial information asymmetries. Land resources (and wildlife) are less susceptible to these problems, particularly those under effective public control, and thus trading might work better. The issue of biodiversity is however harder to deal with.

The theoretical foundation of carbon trading with bargaining, whether discussed in connection with *either* the Coase Theorem *or* the land use conflict example (Coase, 1960), or with how the Coase Theorem "internalizes" externalities (Wangler, 2012), is not always clear. For one thing, the Coase Theorem, as formulated by Stigler (1966, 1987), admits to no bargaining, although Coase used the term, "bargain (s)" sixteen times. Coase was referring really to a "rearrangement of legal rights" rather than a process of searching for contract agreement, negotiation or enforcement.

Logically, there is no need of/room for any bargaining or negotiation, as transaction costs are assumed to be zero: adjustments are instantaneous, as under a neo-classical Walrasian scenario. In other words, a strictly Coasian world is a *non-communicative* world of *impersonal*, *dispassionate* and *instantaneous* exchanges. This must be the case as Coase began his story by specifying the assumption that "the ultimate result (which maximises the value of production) is independent of the legal position if the pricing system is assumed to work without cost." (Coase, 1960: p.8).

That may need to be spelled out because, at least by inference, what plays out in the real Coasian farmer's world may seem rather harsher than the paper exposition. Recall, we are supposing a Walrasian simultaneous adjustment with no one either talking to anyone else or needing to.

At time T1 there exist two properties defined by clear, legally enforceable *de jure* boundaries but not separated by any fences marking the boundaries between them. R is a rancher whose spread SR can support H head of cattle. F is a crop farmer whose spread SC can support a corn output of C tons of corn. The markets for the respective products fluctuate, as produce markets do.

If we assume a given state of the markets at T2, whereby the return per head of cattle to R and the return per ton of corn to F are such as to satisfy F with the income derived from C–X output but R only satisfied with the income that could be derived from running H + Y head of cattle, then we have a state of affairs which, in Coasian terms, should lead to an instantaneous Walrasian outcome. And that outcome is a simultaneous adjustment of boundaries to SR + f(Y) and SC-f(Y) or, coded the other way, SC-f(X) and SR + f(X), where f(Y) = f(X).

This adjustment is one in which R's additional cattle Y invade F's crops, reducing F's crop by X and increasing R's healthy, well-fed herd by Y. R has no reason to control his herd either by corralling them or reducing their numbers to that which his spread can sustain. F has no reason to bemoan his loss of crop or to wish to chase R's cattle from his land. Both producers in theory end up satisfied by this 'instant' reordering of their *de facto* land boundaries.[9]

Bargaining as a means to determine price incurs transaction costs. In the real word, as the air of implausibility of what was spelled out in the previous paragraph suggests, Coasian bargaining may not in practice work out. For example it was shown to have not worked well at all in a planning case study on Britannia Beach, British Columbia, Canada. In that case the issue had been how to internalize the externalities of a disused copper mining town via the conventional form of real estate development alone (Lai & Lorne, 2006). There is a similar problem with the rancher/farmer problem sketched above.

As far as carbon trading and "Coasian/Coasean bargaining" as a means to enable the trade (see for instance Dawson, 2011; Rhoads & Shogren, 2003) is concerned, we are of the view that "bargaining" is a just a signal of Coasian thinking unless such bargaining is taken to mean "political bargaining" via governments or institutions (Lele, 2017) as to the quantum of a carbon cap. The reason is that in practice, a carbon trade market operates like the stock market with transactions made in an impersonal virtual and almost instantaneous Walrasian fashion.

The issue of "Coasian/Coasean bargaining" is intriguing. Coase did indeed use the expression "bargain" in his 1960 work, and this is probably why the term "Coasian bargaining" has such a wide circulation, but it is theoretically incompatible with Stigler's "Coase Theorem" formulae given the conditions of zero transaction costs. The stock market is definitely an institutional arrangement that reduces transaction costs. If transaction costs are zero then there is no need for either bargaining or institutions – the latter we, like Svetlov (2010), follow Cheung (1982, 1987, 1998) considering as but means to reduce the transaction costs of bargaining in facilitating transactions. In other words, "Coasian bargaining" can only occur in a contractual process under positive transaction costs, as under what has been called the "corollary of the Coase Theorem." (Lai, Davies, & Lorne, 2016). We have elaborated on this point in the revision and use "bargaining" in the sense that transaction cost is more than 0 but "negligible" to keep within the *Coasian tradition* as much as possible.

It is the concept of "Coasian bargaining" is part of the *Coasian tradition* of economic inquiry but it is a long evolution from the numerous bilateral "bargainings" of representative cattle/wheat farmers that would result in an "equilibrium" social price of cattle raising. In this paper, the term "signal" is used in anticipation of this evolution. This is where carbon trading has contributed to the Coasian bilateral "bargaining". When rights to trample can be traded in the market, it alleviates the transaction costs involved in micro bilateral bargaining. The efficiency of carbon trading is advocated on that basis. It is a system by which the market price of the social costs of cattle is being competitively determined, rather than by scattered micro bilateral negotiations conducted in locationally specific neighbourhoods without a means of integration for the whole industry.

1.7. Pollution trading and zoning as supported by Coase, Stigler and Nozick

Coase's (1960) example is a land example in which stray cattle can be equated to pollutants (in a situation in which the law assigns rights to the crop farmer) and does not involve any aerial pollution, which, unlike with the farmer's crop, means pollution affecting not only the farmer. The jump from a "down here on earth" to an "up there in the sky" scenario in the carbon trading epic needs some elaboration.

Recall that zoning has a history of industrial pollution and Pigou used the example of smoke pollution to support taxation. Such taxation, which is applied to Australia until it adopts an emission trading scheme along the European Union line, has mostly been discussed in the literature on ecological economics and environmental justice (Andersson & Karpestam, 2012), but rarely in main stream landuse planning.

Amazingly, many libertarians are Coasian in thinking in terms of

[9] A more 'real world' exposition of these Coasian farmers' worlds is explored (*footnote continued*) in section 4.1 below.

transaction costs but Pigovian or zoning interventionists in their solutions. We might enquire as to why this should be.

Like Nozick (1973), both Stigler, the founder of Coase Theorem Nos. 1 and 2, and Coase himself considered the Coase Theorem *inapplicable* to a world of positive transaction costs due to the number of parties involved (Lai, 2002). Nozick's (1973) work, *Anarchy, State and Utopia* is famous for its plea for a `minimal state' playing the role of a `night-watchman', an ideal highly acclaimed by libertarians. He appears therefore to be a Coasian. He said,

> "Perhaps a few words should be said about pollution – the dumping of negative effects upon other people's property such as their houses, clothing, and lungs, and upon unowned things which people benefit from, such as a clean and beautiful sky." (p.79)

His few words[10] precede the conclusion that "It is ironic that pollution is commonly held to indicate defects in the privateness of a system of private property, whereas the problem of pollution is that high *transaction costs* make it difficult to enforce the private property rights of the victim of pollution." (pp. 80–81)

Nozick's solution is however not Coasian, i.e., one of a trade in rights to pollute, but a judicial solution using the courts and such things as class action suits.

Stigler contemplated government intervention, which limits private property rights (Stigler, 1987: 120–121), as a remedy for this situation. He justified it on efficiency grounds at a time when global warming had not yet emerged as a serious environmental issue. Stigler was completely Pigovian when he stated:

> "The proposition (of Coase) must, to be sure, be qualified by an important fact. When a factory spews smoke on a thousand homes, the ideal solution is to arrange a compensation system whereby the homeowners pay the factory owner to install smoke reduction devices up to the point where the marginal cost of smoke reduction equals the sum of the marginal gains to the homeowners. But the costs of this transaction may be prohibitive – of getting the people together, of assessing damages, and so on – so only a statutory intervention may be feasible. The statutory policy is itself far from simple to devise: the amount of smoke reduction that is socially optimal depends upon the technology of smoke reduction, the number of people involved, and so forth, and *on the fact that the state may use coercion, which is not possible with voluntary contract*. The differences between private and social costs or returns have provided a fertile ground for public control of economic activity. In fact one can attribute most limitations on private ownership or control of property to this source." (Stigler, 1987, 120–21; brackets and italics authors').

Coase (1960) did not agree with Pigou's views about taxing a polluting factory but did not advocate an exchange of interest trade between the third party and the factory. As a friend of town planning, he supported zoning!

> "Without the [pollution] tax, there may be too much smoke and too few people in the vicinity of a factory; but with the tax there may be too little smoke and too many people in the vicinity of the factory. There is no reason to suppose that either of these results is necessarily preferable. I need not devote much space to discussing the similar error in the suggestion that smoke-producing factories should, by means of zoning regulations, be removed from the districts in which the smoke causes harmful effects … The aim of such regulations should not be to eliminate smoke pollution but rather to secure the optimum amount of smoke pollution, this being the amount which will maximise the value of production." (Coase, 1960, 42)

Note that Pigou's solution is actually a *special case* of Coasian solutions and both Pigovian and Coasian lines of thinking are in agreement that industrial pollution does not entail the elimination of industries, the extreme position of McGee and Block (1994) which treated pollution as "garbage" and recommended a penal solution.

Besides, as already mentioned, Coase's crop damage-by-animal parable was actually devised to attack Pigou's (1932: pp.184–185) factory air pollution saga. To find a way to tie Coase's farm example and way of thinking to gaseous pollution would make it on par with Pigou's smoke pollution story, against the objections of Nozick, Stigler and even Coase himself.

1.8. Fitting pollution trading to Coase Theorems

Given the above context, this monograph seeks to examine how well trading in rights to aerial pollution by greenhouse gases fits the Coase Theorem in its various forms and how a private exchange of land use interests, as envisaged in the original story of Coasian trading, can help reduce greenhouse gases. This evaluation is timely not only for tying up some loose ends in theoretical articulation, as mentioned above, but also to see if trading in rights to air pollution has any real property (land interest) application through town planning and/or land management. Moreover, researchers (Bristow, Wardman, Zanni, & Chintakayala, 2010) have proposed trading private greenhouse gas emissions to individualize the tackling of global warming as a matter of personal praxis. The discussion here attempts to anchor concepts and their practical application to their proper foundations in Coase's thinking. Hopefully this will help the exploration of better land-related policies to address the issue of greenhouse gases in a transaction cost paradigm in ecological economics (Coggan, Whitten, & Bennett, 2010).

Before fitting the concept of pollution trading in relation to land resources as a potentially practical contribution to the reduction of greenhouse gases, there is a need to explain the methodology used in this work as a planning paper.

2. The methodologies of Coase and the methodology of this monograph

Prior to dealing with trading of pollution rights as an *analytical* exercise informed by some hypothetical cases, there is a need to position our methodological approach by reference to Schumpeter's "pre-analytical vision". This must be distinguished from the "pre-analytical" inquiry prior to laboratory tests in medical science. In other disciplines such as in psychology anthropology, or in business entrepreneur studies, a qualitative inductive (specific to general) approach is often used. The approach is sometimes referred to as "naturalistic inquiry". This is important as it can help interpret this monograph vis-à-vis the "empirical studies" as usually adopted by economists, which are mainly statistical exercises.

In scenario building in this monograph, we start with well-established paradigms, neoclassical economics of marginal value/utility (MV/MU) and marginal cost (MC) but interpreted from a Coasian perspective informed by some ideas of Schumpeter. The methodology adopted here is very Coasian, as explained below.

2.1. Coase's own methodology

To begin with, it must be recognised that none of Coase's writings is "empirical" in the sense of statistically based. Yet, it would be wrong to think that they are non-empirical. There are two broad approaches through which Coase conducted his studies and wrote his papers.

One approach was empirical, though a deductive (general to specific) approach rather than the inductive approach that is usually

[10] Nozick is considering the externality of localized noise pollution by an airport stressing the problems posed by scale and distribution. Such pollution is in Pigovian terms not different from the greater global externality of greenhouse gas pollution.

adopted in "testable hypotheses". Coase tested, in a deductive manner, in meticulous case studies through which he pursued various important economic theories or arguments. This approach was what was adopted for his studies in the Federal Communications Commission (Coase, 1959), private lighthouse supply in England and Wales (Coase, 1974) and the Fisher body and General Motors (Coase, 2000). This approach has been followed by those who developed his ideas further as exemplified by Cheung's empirical study on sharecropping (Cheung, 1969) and the private market for bee pollination of apples (Cheung, 1973) and Lai's (1993) study on marine fish culture zoning and pollution.

The other approach was basically conceptual reasoning, as exemplified in the works that earned him a Nobel Prize, namely "The Theory of the Firm" (Coase, 1937) and "The Problem of Social Cost" (Coase, 1960). The former work, which is the foundation of the nature of organisations, contains no mathematical equations or statistics but just a simple diagram to show an idea in relation to von Thunen. In the latter, the basis of the Coase Theorem, there is none of the graphical analysis typically used by economists, but rather one simple table with hypothetical numbers (in Part III of his paper) about the aforesaid imaginary conflict of interest between a crop farmer and a cattle rancher, which in spatial terms is a land use conflict scenario. This approach had a great impact in the profession and is sufficiently illustrative for students in economics and policy analysis to study without heavy mathematical modelling. The same approach was followed with or without case examples for instance by Cheung (1973), Yu, Shaw, Fu, and Lai, (2000), Lai and Hung (2008) and Lai and Lorne (2014, 2015). This monograph is in line with this methodology.

2.2. The approach of this work

The approach followed here is not to dismiss the value of statistical tests. Indeed, many empirical inquiries using Coase's ideas have been made. Contrary to some erroneous beliefs that the Coase Theorem is not testable, empirical inquiry using the theorem by way of statistical tests of the effects of SARS and other social incidents on property prices (Lai, Chau, Ho, & Lin, 2006) and the time spans of finalizing planning permissions on property prices were conducted by Lai, Wong, Ho, and Chau, (2008). However, it is submitted that before any formal statistical modelling is attempted, there must be *a prior* formulation the nature of the problem especially where no policy or law exists to be observed in the first place.

2.3. Coasian micro and macro thinking

Coasian inquiries have a micro foundation, originally devised to address to a specific case, a specific industry or at best a country (as in the case of the development of *de facto* capitalism in China by Cheung (1982)). Yet, if the setting in which a micro issue is to be addressed is also broadly within a macro international phenomenon, e.g. global climate change, a thinking framework that exclusively utilizes the analytical tools in a limited paradigm may not be sufficient. This was the motivation in Yu's model (Yu et al., 2000) (as discussed in Sections 5 and 6 below) – that is, to retain neoclassical working tools but also extend them to possible use beyond the neoclassical paradigm. The analysis provided in an earlier section of this monograph is a similar attempt.

3. Coasian bargaining and various forms of the Coase Theorem

Bargaining as a transaction cost phenomenon is definitely alien to the Coase Theorem in the sense of Stigler's "Invariant Theorem". This holds that the ways in which rights and liabilities are assigned do not affect resource allocation, granted that property rights are clearly defined and transaction costs are zero. This Coase Theorem (No. 1) is well known in ecological economics, having been used, for instance, by Cerin and Karlson (2002) and Farley and Costanza (2010). Coase Theorem No. 2 by Stigler is that given these two assumptions, resource allocation is always optimal and this is the so-called "Optimality Theorem".

3.1. Coase Theorems 1 and 2

Under Coase Theorem No. 1 or 2, given these two drastic assumptions, neither law nor institution matters in resource allocation. Exchanges occur without negotiation or bargaining, not as Weersink, Livernois, Shogren, and Shortle (1998: 309) or Helm (2005: p. 209) considered when referencing Coase (1960). Note that Sandor, Bettelheim, and Swingland (2002) was very careful not to impute bargaining in his explanation of the Coase Theorem in relation to the ideas of Coase (1960). To argue that the Coasian world is one in which bargaining occurs at zero cost (Gelbach, 2015) leads one to ask why bargaining is necessary to begin with. As early as 1982, Veljanovski recognised that adjustment under the conditions of the Coase Theorem was "instantaneous" (Veljanovski, 1982: p.58). This view was shared by Cheung (1998), a friend of Coase, who described instantaneity as a "fallacy in the Coase Theorem" (pp.518–519), as did Lai et al. (2016).

The only way to logically connect "bargaining" with the Coase Theorem is to either use the so-called "corollary of the Coase Theorem" (No. 1 or 2), ignored by Harstad (2012) in his discussion of carbon trade, or another version of this theorem, call it Coase Theorem No. 3, found by Cheung and affirmed by Coase (1988) in his last book *The Firm, the Market and the Law*. The corollary holds that in a world of positive transaction costs and/or unclearly defined property rights, institutional arrangements affect resource allocation. Bargaining is a transaction cost phenomenon aiming at a win-win outcome in a choice theoretic framework.

3.2. Coase Theorem No. 3

Coase Theorem No. 3 holds that the delimitation of rights is a prelude to market transactions. This can be found Coase's (1959) work, "The Federal Communications Commission," and was confirmed by Coase (1988: p.173) as "the" Coase Theorem. It was used by Cheung in the Institute of Economic Affairs monograph *Will China Go Capitalist* (Cheung, 1982) and in his praise of Coase in the Nobel presentation ceremony in Stockholm 1992.

Under either approach, carbon trading and its associated bargaining, as libertarian endeavours, can be validly denominated in terms of the Coase's reasoning as a means to allocate resources.

3.3. Coase Theorem No. 4

A Fourth Coase Theorem based on Coase's (1988) book was found by Lai and Lorne (2015). This held that under some specific conditions, government rules can enlarge an existing market. In this case, the state can play a role in expanding the trade in pollution rights by proper laws and policies, including those denominated in land terms. This theorem is more powerful when Schumpeterian innovation is enabled by appropriate entitlement arrangements, as we shall examine further.

4. Coasian exchange for achieving optimality in trading of rights generalized

The four Coase Theorems together suggest the analytics in the original "Problem of Social Costs" need to be rephrased to and restated for a more general applicability suitable for land use considerations. We shall do that in this section.

4.1. The supply and demand model of Coase's farming fable

The cattle raiser and crop farmer problem can be graphically

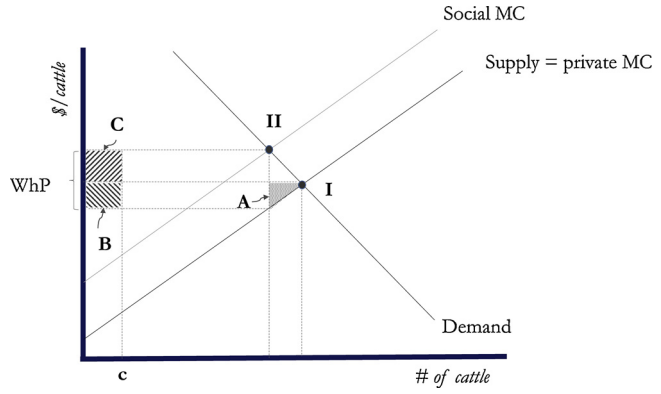

Fig. 1. Coasian model.

described in Fig. 1. The labelling of the axes and the supply and demand for cattle in terms of the marginal cost (MC) and marginal benefit (MB) of cattle is a familiar story told in economics classes. Note that the Coase problem, though hypothetically stated in terms of a cattle-raiser and an adjacent crop farm, is universal in that cattle raising may lead to cattle trampling[11] on adjacent areas that may or may not be privately-owned. Thus, the problem of cattle intruding into nearby farmland is really a cattle externality problem and, as such, it can be conveniently captured in terms of the market supply of and demand for cattle.

The social cost of cattle in this case is trampling (straying). An estimation of that can be theoretically determined by the quantity of crop (say wheat Wh), on average, that can be destroyed by stray cattle. Multiplying that average quantity by the price of the crop results in the per unit social cost of cattle due to straying. One can label that as "WhP" in the graph. Notice Wh is a form of technology data based on the living habits and methods of raising cattle, while P is the market data based on the demand and supply of the crop. The inputted P would be an average of the daily fluctuations in the price of the crop, which is a competitive bidding parameter similar to the bidding on an environmental quota in that the institution facilitates the shadow price rather than an administratively set per-unit tax.

If the cattle-raiser does not have the right to stray, the solution to a Coasian exchange is very simple: the cattle raiser has to pay a fee of WhP per beast raised to the crop farmer. The price per head of cattle would rise as a result of the fee, but an optimal quantity of cattle (beef) would be produced. A particular cattle farm will keep the herd of cattle at c, which will be smaller than the private supply-and-demand size of the herd that the raiser would like to keep. This outcome is "efficient". This raises a theoretical question of great important: is not the efficient outcome corresponds to an equilibrium? It may be considered obvious that in the diagram that when a fee of WhP per beast is added, the equilibrium is in point II. In this case the number of cattle will be Hs. According to the definitions on p. 17, Hp = Hs + Y, which means Hp – Hs = Y. Therefore one is reasonable to say that the cattle farm will keep the herd of cattle at Hs, not at "c". In our analysis, point c is in fact the point where a representative cattle farmer's marginal cost intersects marginal benefit, Pe. The supply curve assumed in the diagram is upward sloping; thus, the average cattle farmer receives economic rent over and above opportunity costs. The aggregate of cattle farmers rent is the producer surplus. However, the efficient outcome corresponds to an equilibrium because the marginal producer, i.e. the highest cost cattle producer is earning zero economic rent. It is obvious in the diagram that when a fee of WhP per beast is added, the equilibrium is in point II. In this case the number of cattle will be Hs. According to our earlier definitions, Hp = Hs + Y, which means Hp – Hs = Y. Therefore the cattle farms in the aggregate will keep the herd of cattle at Hs, while representative cattle farmer size remains approximately at "c". Thus, loosely speaking, "c" is the *average of several averages, an average of all intramarginal* cattle producers and an average of all points where marginal costs intersect marginal gains. We assume that average can be simplistically represented by "c", for a simpler graphical exposition.[12]

The compensation to the representative cattle farmer *cannot be easily illustrated graphically* because it will require the representative cattle farmer to cut back his herd size below c, which is infinitesimal in the scale of the diagram as shown, as we assume that the industry has an infinite number of cattle farmers. Thus, the curtailment of cattle size can only be shown at the industry level, Hp - Hs, and the aggregate compensation from wheat farmers to cattle farmers will be the size of triangle A. Therefore, if there are n cattle farmers, the compensation to a representative cattle farmer will be A/n. According to theory taught in economics classes, losses due to negative externalities/social costs are presented by triangle [I II III] *if cattle size in the aggregate is not curtailed*. This is not the amount that the crop farmers will compensate the cattle farmers, in the aggregate or individually if the amount is divided by n, because it is social loss taken into consideration by the consumer of beef, which neither the wheat farmer nor the cattle farmer cares too much about. The calculation of consumer gains is embedded in triangle [I II III]. Triangle "A" is a small part of the producer surplus. The producer surplus (the whole of it) is triangle [P0 Pe I] but it is irrelevant here. *It is the decrease in producer surplus (in the aggregate) that is of relevance* as far as the amount to be bargained is concerned. Insofar as the idea of Coasian trading is to compensate the party that incurs losses, the crop farmer's losses are defined by the quantity of crop destroyed by the extra (excess) number of cattle (the number that causes straying). This is not exactly correct. While cattle without paying for social costs will be "excessive", it does not mean the costs associated with the excess is solely attributed to the incremental excessive cattle quantity. Every beast, marginal or intra-marginal, tramples crops on a probabilistic basis. Therefore, every beast imposes a social cost on its wheat farmer neighbour. For bargaining of a representative cattle farmer, the relevant amount to use as reference is Area B + C, not triangle [I II III].

If the cattle raiser has the right to trample on the crop farmer's field, meaning that adjacent public or private farmland does not have the right to exclude or prevent the straying of cattle, the contractual solution is just a little more complicated, but equally doable. A crop farmer in this case will simply ask the cattle raiser to keep its herd size at c by compensating him an amount based on the shaded triangle, A, in the diagram. More precisely, the equation would be A divided by n (the number of cattle raised). The amount of damage suffered by the farm can also be arithmetically estimated by areas B and C, which would likely result in a reduction in the crop farm's land price, along with a corresponding increase in the cattle farm's land price by B. This outcome is also "efficient". Again, we believe every beast imposes a social cost and not only the socially excessive number of cattle doing the spillover.

It is correct that the extra number of cattle is Y = Hp – Hs. Therefore the loss incurred is (Hp – Hs)WhP, that is, quadrangle [IV II III I]. However, that is *loss in the aggregate*, i.e. for the whole industry.

[11] Coase (1960) did not specify the way crop was destroyed but trampling was implied at p.5.

[12] Footnote: We see the creation of a representative cattle farmer to be more in line with the spirit of Coase's cattle rancher/crop farmer example. Although Coasian bargaining in the aggregate could result in some type of a triangular welfare comparison in the framework of supply and demand analysis, bargaining is always individualistic and at the micro level. In the industry of cattle, farmlands are heterogeneous, and bargaining with their respective wheat farmers may or may not entail the full compensation of the spillover social costs. The focus on a representative cattle farmer and his wheat farm neighbour allows a simplistic representation of the approximate gain and loss of land rents to the two sides. This avoids reasoning in the aggregate in terms of supply and demand, which goes beyond a bilateral Coasian problem between a cattle and a wheat farmer.

For the representative farmer, it is B + C, which is drawn to the same scale as quadrangle [IV II III I] because we want to use the same diagram for the representative farmer as well as the industry aggregate. To be mathematically correct, the representative farmer should only appear as a dot in the scale of the industry as n is a large number, based on the assumption of perfect competition. That is the basis on which we can use the tool of a supply and demand diagram.

The comparison of "increase" here is between the scenario of cattle farmers fully liable vs. cattle farmers not liable. If a cattle farmer is fully liable, his rent under a higher price of beef will decrease by B + C. If the cattle farmers are not liable, the price of beef will be lower, but their rent under a lower price beef would increase by B only. C will be the loss to the crop farmers.

This scenario is of potential interest for analysis in a situation where the wheat farmer is the first on site to grow his crops. The arrival of a neighbour cattle farmer will damage his crops and thus lower the rent of the crop farm. If the court rules that the cattle farmer has the right to trample, the most increase in rent for the cattle farm land will only be B and not the previous loss in rent of the wheat farmer.

4.2. The model and Coase Theorem

The exposition in Fig. 1 is but a restatement of the Coase Theorem, which states that irrespective of the liability assignment between the cattle-raiser and the crop farmer, the outcome is equilibrium at Point II, rather than the private supply and demand intersection at Point I, assuming that the transaction costs of contracting are zero. But this is only a partial equilibrium.

As Coase (1960) also pointed out in "The Problem of Social Cost," the externality problem is actually *reciprocal* in that one cannot unambiguously say that the cattle raiser is always a polluter, as this is only true only under a certain legal tradition (say the law of tort in common law, rather than a tradition, like in Hindu India, which treats cattle as sacred). Is Coase here committing something of the same logical *legal* fallacy that Coleman identified with Coase's cavalier use of the concept of "harm"? Sacred cattle may still do harm, but the Hindu tradition does NOT suppose that the harm is not harm, but rather that the harm is entirely 'paid for/remedied' by the blessings accruing to those who have not impeded the cow as it pursues its sacred path. In any event, the 1871 Indian Cattle Trespass Act confers rights on a crop farmer to seize and detain trespassing cattle, thus providing the economic basis of Coasian exchanges.[13]

This possibility could become a significant point of discussion if the straying cattle become healthier, grow faster, and produce better beef for the consumer. In other words, the larger the land area on which cattle are allowed to roam, the higher is the value of the cattle. If such were the technology for raising cattle, the damage (or social costs in Fig. 1) would not be a fixed variable. The joint maximization problem could entail encouraging crop farmers (or the owner of the wilderness) to allow their land to be used for cattle roaming as a matter of the rights of the cattle (or their owner).

4.3. The model with shifts in MU

Fig. 2 illustrates this possibility by assuming that additional straying can improve beef quality, as well as the marginal value of each cow allowed to roam. The additional dimension of comparison in this case

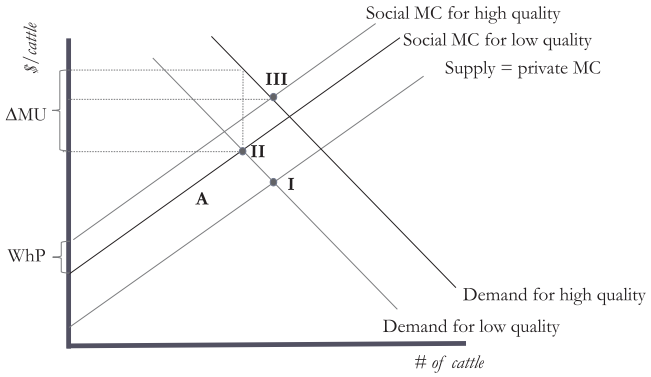

Fig. 2. Coasian model with shifts in marginal utility.

would be to evaluate whether the additional crop destroyed (ˆWhP) is greater or smaller than the additional value benefit of better quality beef (ˆMU). As things are drawn in Fig. 2, having more space provided for roaming cattle is a welfare improvement. Equilibrium III is unambiguously a welfare improvement over II, and certainly over I.

This scenario of an interaction between two land uses is not far fetched[14] and can be imagined as an initial exchange of rights between a crop farm without fences and an open range beef cattle farm, which leads to the development of a closed range dairy cattle farm sharing a common border fence with the wheat farm. The fencing-off of the two properties is not to serve the screening effect of a zoning approach but a convenient way of leasing land resources by one farm to another depending on relative prices of their respective products. In case dairy products are more lucrative, the *de facto* common fence will be moved into the wheat farm according to a commercial agreement.

4.4. Some costs in the model

Another issue associated with the explanation of Figs. 1 and 2 concerns how the fees and contractual compensation are to be administered. In the literature this has attracted a great deal of attention – for example if and how intra-marginal rents between the two parties (cattle raiser and crop farmer) are to be split. It is in this sense that writers in the past considered this to be a case of "Coasian bargaining"; namely the splitting of the intra-marginal rents is a zero sum game. However, all this would be made irrelevant if there are numerous cattle farmers and adjacent land for the cattle to roam over. A self-selection process would match locality pairings so that WhP can be minimized and net beef values can be maximized. In other words, a competitive process of sorting and matching would probably result in some type of a market practice of fixed fees and fixed compensation packages much like a price-taker in a perfectly competitive market. All these require neither a Pigovian administrator of tax nor a specialized court enforcing bilateral bargaining outcomes. All can be standardized practices enforced by common law.

5. A Coasian-with-technological change approach to sustainable development

Land use policies typically also address various elements of sustainable development. At first sight, neither Coase Theorem No. 1 nor 2

[13] Laws of India, The *Cattle-Trespass Act*, 1871, (Act No. 1 of 1871), s.10. It is important to note here that there is an element of state/institutional involvement in two ways. First, in that the detention of straying cattle is temporary and the farmer is obliged to send any detained cattle to the nearest village pound, established for this purpose (s.4). Second, that the farmer is supported by the police in both being protected from being prevented from making a seizure and in being helped in making such seizures (s.10).

[14] Though some may consider that beef and dairy cattle rearing are on different types of land, it is a matter of switching production functions. See Jordan (1972, p.120) for the transition of open range to fenced range then to dairy farming. This switch of production functions of course involves very large social and financial costs. In Malaysia, where both types of cattle are raised, the rearing of beef and dairy cattle is just a matter of choice based on labour cost concerns. See Hasan (2017: p. 77).

has any relevance to sustainable development. Since the Brundtland Report (Brundtland Commission, 1987) this concept has become an almost universally socially recognised and politically entrenched value, although its original formulation in the 1980s was no more than a slogan with good intentions. Under the Brundtland view, sustainable development can be seen as a journey from an unsustainable present, rampant with tradeoffs among goodies, to the future during which technological advancement is envisaged that will be for the benefit of the future generations, so that they will enjoy no less, and perhaps more, of those goodies than is the case in the present.

5.1. The Coasian world and innovations

On a close examination, such advancement makes no sense under Coase Theorem No. 1 or 2, which are about an "internalization" of externalities (often negative) by what economists call a "pure exchange", as the alternative to judicial action, interventionist taxation, or planning sanctions against them. There is no scope for technological advancement, as technology is already the best, given the assumption of zero transaction costs, which means perfect knowledge. The Brundtland proposition presupposes exceedingly high transaction costs between present and future generations, which require government, as an omnipotent and omniscient entity, to impose proper regulation. Yet, there is no good ground to believe that government knows the future better than the market, particularly given that in land use planning the present value concept in land valuation already explicitly takes future values into consideration.[15] It was for this reason that the concept of sustainable development as proposed in Brundtland was not endorsed in mainstream economics.

However, the "corollary" of either Coase Theorem No. 1 or 2, i.e. Coase Theorems Nos. 3 and 4, all take transaction costs as positive and hence potentially open the Brundtland proposition to include technological advancement and institutional reforms. When technological advancement is added to the analysis of a static Coasian model, which presupposes that externalities can only be either positive or negative, but not possibly both, the scope of analysis is very much limited. Yu's model (Yu et al., 2000) represented this combination of a neoclassical economic approach and technical change by replacing a linear production function with fuzzy functions with both possibilities of positive and negative external effects.

5.2. The heart of the matter: a fuzzy production function that embodies innovations

This new concept of a production function enables a transformation of a negative externality into a positive one, so that an original trade-off between an environmentally- dependent good G1 and an environment-using good G2 can become a win-win outcome in a given ecology e: G1 and G2 can expand together. The hypothetical examples of G1 and G2 that Yu et al. (2000) used are seafish and power production using seawater for cooling the generators. Note that G1 and G2 are not non-tradables and neither involves any ethical issues in production or consumption. Coleman's criticism (in Section 1.4.1) does not apply to them in any Coasian transaction.

A classical production function of G1 (e), even with technical progress, can never enable a trade-off with G2 (e). Yet, where there are enabling Coasian institutional arrangements this may not be the case.: For example granting entitlements to ocean water to fishermen, whose interest is affected by the power plant, so that warm-water sea fish can be cultured as exclusive property, is a transformation of capture fishery to aquaculture as a result of Schumpeterian experimentation and innovation. The experimentation may succeed or fail. This is so as the production of fish is now a stochastic probabilistic region with a portion above and another below the neo-classical production function of fish capture. Where the innovation succeeds, there is no more tradeoff between G1 and G2 as there is a joint maximization solution. This fulfils the definition of sustainable development.

5.3. Meaning of Schumpeterian innovations

Innovations need not be inventions but can be new combinations of existing methods. Innovations, in Schumpeter (1934), refer to five distinct categories of "new combinations" that are put together by the entrepreneur, who may be an individual or a whole team or company (Swedberg, 1991, p. 173)[16]. They refer to:

(a) "The introduction of a new good or of a new quality of a good";
(b) "The introduction of a new method of production";
(c) "The opening of a new market";
(d) "The conquest of a new source of supply of raw materials or half manufactured goods";
(e) "The carrying of the new organization of any industry, like the creation of a monopoly position or the breaking up of a monopoly position"

(Schumpeter, 1934, quoted in Swedberg, 1991, p. 34).

In the real world, sea farming enabled by suitable institutional innovations has happened in Norway for salmon farming, in Hong Kong for coral fish farming and in many other places[17]. In Hong Kong, Schumpeterian experimentation under the *Marine Fish Culture Ordinance* that provides the IP structure, has led to the rise of a live seafood restaurant business, a good social indicator for the state of the local economy. (Lai, Chau, Wong, Matsuda, & Lorne, 2005)

6. The importance and planners' reception of Schumpeterian ideas on innovations for urban planning

Prior to discussing the trade of pollution in land-specific situations, it is worthwhile to recollect the importance of Schumpeter's concept of innovation and its position in the planning arena.

6.1. What is special about Schumpeterian innovations

That technological advances can be integrated with a neoclassical

[15] We are aware that there is a disguised issue here, in that 'value' in this context means only 'price'. Discount rates can anticipate future prices, they manifestly cannot anticipate major future changes in (social) value that may significantly affect prices one way or the other. That said, governments are no better at anticipating significant changes in social values. What they hope to do is to occasion them. What they may not do is succeed in so doing.

[16] The full details in Schumpeter (1934: p.66) are: "The introduction of a new good - that is one with which consumers are not yet familiar - or of a new quality of good." "The introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially." "The opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before." "The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it first has to be created." "The carrying out of the new organization of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position."

[17] See Part II, FAO's "State of the World's Fisheries 2016", Promoting decent work in fisheries and aquaculture, pp. 126-131; and Part IV "Aquaculture and climate change: from vulnerability to adaptation", pp. 132-13 "Aligning the future of fisheries and aquaculture with the 2030 Agenda for Sustainable Development", pp.170-188. Table 6: "Production of main species groups of fish for human consumption from inland aquaculture and marine and coastal aquaculture 2014," at p.23, shows aquaculture going on every continent.

production function is nothing new. Most neoclassical economists would argue that a static non-probabilistic production function is a simplification for the convenience of exposition. However, technology advances bring in substantive paradigmatic changes the significance of which Schumpeter has best articulated:

> "In practice we all start our own research from the work of our predecessors, that is, we hardly ever start from scratch. However, suppose we did start from scratch, what are the steps we should have to take? Obviously, in order to be able to posit to ourselves any problems at all, we should first have to visualize a distinct set of coherent phenomena as a worthwhile object of our analytic effort. In other words, analytic effort is of necessity preceded by a preanalytic cognitive act that supplies the raw material for the analytic effort. In this book, this preanalytic cognitive act will be called Vision. It is interesting to note that vision of this kind not only must precede historically the emergence of analytic effort in any field, but also may re-enter the history of every established science each time somebody teaches us to see things in a light of which the source is not to be found in the facts, methods, and results of the pre-existing state of the science."[18] (Schumpeter, 1954: 41, as quoted in Costanza, 2000)

In Schumpeter's *Theory of Economic Development*, innovation is not just viewed as a probability statement, as neoclassical economists like to claim they have captured. Schumpeter described development and innovation as an "outside circular flow"[19] activity—something that is not routinely done using existing production methods. Unfortunately, how resources and exchange occur outside circular flow activities has been completely ignored by neoclassical economists.

6.2. Planners' endorsement of Schumpeter

The ideas of Joseph Schumpeter were probably known much earlier than those of Coase in the planning field. The best planner's tribute to Schumpeter was probably found in the works of Sir Peter Hall (1982). He referred to Schumpeter in support of enterprise zoning, an idea of a "Freeport" that he presented back in 1977 to the Royal Institute of Planners in the UK under Margaret Thatcher, referencing the economic miracle in colonial Hong Kong of the 1950s and 1960s. He also praised Hong Kong and Singapore saying,

> "But then came one of those blinding Schumpeterian flashes. I was invited to Hong Kong to advise on the setting up of an urban studies and planning programme within the university (University of Hong Kong). Apart from a brief visit to Japan in 1970, this was the first visit I had made to the Far East. I was totally mesmerized by the energy, the power, the achievement of the place. Most surprising for me was the achievement: expecting a Third World sort of country, I found a city that in many ways was more advanced than London. And Singapore, to which I paid a flying visit, was even more impressive: it was a kind of 1960s planners' dream, a British city that never was." (Hall, 1996: p.6, bracketed text added by authors)

However, Schumpeter's ideas were mainly touched upon rather than embedded. Glasson's (1992: 507) study on regional planning referred to Schumpeter's stress on technology in a long wave development. LeVine (2007) used the term "creative destruction" after David Harvey (1989). Ward (2013: 303) made a passing statement about Schumpeter's distinction between invention and innovation.

Lai and Lorne (2006) recognized that the Pigovian model of a retrospective environmental tax on copper pollution for a mining community is unsuitable for adopting Coasian bargaining analysis. Equally, incorporating a stochastic element, as in Yu's model, will not take the analysis anywhere. It is the willingness of the community to open itself to a completely different model of operations, through a series of *charrettes* in the form of community brain storming, that opened up a new direction for the community, so they could break the deadlock of land use economics based on past compensation. The *charrette* is a communicative mode of negotiation that relies on respect, trust and willingness to spend time to consider others' ideas and positions.

All of a sudden, the focus of "Coasian bargaining" has been altered. The case study of Brittania Beach is instructive (Lai & Lorne, 2006). It suggests that in the absence of innovations, Coasian "bargaining" for a new real estate project in a town once famous for mining, did not help exploit the social and economic value of its mining heritage. It was only by considering what can happen to an old method of doing things, i.e., by trying Schumpeter's "outside circular flow" of innovative ideas, that the deadlock in *conentional* Coasian bargaining was untied.

Yu's model, with added Schumpeterian notions, has also been applied to other problems in land use-transport planning. Webster and Lai (2003) offered an example of a mass transit rail station tunnel that connects a new real estate development in an off centre location. On their own in isolation, the station and the development could generate negative externalities of congestion at street level. The tunnel, built across government land enabled by a licence, channels people coming out of the station to the development, which may take advantage of this stream of potential clients. Conversely, the railway also expands its catchment to the new concentration of people.

Likewise, the Yu model (2000) was also extended in Lorne and Lai (2011), and in Lai and Lorne (2012), using a mathematical model developed on Yu et al's. (2000) model to demonstrate how a franchised bus company, *China Motor Bus* (CMB), under a government fare capping rule from 1946 to the mid 1970's, was able to expand its scale of operation and make a profit. Econometric analysis shows that CMB enjoyed economies of scale. (Lai, Chau, & Cheung, 2012)

Lai and Lorne (2014) later further extended their analysis by taking into consideration Schumpeter's idea of "creative destruction." Coase and Schumpeter "meet" with the possibility of a transformation of negative into positive externalities. Schumpeter's idea of creative destruction exhibits the characteristic of negative externalities in that the *status quo* is disrupted (wounded) by an outside circular flow innovation that will replace it. Yet disruptive innovation can make the society better off overall, and thus it is also a positive externality. The nature of "bargaining" in this paradigm is very different from the original Coase had envisioned.

7. Spatial trading of greenhouse gases: greenhouse gas trading to make a landing

We shall make an attempt here to argue that trading resources in the world atmosphere can be restructured to have a focus on trading of land, i.e. metaphorically, trading in sky brought to earth by trading of land. This attempt in specific terms is (a) linking the Coasian approach to sustainability; as well as (b) linking Coasian pollution trading to

[18] This reminds us of Elizabeth Anscombe's recollection of Wittgenstein (Anscombe, 1959: p. 151), "He once greeted me with the question: 'Why do people say that it was natural to think that the sun went round the earth rather than that the earth turned on its axis?' I replied: 'I suppose, because it looked as if the sun went round the earth.' 'Well,' he asked, 'what would it have looked like if it had looked as if the earth turned on its axis?'

[19] Schumpeter does not imply resource (acquisition) or exchange occur in an outside circular flow, only that the 'new combinations' AS IDEAS do in the sense that they are NOT at the outset existing parts of the INITIAL circular flow's conceptual/theoretical currency. Rather, they are new things, or new ways of doing/making things thought up, formulated and instantiated by new individuals WITHIN the present flow but in some sense (necessarily) to one side of it (i.e. new firms - his example is that it wasn't stage coach operators who invented railways) and using "some part of the existing economic system's productive means", they enter the flow and disrupt/change it. He goes on, "development consists primarily in employing existing resources in a different way, in doing new things with them, irrespective of whether those resources increase or not." (Schumpeter, 1934: p. 68)

spatial planning and land use polices, considering TDR and land readjustments as pollution control mechanisms. This is in support of and articulates with the "land use, land-use change and forestry" (LULUCF) endeavours under the Kyoto Protocol (Hepburn, 2007). Research on LULUCF has hitherto focused on methods of better animal farming management (see for instance Crosson et al., 2011).

7.1. Transfer of development rights (TDR)

The carbon trading concept as explained in Section 4 can be translated into a land interests trading concept, following Coase's (1960) farming parable, but making an institutional arrangement to demonstrate how this mechanism can be applied to land. The translation would hopefully help show how the generic nature of the mechanism of the "transfer of development rights" (TDR), often listed alongside carbon trading as a tool informed by property rights economics, may help achieve sustainable development.

Wang, Tao, Wang, and Fubing (2010) and Barrett, Bulte, Ferraro, and Wunder (2013) made a connection between carbon trading and TDR but did not show how the two are similar. Salkin (2004) mentioned TDR as a component of a green policy of Montgomery County, USA but did not elaborate on it. Schröter-Schlaack (2011) picked up the US approach to TDR and discussed its application to Germany. However, it is unclear how carbon gas emission can be curtailed. This attempt to link carbon trading with TDR is timely as both are recognised by the World Bank as property rights tools that help promote sustainability (Kelly & Jordan, 2004).

TDR is generally an old planning measure to free the development potential of land from the confinement to its *de jure* property boundaries. "The TDR concept is not new. The 1916 New York City (NY) zoning ordinance gave rise to the concept of so-called air rights; previously, New York City did not regulate the height of buildings. Lot owners were then permitted to sell their unused air rights (development potential) to adjacent lots under the proposed zoning." (Shahab, Peter Clinch, & OöNeill, 2018: 63)

7.2. Land readjustment

TDR can be a dimension of "land readjustment", i.e., permanently reconforming a certain (notably irregular and traditional) morphology of an early cadastral pattern to a planned (modern) layout with better vehicular and other infrastructural services to each re-delineated land parcel. Land readjustment has a long history (Home, 2007). It refers to the transformation of an informal and often rural and certainly less than efficient lot pattern, unsupported by urban infrastructure, into a formal and more efficient lot plan for modern rural, suburban or urban development with road access and infrastructural services. The transformation often involves the state or an authority as a facilitator (Van der Krabben & Needham, 2008).

Though land readjustment has not yet been practiced but only discussed in the UK (Home, 2018) or USA, over a century ago with the Meiji Reformation it began to be implemented by Japan successfully to modernize her traditional farmland under informal patterns of subdivision (Home, 2007). It has been put to practice in more than 14 jurisdictions including Spain (Muñoz-Gielen 2014, Gozalvo Zamorano & Muñoz Gielen, 2017, France (Turk, 2008), Germany (Davy, 2007), Sweden (Turk, 2008), Turkey (Türk, 2004), Israel (Home, 2003), India (Mathur, 2013), Nepal, Thailand (Archer, 1986), Indonesia (Agrawal, 1999), Taiwan (Kigawa, Seo, & Furuyama, 2007), South Korea (Kim, Lee, & Lee, 2009), Japan (Home, 2007) and Australia (Archer, 1988).

TDR may be in the form of the permission for a market transfer of some present rights to develop, or of any unexploited development potential in one site to another within a delineated district or region; an inter-change of sites in different locations; the present surrender of a site in one (say rural) location for a tradable entitlement to a (fraction) of site in another (say urban) location. These will be visited in our land-based proposals for carbon trading. Generically, TDR articulates with Coaseös (1960) farming parable in which one possible form of exchange of rights, as demonstrated, operates through the relocation of the *de facto* border fence such that the *de jure* boundaries serve only as a referent for the deal.

The modern formulation of TDR in the US and Canada presents the mechanism in terms of three basic concepts, namely "development rights" treated as a bundle of separable units; "sending areas" (a low density preservation zone or place) from which development rights are sold; and "receiving areas" (a higher density or urban growth zone or place) for which such rights are bought (Hoggins, 2001; Centre for Land Use Education, 2005). Hoggins (2001) specified several conditions for success in TDR:

> "A clear and valid public purpose for applying a TDR program, such as open space preservation, agricultural or forest preservation, or the protection of historic landmarks.
> Clear designation of the sending areas and the receiving areas, preferably on the zoning map.
> Consistency between the location of sending and receiving areas and the policies of the local comprehensive plan, including the future land-use plan map.
> Recording of the development rights as a conservation easement, which will inform future owners of the restrictions and make them enforceable by civil action.
> Uniform standards for what constitutes a development right, preferably based on quantifiable measures like density, area, floor-area-ratio, and height, should be used to determine what development right is being transferred.
> Sufficient pre-planning in the receiving area, including provisions for adequate public facilities."

Pruetz and Standridge (2008) listed 10 factors from the research literature and concluded that the demand was for bonus development, customized receiving areas, strict sending-area regulations, few alternatives to TDR, and market incentives. An application of TDR that does not satisfy these conditions may not be too fruitful, as interpreted by Linkous and Chapin (2014) and Linkous (2016).

An innovative approach to apply TDR has been proposed in the form of a land bond (Lai, Chau, & Choy, 2018). The concept is for the government to call for the surrender of private land plots anywhere in Hong Kong fit for various planned purposes, but especially in the New Territories where communal land ownership leads to huge transaction costs for land assembly, and paying their owners land bonds that are internationally tradable. Holders of these bonds are entitled exchange their holdings for a calculable amount of new land formed by the government through say sea reclamation or hillside terracing. This land bond would be openly traded in a public exchange so that transactions would be perfectly competitive and transparent. The proposed bond should help break the deadlock in land transactions posed by various forms of rigidity in assembling collectively-owned farmland for development. The property rights of planned comprehensive development in the future are assigned to landowners holding fragmented and scattered parcels.

7.3. Irreversibility of TDR and land readjustment

The current understanding of TDR in the planning literature conceives of a one way trade of development rights from the sending to the receiving zone for real estate construction. The sending area is always a seller and the receiver is always a buyer of rights. The same applies to land readjustment, which has also been considered in terms of Coasian transaction costs and is understood to be a one way transformation of the physical structure of land ownership. The one way change is due to the extremely high transaction costs of reversing or changing intensive real estate development as ownership usually becomes more fragmented and road corridors more rigid due to successive laying of such

infrastructure as drains, sewers, communications cabling, and utilities supply.

The scenarios to be discussed below, however, contemplate reversible flows of rights to land resources[20].

7.4. Aligning Coase's fable to carbon trading

In Coase's parable, stray cattle that wander into the crop farm generate an inter-individual effect of a bilateral nature, in which the law of tort favours the crop farmer as a land owner. That may not be the case if the land is not privately owned. However, once public spaces are involved, there will be too large an environmental issue of gas or smoke for any innocent third party to become directly involved, as Pigou argued. This is an interesting twist on the problem, as we know that cattle generate MH_4, another greenhouse gas. Is it possible to expand Coase's story to deal with a trade in the rights to produce cattle methane in the same way carbon trading works?

The idea behind carbon trading is to set a unitized annual quota of CO_2 generated (set below an estimated total amount) and let the whole world, especially carbon producers, purchase units on the market that entitles them to produce CO_2. Now one way to fit this method into a reduction of cattle methane is to *define the quota in terms of land*, assuming that there is a fixed cattle-land ratio. In other words, instead of applying a greenhouse gas tax directly to cattle raising, the cattle-raisers would be asked to bid for the rights to use the land for their cattle to roam. The property rights of the land allocated for this purpose can assume a variety of forms other than outright ownership. The title of land allocated for cattle roaming could be vested in the crop farmer or a public wilderness entity. The cattle-raisers will then bid for the right to allow their cows to stray on those lands, which constitutes a very limited aspect of the use of property rights.

It should be stressed that this paper is not intended to holistically deal with the problem of methane. Rather, the emphasis is on how the Coasian "bargaining" can be evolved to a carbon-trading-like type of mechanism. The example only serves an illustrative purpose rather than an agenda for policy implementation. However, as the cattle (beef) industry has been subject to criticism by green groups, the idea of a trade in land is offered outlining the basic components and its parallel to carbon trading.

The assumption of a fixed cattle-land ratio is to allow the simplification of using land as a good proxy of pollution generated by cattle. Admittedly, though *land area* was used by many in conservation agriculture (see for instance Razafimahatratra, Bignebat, Bélières, David-Benz, & Penot, 2017), *herd size* is definitely a better proxy (Saam, Mark Powell, Jackson-Smith, Bland, & Posner, 2005 and Sserunkuuma & Olson, 2001. In other words, our model needs the support of a *cattle density* cap.

Fig. 3 shows the method, which assumes a world of property rights clearly defined in the sense of an unambiguous spatial delineation in terms of location and size, but not prohibitively high transaction costs of contracting. Consider a crop farm, C, being situated next to two cattle farms, A and B. For both farm A and B, some land (Region IV) was not for cattle grazing, presumably because the crops raised or the wild grasses and flowers that grow there are too valuable to be trampled. However, some land (Region II) in both cattle farms was tradable among cattle farmers A and B and crop farmer C, who could cultivate crops on cattle farms, depending on the marginal revenue product of doing so. The property rights structure in Region II could be intriguing, in that they need not be owned outright by either the cattle raiser or the wheat farmer.

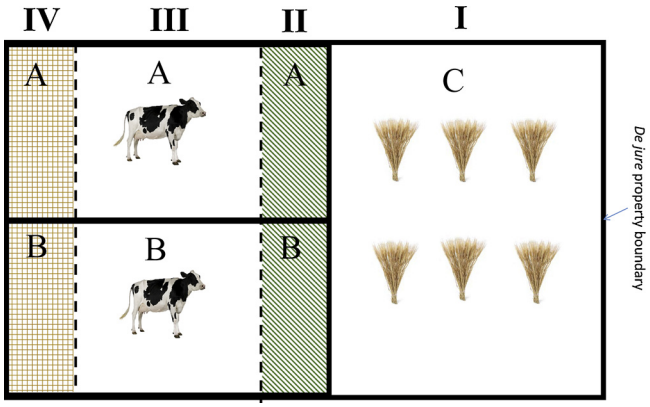

Fig. 3. Coasian model denominated in land.

However, if the Region II lands are owned by the crop farmers or an NGO caring for the wilderness, the owners can allow cattle to stray on them, although the cattle raisers would have to bid for this right. This aspect of the competitive bidding process is similar to that for the bidding on greenhouse gas emissions. The suppliers of these quotas are land owners who are adjacent to cattle farms in Region III. A market trading institution can be designed to trade in the greenhouse gases emitted by cattle in the same way greenhouse gases emitted by coal burning industries are traded. The quota can be denominated in terms of acreage or locality. A cattle raiser would then simply calculate the land required to allow his/her cattle to roam and graze – a technology parameter presumably based on a land/cattle ratio. Together with a competitive bidding price for the right to stray, both parties can decide on the optimal size of the herd to be placed on their farms for healthy growth and better quality beef.

The actual outcome of an exchange can become much more significant if both parties are ready to change their original mindsets instead of confining them to a cattle raising-crop farming interaction. This can happen in several ways. One way is that Region IV lands are devoted to re-forestation, re-foresting native trees (Bekessy & Wintle, 2008; Coomes, Grimard, Potvin, & Sima, 2008; Smith & Scherr, 2003) or establishing other forms of bio-diversity that reduce methane. It is not necessarily clear whether the titles of Region IV lands are best vested in cattle raisers or crop farmers, state wilderness entities, or some NGOs. The ownership of Region IV lands may have to be decided by an extended form of Coasian exchange that is contingent upon changing the mindsets of the parties involved. An even more drastic way is when global warming stimulates the adaptive substitution of wheat for rice and cattle for water buffaloes, which also produce milk.

This "change in mind set" may appear to be rather strange because it seems to contradict the nature of property rights supported in this monograph, i.e., the owners need not sacrifice their interests and property rights in an environment of emerging innovation. This subject matter may be a paper by itself, Cheung (1982) predicted that China will go capitalist in the sense of developing a market economy based on private property when the country began to open up in the late 1970s. Allen and Lueck (2018) also argued that property rights and transaction costs must be discussed simultaneously and indeed could be considered as the same thing. If so, rights are not absolute elements in the economic system like DNA in a human body. Ultimately, individuals make tradeoffs between different types of rights, different type of transaction costs, in accommodating the reality of changing technologies. The point is not about a tradeoff under given conditions (i.e. a static view), but the possibility of joint maximization by an innovation via mutual agreement in an environment of emerging technologies.

The gist of Fig. 3 is a voluntary reduction by cattle-raisers in the amount of land on their farms dedicated to cattle raising, while setting

[20] In the literature on sustainability and conservation payments, irreversibility of some actions in respect of land resources, like deforestation, has been seen as a major issue (Deng, Li, & Gibson, 2016; Engel, Palmer, Taschini, & Urech, 2015). In the land model of this monograph, it is assumed that crop and cattle land are easily reversible uses of land.

aside a fixed quantum of land to lease or license to others for cattle or crop farming. In other words, a monoculture of cattle in a cattle farm is only an option and there is a self-imposed restraint not to overgraze.

The freedom of farmers A, B, and C to use their land is *voluntarily* attenuated. There is a voluntary global cap and reduction on the tradable zone for cattle, as well as a conservation of C's land by A and B for crop farming. In the original model depicted in Coase, a monoculture of cattle or crops, depending on market conditions, can cover all the land of A, B, and C as an extreme case. In Fig. 3, the maximum area for cattle raising is limited to Regions II and III owned by A and B, who prohibit their cattle from stepping on C's land. Such a restriction on trade, unlike a Pigovian tax or quota, does not result in rent dissipation because it was self-imposed.

Self-imposed quotas by NGOs, such as cooperatives, are not new or unique to carbon trading. It can be found in broadcasting (Deakin & Pratten, 1999), fisheries (Berkes, 1985; Berkes & Pocock, 1981; Boggs & Kikkawa, 1993; McCay, 1980), coffee farming (Winters, 1964), and cattle raising (Hughes, McClatchy, & Hayward, 1971).

8. Policy questions and implications for land use trading and regulations

Suppose the story in Fig. 3 is a good fit for the carbon trading practice as a manifestation of the Coase Theorem in land terms. What, then, are the policy implications of this arrangement for land use regulations?

8.1. Cap and trade: regulated or free trade?

Before dealing with practical applications, there is a need to clarify one big question: how would self-imposed limits on the opportunities to trade stand up to the maximization postulate other than charitable concerns over global warming? In the first place, not to put up privately owned resources to generate the maximum income is perfectly compatible with the notion of private property. Other things being equal, such self-denial makes little economic sense. However, when self-limitation is a condition for innovative quality enhancement, it makes good economic sense. Raising fewer cattle may allow the grassland to regenerate faster and free resources for experimentations with new cattle breeds or cattle-rearing techniques. Extensive farming would be replaced by higher-yielding intensive farming and, ideally, this should generate less cattle methane without harming employment, business returns, and government tax revenue.

Many scientists consider substantial reduction in herd size and change in human diet in favour of vegetables are the most eminent measures to reduce CH_4 (Schipper, 1997). Perhaps as or more pertinent, which may relieve pressures on herd size, recent research has shown that the most important path to CH_4 reduction is a change in the diet of the cattle.[21] It may thus turn out that the optimal fix requires a market mechanism that will encourage farmers to switch to a better feed for the cattle, which would be something like the "sustainable catch" certification labelling on fish and "sustainable product" labelling on consumer goods and foodstuffs: a "low methane output herd" meat label. This of course depends on environmentally committed consumers. As long as the normal market is one in which consumers have the dietary preferences they have, which change but slowly, and chase lower prices, there can be no market incentive for farmers to environmentally optimise feed. So some equivalent to "zoning" (i.e. restrictions on land use by type of feed stuff - call it "low methane output farming zones") or a Pigovian tax (i.e., a differential tax of some sort on feed production or sales) might be necessary unless and until significant changes in social values have effects on the animal protein component of the average diet.

8.2. A change in the mindset?

The discussion can be enriched by thinking beyond the proper (optimal) quantity of cattle roaming if there is a change in the mindsets of all stakeholders over the possible use for the land that surrounds cattle raising areas and that surrounding crop farms. The nature of transaction cost analysis is not to work out the point of optimality, but to focus on the proper use of an area where externalities are minimized. The answer to that could very well be ZONING, a point to which the authors will return, bearing in mind that Coase stated that government rules can help promote exchange, according to the so-called "Fourth Coase Theorem," to distinguish it from those mentioned above (Lai & Lorne, 2015).

8.3. Cap and trade as freed trade

The original idea of cap and trade in pollution may seem to be Pigovian as it involves a ceiling, which conjures up measures heavily criticised by liberal economists like minimum wage, maximum rent or quotas as covered by the theory of price control (Cheung, 1978), as applied to discuss racially discriminatory zoning by Lai and Yu (2003) and Lai, Kwong, and Kwong (2011). The case of cap and trade in green house gases can surely be articulated along this classic line of thought. However, where a restraint is self-imposed or voluntary, the picture is completely different and there are many good examples in private land use zoning that such restraints can lead to an outward shift in the MB or a downward shift in the MC curve due to Schumpeterian innovations.

In the real world, examples of voluntary payments of higher user pay charges and self-restriction in supplying land or development can actually be found. During the 19th Century, a business club, the Hong Kong Chamber of Commerce, lobbied the colonial government to build a lighthouse in Chinese waters, which could benefit free-riders who did not enter, but bypassed Victoria Harbour. The lighthouse was a public good in the eyes of Pigou and Samuelson, but a private good in the eyes of Coase (1974). Users did not care whether it was, theoretically speaking, a private or public good, but saw it as useful for shipping and commerce. To back their petition, they accepted a doubling of the light dues paid to the Harbour Master (Lai, Davies, & Lorne, 2008a, 2008b).

Other researchers (Lai & Kwong, 2012) reported the case of a private company that required its shareholders, who held leasehold interests on land (as subscribers of shares), to make all prospective changes in the use, redevelopment, leasing, or selling of their landed interests subject to the approval of their company board of directors, who themselves happened to be proprietors. No lessees have unfettered rights to use, derive income from, or alienate their rights, but they have entered this club system freely. In that case, it is a private government (called the "Shek O Development Company") that oversees this voluntary surrender of full freedom to use, derive income from or alienate one's property. All in all, some form of private governance is essential to sustain the voluntary cap on land use. This institutional requirement tallies with the concept of subsidiarity in the sense that industrial interests can manage their own affairs without the intervention or day-to-day management of a higher apparatus, usually a government department, and this should reduce the transaction costs of state enforcement. The outcome has been a rise in the general and individual values of properties in the club area. Thus, in the scenario shown in Fig. 3, something akin to a cattle farmer association may be formed to credibly handle land trades.

By extension, the state may allow private development companies under state franchises or land leases to implement environmental planning goals and quotas voluntarily. Hitherto, attention to private governments in land development has focused on the adverse social effects of gated communities, which continue to flourish. If and how

[21] (https://www.sciencealert.com/adding-seaweed-to-cattle-feed-could-reduce-methane-production-by-70 and https://www.theguardian.com/science/2007/jul/10/ruralaffairs.climatechange).

they can contribute to sustainability, as a form of contractually engaged governance, say, by lowering greenhouse gas generation, is worth exploring and discussing.

This approach has been considered by Lee (2010) regarding international ordering of the environment, who observed:

> Free-market Coasian bargaining and private institutions are other mechanisms through which parties cooperate to overcome collective action problems. Globally, such self-ordering already exists with networks of private contracts that operate like public regulation and private international institutions like Greenpeace and Amnesty International. Additionally, nation-states can engage in Coasian bargaining by signing treaties like the Kyoto Protocol and NAFTA, or by becoming members of institutions like the WTO and the IMF. (Lee, 2010: p.350)

The model in Fig. 3 actually illuminates from a Coasian-Schumpeterian perspective the merits of innovative government zoning controls of land uses that permit, within the framework of traditional development control as a development rights rationing regime, the transfer of a quantum of approved development rights and obligations that are not essentially site-specific from one site to another within a well-defined planning area. This illuminates the concept of TDR, which may refer to any of, but especially the second, of the following scenarios (Lai et al., 2016):

(a)a land owner may transfer site coverage, (residential) development rights, and (residential) allocations from one part of the land he owns to another part of the same plot of land (Maraist, 1995) or to another plot;

(b)to elaborate, a predetermined maximum level of development within a specified region is distributed as "development rights" within the region such that landowners who keep their development levels below their allotted development rights levels can sell their surplus development rights to other landowners. Or they can use them to offset developments on other lands (Shogren, Parkhurst, & Settle, 2003);

(c)a way used by the state to compensate a landowner deprived of his property by exchanging another plot of government land of comparable economic value with him by mutual agreement; or

(d)a tradable and redeemable land certificate that can be used to obtain a certain ratio of new sites planned and serviced by the state (as in the case of land bonds mentioned above).

9. Freeing exchange from the confines of property boundaries

At this juncture, we may "complicate" our discussion of grounding pollution to land by freeing the pollution from *land boundaries*, thus lowering the transaction costs of exchange of rights in terms of boundary or area measurement. This reduction in cost is made possible by new technologies that are rapidly advancing. Two are considered here.

The first is drone technology, which has hitherto only been articulated in the planning field in terms of its regulation as a kind of intrusive and air traffic problem on the hand and its usefulness as an aid for aerial surveying and planning scenario simulation (Koch et al., 2011) on the other hand.

The second is the developing technology of a pneumatic stabilized platform (PSP)) (Lamas-Pardo, Iglesias, & Carral, 2015).

9.1. Avoiding boundary crossing

Recently, a research team developed a new drone technology to track cattle, which grow better if allowed to roam. This can free cattle farming from a specific privately owned field as they can be kept into the *de jure* open-access wilderness owned by the government. This technology may not fully prevent the problem of stray cattle invading an adjacent crop farm, but can channel cattle to lands that do not have private boundary issues and, thus, save on the transaction costs of negotiation over an agreement between landowners, or litigation in case no agreement could be worked out in Coase's cattle-crop story. Indeed, it saves land for other agricultural and suburban uses.

Factored into our discussion in section 7 above, the drone technology, when applied with other necessary requirements including a change in both cattle and human diets for instance, reduces the costs of implementing the land based trading of greenhouse gases and can enable further innovations in enhancing ranching productivity and quality of cattle while reducing greenhouse gases.

Basically, the neoclassical MB (MV) and MC methodology in section 7 presumes a property boundary between the cattle rancher and the crop farmer. However, with "drone cowboys", there is less of a need to have a boundary in order to manage inter-individual spillover effects, as "drone cowboys" may be able to track all activities of cattle, and the type of vegetation they eat and trample.

The problem, in the neoclassical formulation of the issue in terms of Coaseös (1960) parable, is a joint maximization of the cattle and crop business as two departments of a firm (Lai & Yu, 2003). For this problem, there need not necessarily be a departmental division for cattle and a separate departmental division for wheat. The compartmentalization of the two activities is for management of affairs within each department, like a department of real estate and a department of planning. When the state of knowledge (technology) progresses in such a way that effective utilization of resources may require more interactivity between the two, say the importance of having everything conducted under a mission of sustainable development, the two departments should merge. In that case, it becomes a joint maximization problem.

TDR or land readjustment is a pre-staging of a joint maximization problem. The discussion of this, which also entails how important is for cattle to find the right feed, eat the right vegetation and to find space to roam and exercise can vastly increase the value of the meat, which is highly valued in the western world, as people there like fat juicy steaks.

9.2. Making development reversible?

A possible form of property development that can escape the fate of the irreversibility of TDR or land readjustment is to locate it not on land but on the sea surface, applying the idea of "floating cities" (Very Large Floating Structures/Platforms (VLFS/VLFP) such as the Mega-Float floating airport being evaluated in Japan). This idea is possible by combining the PSP and real estate projects that are using pre-fabricated and reusable units.

The PSP technology has been recommended with claims to some initial small scale trial success in Singapore, China and Japan (Tajima & Asakura, 2002). The aim will be to scale up and construct "very large floating structures" (VLFS) (Lamas-Pardo et al., 2015) or "mega float projects" such as airports and sports stadia. PSP and VLFS are forms of innovative "reclamation", i.e. the creation of new "land", without filling up the ocean with solids. If the technology becomes mature, the prospect of supporting superstructures to hang fish culture cages, thus combining urban uses, aquaculture and maritime activities is a possible development. The location, size and shape of the PSP platform itself can also be adjusted and realigned in time according to new planning needs. Already in 1985 real estate projects, like Norman Foster's HSBC Hong Kong Headquarters, could be designed to be fully removable and reversible. Such technologies can free buildings from their locations and hence render land uses reversible. When they are erected on a PSP or other very large floating platform with an equivalent performance envelope, a completely reversible urban system is in place.

10. Conclusion

This monograph proposes to address greenhouse gas emission problems from an angle not previously examined. The lack of inquiry in this direction is due to a limited paradigm with limited tools grounded

in neoclassical economics. The carbon trading mechanism, the most pragmatic and innovative application of the Coase Theorem, was founded upon rejecting a presumption that greenhouse gases are necessarily "social baddies" or mere garbage, i.e. externalities that are unambiguously negative.

No one can confidently say that in the realm of technology changes, there is no scientific principle that would argue that greenhouse gases cannot be recirculated into production of useful products.[22] Indeed, much scientific research has been geared to this direction.[23]

As a matter of an appropriate economic paradigm to use for future analyses, we cannot rule out that resources have both negative and positive benefits. The correct approach therefore should not be to presume an activity to be negative. Indeed, it should be the task of our modern Coasian bargainers to examine areas where positive externalities can be identified. Technological changes must be an integrative component of this analysis. Otherwise, it is incomplete. This is the true spirit of a modern version of sustainable development—an inquiry into development directions that will be win-win for the economy, society, and the environment.

In this monograph, the analysis of carbon trading as an environmental economic tool for *global* atmospheric pollution is linked to a theorem formulated in terms of Coase's land pollution story in "The Problem of Social Cost". Coase intended to use this story to ruin Pigou's *local* air pollution example in *Welfare Economics* (Pigou, 1932). It is hoped that this monograph translates the logic of carbon trading in its best possible light back to a land environmental economic policy or statutory tool, thereby preserving the principle of a quota system. As shown in the hypothetical and real world examples, the stress is not so much on curtailing excessive production mooted by Pigou, but rather on setting up a platform on which innovations for promoting sustainable development are feasible. The relevant Coase Theorem that is the focus of this monograph is not so much that formulated by Stigler based on Coaseös (1960) work, but the one affirmed in his 1988 book, *The Firm, the Market and the Law* (Coase, 1988a).

Philosophers have found carbon trading effective, albeit objectionable, on the grounds of distributive justice (Caney & Hepburn, 2011). They may not realise that Coasian thinking, as a social philosophy that fuels carbon trading, is often more right-wing and restrictive in practice than its "authentic" economic principles. It places much emphasis on efficiency via transaction cost reduction and pays less attention to innovations or equity that private property enables. It comes with many grounds for rejecting government controls on the basis of efficiency, but pays less attention to private demands for public control. Individuals, groups, and families can be compelled to do certain things, but often such compulsion is self-imposed voluntarily rather than forced from without. Good sportsmen follow rigorous programmes of exercise and hire coaches to "enforce" them.

Land boundaries can be seen for whatever reasons as rigid defensive lines signifying segregation, isolation and preservation, or as an expedient means for partitioning land resources as a matter of a spatial division of labour. The former stance is antithetical to trade and brings up ideas of unfriendly warning signs, guards, fences and high walls. The latter entails inter-dependence and therefore communications and exchanges. Where exchanges to reap Adam Smith's gains from trade involve re-delineation of land boundaries, more transaction costs are often incurred in re-delineation than initial delineation. Coaseös (1960) story merrily assumes away such costs. In our analysis, such costs are also assumed to be low enough to simplify articulation. In any case, new institutional designs and technologies have reduced costs of boundary delineation and re-delineation, not to mention freeing activities from their territorial confines. TDR and land readjustment are one-way approaches to free development potential from boundary restrictions.

The land institutional arrangement as a kind of eco-innovation proposed in this monograph involves probably the same degree of information costs involved in identifying a world quota for greenhouse gases, but it offers more alternatives in terms of voluntary research efforts for providing solutions to the global warming problem. That is, a restrictive setting in the quantity dimension of resources that need to be produced is not necessary. Just as competing sportsmen self-impose rigorous programmes, so can society find solutions to the environmental problem.

It is hope that this monograph, as a new connection between what may appear as dull impersonal Coasian exchanges with noisy[24] individualistic Schumpeterian innovations, would attract further and better research on the formulation of practical land use planning policies for tackling pollution beyond a local area.

This paper stresses Schumpeterian innovations but this is in no way dismissive of the role of Coasian bargaining which, is everywhere in the real world. The bringing up of property rights bargaining in this context is relevant. But here is the crux of the difficulty in implementing the concept of sustainability, the bargaining of property rights with the future generations. Property rights as narrowly defined by the physical boundaries of land are insufficient as the parameter to be negotiated with the future generations, particularly given that the future generations are likely to have a new technology that neither they nor the present generation know about yet. Thus, the Coasian bargaining must rely to some extent on the emerging technologies. There are many examples where emerging technologies can change the nature of a Coasian bargain beyond the textbook example of bargaining on the basis of a static framework of marginal benefit and cost. That is why the shifting of marginal benefit and cost should be the essence of the matter being bargained, rather than achieving the static point of economic efficiency.

Again, the paper emphasizes that Coasian bargaining should be on the methods of *SHIFTING* the marginal benefit and cost curves, rather than solely on the static framework of willingness to pay and willingness to sell. Furthermore, the paper does not (and should not) say that government is the best representative of future generations in this bargaining process, but that government can *facilitate* bargaining in the direction of shifting the curves without dictating the property rights structure that will evolve from that.

The Coase Theorem if not Coasian economics itself is a form anthropology that assumes that cooperative, voluntary exchange, as an alternative to administrative fiat or litigation is an option for better achieving wealth maximization. The Theorem itself, based on radical presumptions about human nature, is surely legally and philosophically contestable. To some of the difficulties raised by critics we have sought to employ Coasian antidotes to the best of our understanding and we do not claim that we have the last word. However, it is certain that in carbon trading there is really not much actual "bargaining". The most important message is that in a world of positive transaction costs with room for Schumpeterian innovations, whether inside or outside circular flow phenomena, the door is open for some government or regulatory institutional arrangements. Zoning, the age-old tool of the planner, may be a useful vehicle for pollution trading.

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[22] See https://www.sciencealert.com/scientists-plan-to-recycle-waste-carbon-dioxide-co2-into-plastic, http://www.sciencemag.org/news/2018/03/scientists-say-we-re-cusp-carbon-dioxide-recycling-revolution

[23] see https://phys.org/news/2016-08-recycling-carbon-dioxide-climate-warming-co2.html

[24] Schumpeter (1975) compared innovations as bombardments that shock the economy.

the meaning of value c in Fig. 1. They are also grateful to Dr. Mark Hansley Chua for helping to draw Figure 3 and Dr. Alex Y.H. Lo for his advice on carbon trading research. All faults are the authors.

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Prof. Lawrence W.C. Lai Academic qualifications: B.Soc.Sc. (HKU), M.T.C.P. (Sydney), M.Soc.Sc. (Econ) (HKU), LL.B (London), Ph.D (HKU). Professional qualifications: M.A.P.I., M.H.K.I.P., F.R.I.C.S., F.H.K.I.S., M.C.I.L.T., Registered Professional Planner.Government committee appointments: Board of Review (Inland Revenue Ordinance); Building Appeal Tribunal; Planning Appeal Board; Transport Tribunal; University Grant Committee.Former positions in Hong Kong Government: Executive Officer, Royal Hong Kong Police; Town Planner, Town Planning Office; Environmental Protection Officer, Environmental Protection Department. Present position: Professor, Ronald Coase Centre for Property Rights Research; Department of Real Estate & Construction, University of Hong Kong. Publications: has published since 1985 a total of 120 refereed academic research papers and 14 books in English on town planning and property rights and related subjects.

Prof. Frank T. Lorne Academic qualifications: B.A. (Maths), M.A. (Maths), Ph.D (Economics): University of Washington. Former teaching positions: UCLA (Econ School) Assistant Professor in Economics; HKU (Econ school), Lecturer in Economics; California State University (Econ school), Professor in Economics.Present position: Professor, NYIT (Vancouver); Hon. Professor, Ronald Coase Centre for Property Rights Research; Department of Real Estate & Construction, University of Hong Kong.Publications: has published in Ecological Economics, Land Use Policy, Habitat International, Planning Theory, Town Planning Review, Survey and Built Environment.

Professor Stephen N.G. Davies Academic qualifications: B.Sc. (Econ, UWIST), M.Sc. (Econ, LSE), Ph.D (LSE).Former teaching position: Lecturer in Political Science, HKU.Present position: Hon. Professor, Department of Real Estate & Construction, University of Hong Kong. Publications: has published in Progress in Planning, Planning Theory, Town Planning Review, Planning Practice & Research, Survey and Built. Environment