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# Increasing returns, individuality and use of the common pool*

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A model of monopolistic competition is suggested to study common-pool resource use. Individuals extract an input from the pool to produce a consumption good under decreasing average costs. The equilibrium output and population sizes are obtained under two types of usage conjectures. Somewhat counter-intuitively, a cooperative equilibrium results in a larger population of harvesters but lower welfare than the noncooperative one. Some degree of population heterogeneity helps minimise the welfare gap between the two equilibria, but the size of heterogeneity may be a determinant if the resource pool becomes subsequently depleted. The model's potential for policy analysis is illustrated by considering how governance via institutional arrangements and transaction costs may be incorporated and inferred.

**Key words:** common-pool resources, heterogeneous individuals, institutions, monopolistic competition, transaction costs.

## 1. Introduction

Patterns of common-pool resource use are regularly ascribed to a number of possible reasons. Examples include the legal environment and various social and cultural contexts. Ostrom (2000) gives a succinct discussion of these but contends that they are specific cases of a more general theory of common-pool resource use and management (which, she argues, remains a work-in-progress). A major obstacle against the formulation of a common analytical framework is that communities and individuals are often heterogeneous in a variety of ways.

Recognising heterogeneity in agents implicitly suggests the potential absence of internal consistency in any type of aggregative function or formulation. This makes generalisations and predictions of usage behaviour difficult, if not impossible. To try mitigating this issue, Ostrom (2000) suggests focusing on case studies and cross-examining the findings across a variety of settings as a prelude to building an overarching theoretical framework. The purpose is to gather a sufficiently (and statistically) large sample in the anticipation that some common traits may yet be observed from the data. Yet, prohibitive time and related data collection costs also mean

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that (some) data-poor environments must be omitted as a matter of practicality. Subsequently, this still necessitates the construction of a theoretical framework for analytical purposes.

This paper suggests that the concepts underpinning the theory of monopolistic competition in the spirit of Chamberlin (1951) provide an appropriate theoretical foundation and structure for the study of common-pool resource use and outcomes. In particular, the generalised Dixit and Stiglitz (1977) model of monopolistic competition by Cox and Ruffin (2010) stands as especially suitable for requirements here.

In a more typical textbook treatment, the analytical view follows that of a utility-maximising individual who provides labour in tandem with the natural resource as a production input to goods-producing firms. This approach starts with the basis that each agent in the economy maximises their individual objective functions subject to the resource constraint to determine the optimal usage pattern for each factor of production. The causal direction of the pattern of resource use thus runs from the individual to the pool.

In studying the use of a common-pool resource, however, the perspective ought to be for the causal link to go from the resource pool to the individual. As common-pool resources often exhibit spillover effects from rivalry in extraction, the individual considers what he/she can extract from the pool without incurring repercussions from the community.[1] Essentially, one decides on the optimal extraction by considering his/her own utility and ensuring he/she has continued access to the resource pool. In this case, therefore, the interaction is between individuals who form the community and an exogenously defined renewable pool.[2]

The community is assumed to derive some benefit (or suffer no loss) from an individual's particular extraction pattern, therefore allowing the extraction to continue. For simplicity of exposition, this benefit is derived from the consumption of a differentiated good produced by each individual using a resource input from the common pool. Thus, in the spirit of Chamberlin,[3] social welfare depends on (i) the number of varieties produced and (ii) the quantity of goods produced.

The main advantage of this reading is that population size can be endogenously determined in response to the extraction decision of each individual within a general equilibrium framework. The quantity of resource that is extracted by each individual depends on a set of individual parameters (characteristics), including the degree of individuality (differentiation), which are innate within agents. This modelling set-up also permits an explicit

[1] A motivation for this consideration is simply the knowledge of a potential denial of access to the resource pool. See, for example, the studies of Japanese village communities by McKean (1992).

[2] Non-renewable resources are omitted in the definition of a resource pool primarily for intuitive simplicity. However, non-renewable resources are clearly important to consider in future work.

[3] See Chamberlin (1951).

analysis of welfare and allows a straightforward comparison between an equilibrium of cooperative extraction versus one of individual optimality.

The welfare differential between the two may be considered as the impetus in determining which type of extractive behaviour prevails. In contrast to what is observed empirically and agreed in the literature, a homogenous population may not be an ideal condition for a welfare-optimal outcome. Some individuality in a community may actually be required.[4] The model also provides a way in analytically determining ownership states of the resource. This further adds to its appeal and suitability for use in studying issues of common-pool resource use.

The rest of the paper is structured as follows. The next section discusses some of the literature in modelling and analysing the use of common-pool resources. Rationalising the choice of the modelling framework is also covered here. Section 3 presents the model following Cox and Ruffin (2010) and discusses its behaviour and suitability for studying issues of common-pool resource use. Section 4 examines some welfare implications and presents an illustration of how resource management practices may be inferred. The final section concludes.

## 2. Background

### 2.1 Some literature

A common-pool resource typically refers to a resource system where utilisation and/or consumption is rival in nature, but is largely nonexcludable in access to all members of the community.[5] Thus, perceived wisdom suggests that so long as the marginal benefit accruing to an individual exceeds his/her marginal cost of extraction from the pool, extraction continues until these two schedules equalise.

The caveat, however, is that social and individual cost-benefit schedules do not necessarily coincide when there is rivalry in extraction. In this case, if each individual views his/her total costs as small relative to the rest of society and extracts at the individually optimum level of benefit from the commons, it leads to overextraction and a depletion of the pool. This is essentially the Hardin (1968) scenario.[6]

[4] This should be read as suggesting that a community requires a bundle of goods and services for its livelihood, with each individual in the community possessing some degree of specialisation in each. In what follows, individuality and differentiation are regarded as synonymous.

[5] Excludability is possible in a variety of ways, but this issue is not explicitly considered in this study.

[6] There is reason to believe this conclusion holds empirically. For example, McWhinnie (2009) estimates the likelihood of overfishing relative to sustainable extraction using global fisheries data. She finds that shared fisheries – those with open access to all parties – generally exhibit a greater chance of overfishing and subsequent depletion of stock. However, Hardin may also not have intended to arrive at a definitive analytical conclusion. See Elliott (1997) for a discussion.

Prior to Hardin (1968), there were already attempts to formalise and analytically study the behaviour of common-pool resource usage. Gordon (1954) specified a set of equilibrium conditions characterising the utilisation capacity of a fishery. He subsequently derived the conditions which lead to an outcome of sustainable fishing or of a depletion in the fish stock.

Market-clearing conditions imposed in general equilibrium models typically suggest the existence of some form of welfare-optimising behaviour, where the allocation of resources is Pareto efficient and agents have no incentive or ability to deviate from a particular utilisation path. However, the development of game-theoretic models demonstrated this may not necessarily the case. These models allowed the study of a wider range of scenarios and behavioural conjectures besides that of the self-optimising individual. Thus, they provide a wider set of possible insights of common-pool resource use, some of which do not conform to the conclusions obtained from general equilibrium models. Readers are referred to Seabright (1993) for an intuitive discussion and Long (2011) for a survey of the developments in this strand of literature.

Yet, while game-theoretic models are insightful and instructive, they are also typically reliant on specific contexts and behavioural conjectures. This narrows the scope for generalisation of the results obtained.[7] More importantly, they have been critiqued for having a lack of predictive power (Ostrom 2000) when matched against the findings from fieldwork studies and surveys such as Wade (1987), McKean (1992), Leal (1998), Ostrom *et al.* (1999) and the references in Ostrom (2000), among others.

### 2.2 Monopolistic competition as a foundation

Formalising a sufficiently simple and general theoretical model for the purpose here requires, broadly speaking, the following: (i) an aggregative social welfare function able to accommodate some degree of individual differentiation between actors, (ii) some degree of interaction as a possible conjecture without having to (substantially) modify the structure of the model and (iii) yielding a set of analytically consistent and (plausibly) closed-form solutions.

Following Chamberlin (1951), the assumptions underpinning monopolistic competition present itself as a suitable modelling foundation for the purpose here. The essence of monopolistic competition, as argued by Chamberlin (1951), is that each goods-producing firm or individual in this market structure produces a good that is slightly different from the next, so each holds some degree of market power in its own product, that is each is a close, but imperfect substitute of the next. However, the number of producers which exist in the market is sufficiently large that no individual or firm is perceived to have any impact on the general level of prices. Thus, producers assume themselves to be too small to be able to influence the behaviour of others and

[7] This is evidently a simplified view. See Hodgson (2007) for a more in-depth discussion.

exhibit little/no potential considerations of interfirm strategic interactions in their output and pricing decisions. These assumptions further allow the derivation of a stable set of solutions, a consideration which adds to the appeal and suitability of monopolistic competition as the modelling foundation of choice in this case.

Chang (2012) surveys the models and their properties in this class of literature, but for the purpose here, the generalised Dixit and Stiglitz (1977) model by Cox and Ruffin (2010) stands as particularly appropriate. The features which distinguish it as such will become evident subsequently. However, a reminder is in order that no claims are made that the conclusions inferred from the model's analytical solutions are indeed general. Instead, it is hoped that what is presented here will lend some way towards further work.

## 3. The analytical model

### 3.1 Cooperative extraction

Consider a common-resource pool with a fixed endowment, $\bar{Z}$, able to sustain a community with an endogenously determined population mass, $N$. Each member of the populace produces a differentiated good, $y_i$, for consumption within the community. Total welfare which the commons yields is given by:

$$U = \left( \int_0^N y_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $\sigma > 1$ gives the elasticity of substitution between varieties. In this case, instead of the regular interpretation of $\sigma$ being a measure of market power held by a producer, $\sigma$ indicates the degree of individuality associated with an individual's good, service or ability.

Production of $y_i$ requires extracting a resource quantity $z_i$ from the commons, and for simplicity, each individual chooses either of the following: (i) he/she stays in the community and incurs a cost, $q$, of extraction to produce $y_i$,[8] or (ii) he/she produces $y_i$ for a unit wage $\omega_i$ outside of the community. The value of $\bar{Z}$ thus equals the sum of all outside options available to the population or: $q\bar{Z} = \int_0^N \omega_i y_i di$

Production of $y_i$ requires a fixed input quantity of $\alpha$ units of the common-pool resource and a marginal resource requirement of $\beta$ units.[9] The amount

[8] Two simplifications are made here. The first is that product markets for $y_i$ clear and all output is consumed internally within the community. The second is that $q$ is a broadly defined cost that the individual incurs for using the commons. This can be interpreted in a variety of ways, such as a licensing fee, a contribution towards maintaining the commons, or even as some form of social norm or monitoring costs which the individual is subject to.

[9] $\alpha$ can be thought of as a minimum subsistence or effort requirement.

of resource, $z_i$, that each individual draws from the commons is thus $z_i = \alpha + \beta y_i$. To be indifferent between staying in the community and leaving, they have to receive at least the outside unit wage rate for their output. An individual's 'welfare profit' function can be written in the form:

$$\upsilon_i = \omega_i y_i - (\alpha + \beta y_i)q \tag{2}$$

In equilibrium, all individuals set the same $\omega_i$, and together with assumption of symmetry, the subscript $i$ can be dropped for convenience. The elasticity of demand *a la* Bertrand faced by each individual for their output is $\varepsilon(N) = \sigma - \frac{\sigma-1}{N}$, and each sets its welfare-maximising wage rule following a mark-up rule of $\frac{\varepsilon(N)}{\varepsilon(N)-1}$ over marginal cost.[10] This gives $\omega$ as:

$$\omega = \frac{\beta q[(N-1)\sigma - 1]}{(N-1)(\sigma-1)}, \tag{3}$$

where $\omega$ is decreasing in $N$. Using Equation (3) into (2) and imposing a welfare-indifference condition, that is $\upsilon = 0$, optimal production of each individual solves to be:

$$y = \frac{\alpha(\sigma-1)(N-1)}{\beta N}. \tag{4}$$

As the size of the resource pool is exogenously determined, the resource constraint means the resource condition: $\bar{Z} = N(\alpha + \beta y)$ must hold in equilibrium. Together with Equation (4), the optimal population that can be supported by the commons is:

$$N = \frac{\bar{Z} + \alpha(\sigma-1)}{\alpha\sigma}, \tag{5}$$

which is independent of the marginal input requirement, $\beta$. Using Equation (5) into Equations (3) and (4), $\omega$ and $y$ can be expressed in terms of the structural parameters as:

$$\omega = \frac{\beta q \bar{Z} \sigma}{(\bar{Z} - \alpha)(\sigma - 1)}; \tag{6}$$

$$y = \frac{\alpha(\sigma-1)(\bar{Z}-\alpha)}{\beta[\bar{Z} + \alpha(\sigma-1)]}, \tag{7}$$

respectively.

[10] See Helpman and Krugman (1985) and Cox and Ruffin (2010).

### 3.2 Individually optimal extraction

The optimal extraction and production strategy of each individual is derived as follows. With a symmetric equilibrium, Equation (1) can be rewritten as:

$$U = N^{\frac{\sigma}{\sigma-1}}y.$$

Together with the resource constraint, $\bar{Z} = N(\alpha + \beta y)$, every individual in the commons maximises the following Lagrangean:

$$\mathcal{L} = N^{\frac{\sigma}{\sigma-1}}y + \lambda[\bar{Z} - N(\alpha + \beta y)]. \tag{8}$$

The resulting first-order conditions with respect to $N$ and $y$ yield:

$$\frac{\partial \mathcal{L}}{\partial N} = \frac{\sigma}{\sigma - 1} N^{\frac{1}{\sigma-1}}y - \lambda(\alpha + \beta y); \tag{9}$$

$$\frac{\partial \mathcal{L}}{\partial y} = N^{\frac{\sigma}{\sigma-1}} - \lambda N \beta. \tag{10}$$

A $^*$ is included to relevant variables to differentiate between the solutions in this section from the previous. Solving for $y$, each person's welfare-optimal output is actually:

$$y^* = \frac{\alpha(\sigma - 1)}{\beta}. \tag{11}$$

With Equation (7), it is clear that $y^* > y$ – the individually optimal production (and extraction) is higher. Next, using Equation (11) with the resource constraint gives $N^*$ as:

$$N^* = \frac{\bar{Z}}{\alpha\sigma}. \tag{12}$$

Substituting Equations (11) and (12) into Equation (2) and imposing $v = 0$, $\omega^*$ solves to be:

$$\omega^* = \frac{\sigma\beta q}{\sigma - 1}. \tag{13}$$

Note that Equation (13) is the wage-setting rule of Equation (3) where $N \to \infty$, while Equations (11), (12) and (13) correspond to the solutions of the model of monopolistic competition following Dixit and Stiglitz (1977).

### 3.3 Behaviour

As the Cox–Ruffin model is a generalised version of Dixit and Stiglitz (1977), aspects of its behaviour follow the latter. From Equation (1), it is clear that a greater population mass, $N$, is welfare-increasing. A larger $N$ increases total output (and consumption) in the economy, leading to higher welfare. Conversely, welfare is inversely related to the size of $\omega$, the external wage rate. A higher $\omega$ implies that the revenue obtained per unit is higher. With a fixed resource constraint, $y$ must fall, subsequently lowering welfare.

Next, given a fixed resource constraint, it is straightforward to deduce that an increase in the fixed input requirement, $\alpha$, in production necessarily reduces the population mass, $N$, that the commons can support. A larger $\alpha$ also means that $\omega y$ has to be correspondingly higher[11] for individuals to be indifferent between staying and leaving. A similar line of reasoning applies to the changes of $\omega$ and $y$ with regard to $\beta$ – an increase in $\beta$ raises $\omega$ and will need to be balanced by a reduction in $y$ to maintain the welfare-indifference condition.

However, the defining feature of the Cox–Ruffin model which makes it suitable for the analysis of common-pool resources is that it gives an explicit distinction of whether the resource pool is communal or private property. This is due primarily to the $(\bar{Z} - \alpha)$ term in Equations (6) and (7). This condition requires that the resource endowment be greater than the fixed input to support just a single variety and is absent in the Dixit–Stiglitz model. This can be seen from the solutions of $N$ and $y$ from Equations (5) and (7) at the limit when $\alpha \rightarrow \bar{Z}$.

From Equation (5), as the quantity of $\alpha$ increases to $\bar{Z}$, this gives $N \rightarrow 1$. In essence, if an individual's fixed resource requirement takes up the entire pool, the population size which the pool can support is just $N = 1$; the commons is private property. This corroborates with Equation (7) where no production is possible since the resource pool is exhausted.

In contrast, $\alpha \rightarrow \bar{Z}$ yields $N \rightarrow \frac{1}{\sigma}$ and $y \rightarrow \frac{\bar{Z}(\sigma-1)}{\beta}$, respectively, in the Dixit and Stiglitz (1977) formulation. In a continuum of individuals, the resource pool remains as communal in use and ownership, and the persistence of a positive output implies there is still communal benefit being derived.[12]

## 4. Welfare and extraction management

### 4.1 Welfare differential

Evidence from the empirical literature suggests that communities and groups are more likely to cooperate when they are small and/or relatively homogenous with regard to preferences and characteristics (Ostrom 2000).

[11] Since $q$ is constant.

[12] The other polar case of $\alpha \rightarrow 0$ yields identical results of $N \rightarrow \infty$ and $y \rightarrow 0$ for both formulations.

Instead of behavioural conjectures, a plausible impetus for (non)cooperation may be due to the welfare differential between the two equilibria.

In the cooperative equilibrium, the equilibrium population size given by Equation (5) exceeds the optimal (given by Eqn (12)), by a fraction:

$$N - N^{*} = 1 - \frac{1}{\sigma}. \tag{14}$$

Cox and Ruffin (2010, p. 1073) thus contend that the cooperative equilibrium approximates the individual optimal and the welfare difference between them may not be too significant.

However, under monopolistic competition, welfare is driven by both output quantity and, for this case, the number of varieties produced by the population mass. Given a fixed resource constraint, a quantity–variety trade-off exists between $N$ and $y$ in equilibrium; a larger $N$ needs to be balanced by a smaller $y$ and vice versa. While the welfare loss from a suboptimal $N$ may be small, this will be magnified by the corresponding suboptimal provision of $y$.

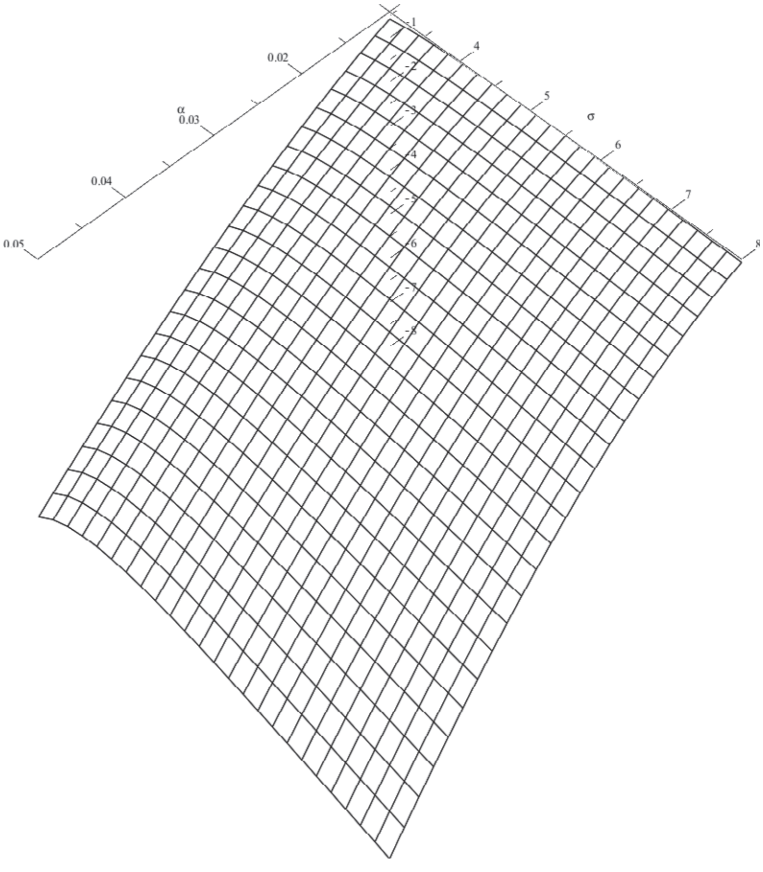
The literature explicitly suggests that population size is a key factor in determining which equilibrium prevails. However, as $N$ is jointly determined by $\alpha$ and $\sigma$, it is thus possible to find combinations of both parameters which ascribe to the required size definitions, but with differing impacts to welfare. Using Equations (5), (7), (11) and (12), the welfare differential between the two equilibria is written as:

$$U - U^{*} = \left(\frac{\bar{Z} + \alpha(\sigma - 1)}{\alpha\sigma}\right)^{\frac{\sigma}{\sigma-1}} \frac{\alpha(\sigma - 1)(\bar{Z} - \alpha)}{\beta[\bar{Z} + \alpha(\sigma - 1)]} - \left(\frac{\bar{Z}}{\alpha\sigma}\right)^{\frac{\sigma}{\sigma-1}} \frac{\alpha(\sigma - 1)}{\beta}, \tag{15}$$

where $N$ is now expressed in terms of the exogenously determined structural parameters and not as a distinct variable.

Figure 1 maps the loss function for a range of parameter values of $\alpha$ and $\sigma$, where $U$ - $U^*$ is unambiguously increasing in $\alpha$ but displays a concavity with respect to $\sigma$. Two conjectures can be made here. Firstly, as $U$ - $U^*$ is a loss function, there is some value of $\sigma$ necessary to minimise the difference between the two welfare schedules. And secondly, as the differential between the two equilibria increases, there is a possible incentive for an individual on the welfare schedule $U$ to change his/her extractive behaviour to be on $U^{*}$ to minimise the differential as given by Equation (15).

The role of $\alpha$ in determining $N$ was already discussed in Section 3.3. For $\sigma$, as individuals become more individualistic ($\sigma$ becomes smaller), the more differentiated each is in his/her own product is greater until each essentially behaves as a monopolist in their output decisions at the limit. Subsequently, even for a small population, it becomes possible for an individual to elicit a welfare gain by deviating with a slight increase in output for any given $\omega$.




Fixed parameter values: $\overline{Z} = 1$, $\beta = 0.001$

**Figure 1** Welfare Difference.

The interesting case is when all individuals are identical. Established intuition is that a cooperative outcome is likely to be more beneficial with a homogenous population. Yet, an extremely homogenous population (good) essentially negates the effect of variety; consumption quantity becomes the main driver of welfare.

It turns out that as $\sigma \rightarrow \infty$, behaviour in the cooperative extraction equilibrium becomes one where use of the commons takes on the characteristics of a club, and there is too little production taking place.[13] Thus, as Figure 1 suggests, this underproduction increases the welfare differential between the two equilibria and it becomes to the individual's benefit to increase his/her output in order to move to $U^*$.

[13] Since the pay-off, $\omega$, becomes smaller as $N$ increases. See Buchanan (1965) for a more detailed analysis.

## 4.2 Governance

The potential of the Cox and Ruffin (2010) model for further analytical purposes is examined by considering how the effects of governance practices may be inferred from it. Only informal practices are considered here since governance of the commons without external policy stimuli is often observed through the use of some (likely) nonlegally binding social norms, rules, quotas or the like. These are often collectively categorised under the labels of institutional arrangements or transaction costs. An institution, as is often read, defines 'the rules of the game' which can be both formally or informally imposed.[14] While the following discussion is concerned with an informal arrangement, formal policy measures can be considered and similarly incorporated.

The necessity for some management or governance mechanism to ensure the sustainability and continuity of the resource pool *ad infinitum* can be illustrated with a simple thought experiment. Suppose the commons is at an equilibrium population mass as given by Equation (5), but each individual decides to extract at the welfare-maximising level given by Equation (11). The resource capacity necessary to sustain the community in the long run is now:

$$Z^{*} = \bar{Z} + \alpha(\sigma - 1). \tag{16}$$

Yet, as $\bar{Z}$ is fixed, this implies there will be overextraction in the short run and a depleted resource pool in the long run. Welfare is thus zero in the long run.[15] This is Hardin's (1968) prediction of overextraction and depletion.

In her study of Japanese village communities, the attributes listed by McKean (1992) as being necessary for successful governance of the commons are generally synonymous with the community penalising an individual for breaching an agreed 'norm': financial punishment, social exclusion, etc. The crucial underpinning is that these penalties temporarily limit the quantity of common-pool resources which a rule-breaking individual can extract. This makes him/her worse-off in the short run and forcibly imposes an exit from the community if long-term noncompliance continues. The argument underlying this is as follows.

Under monopolistic competition, the wage rate of each individual has to be at least at the average cost to in order to break-even and leave him/her indifferent between staying in or leaving the community. The mark-up formula of the model should not detract from the fact that $\omega$ is directly related to each individual's average cost function. Imposing $\upsilon = 0$ on Equation (2) and rewriting gives:

[14] There are others, but this definition offered by Douglas North is one of the most invoked. See Hodgson (2006) for a review and discussion.

[15] It can be argued that individuals can always leave in such a scenario, thereby restoring the equilibrium condition for a sustainable commons. This is plausible, but the outside wage option needs to be lower as following Equation (13) before any exit will result. If the equilibrium population mass is already at that given by Equation (5), $\omega$ must correspond to Equation (6) and no individual will leave until the commons is completely depleted.

$$\omega = \left(\frac{\alpha}{y} + \beta\right)q. \tag{17}$$

This is the average cost of every unit of $y$ produced, where $\alpha$ and $\beta$ are the main determinants of $\omega$ and $y$ since $q$ is a constant. From Equation (17), it is straightforward to find that $\frac{\partial\omega}{\partial y} < 0$ and $\omega$ is an increasing function of $\alpha$ and $\beta$. For any (exogenously defined) value of $\omega$ and $y$, a reduction in the quantity of $\alpha$ and/or $\beta$ that can be extracted essentially means $\omega$ must correspondingly fall for $\upsilon = 0$ to be maintained.[16] Otherwise, an individual is better off leaving the community and taking up the outside option.

Similar interpretations can be extended to consider the role of transaction costs in Equation (17), except that these (and other formal or informal costs) are likely to influence $q$ along with $\alpha$ or $\beta$. Thus, together with the finding that the resource pool becomes *private* property in the limiting case of $\alpha \to \bar{Z}$, what this (in effect) means is that the model can potentially offer an avenue by which to analytically explore how and why detrimental outcomes[17] may arise as a result of the type and form of policy being implemented.

### 4.3 Extensions

At this stage, there are clearly a number of avenues where further work can be done. In particular, as the model is static in nature, it illustrates the long-run equilibrium outcomes which result. Short-run costs and adjustments have to play an important role in determining which type of long-run equilibrium will ultimately evolve.

An extension which is both interesting and relevant for theory and policy analysis incorporates elements such as congestion and network externalities.[18] These will influence extraction costs and are likely to impact usage patterns of the resource pool. Given a resource-dependent community's development trajectory is typically tied-in with its resource utilisation path, there are potentially significant welfare implications involved.[19]

Also, while both types of extractive behaviour yield outcomes which are Pareto efficient, it is clear that the noncooperative equilibrium welfare-dominates that of the cooperative equilibrium (as $U$ - $U^* < 0$), In contrast, the respective welfare-maximising wage levels are $\omega > \omega^*$. This raises a more intriguing issue of policy design for resource use and governance.

Contemporary economic policymaking often assigns welfare (or some proxy measure such as wages) maximisation as a key objective. Thus, the

[16] But since $\omega$ is exogenous to the community, this adjustment is unlikely to take place.
[17] A simple example is land grabbing. See Deininger and Feder (2001) for a review.
[18] See MacKie-Mason and Varian (1995) for example.
[19] This bears some semblance to Brian Arthur's notion of path dependence and lock-in by 'small historical events' (Arthur 1989), whereby each occurrence of congestion in resource use, or some other externality, induces an individual to deviate from the status quo. Over time, the cumulative experience obtained could shift him onto a new behavioural (and plausibly welfare-detrimental) path altogether.

basis for any policy analysis begins with the assumption that the individual's behaviour is self-focused (or 'egotistical'), and this yields outcomes which are ideal or at least the best attainable (Sen 1977).

However, consider the case where all individuals are on the welfare schedule $U$ and earning a wage of $\omega$. Utility maximisation by a self-interested individual suggests that he/she is better off on the welfare schedule, $U^*$. Intuitively, the policy objective is to shift the individual to $U^*$ by (maybe) raising $y$. Yet, this leads to a socially detrimental outcome as the resource pool becomes depleted subsequently. Thus, as Bowles (2008) argued, a policy intended to maximise the utility of every individual may *not* necessarily be beneficial to the community as a whole.

Instead, the objective underpinning any policy for common-pool resource management ought to be to induce an equilibrium of cooperative extraction.[20] In the context of this study, this implies that the policy objective is to ensure that $\frac{\sigma-1}{N} > 0$ remains binding, regardless of the size of $N$. This, however, is an issue of mechanism design and beyond the immediate scope here.[21]

## 5. Closing remarks

This paper adapts and shows how a model of monopolistic competition following the seminal contribution of Cox and Ruffin (2010) provides a somewhat sufficient, if not adequate, incorporation and exposition of the factors influencing common-pool resource use. The simple assumption that there are fixed costs in resource extraction for the production of a differentiated good provides a motivation for each member of the community to maximise his level of extraction (and welfare) in order to take advantage of decrease averaging costs of production.

The results and discussion thus far are largely exploratory. However, the model displays several features and results which are clearly relevant for the study of common-pool resources. The first is that population size of the community is endogenously determined from a set of structural parameters. This allows an analytical exposition and examination of how individual characteristics may potentially affect social welfare. Interestingly, a cooperative outcome is found to result in a larger equilibrium population, in contrast to the more general agreement on small groups as being more conducive towards exhibiting cooperative behaviour. Another finding is that some individuality may actually be more socially beneficial, in contrast to conventional wisdom which suggests population homogeneity to be a

[20] Hume (in Bowles 2008) states that such policies 'support socially valued ends not only by harnessing selfish preferences to public ends but also by evoking, cultivating and empowering public-spirited motives'. Yet there is reason to suggest that this type of policies is lacking. An example is the long-standing non-agreement of carbon emission targets in response to climate change. See Pandey (2014) for a recent overview.

[21] See Myserson (2008) for an introduction.

desirable characteristic in the use of common-pool resources. Finally, the model suggests the potential of being able to model ownership states analytically.

Fieldwork studies of common-pool resource use regularly suggest that population size and heterogeneity are key influences in determining extraction and usage patterns. Yet, owing to conceptual difficulties, it remains ambiguous how to model these elements and their effects on differences in behaviour in a (reasonably) general and consistent form.

It is suggested that a model of monopolistic competition in the spirit of Chamberlin may be a way to circumvent this ambiguity. Despite the preliminary nature of what was presented, there are indications of the model's potential to serve as a theoretical framework for studying issues of common-pool resource use and governance.

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