Scarcity, Scarcity Knowledge and the Legitimation of Market-Based Scarcity Indicators

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Abstract

This paper explores whether market-based scarcity indicators can reflect resource scarcity correctly. In this context, two objections against market-based indicators made by Norgaard [15] are examined. Potentially, resource allocators are not informed correctly of scarcity and maybe they ignore some aspects of scarcity consciously. The traditional view of scarcity is reviewed and its flaws revealed. Finally, a reinterpretation of scarcity is introduced which legitimizes market-based scarcity indicators.

1 Introduction

The question whether scarcity indicators such as unit costs, real product price and user cost can reflect resource scarcity correctly, has been intensely discussed in economic literature [2, 3, 12, 8, 4, 6]. The main problem economists have with these indicators is that there is no guarantee that they will move in the same direction when a scarcity-determining parameter, e.g. technological progress, changes. And even if they move in the same direction, the extent of their reaction can differ dramatically. Market-based scarcity indicators such as price and user cost are vulnerable to all kinds of market failures like exercised market power, externalities, the absence of working spot and future markets

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or over-extraction due to an unresolved common property problem. Because the respective scarcity indicators are perceived to own different properties to remedy the problems mentioned above in different ways, a discussion emerged in economic literature as to which scarcity indicator is preferable. Successively, unit costs [2], user costs [12], and prices [20] were considered to be the best scarcity indicator available.

Hall and Hall resolved these disagreements in their pathbreaking paper [7] which distinguishes four kinds of scarcity: Malthusian stock scarcity (MSS), Malthusian flow scarcity (MFS), Ricardian stock scarcity (RSS) and Ricardian flow scarcity (RFS). The Malthusian stock scarcity describes a constraint on the total available resource stock. The Ricardian flow scarcity is defined as extraction costs only depending on the extraction rate. The Ricardian stock scarcity includes a constraint on the extraction rate and additionally on the amount of total extracted resources. Weak Malthusian flow scarcity[1] includes a limit on the available resources and on the extraction rate; strong Malthusian flow scarcity additionally contains a constraint on the amount of total extracted resources.

The different kinds of scarcity are associated with three kinds of scarcity costs: (1) costs due to the exhaustibility of a stock, (2) costs due to the decline in quality as the best deposits are exploited first and (3) costs which depend on the rate of extraction in a period without consequences for later periods. Strong MFS covers all three cost categories, weak MFS (1) and (3), RSS includes (2) and (3), MSS only (1) and RFS implies (3). The decision as to which scarcity indicator should be used is determined by the underlying scarcity: unit costs are an appropriate measurement of scarcity only in the case of RFS, otherwise, i.e. in the case of non-renewable resources, user cost or real price should be used.

However, the alleged supremacy of market-based scarcity indicators was severely damaged by Norgaard's illuminating paper [14, 15]. His position implies two weighty objections: (a) If resource allocators are informed about resource scarcity, why cannot we simply ask them? (b) How do we ensure that market participants know of resource scarcity? In the next section, we will examine these objections in detail. In this context, the concept of scarcity knowledge is introduced and problems of a misclassification of scarcity are clarified. In

[1] Differing from the classification of Hall and Hall, we divide Malthusian flow scarcity into weak and strong MFS to obtain a complete set of possible scarcities without inflows.

section 3, the concept of scarcity itself is redefined in order to achieve a better legitimation of scarcity indicators.

2 Scarcity Knowledge

Norgaard's first objection, i.e. why do we need scarcity indicators at all when we could just ask the resource allocators, arises from the traditional way of legitimizing of scarcity indicators, which is (implicitly) used by Ricardo and Hotelling [17, 10]. According to this legitimation, economic indicators reflect resource scarcity if and only if the resource is scarce and the resource allocators are informed of this scarcity. But when they know, they could just be asked how scarce a resource is.

Norgaard's objection results from a misunderstanding of scarcity knowledge. Scarcity knowledge is the ability to identify, classify and evaluate scarcity. To identify scarcity means recognizing whether a resource is or is not scarce.[2] To classify scarcity properly means including all relevant costs associated with the type of scarcity. To evaluate resource scarcity is determining a price for a resource unit. It must be distinguished between individual and societal assessment of scarcity, because it is quite easy to get an individual and very difficult to obtain a societal assessment of scarcity. To achieve an individual assessment of scarcity, any resource allocator could be asked. But if a second resource allocator was be asked, his answer would probably differ from the first, and a third might have a completely different opinion from the first two and so on. This does not mean that their answers are wrong – in fact, they express their individual assessments of scarcity – but no single resource allocator is informed of the societal scarcity. To obtain a societal assessment of scarcity all relevant individual assessments must be taken into account, structured, and evaluated according to some rule. One way of doing this is using market prices. An efficient market produces a price which maximizes the volume of welfare increasing and scarcity decreasing transactions. Of course, there cannot be more information in the market price than the resource allocators had who generated it, but nevertheless the market price represents new information to

[2] In the majority of cases this will not present a problem. However, the identification of scarcity is not always trivial. Consider an ecological system, which shows (almost) no signs of deterioration until it is irretrievably damaged. In this case the scarcity of ecosystem services is unobservable and cannot easily be identified by the resource allocators.

the market participants. No one knows the market price for sure until the market produced it. Thus, Norgaard's first objection must be rejected.

Norgaard's second objection, i.e. whether the market participants have sufficient scarcity knowledge to evaluate scarcity, is a much weightier one, because if all available scarcity knowledge is already included in the market price, no scarcity knowledge is left to evaluate the scarcity assessment of the market. Therefore, Norgaard's second objection goes beyond the argument that imperfect information results in imperfect markets and this in turn results in imperfect scarcity indicators [11]. The point of Norgaard's second objection is that we cannot *know* whether we have sufficient scarcity knowledge. Having said that, we turn our attention to a specific case of insufficient scarcity knowledge: the ignorance of geological constraints.

Consider two groups of profit-maximizing resource allocators which are identical in all respects (same group size, cost structure, resource inventories etc.), but in their belief whether the resource in question is exhaustible. The first group believes that the geological constraint is binding while the second group does not. Why is the geological constraint uncertain? Peterson and Fisher [16] compare an exhaustible resource with an orange: the total amount of juice extracted depends on how hard the orange is squeezed and even in a "depleted" orange, there is always some juice left. Hence, the exhaustibility of a resource is determined by two factors: the total amount of resources in the earth crust (How much juice is in the orange?) and technical and ecological constraints (How hard can the orange be squeezed?). When one of the three constraints – geological, technological or ecological – is binding, rational and well informed resource allocators include the appropriate costs. However, there are two good reasons why exhaustible resources in the real world are maybe not treated as such: (1) There are considerable obstacles to compute the user cost practically; (2) the market participants have ample incentives to ignore resource exhaustibility.

Ad (1): User cost cannot be computed easily because fundamental parameters of resource exhaustibility are uncertain. First of all, the quantity, quality and location of remaining resource deposits are mostly unknown. Besides, substantial uncertainty emerges from future technological progress. Technology does not only have a cost-reducing influence on finding and extracting resources, it also determines the possible uses of a resource and it can redefine what is called a resource. For many centuries oil was useless to mankind. It became

a resource only through technological progress: oil could not be used as a light source until the oil lamp was invented, it could not be used as an energy source until the discovery of the combustion engine and it could not be used as the basic material for the chemical industry until this industry had evolved. Technical progress also determines potential future substitutions of a resource. Principally, a resource can be substituted either by another resource – exhaustible or renewable – or by capital. The substitution can take place in the production process or in consumption as new products replace old ones. Therefore substitution processes are highly complex and models trying to include all relevant potential substitutions are likely to fail. In real life it is almost impossible to determine the correct user cost of resource usage. But if the user costs cannot be computed practically, how could they be included correctly in the resource price? How could market participants know about the impact of exhaustibility when the associated scarcity costs are unknown? They cannot.

Ad (2): It could be argued that it is better to include some kind of user cost – even if they are wrong – than to ignore their existence completely. But even if a resource is exhaustible due to a technical or ecological constraint that does not mean that the market participants will treat it as such, because they usually consider exhaustible resources replaceable and therefore will not include user cost in their calculation. There are three reasons for this. The first reason could be called the "optimism trap". In the past, it has always been possible to generate new reserve additions when they were needed. Why will this have to change in the future? The genius of man will always find a way to reduce scarcity. This kind of optimism seems naive at first, but from an empirical point of view it represents our best guess about the future [19]. Secondly, no market participant knows if there is really a technical and/or ecological constraint. There is not only uncertainty due to the extent of exhaustion, but also uncertainty whether a resource is exhaustible at all. But if a resource is not exhaustible, user cost does not have to be included. Thirdly, – and most importantly – the planning horizon of market participants is too short to include scarcity costs due to exhaustion. This last point does not refer primarily to the problem of intergenerational equity which has been discussed at length in economic literature (e.g. [9, 21, 18, 1]) but to the real life of market participants. Nobody on the demand side will insist to include all scarcity costs, i.e. to pay more for a product, because the time horizon of demand only goes as far as need satisfaction. In most cases the planning

horizon of demand will not exceed a few hours or days. A trader/broker will only include the costs which occur until maturity of the traded contract, i.e. at the most 4 years. A firm will only look far enough into the future to be sure that it will get its investment costs back; even in this case the planning horizon will not exceed 30 years.[3]

None of these time horizons is long enough to include the scarcity costs of exhaustibility. The reserve-production ratio of most natural resources is more than 40 years and the R/P-ratio is a quite conservative statistic. But if the exhaustion date does not occur within the planning horizon [0, T] of the market participants, the exhaustibility of a resource will be ignored.

Therefore, the cost function of the first group which believes in a binding geological constraint may be written as

$$C_1(\dot{Q}_1, Q_1, \bar{Q}_1, \Theta, \Phi) \tag{1}$$

and the cost function of the second group may be written as

$$C_2(\dot{Q}_2, Q_2, \Theta, \Phi) \tag{2}$$

where $\dot{Q}$ is the rate of extraction at t, Q the cumulative amount mined at t, $\bar{Q}$ the total amount of resource in ground, Θ the state of environment and Φ the technological state. Assuming, the ecological and technological constraints are equal for both groups, the aggregate supply in a given period is

$$S_{1+2} = \dot{Q}_1 + \dot{Q}_2. \tag{3}$$

Further, assuming a point in time $T^* \in [0, T]$ exists at which the *real* scarcity becomes apparent to all resource allocators. A resource owner who believes in a geological constraint will only produce as long as his whole costs, including all scarcity costs, are covered. In the first period ($0 < t < T^*$), the second group faces lower costs since the resource owner in this group does not have to include the costs due to the finiteness of the resource. Hence, resource producers of the first group are crowded out by resource producers of the second group. The

[3] Sometimes it is argued that state-owned companies have a longer planning horizon than private ones. It is difficult to decide whether this is true. But, even if this is granted, the state-owned companies still face the problems which arise from the substantial uncertainty about the future.

extent of this crowding-out effect depends on the change in price and the cost structure of both groups. The resulting the price p should lie above the price $\underline{p}$ which would occur when all resource allocators would believe in a binding geological constraint and under $\overline{p}$ which would result when no one does believe in a binding geological constraint.

In the second period ($T^* < t < T$), either the price $\underline{p}$ or $\overline{p}$ arises since all resource allocators do know the real scarcity. The group who had the wrong scarcity classification looses money. If the geological constraint was binding, the second group produced too much in the first period; if it was not binding, the production of the first group was too low.

What does this mean for the legitimation of scarcity indicators? The price does not reflect the scarcity assessment of neither group. The possibility that market participants might classify scarcity wrongly questions the legitimacy of market-based scarcity indicators severely. As Norgaard said, perhaps market-based scarcity indicators only express the ignorance of the market participants – even when some resource allocators are right.

3 Another Copernican Turn

In the light of the last section, the legitimation of market-based scarcity indicators seems hardly possible. Due to our limited scarcity knowledge we will never *know* whether resource scarcity is reflected correctly. If resource allocators have different classifications of scarcity, price will (almost) never reflect the right scarcity.

However, what is scarcity anyway? It is quite difficult to spot the traditional definition of scarcity. A basic view in textbooks is that a good for a person/a society is scarce when this person/the society wants to have more from the good than she possesses. A similar view is that a good is scarce when it has a positive price.[4]

Both definitions of scarcity are hardly applicable in serious economic analysis, since they consider neither the kind nor the extent of scarcity. According to these definitions, a glass of water and a picture by Edward Hopper are equally scarce to an art-loving person who is dying with thirst in a desert: the person

[4] In fact, the main difference between these two definitions is that the first one aims at human needs and the latter at the willingness to pay.

wants to have more of the two goods and would pay a positive price for both. However, given this situation, probably even fanatic art lovers would value the glass of water higher than the picture by Hopper. Another peculiarity about the traditional view of scarcity is, that something is either scarce or not scarce. After receiving a glass of water, water would be just as scarce as before, because the traditional definition of scarcity does not allow neither measuring nor evaluating scarcity. But when we speak of scarcity, we always assume that scarcity can be measured and evaluated in some way. Another aspect of the traditional view of scarcity is that scarcity is imposed upon us from the outside. The only reason why water is limited in a desert is because there are so few oases. This logic can be applied to all natural resources: they are only scarce because they do not occur in sufficient quantities in nature. Scarcity is a physical phenomenon; it emerges from geological constraints.

This view is fundamentally wrong. Scarcity is not the result of nature, but from human society. There was a time, when iron, copper, oil and even gold were overabundantly available: the stone age. These natural resources were not scarce back then, because nobody wanted them. They were not viewed as scarce and so they were not. Scarcity does not pop into existence until it is identified; and the identification of scarcity can only be accomplished by individuals. Geological constraints are irrelevant to the act of identifying scarcity. If a metal (e.g. Beckermonium) does not occur in nature and cannot be produced artificially, which is the strongest possible physical constraint imaginable, then it is not scarce at all, because nobody misses it. This does not mean that the abundance of natural resources is irrelevant. Both extent and kind of scarcity have to be included into the evaluation of scarcity. It still matters how many oases there are in a desert and how much oil and gas lie in easily extractable reservoirs. However, natural abundance is not the *reason* for scarcity, it is just a determinant for the *extent* of scarcity. Likewise, it is important whether e.g. my only water supply is a perpetual river or a cave lake without inflows of any kind, because different scarcity costs are associated with different kinds of scarcity.

An appropriate definition of scarcity has to be twofold: it should treat scarcity as a societal phenomenon and it should allow for different kinds and extents of scarcity. As we have seen, the traditional definition of scarcity is not able to do that. But if we cannot legitimize market-based scarcity indicators with the traditional definition of scarcity and the definition of scarcity itself is flawed,

why not radically overhaul our definition of scarcity and try to kill two birds with one stone? So far we have viewed scarcity knowledge as the knowledge about a given, physical-based scarcity. Why not view scarcity as a result of scarcity knowledge? An adequate definition of scarcity could be: *Scarcity is that, which is identified, classified, and evaluated as scarcity by resource allocator(s).*[5] This definition of scarcity has its origins in the individual and includes both kind and extent of scarcity.

This redefinition of scarcity has three obvious advantages over the traditional view. First, we do not pretend to have more scarcity knowledge than we actually have. When scarcity is seen as a physical phenomenon, we can never be sure that we know all relevant facts. When we try to assess scarcity, we have to evaluate something which we do not understand entirely. We have to *assume* that our scarcity knowledge is sufficient to evaluate scarcity. With the redefinition of scarcity, we *know* that our scarcity knowledge is sufficient.

Secondly, the evaluation of scarcity is part of the definition of scarcity. As we have seen, scarcity and the evaluation of scarcity cannot be divided. A resource cannot just be scarce, the scarcity must also be rateable in some way. As we have seen, water and pictures by Edward Hopper would otherwise be equally scarce in a desert.

Thirdly, the redefinition of scarcity allows a sound legitimation of market-based scarcity indicators. In fact, market-based scarcity indicators are legitimized in a fundamental and non-disputable way. If scarcity results from scarcity knowledge of resource allocators, then the scarcity knowledge *must* be sufficient to reflect the underlying scarcity.

The redefinition of scarcity also covers the distinction between exchange scarcity and use scarcity which is one of the most prominent distinctions of scarcity in economic literature [13, 5, 17, 22]. Exchange scarcity is the exchange value of resources measured by price or rent. Use scarcity is the scarcity associated with the use value of a commodity. For example, water has a quite low exchange value (price), but a very high use value (i.e. not dying with thirst). The proposed redefinition of scarcity applies to both kinds of scarcity: Exchange scarcity is the identification, classification, and evaluation of scarcity by *all* resource allocators (societal scarcity); use scarcity is the identification, classifi-

[5] The definition may seem tautological at first sight. Of course, scarcity is what we think it is. But it is the act of identification, classification and evaluation of scarcity which constitutes scarcity.

cation, and evaluation of scarcity by *one* resource allocator (private scarcity). In this way, we do not have to fragment the concept of scarcity.

Of course, we have to pay a price for redefining our view of scarcity. A curiosity which results from the redefinition is that the price in an efficient market is no longer a scarcity indicator, but the scarcity itself – at least for exchange scarcity. In this view, an efficient market price and societal scarcity are identical. On the other hand, there is no such relationship for use scarcity.[6]

Another, more important drawback of this redefinition is that scarcity can change when the underlying scarcity knowledge changes. Natural resource scarcity of different times cannot be compared, if the underlying scarcity knowledge has changed meanwhile. Finally, normative statements are no longer possible, because we would pretend to have more scarcity knowledge than we actually have. The price we have to pay for a working scarcity definition is relativism.

4 Conclusion

The intention of this paper was to explore whether market-based scarcity indicators can reflect resource scarcity correctly, i.e. the legitimation of market-based scarcity indicators. Unfortunately, this legitimation is barely achievable due to Norgaard's second objection. As we have seen in the case of a uncertain binding geological constraint, we can never be sure to have adequate scarcity knowledge – at least with the traditional view of scarcity. Consequently, a (minimalistic) redefinition of scarcity was introduced, which is superior to the traditional view in many ways: Scarcity is that, which is identified, classified, and evaluated as scarcity by resource allocator(s). In this way, the scarcity knowledge of resource allocators has to be sufficient by definition.

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