Learning not to Trade: On Scarcity, Emergence and Failure of Markets

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KEYWORDS

missing markets; scarcity; theory of value; transaction cost; agent-based modelling; zero-intelligence agents

ABSTRACT

This paper addresses the substitution of virgin resources used in industrial processes with by-products that would otherwise be regarded as waste and questions why some by-product markets fail to emerge. It highlights the long-forgotten distinction between the use-value and exchange-value and points out that markets can only work for assigning the latter. It argues that in some industrial settings, waste resources are not scarce and their supply schedule in the classical market plot are at the right of and far from the demand schedule. Hence, even though the waste resource has some positive use-value, a positive price level cannot be established at the intersection of demand and supply schedules. The paper employs agent-based simulations with zero-intelligence traders to illustrate that when agents are unable to learn, transactions do occur in the abovementioned context but when agents have simple adaptive capabilities, the market fails to emerge. Thereby, the paper employs the zero-intelligence traders in a different way than usual; whereas the literature on zero-intelligence traders aim to show markets can emerge even when agents lack rationality, this paper illustrates that markets can fail to emerge when agents have some ability to learn.

INTRODUCTION

Market failure arguments are frequently raised in relation to environmental issues. It is, for example, well known that public goods, such as ecosystem services, can be overused in the absence of institutional arrangements that limit their use or internalise their cost. There is, however, another type of market failure that has important implications for the environment and is not adequately addressed in the existing literature. The non-emergence of some by-product markets is a neglected issue that can lead to 'wasted waste' (Kronenberg and Winkler, 2009); an underuse of waste and corresponding overuse of virgin resources.

The importance of the efficient use of natural resources for current and future generations cannot be overstated. Yet, our production processes usually focus on the value of a small, selected part of a resource and ignore the rest. For example, most agricultural products use only a small part of the crop and even the secondary residues, which are produced while processing the crops and are often available in large quantities at the processing sites, are not fully utilised (Bhattacharya et al, 2005; Johnson and Linke-Hepp, 2007; Gressela and Zilbersteinb, 2007). Secondary forest residues, such as wood bark, is also among the commonly wasted (Anon et al, 1994; Dasappa, 2011; US Department of Energy, 2011). Similarly, some of the waste material produced by the metal processing industries, such as slag and foundry sand, and the coal combustion products, such as ash, can be used in construction industry as substitutes for virgin aggregates. Although these potential uses are well known, most of these materials are stockpiled or sent to landfill (Chertow and Lombardi, 2005; Carpenter and Gardner, 2009). Residual industrial heat is yet another common example of unused potential of waste. While the discharge of residual heat is a clear threat to the environment, wasting important proportions of the energy input via residual heat is common practice in many industrial processes. So much so that cooling towers and smokestacks have become the characteristic elements of industrial landscapes. (Nguyen et al, 2010).

The issue of virgin resource substitution is most frequently addressed in the industrial ecology (IE) literature. This paper, develops a synthesis between the findings of the IE literature and the economic theory on missing markets within a simple theoretical framework. The remainder of the paper is organised as follows. The next section very briefly discusses key issues around missing markets and scarcity to introduce the theoretical background of the paper. The third section presents the lack of scarcity hypothesis in a simple microeconomic framework. The fourth section elaborates on the policy and business implications of the hypothesis focusing on how transactions can be initiated in a lack of scarcity context. The final section presents the conclusions. It may be useful to note that the distinction between waste and by-product emerges through transactions. In order to avoid confusion the term *waste resource* will be used to refer to both waste and by-

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product in the rest of this paper.

MARKETS, SCARCITY AND THEIR ABSENCE

Markets are systems of institutions that facilitate and shape exchanges of goods and services. They are complex entities that evolve through path-dependent social processes. A market can be thought to have emerged when agents have an, albeit implicit, understanding of the good and how it will be traded. This understanding is established together with routines and agreements on a broad range of issues such as the essential properties of the good, how its quality can be assessed, the ways in which the buyers and sellers find each other and exchange information, and the type of transactions that are likely to take place. The process by which market institutions evolve may involve elements of learning that reveals what works better in a given context and co-ordination on one of the alternative ways all of which might work. Market institutions typically reflect the nature of the good as well as the broader social context in which the exchanges of the good occur. Shared assumptions about ownership and nature in particular have central roles in the process.

Market failure is the general name for inadequacies of markets in providing economically efficient or socially desirable allocations of scarce resources. It is a negative concept that only makes sense in comparison to a Weberian ideal type of markets that works perfectly. Market failure explains why real life markets do not look or work like textbook descriptions of their ideal types, whether these discrepancies are taken as limitations of the theories themselves, or as lists of what is wrong with the real life markets. A missing market is one kind and, arguably, the extreme case (de Janvry et al, 1991) of market failure. It refers to the non-emergence of the system of institutions that were needed for shaping and facilitating exchanges. Being a type of market failure, the missing market is also a negative concept, which is only identifiable in comparison to a supposedly better alternative. In this case, the benchmark is the potential gains from exchanges at the individual or society level.

Market failure has a special importance in welfare economics because its existence is often taken as an argument for state interference or nonmarket allocation (see Bator, 1958; Arrow, 1970; Barr, 1992; Medema, 2007). Although market failure has been associated with a long list of conditions such as externalities, indivisibilities and public goods, explaining what is at the core of market failure in general or what exactly causes non-emergence of markets appear to be difficult tasks. What emerges from the analyses of Bator (1958), Demsetz (1964), Arrow (1970) and Randall (1983) is that, often, market failure occurs when simple individual ownership of a good does not suffice for realising exchanges that accurately reflect the level of scarcity of that good. Bator (1958) calls this condition a *divorce* between ownership and scarcity.

Hence, scarcity has a central role in both how market failure occurs and why it is important. Within the scarcity-based definition of economics (Robbins, 1945; Samuelson, 1948), *economic goods* are, by definition, scarce. *Free goods*, on the contrary, are so plentiful that a particular use of the good does not require diversion from another use. It is useful to make two notes here, as they will be relevant in the following sections. Firstly, from the viewpoint of scarcity-based definition of economics, the cases in which a good is not scarce are trivial and uninteresting to economics. In the following sections, this paper will argue otherwise. Secondly, in this economic conceptualisation of nature and ownership, goods are either zero-priced and freely available in nature for economic agents to exploit, or they are scarce and exchanged at a positive price. A negative price does not have a meaning from this perspective. As it will be explained in the following sub-section, however, the common perspective is changing with new conceptualisations of nature.

THE LACK OF SCARCITY MODEL

A. Theoretical Overview:

This section explains the missing markets for waste resources within a simple theoretical framework and an agent-based simulation model. It is not unknown but often neglected that since demand and supply schedules are assumed to be independent from each other, they do not have to intersect at a positive price level. This issue is different from the idea of temporary disequilibriums where there is a positive and market-clearing equilibrium price but the transactions occur at a different price, often following an exogenous shock until the necessary adjustments in price, wage and output levels take place.

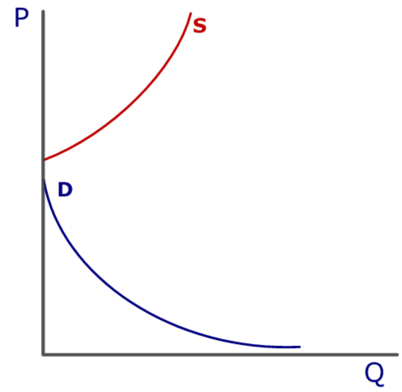

Figure 1:
Arrow's Futures Market

The cases where demand and supply schedule do not intersect are likely to be long-term phenomena that reflect the structural properties of demand and supply and are not expected to disappear through price and output adjustments of individual agents. Arrow's (1970; see also Heller, 1997) explanation for missing markets for some future transactions depicts one such case. Arrow suggests that in the case of futures, it is possible that the highest price any agent is willing to pay for future transactions is still lower than the lowest price any agent would sell (see Figure 1). It is also recognised that in labour and credit markets (Stiglitz and Weiss, 1981), the supply schedules may be not convex but backward bending (see Figure 2), and do not intersect demand schedules positioned at far right.

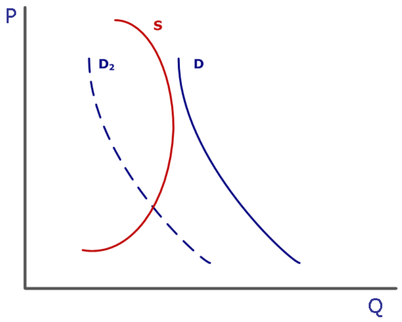

Figure 2:
Stiglitz and Weiss model

B. Assumptions and Justifications:

This paper suggests an explanation that is similar to these seminal contributions for the context of missing markets for waste resources. Here, it is assumed that in many industrial settings, waste resources are not scarce compared to the level of demand for these resources at price levels of zero and above (Assumption 1). Hence, the supply schedule lies at the right of and far away from the demand schedule.

In addition, since the market institutions that facilitate the exchanges have not yet developed in this industrial setting, a lot of innovative, creative and entrepreneurial preparation is needed for establishing expected properties of the good, the unit of exchange and the ways in which the exchanges will take place. It is envisaged that most of these transaction and search costs correspond to technical and organisational preparation, exploring the potential market and contacting potential customers. For this reason, it is assumed that a significant part of transaction and search costs will incur before securing transactions (Assumption 2a).

Finally, it is assumed that the transaction costs are expected to be high, heterogenous and difficult to calculate a priori (Assumption 2b, see Johnstone and de Tilly, 2006, for a review). As producing and exchanging the waste resource is not the main priority or objective of firms, there are likely to be unintended idiosyncrasies between firms in terms of how well and easily they can make those preparations. For example, search and matching costs of different firms may vary due to existing business and social links. The transaction costs would also vary between active and passive suppliers (buyers). If there are spillovers of information, passive suppliers (buyers) may free ride and exploit learning and innovations of others.

These are the main assumptions of the model and they are listed below for clarity.

Assumption 1: Waste resources are not scarce compared to the level of demand.

Assumption 2a: Some of the transaction and search costs occur before the actual exchange takes place.
Assumption 2b: Transaction and search costs are high, heterogenous among firms and difficult to calculate a priori.

Under these revised assumptions, the missing market with lack of scarcity (MMLOS) looks like in Figure 3. The demand and supply schedules do not intersect at a positive price and there is excess supply at each positive price level. Pareto-improving exchanges can occur at infinitely many price levels. Even though the waste resource has some positive use-value, a positive market price cannot be established due to lack of scarcity.

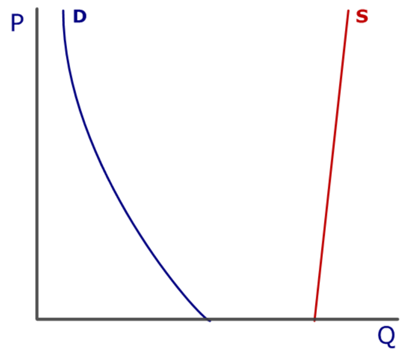

Figure 3:
MMLOS

C. Simulation Model:

I will now explore the properties of the model under different assumptions about agents' rationality and learning. This part of the paper builds on the existing literature on zero-intelligence (ZI) traders following the influential paper by Gode and Sunder (1993). Gode and Sunder conducted experiments comparing human agents with ZI artificial agents in double-auction markets with a central auctioneer who keeps a record of all offers and matches the buyers to sellers. The authors found that the ZI traders can lead to high levels of market efficiency even through random decision making. They concluded that rationality is not a necessary assumption for a market to achieve efficiency; it is rather the market institutions, that is represented by the central auctioneer in their model, produces efficiency.

Thus, the main *problematique* of the ZI traders literature is identifying those capabilities of agents that are necessary conditions of market efficiency given established market institutions. I am, however, referring to a context where such institutions hasn't evolved yet. Thus, the agent-based MMLOS model replaces the central auctioneer with a matching process between agents.

More specifically, the model creates agents in two classes: buyers and sellers. In the experiments reported in this paper, the number of buyers were set as 200 and the number of sellers were set as 30. These agents are assigned demand or supply schedules that are instances of the market demand and supply schedules respectively. That is, each buyer or seller has linear demand or supply schedules with different slopes and *xy* intercepts. Aggregation of output levels that agents are willing to buy or sell at each price level given their demand or supply schedules yields the market demand and supply schedules that are in line with an MMLOS context similar to the one shown in Figure 3. This is the basic setup of the simple simulation model used in this study.

The model is then used to run experiments on interactions between traders. At each period, they prepare their offers to buy or sell. Preparation of an offer involves deciding on an output level that they wish to trade and a corresponding price level. Traders decide on the level of output they want to trade, which is a random number between zero and the maximum output they could trade. For buyers, the maximum level of output they can trade is the *x* intercept of demand curve, i.e. the quantity demanded if the price was zero. For sellers, maximum trade level is the output level they would be willing to sell at a very high price, which is assumed to be slightly above the price of the waste resource's substitute (the virgin resource).

After deciding on the level of output they are willing to trade, the traders establish the price they are ready to accept. This would be the maximum price they are willing to pay if they are buyers and minimum price they are willing to take if they are sellers. Traders establish these prices based on their own demand or supply schedules.

They then announce their offers with output and price level to the market. The matching between buyers and sellers occur randomly under basic simulation settings. If traders can find a trade partner, who is willing to accept their offer, they trade. If the output they traded is lower than their intended level, they can continue making transactions, until this level is reached or there are no available and acceptable offers left in the market.

D. Results of Simulation Experiments:

In the ZI trader literature, constrained traders (ZI-C) know their own demand or supply structure and do not make a transaction that would yield negative profit or utility. The unconstrained traders (ZI-U), on the other hand, would even sell their goods at a loss or buy goods that are overpriced. Studies in this field commonly experiment with different learning capabilities of agents including that of recognising best available price at a point in simulated time.

This study made similar comparisons. In the first set of experiments, the model generates experiments with ZI-U and ZI-C traders, and with and without the ability of traders to identify the best offer available in the market when it is their turn to trade.

Figures 4a and b illustrate the transactions in 100 periods. These figures show that both ZI-U and ZI-C traders trade in MMLOS contexts. The difference between these two figures is that ZI-U buyers trade even at prices that are higher than those they are willing to pay, ZI-C buyers do not. Hence, transactions of ZI-C traders are constrained with the demand schedule.

Simulation time is kept short in order not to crowd these illustrative figures. However, ZI agents continued to trade with each other in experiments as long as 10,000 periods as well and this is not surprising given that there aren't any elements that would stop their trading behaviour in these model settings.

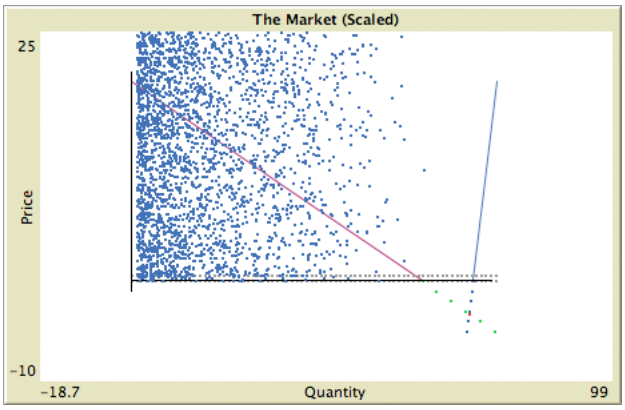

Figure 4a:
MMLOS with ZI-U traders

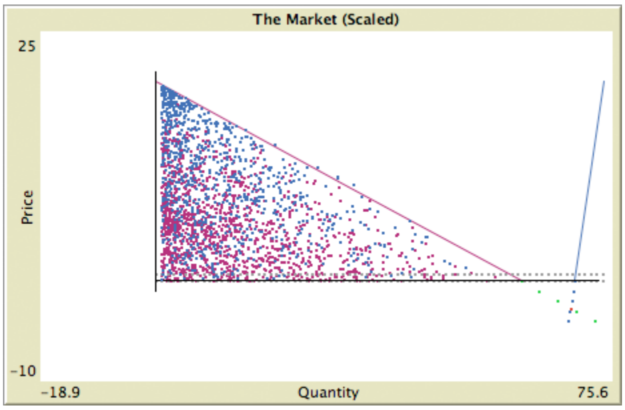

Figure 4b:
MMLOS with ZI-C traders

These results indicate that in the absence of heterogenous, uncertain and a priori transaction costs, the ZI-C traders would not make a loss, or in the case of buyers, pay more than they are willing to. In the second set of experiments, however, we are allowing for such transaction costs. It is important to highlight that Assumption 2b above describes a sunk cost. Hence, although traders would ideally like to collect these costs back, once they occur, it may be more beneficial for traders under price competition to accept these costs as loss and charge (accept) a lower (higher) price than not to sell (buy) at all.

To represent this property of sunk costs as simply as possible, I equipped the ZI-C traders in the model with a simple learning mechanism. I allowed them to ignore the transaction costs while trading as in the first experiment set, but they now have the simple ability of looking back to previous periods, seeing the price of their last transaction and assessing the profit or buyers' surplus they are likely to get from their prospective transactions. If this value is lower than their transaction cost in the last period, they lose their interest in trading in this market and drop out.

I run 100 experiments in this second experiment set, and in all of these runs all traders eventually dropped out, leading the market to disappear. In the 100 runs of experiments that I conducted, the simulated time of last transaction varied between 56th and 230th periods with a mean of 118 and standard deviation of 37.3.

Hence, whereas the ZI-U and ZI-C traders who doesn't have any other capabilities of assessing market conditions continue trading in MMLOS conditions, the low intelligence traders who can remember the previous period and make a simple calculation using this memory did not continue to trade keeping everything constant.

This result is not surprising in retrospect. The price competition described above corresponds to a Bertrand game (see, for example, Baye and Morgan, 1999) and since the waste resources are by-products of other productive activities their marginal cost is zero. Since the transaction costs are heterogeneous, uncertain and a priori, the traders cannot co-ordinate at any positive price level, leaving no incentives for the sellers to trade.

CONCLUSIONS

It is generally taken for granted in the IE literature that in the current organisation of our industrial activities there are mutual economic gains from symbiotic waste resource exchanges that are significant and not adequately exploited. This potential, however, refers to the use-value of waste resources, and not to their exchange value.

This paper examines why some waste resource markets fail to emerge and proposes a simple and well-grounded hypothesis. By relaxing the common assumption of scarcity, the paper illustrates a potential market without a positive equilibrium price. While scarcity and abundance are opposite terms, the lack of scarcity as explained in this paper is not equivalent to abundance. Waste resources are no longer a part of the natural environment and in many cases, cannot be simply put back into nature without causing environmental damage. In addition, in the case of waste resources the good or the resource has a clear owner who needs to be actively involved in order for the exchange to occur. Thus, the story being told here is different from public goods and free goods. Whereas lack of clear ownership and nonappropriation are the common problems for public goods, the very source of the market failure in this case is the difficulty of co-ordination on a positive price and the corresponding lack of incentives to trade.

The main argument of this paper is that in the absence of scarcity, markets may not be able to provide a socially efficient approximation of the use-value. In this respect, the technical possibilities of useful resource exchanges that IE experts identify may not suffice for adequate incentives for economic agents. In the MMLOS case, it is not the technical properties or the use-value of the waste resource that deters the emergence of the market but expectations about competitors' pricing behaviour.

The MMLOS case is different from and arguably more interesting than Arrow's (1970) missing market for futures contracts. Unlike in Arrow's missing market, it is possible to realise mutually beneficial exchanges in MMLOS, and so, the absence of a market is not strictly Pareto efficient.

The hypothesis is also in compliance with the observed effects of landfill tax on waste resource exchanges, in particular on the appearance of negative prices. The negative price is a relatively new, economically interesting concept and a by-product of a revised conceptualisation of nature that recognises ecosystem services such as pollution absorption as scarce. The peculiarity of negative prices is most clearly exemplified in Baumgartner and Winkler's (2003) study where the price of some waste paper types oscillate between positive and negative prices. With the introduction of landfill tax, negative prices can be more widespread than it is reported in the existing literature.

The paper employs agent-based experiments with zero and low intelligence agents as possibility proofs showing that the lack of scarcity of a waste resource in a given industrial system or region may impede exchanges of this resource and block the formation of corresponding markets. The hypothesis is potentially useful as theoretical background for IE studies and for underpinning the environmental and distributional implications of different business and policy tools.

It is important to clarify that this paper does not suggest that lack of scarcity is the only reason why some waste resource markets may fail to emerge. On the contrary, it is important to stress that this issue is only relevant to incentives to trade. While incentives may be necessary conditions for the emergence of markets, they are not sufficient conditions. This paper defines markets as complex systems of institutions and the emergence of such institutions occurs over time and within a material and social setting.

That lack of scarcity may be the reason why some waste resource markets fail to develop is proposed as a hypothesis which remains to be tested with empirical observations. One of the difficulties of studying missing markets is that it is a negative concept, a case of non-emergence that is difficult to identify and study empirically. In the case of MMLOS, the identification of missing markets can roughly correspond to identification of a waste resource with significant use-value that is not being utilised. It is then necessary to investigate if the lack of scarcity condition is among the reasons of non-emergence.

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