

The Economics of Downcycling:
An Overview with Illustration from the International Used Car Trade

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Abstract:

The downcycling of goods, materials and energy from their highest to lowest use after production and prior to disposal is an important element of industrial ecology. There appear to be many instances where what no longer has value to one consumer or process has value to another. It is the belief that such transfers can be carried out economically as they occur in natural ecosystems that drives much of the research in industrial ecology and related fields. What can economics tell us about downcycling? How does economics explain why downcycling that might appear "economical" does not occur? This paper will provide a basic review of the economics of downcycling and how it might explain the apparent failure of what are often described as economically efficient economies to be resource efficient in the eyes of engineers, environmentalists and others. The paper provides a tree-top overview progressing from a discussion of how downcycling does not occur under standard microeconomics assumptions through the conditions under which such trade might emerge, including transportation costs, heterogeneous factor distributions, imperfect information, the presence of distortionary policies, and the presence of government policy. Illustration of how these factors come into play is provided in reference to the international trade in used automobiles. This paper is an element of on-going dissertation research.

Introduction

Over the past decade, the field of industrial ecology (IE) has spread quickly both inside and outside existing academic disciplines. This growth has largely taken place on the foundation of a growing number of case studies, an appeal to the basic principle of resource and energy efficiency, and above all the evocative metaphor of natural ecosystems as role models for human economies. Of particular interest has been the concept of industrial symbiosis (Frosch & Gallopoulos, 1989; Gertler, 1995) and more broadly the notion that by encouraging the "downcycling" of materials, energy, and goods from one economic use to another it will be possible to greatly reduce primary material extraction and increase overall resource and energy efficiency.

As with any nascent academic field, IE faces a shortage in two important areas: 1) well-defined and generally accepted theory; and 2) sufficient data with which to extend, test and modify that theory. Related to this, a need has been identified to explore and define the "micro foundations" of the field (Andrews, 2001) - to establish a link between the actions of individual agents and the meso and macro outcomes being observed and proposed by academics, businesses and policy practitioners. The academic fields that Andrews suggests have potential to contribute to the micro foundations of IE are economics and ecology. Both are part of the foundation of IE and both have been relatively successful in building viable disciplines on a behavioral foundation (Andrews, 2001).

This paper takes a broad look at what the field of economics can (and can not) provide us in the way of micro foundations for describing and analyzing the motivation for downcycling by economic agents and prescribing policy for downcycling within the

economy. With over a decade of renewed¹ theoretical and applied research into this phenomenon, many authors have borrowed convenient concepts from economics to explain their observations but there have been few surveys or reviews of the economics governing it (Pelletiere, 1997, 2001; Chertow 2000; Schlarb 2001).

This in turn has limited the progress in answering the immediate question often presented to researchers and policy makers advocating downcycling *if it makes so much sense, why don't we see more of it?* Potential answers to this question are many:

1. there are significant policy barriers to efficient downcycling;
2. there are significant economic barriers and perhaps downcycling is a sign of inefficiency rather than efficiency;
3. downcycling is efficient but only when it takes place where transaction costs are minimized within a single firm (as in the petroleum industry) and hence trade is unobserved; or
4. downcycling can increase efficiency but we should assume that firms have already exhausted the opportunities.

Where previous papers (Pelletiere 1997, 2001) have looked primarily at the barriers to downcycling in addressing this question, this paper focuses on the economic motivations.

Defining Downcycling in the Terms of Economics

Downcycling is the process of transferring a material, a good, or a flow of energy that is no longer useful in one process of production or consumption to another where it is useful. In simpler terms, it is "Reuse" and "Repair" in the environmentalist mantra "Reduce, Reuse, Repair, Recycle, Refuse." Industrial symbiosis for its part is a specific form of downcycling where the by-products from one production process are transferred to another process at another firm to the mutual economic benefit of both firms and an over all increase in resource efficiency for the economy (Gertler, 1995).

As the name implies, downcycling differs from recycling because the material, good, or energy is transferred in a post-consumer and degraded form to a new use. In the case of recycling, significant additional energy and material are applied to the transferred product so that it or some portion of its constituent materials and/or subcomponents can be reintroduced in the original market from which it came.² Therefore downcycling is generally seen as a less energy and resource intensive process than recycling and, as indicated by the mantra above, as the environmentally preferred option.

Given the environmental aspects of downcycling, it is logical to begin a search for a comparable concept in economics within the sub-field of environmental economics. As a

¹ Current interest was spurred in large part by the publication of Frosch and Gallopoulos' seminal article in Scientific American "Strategies for Manufacturing" (1989). For a historical perspective on the antecedents to the current interest in industrial symbiosis see DesRoches (2000), and for downcycling in general Strasser (1999)

² Clearly the line is not always clear as many recycled products are also degraded and enter as inferior substitutes into markets. Therefore the distinction is best understood as a continuum from purely downcycled to purely recycled, with the extremes being rare.

whole it does not present a good fit.³ The concept of downcycling does exist in the durable goods pricing, information economics, antitrust (competition policy), and trade and development literatures of economics. In each of these areas there has been interest in various aspects of second-hand goods markets. There is also a small body of literature that discusses the economics of second-hand markets explicitly (Fox, 1957; Miller, 1960; Scitovsky, 1994). Second-hand trade is analogous to downcycling. For reasons discussed below the focus in economics has been on goods as opposed to materials and energy and therefore for the rest of this paper goods will be the focus of the discussion. In the conclusion the special characteristics of second-hand materials and energy will be raised.

Differentiating New from Second-hand Economically

A priori the only difference between second-hand and new goods that can be known without further description is that the source of a second-hand good is a prior consumer and not its producer. In all but a few cases, namely art, antiques, collectables, and some real estate (all exceptions that prove the rule [Scitovsky, 1994]), meeting second-hand demand is not their primary objective - consumption for some primary purpose is. Thus decisions about consuming and discarding the good can be made independently of the second-hand market. Similarly, the demand for second-hand goods is affected by conditions in some future period that could only be guessed at when initial production and consumption decisions were made. This has four major implications for used goods markets relative to new goods markets.

First, primary demand is not a direct function of future second-hand demand and therefore, in the absence of perfect information, there is uncertainty about how future second-hand supply will meet demand or, vice versa, whether demand will meet future supply. Even in theoretical terms it makes no sense to assume supply will automatically equal demand at any future period in second-hand markets and second-hand markets must be characterized by a high risk of disequilibrium.

Second, there is more quality heterogeneity in used goods, primarily because there are more consumers of a good than original producers but also because consumption behavior is by far more diverse than production behavior. This cuts both ways. It allows second-hand markets to increase the overall variety and meet a wider range of tastes and budgets among consumers, but it also increases the information costs of determining what characteristics are on offer in the second-hand market. Consumers will not be indifferent between second-hand goods on offer even if there are of sufficient quantity and were consider homogenous when new.⁴

This leads to the third implication, the well-studied problem of information asymmetry (Akerlof, 1970). This occurs because in the absence of perfect information a consumer is

³ There is considerable focus on recycling in this literature and some of its points are applicable to the economics of downcycling. However, though recycling and downcycling share many of the same characteristics prior to processing and secondary sale, as discussed above they differ significantly in processing and often in final marketing and use. Though similar it is useful to treat them separately.

⁴ This may also have a number of implications for assumptions about the nature of competition and market power in second-hand markets beyond the scope of this paper.

unable to readily determine the quality of a good and must incur some costs in discovering or legally guaranteeing its quality. Just as with quantity uncertainty, information asymmetry exists to some degree in all goods. Every good from a single producer is not equal to all the others - as the frequency of limited product recalls attests - but the problem is particularly pronounced and unavoidable in considering the economics of second-hand goods. It is for this reason that Akerlof chose it as an example for his research, which was recently awarded the Nobel Prize.

The fourth implication arises out of the general situation that there are both more consumers to sell in second-hand markets than producers selling to primary markets and that these consumers are pursuing an objective function relatively independent of the demands of secondary consumers creates one further problem. The location where a second-hand good is offered is not necessarily where it will be demanded. Furthermore, in many sectors consumers are likely to be distributed much more widely across space than primary producer competitors increasing the cost of bringing goods to consumers. This is exacerbated because the value-to-transportation-cost ratio is lower for second-hand compared to new goods (with some exceptions, antiques, art, etc. (see Scitovsky 1994)) In other words, while they are more widely distributed they are also more sensitive to distance as a factor in their price (Pelletiere, 1997; 2000).

As presented above the disadvantages faced by second-hand goods appear to outnumber, if not outweigh, any economic advantages they may have in exchange. Yet, there exists considerable trade in used goods (downcycling of a sort). What follows is an overview and assessment of the motivations that microeconomics can provide in explaining the trade that does occur. The example used here is the international trade in second-hand automobiles.

The Global Used Car Trade

In 1999 the US exported 127,000 used passenger cars compared to 235,000 new. In that same year Japan exported 360,000 (est.) used cars compared to 4 million new cars. This also reflects the general pattern that the global trade in used cars flows from more to less developed countries. While the volume of used cars lagged behind new cars in international trade flows, in the US domestic market 40 million used vehicles were sold in 1999 compared to only 17 million new. There are a number of potential economic reasons for the discrepancy between the popularity of used cars domestically and in world trade, such as the lower value-to-transportation-cost ratios experienced by most used products. There are also, however, a number of institutional barriers. In research by this author 61 of 111 countries with available information restrict used car imports.⁵ Of these countries 21 had a strict ban on used car imports; 23 banned cars over 5 years (or less) and/or had a significant additional tariff; and 17 banned cars 6 years old or older and/or had small additional fees or tariffs. These numbers understate the institutional friction faced by used cars in international trade as national environmental and other car related technical regulations and subsidies to new car production can have a

⁵ Most data from United States Trade Information center additional information from interviews and survey research.

discriminatory impact on used car sales, not to mention the many informal hurdles to be overcome along the way.

In short, as with used goods in general, used cars are at a general economic disadvantage relative to their new counterparts. It is important to note, however, that as high-value, highly differentiated goods they are less disadvantaged than lower value, less differentiated products. Indeed the discrepancy between the new to used car ratio in sales in a large integrated economy such as the US and in world trade may suggest that used cars are under-represented in world trade. Thus, though some of the barriers to trade have already been discussed, the discussion turns to the more fundamental issue of what motivates second-hand trade, and can economic theory provide hypotheses that are sufficiently plausible to be tested.

The Microeconomic Model of Trade

So what are the relevant micro-foundations within economics that may help us explain second-hand trade? The discussion of the economic characteristics of second-hand goods given above was relatively informal and without explicit consideration of the various assumptions that form the micro-foundation of theory on which it was based.

In basic economics there are two types of good: consumption goods and durable goods. Consumption goods are purchased and completely consumed in a single time period,⁶ while durable goods are purchased and consumed over the current period and one or more subsequent periods. A hamburger is thus an example of a consumption good while a piece of furniture is an example of a durable good. An important subcategory of durable goods is capital goods. Capital goods are defined as durable goods that are themselves used to produce consumption or durable goods. Factory plant is what is most often meant by capital goods but other durables used in production such as agricultural vehicles or infrastructure, for example, can also be included. Therefore a used car is clearly a consumer durable but under a wide range of conditions might also be classified as a capital good.

When goods are defined this way, it is clear that a second-hand market can only exist for durable goods: consumption goods by definition are consumed immediately and completely. Nothing is left to sell second-hand. Therefore the economics literature has focused attention on explaining the second-hand market for second-hand consumer durables, capital goods and, in one case, textbooks (Miller, 1974).

The standard model further assumes perfect competition and more importantly perfect information: there is free entry to the market and consumers and producers are privy to all relevant information on all goods and services and the actions of all other agents in the market. This applies both in the current period and looking ahead to future periods. There is a further assumption that markets are frictionless: trades occur instantaneously

⁶ Clearly, no good can be completely consumed, and this ignores the existence of wastes and by-products from consumption and production. But standard economic theory has no explicit treatment of wastes other than to suggest they would not exist in an efficient economy.

and without additional trade-related costs such as transportation. The final assumption is that all consumers in the market have homogeneous preferences (tastes).

How does a second-hand market function under these assumptions? It doesn't.

The producer sells a durable good for its "net present value", which is the known sum of the stream of value the good provides over its entire life, discounted by a rate that reflects wear and tear (maintenance costs) and the onset of obsolescence over its lifetime. This has very different implications for current owners (potential sellers) than it does for the potential second-hand consumers.

For a potential consumer faced with a budget constraint, entering a second hand market makes sense. This is particularly true when budgets vary across consumers, an important source of variation in the standard model. Unlike in much of the discussion above, due to the presence of perfect information to the consumer used goods are simply goods like any other in a continuum of goods offering different characteristics and prices to choose from. The consumer chooses the good that maximizes his utility given his budget without reference to whether the good is new or second-hand. In the case of intermediate consumption, the purchase of inputs to production, a firm will purchase inputs that maximize its own production function using a similar calculus.

Under these same assumptions, however, for the current owner of the good there is no similar motivation to sell. Entering the secondary market the initial consumer and current owner will receive the original price he paid less depreciation that has already occurred, i.e the good's net present value in that period. The implication is that the secondary consumer will only be willing to pay what the good is worth to the current owner. The current owner therefore will only be able to use the return from the sale to purchase a good that he prefers no better than the one he sold. He would do just as well to continue using the good until the end of its life (Sen, 1962).⁷

Therefore, using the standard micro foundations of economics the market for second-hand goods does not exist. At the same time, the logical conclusion is that all goods are used efficiently and until they are without value. There is no need for concern environmentally or economically about a perceived lack of downcycling. If anything the presence of downcycling suggests inefficiency.

As the case of the international used car trade above illustrates, second-hand markets do exist. The standard assumptions may suggest they *should* not exist, however, since they do indeed exist it is necessary to augment or relax the basic assumptions of the standard model in one or more ways to explain their existence.⁸ The question of whether second-

⁷ With perfect information it is also impossible that unexpected events will force an unexpected sale: even one's date with death is known.

⁸ It should be noted, however, that in many cases where economists have confronted second-hand markets as part of another problem, rather than altering the assumptions to allow second hand trade, the approach taken has been to "assume away" the problem, for example by simply positing the existence of a smoothly functioning second-hand rental market (Rust 1986 looks at these approach to durable goods pricing). Others have used these assumptions to derive influential policy conclusions about second-hand markets and

hand are economically optimal or a sign of economic inefficiency must be answered in the degree it is believed the assumptions of the standard model can be approximated in real economies and to what degree the various extensions, "distortions" and "imperfections" introduced below are accepted as part and parcel of economic production, consumption and exchange.

Trade theory is the field of economics that deals explicitly with the motivation to trade, and there is even a small literature within this field devoted to second-hand trade (Sen, 1962; Smith 1976, 1974; Schwartz, 1973; Bond 1983; Navaretti, Soloaga, Takacs, 1998a&b, 2000) The theory is most often placed in an international context, but the fundamental insights from the international trade literature, however, can be applied not just in the international context but to trade in general (i.e. Sen, 1962; Bond 1983). In this paper the international context is used but the lessons may well apply to all manner of trades.

Trade Theory and Secondhand Goods

In international trade theory five conditions are recognized as being sufficient for trade to occur between two economic agents or economies. These are:

- 1) differences in production functions (technology);
- 2) differences in relative endowments between trading partners;
- 3) the presence of increasing returns to scale;
- 4) differences in preferences (tastes); and
- 5) the presence of distortions due to government policies, imperfect information, or the existence of imperfect competition.

In very basic terms, the body of international trade theory is largely built around making different assumptions about which set of these conditions hold (Markusen et al 1995: 81). The first three are really additional assumptions about the cost functions facing participants in exchange while the last two alter some of its key assumptions. If none of these conditions hold between two trading partners, trade will not occur; if one or more does hold, trade is likely to occur. The purpose here is not to provide a review of trade theory but to show that with each of these a number of different motivations emerge for some owners of durable goods to enter second-hand markets.

Technology

Differences in technology, or as economists would say, production functions, are the basis for David Ricardo's theory of comparative advantage. In simple terms, the outcome of the this model is that when there are differences in production functions among countries, each will be better at producing one (or perhaps a few) goods relative to the other goods it is also capable of producing. Given the opportunity, each partner will

durability. A prime example of this is Swan's (1972) much trumpeted analysis of planned obsolescence. Swan uses the logic of net-present value to formally show that it would be irrational for firms to design their products for premature (sub-optimal) obsolescence. Since the price they receive is the net present value, artificially limiting the life of a product would also reduce its initial price. Swan showed that under standard assumptions there is no room for uncompetitive behavior of this sort. This result is sorely tested when the assumptions are changed (Rust, 1986; Hendel & Lizzeri 1999).

specialize in the goods that it produces comparatively well. Thus an opportunity to trade is also an opportunity to produce and sell the good in which it has a comparative advantage. In return the country can receive other goods from other countries who have a comparative advantage in those other goods. It can be shown that this result will hold even in the case where a country has an absolute advantage in production, that is where it is a more efficient producer of all goods (see Markusen et al., 1995: 84-97 for further discussion and derivations). Everyone is better off from trade.

In the case of second-hand goods, there is an immediate problem in discussing technology-based comparative advantage. Since they are brought to market by the process of consumption and not production, it is difficult (if interesting) to try to conceive of something analogous to a "production functions" in a case such as second-hand cars. What would it mean to be technically better or worse at producing (creating) used cars?

It is more straightforward, however, to posit that a foreign country has a technological advantage in maintaining used cars. Foreign mechanics might have the skills and technologies to keep a car in working order longer than domestic mechanics. If as a result, foreign demand for older cars is greater than the domestic demand, and especially if it exceeds the foreign supply of older cars, the resulting higher price in the foreign market might motivate trade from the home market. Thus, unlike in the standard microeconomic model, and even though it is based on the consumer's rather than the current owner's comparative advantage, there is - at least theoretically - a motivation for the current owner to sell the car and thereby increase his welfare. Similarly for the foreign consumer, the technological advantage would make the exchange worthwhile even if the car exchanged was considered to be "worth nothing" and at the end of its life in the home country

While this makes sense in general terms, the "face validity" for such a hypothesis is low. It seems unlikely that developing countries are the primary importers of used cars simply because they possess a technological capability that developed countries don't have. To be sure there is strong evidence of the know-how that exists developing countries on how to keep old cars running (witness 1950's cars still running in Cuba), and it appears likely that some techniques these mechanics use are unknown or forgotten in developing countries. Still the motivation and reasons for possessing this know-how, must be questioned. Is it the cause of trade or, as in the case of Cuba, the result of other factors related to trade and access to production in the domestic market?⁹

Factor Endowments

When the trading partners have different endowments of productive factors such as capital, labor or land this can also create a patterns of comparative advantage. In trade

⁹ Navaretti et al (1998a,b, 2000) find that education levels are a significant factor in the importation of second-hand metal working machines from the US controlling for the wage level. They find a positive relationship between skill level and the technological advancement of the machine. This, however, seems to be the result of a technical comparative disadvantage - an abundance in low -skilled workers - that leads to the purchase of used machines. As such it is probably better related to the factor endowment hypothesis, with different types of labor force being treated as separate factors of production without respect to wage. This would apply with cars as they become increasingly technologically advanced and complex.

theory this is summed up by the Heckscher-Ohlin theorem, which posits that when the assumptions of the standard model hold but the potential partners have different factor endowments, each will specialize in and sell the goods of the sector that intensively uses its relatively abundant factor. In turn it will purchase the products of sectors that intensively use the factors in which it is relatively scarce from other countries abundant in those factors (for further discussion and the derivation see Markusen et al., 1995: 106). In the development literature this is often extended to the case where products can be made in a variety of ways. In this case a country will specialize in not just the sectors but also the production processes that use the factors in which it is relatively abundant.

In the case of used goods it was this logic that formed the foundation of Sen's (1962) "On the Usefulness of Used Machines." In a short note, Sen concludes that if used machines are assumed to be labor intensive due to their vintage technology and greater propensity to breakdown, they are well suited to labor abundant, low-wage developing countries. Eric Bond (1983) applies a similar logic in a theoretical model and empirical test of firm purchases of used trucks in the US. Bond posits that small firms face lower factor costs and utilize capital less intensively (as measured by the use of night shifts) than large firms. In his model, small firms, facing higher factor prices and lower capacity utilization, purchase used machines while large firms - facing higher wages and higher opportunity costs from downtime - purchase new. His empirical test appears to confirm that smaller firms were more likely to purchase used trucks, which they assumedly purchase from large firms.

Why in this model does the current owner sell the cars? Given these assumptions, in developing countries repair costs, made up largely of labor costs, are likely to be significantly less than the cost of purchasing new (capital intensive) production; in the industrialized countries this relationship is often reversed. Therefore, the demand for older cars in developing countries exceeds the demand for them in developed countries. The higher demand yields a higher developing country autarky price, and once again a theoretical motivation to sell to developing countries at the end of a product's life in the developed country emerges. A priori this hypothesis appears to have a high face-validity in the case of used cars (i.e. Grubel, 1980).

Increasing Returns

When an economic agent is able to spread fixed costs over larger production runs the marginal and average cost per unit declines and returns increase as production increases. These are so-called internal economies of scale. There are also economies of scale that are external to the firm and even the industry that come from the creation of specialized inputs and producer services, and from economies in transport (Krugman, 1991). Economies of scale can be a motivation for trade since individuals, firms and sectors within countries have an incentive to expand their production and therefore their market as much as possible, and specialize in those goods and sectors where the returns are the greatest. Trade clearly expands markets and encourages economies of scale where they exist.

As discussed above, however, second-hand products are not produced as much as consumed into existence. It is difficult to conceive of economies of scale in consumption and therefore in the creation of used cars. This does not mean, however, that economies of scale do not play a role in second-hand markets. The important economies in these markets come from the aggregation of second-hand products for collection and processing. In this regard, a large and consistent supply enables greater rationalization of the industry and the establishment of specialized services such as financing for what would otherwise be a disadvantaged industry. In other words, these economies can in part serve the creation of processes and institutions capable of partially off-setting (but not overcoming) the disadvantages of second-hand trade.

This may explain the relatively smooth functioning of the domestic used car market in the US. Sellers in markets where customers, specialized services, and supply are aggregated may receive a better price than markets where these factors are not aggregated, and they will not come together unless there is sufficient supply. The consumer reduces search time, financing costs, and similar "transaction costs" (discussed further below) and the seller gains from a higher price. Similarly, the presence of external returns can explain the existence of highly localized centers in the used car trade. Even though they are themselves relatively small markets, location, history, and institutional factors have conspired to make Belgium and Benin the two centers of the Europe-Africa used car trade. Yet, while increasing returns may explain pattern of trade, it fails to provide an explanation for the apparent differences in demand and end-of-life that effect prices and motivate current owners to enter the second-hand market in the first place.

Preferences

Preferences are something of a problem in microeconomics. On the one hand, differences in tastes are the most obvious reason for trade. If one person has a greater preference for a good than another he will be willing to trade (pay) more to get it. Economists have developed an internally valid theory of utility and preferences to discuss how preferences shape exchange. On the other hand, external validity, that is the the empirical side of this research, has foundered on the inability of economists to model "the insides of peoples heads." Notions such as revealed preferences, i.e. the choices consumers have made in the past when selecting goods, can tell us something about past tastes. It is clear, however, that tastes change with time and as new consumers enter a market. Therefore there is little indication in studies of revealed preferences of future preferences or how preferences are formed among economic agents. While surely an important element in explaining both the occurrence and the pattern of trade preferences are often unsatisfying as an explanation to policy analysts and applied economists.

This is apparent in the case of second-hand trade and specifically used cars. Clearly, if one person prefers newer cars he will have a different net present value calculation than a potential buyer who has no such preference. The net present value for the current owner of this used car will be lower than that perceived by the potential buyer and the buyer will be willing to pay a price higher than the car is worth to its current owner. Both will be made better off by trade. This was the approach used by Fox (1957) in the earliest attempt in the literature to explain the existence of second hand markets under otherwise

standard microeconomic assumptions. But do Nigerians really “prefer” used cars? Lindner (1961) suggested that preferences are a function of income, which would seem to apply in this case (Van Beukering, 2001). This might suggest that higher-income people changes preferences at different times than low-income people, or perhaps they are the "tastemakers."

Thus, a more convincing argument is that opportunities emerge as preferences change among agents creating a lag or mismatch in preferences. Along with the income hypothesis, the people or firms in one country may be less willing to switch product loyalties, and therefore may be more willing to purchase a used product that they know than a new product that is "untested." A "preference" for used cars therefore may be more than a simple function of budget constraints but a lag in preferences might also be explained by relaxing the assumption of perfect information: people in developing countries may be willing to pay more for older vehicles because they have little information about new vehicles. For example, if new car producers do not promote their cars in developing countries due to lacking economies of scale, a perceived lack of demand, or other reasons, the lack of outside interest in pushing information may lead to people buying what they know, what they see, without reference to new car availability or price - a cycle of ignorance of a sort. A priori, given the ubiquity of car advertising and images and the worldwide interest in the automobile, however, such a thesis must be received with some skepticism.

Imperfections

The conclusions in the standard model are highly dependent on the presence of perfect information, perfect competition, and the absence of transaction costs (additional costs related to the process of exchanging the good). Up until now these assumptions have remained sacrosanct. What happens when these assumptions are relaxed?

Perfect information is a basic assumption of the standard model; it is also one of the least plausible. As discussed above, though it occur in most economic transactions, the problems of asymmetric information are particularly pronounced in used goods and in particular used cars, the most famous example in the asymmetric information literature. In this literature, asymmetric information about the quality of a used car is seen as a barrier to trade due to the additional costs and risks associated with it. Seen from the perspective that in a theoretically efficient market the second-hand market does not exist, however, it is possible to conclude that by providing an opportunity for arbitrage by the current owner, imperfect information can be a cause for second-hand trade. Indeed, this is an argument heard from primary producers in developing countries quite a bit: the developing are able to foist their "junk" on developing country consumers because those consumers do not know any better.

While in theory this might appear a plausible explanation one would be loath to assume a priori that a African car consumer is less able to evaluate his automobile needs and a car's quality than is a Western European or an American consumer. More plausible perhaps, is that there is a lack of information due to communications technology inadequacies. More interesting and hotly debated, is the issue that the regulatory structures or institutions of

markets in developing countries are less able to transmit information on the "true" cost of second-hand imports. These are so-called external costs not covered in the price mechanism that can arise out of imperfect information. Developing consumers may not pay the full cost of their imports' impact of the health and safety of their fellow country men in the absence of environmental or safety rules. This is discussed further in the discussion of government policy below.

Another imperfection that can enter these discussions is barriers to entry to a market. Barriers to entry confer some measure of monopoly power and market control to current producers. When such market power exists the demand for products may not be met with adequate supply. Just as it is difficult to exercise control over the quality of used goods, it is difficult to exercise control over their supply once they are purchased. Consumers may have an incentive to buy second-hand because a monopoly, for example a sole licensed importer, is not adequately meeting demand. Thus it has been hypothesized that used goods may present an alternative and a check to monopoly rents in industries with increasing returns (Miller, 1974). Alcoa Aluminum, in a famous American antitrust case, argued that the presence of a recycling industry hindered the conclusion that it held monopoly power in the market place. Interestingly, the judge ruled that because Alcoa controlled the primary supply, it also had a significant influence on secondary supply, touching off a hot debate in economics and Law that persists today (Swan, 1980; Grant 1999; Martin, 1982; Rust 1986). A priori it is hard to comment on this as a potential motivation for trade.

A final source of potential "imperfection" is the cost of transportation. As discussed above in the discussion of the economic characteristics of used goods, transportation costs are likely to be higher for used goods, due to lacking economies of scale and an initially wide distribution, even as their value is relatively lower. With a lower value to transport cost ratio, used goods face a distinct disadvantage over distance. That said, in combination with economies of scale, no matter how weak, and the fact that there are more consumers than producers, it is clear that production is likely to be more centralized than consumption. Therefore there will be cases where even though the used good is at a disadvantage over distance, it will be located in closer proximity to the consumer, and at a lower cost than a similar new good, particularly if the consumer is also faced with barriers to entry and imperfect information. This, however, would generally be a better explanation for domestic used car sales than for extensive international trade.

Policies

The final motivation for trade that is particularly of interest to the field of IE is government policy. Governments can encourage as well as discourage trade. As with the factors in the last section, from the perspective of the standard model this leads to an inefficient and distorted economic outcome. In the presence of imperfections, and to the degree they are inherent to economic exchange and not able to be overcome, however, this conclusion becomes more ambiguous.

Clearly, if a country were to subsidize the purchase of a used car this would likely increase demand and the domestic price, and encourage foreign cars to enter the market

even in the absence of any purely economic justification. Conversely, if a country has a subsidy for its citizens to purchase a car (assuming people prefer new cars) or new cars specifically, this will likely increase the number of new car sales, decrease the time cars are owned and increase the supply of used cars and at the same time it would decrease the demand for them. This would lower the domestic price relative to the foreign price, and encourage foreign buyers to enter the market (assuming foreign buyers' purchases were not subsidized to the same degree). While there are no known instances where governments discriminate in favor of used cars, there may be some domestic incentives to purchase new cars or cars in general that may have an impact.

However, the policies most cited to motivate the international trade in used cars are the environmental and safety regulations that may make a car obsolete due to the increased cost of maintenance or legal restrictions. These regulations are heterogeneously distributed across countries and in their stipulations. When the home country has such a standard and foreign country does not, the net present value for those facing obsolescence in their home country is zero while in foreign country it remains positive. This regulatory mismatch leads to higher foreign prices in terms of domestic prices and is therefore a potential motivation for trade.

In reality developing countries often have lower standards raising the price they can pay for a car that does not meet standards in developed countries. Of the 111 countries in this author's survey 47 have vehicle emissions standards, 31 of these are industrialized countries or Eastern European states seeking association with the EU. In other words, only 16 of the remaining 70 developing countries have emissions standards worth noting.¹⁰ This mismatch is often used to underline the claim that imperfect information and the subsequent policy failure of developing countries in rectifying the problem are the cause of trade not improved economic efficiency and mutual benefit.

Ultimately, it becomes a question (and a controversial one at that) of whether the environmental and safety regulations in developed countries are optimal in protecting the environment (how to measure that is open for debate) and whether in the absence of these regulations, consumers in developing countries would be able to purchase a cleaner car (though at the same time consumers in developed countries would likely hold on to their old cars as demand for them would drop). On this last point, however, many economists and others (Kahn, 1994; Panagariya, 2000) have suggested that exports of older but cleaner technology may offer a less economically disruptive way to introduce cleaner technologies into developing countries. For example, while cars currently produced for the Indian market do not have catalytic converters, used cars imported from Japan do.

In the end then, in theory and in practice some government regulations can create an incentive for trade in second-hand goods and specifically cars. As with other so-called imperfections and distortions, however, the question is whether trade motivated in this way is to be viewed as efficient. And once again, the answer to this last question from general policy perspective is highly dependent on the specifics of the situation - unless it

¹⁰ This data comes primarily from Automotive Industry on-line www.ai-online.com and personal communications with Michael Walsh, a recognized expert in the field www.walshcarlines.com.

is believed that the assumptions of the standard model are indeed achievable, in which case second-hand trade of any sort is inefficient.

Conclusion

The application of economics micro-foundations to the question, "if downcycling makes so much sense, why don't we see more of it, " provides a number of fruitful insights. Not least of these is that the standard economic micro foundations are insufficient to explain second-hand trade and therefore downcycling. By starting with this foundation, however, and extending and relaxing the assumptions of the model can help provide hypotheses for the motivations for the international used car trade, and by extension perhaps trade related to downcycling in general. The general logic is likely to apply in the case of all used goods, but the degree to which any specific assumption or set of assumptions is sufficient as an explanation for trade will be highly dependent on the characteristics of the good. Used cars are both high-value goods and are met in the marketplace by heterogeneous preferences and demand facilitating the opportunities for trade. Therefore, while this paper has focused on the goods trade, similar findings apply to materials and energy though, as argued elsewhere (Pelletiere, 2000), the low second-hand value of these goods is likely to severely limit the opportunities for trade.

It is likely as the assumptions of the basic model are relaxed alternative trade theories such as life-cycle or material product chain (Markusen et al, 1995; van Beukering, 2001) theories may better describe the empirical evidence of second-hand trade. These theories, however, are a further step away still from the simplicity and cut and dried conclusions of the standard model. Therefore there is a tendency, even among researchers who are well aware of the economic differences and relationship between secondhand and new products and markets, to forget the implications of these when they use standard theories to draw "non-qualitative" (van Beukering 2001: 24) conclusions about the welfare properties of second hand trade using accepted trade models.

For example, Van Beukering (2001: 24-30), whose recently published research on international recycling markets appears to be the seminal work on the subject, uses a specific factors model - a hybrid between the HO and Ricardian model in which one factor, usually assumed to be labor, is allowed to fluctuate between domestic sectors with different production functions - to illustrate the welfare effects of trade in secondary (recycled) and primary commodities. Not only does this require a number of limiting assumptions, a necessary step in any formal modeling, but the model does not even refer to the link between primary consumption as an input to secondary production. Instead, the model simply assuming exogenously determined stocks of materials in developed and developing countries. While the motivation for this is understandable given the constraints of the model, the result is that the findings can be applied to any two goods where one is labor intensive and the other is capital intensive. While it is empirically justifiable to assume secondary inputs are more labor intensive than primary ones, this is clearly not the sole (or most interesting) difference between secondary and primary goods. It also avoids the asymmetric dependence of secondary markets on primary markets, and the implications of this. The result is that little insight emerges about the

economics or welfare implications of specifically secondary (or secondhand) goods from this exercise. And there's the rub.

The question that emerges clearly here is whether generating and testing hypotheses within standard economics allows us to test the rigorousness of IE or is IE, by focusing on materials and markets largely ignored by economics, testing the rigorousness of economics.

- Akerlof, G. 1970. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *Quarterly Journal of Economics* v84, n3 (Aug. 1970): 488-500
- Andrews, C. J. "Building a Micro Foundation for Industrial Ecology." *Journal of Industrial Ecology* 4 (3) 35-51.
- Chertow, M.R. 2000 "Industrial Symbiosis: Literature and Taxonomy" *Annual Review of Energy and the Environment* 25: 313-337
- Bond, Eric W. 1983. "The Trade in Used Equipment with Heterogeneous Firms," *Journal of Political Economy*, 91 (4): 688-705.
- DesRoches, P. 2000. "Market Processes and the "Closing of Industrial Loops: A Historical Reappraisal." *Journal of Industrial Ecology* 4 (1): 29-43.
- Dilmus, James. 1975. "Second Hand Machinery in Development: A Comment," *The Journal of Development Studies*, 11 (3): 230-233.
- Fox, A.H. 1957. "A theory of Second-hand Markets" *Economica*, May 1957
- Frosch R.A. and N. Gallopoulos. 1989. "Strategies for Manufacturing" *Scientific American*, September.
- Gertler, N. 1995. *Industrial Ecosystems: Developing Sustainable Industrial Structures*. MA Thesis: MIT (www.sustainable.doe.gov/business/gertler2.html)
- Grant, Darren. 1999. "Recycling and Market Power: A More General Model and re-evaluation of the evidence," *International Journal of Industrial Organization* 17: 59-80
- Grubel, H.G. 1980 "International Used Cars and Problems of Economic Development." *World Development* 8: 781-788
- Hendel, Igal and Alessandro Lizzeri. 1999. "Interfering with Secondary Markets," *RAND Journal of Economics* 30 (1): 1-21.
- Kahn, Mathew E. 1994. "Growing Car Ownership in LDCs: The Impact on the Environment and Trade," *Columbia Journal of World Business*, 29 (4):
- Krugman, P. 1991. *Geography and Trade*. Cambridge, MA: MIT Press
- Lindner, S.B. 1961. *An Essay on Trade and Transformation*. New York: John Wiley and Sons
- Mainwaring, L. 1986. "International Trade in New and Used Machines," *Cambridge Journal of Economics*, 10: 247-263.
- Markusen, et al. 1995. *International Trade Theory and Evidence*. New York: McGraw Hill, Inc.
- Martin, Robert E. 1982. "Monopoly Power and the Recycling of Raw Materials," *Journal of Industrial Economics* 30 (4): 405-419.
- Miller, H. 1960. "A Note of Fox's Theory of Second-hand Markets" *Economica*, August.
- Miller, H. Laurence Jr. 1974. "On Killing off the Market for Used Textbooks and the Relationship between Markets for New and Secondhand Goods," *The Journal of Political Economy* 82 (3): 612-619.
- Navaretti, Giorgio Barbara; Isidro Soloaga, and Wendy Takacs. 1998b. "Bargains Rejected? Developing Country Trade Policy on Used Equipment," *Labour* 12 (2): 353-362.
- Navaretti, Giorgio Barbara; Isidro Soloaga, and Wendy Takacs. 2000. "Vintage Technologies and Skill Constraints: Evidence from U.S. Exports of New and Used Machines," *The World Bank Economic Review* 14 (1): 91-901.

- Navaretti, Giorgio Barbara; Isidro Soloaga, and Wendy Takacs. 1998a. "When Vintage Technology Makes Sense: Matching Imports to Skills." World Bank Policy Research Working Paper 1923.
- Pack, Howard. 1978. "The Optimality of Used Equipment: Calculation for the Cotton-Textile Industry," *Economic Development and Cultural Change*, 26 (2): 307-325.
- Panagariya, Arvind. 2000. "The New Tyranny of the Auto Industry" *Economic Times of India*. October 25.
- Pelletiere, D. 1997. *Defining the Ecoindustrial Landscape: The Role of Agglomeration, Industrial Parks and Economic Exceptionalism*. MA Thesis: George Mason University
- Pelletiere, D. "Eco-restructuring and the "Friction of Distance."" in Köhn, Jörg, Gowdy, John, and Van der Straaten, Jan. *Sustainability in Action. Sectoral and Regional Case Studies*. Cheltenham, U.K.: Edward Elgar, (2000)
- Rust, John. 1985. "Stationary Equilibrium in a Market for Durable Assets," *Econometrica* 53 (4): 783-805
- Rust, John. 1986. "When is it optimal to Kill off the Market for Used Durable Goods?" *Econometrica* 54 (1): 65-86
- Schwartz, Sandra. 1973. "Second hand Machinery in Development or How to Recognize a Bargain," *Journal of Development Studies*, 9 (4): 544-555."
- Schlarb, Mary. 2001. "Eco-industrial Development: A Strategy for Building Sustainable Communities" *Review of Economic Development Literature and Practice* 8. US Economic Development Administration.
- Scitovsky, Tibor. 1994 "Towards a Theory of Second-hand Markets," *Kyklos* 47: 33-51
- Sen, Amartya K. 1962. "On the Usefulness of Used Machines," *The Review of Economics and Statistics*, 44 (3): 346-348.
- Smith, M.A.M. 1974. "International Trade in Second Hand Machines, *Journal of Development Economics*, 1 (3): 261-278.
- Smith, M.A.M. 1976. "International Trade in vintage Models," *The Review of Economic Studies*, 43: 99-113.
- Strasser, Susan. 1999. *Waste and want : a social history of trash*. New York: Metropolitan Books.
- Swan, Peter L. "Optimum Durability, Second-Hand Markets, and Planned Obsolescence," *The Journal of Political Economy* 80 (3) Part 1: 575-585.
- Swan, Peter L. 1980. Alcoa: "The Influence of Recycling on Monopoly Power," *The Journal of Political Economy* 88 (1): 76-99.
- USDOC-ITA. 1999. *A Compilation of Foreign Motor Vehicle Import Requirements*. Office of Automotive Affairs.