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# Concept of Dual Traceable Ownership System (DTOS) as a Sustainable Design for Product Recycling

Jun Fujimoto and Dean Poland  
*AIST/Tokyo University of Foreign Studies  
 Japan*

## 1. Introduction

According to statistics by Angus Madison at the Groningen Growth and Development Centre, world population has increased four-fold, and the level of global GDP in 2000 was 19 times the level it was in 1900 (Maddison, 2008). This incredible expansion has exposed several kinds of environmental issues such as climate change, natural resource depletion, environmental pollution, and disposal of waste. In the 21st century, there has been further population growth and economic expansion centred on developing countries. It has been estimated that the global population will reach 9,150 million in 2050 (6,115 million in 2000), and the Global GDP will be about four times larger in the following 50 years, if the GDP growth rate will be an average of 2.8 percent annually. The above trend will greatly increase the pressure of resource consumption. Will resources on our planet continue to support this population and economic expansion?

One essential solution is to promote the "3Rs" (reduce, reuse and recycle) globally so as to build a sound-material-cycle society through the effective use of resources and materials (Ministry of the Environment, 2005). 'Reduce' is achieved by using material and design with care to reduce resource consumption and the amount of waste generated. 'Reuse' involves the repeated use of products or parts of products which still have usable aspects. 'Recycle' is the use of waste itself as resources. The minimizing resource consumption and waste can be achieved in an efficient way by focusing primarily on the first of the 3Rs, "reduce," followed by "reuse" and then "recycle." "Reduce" is related to design products in companies. On the contrary, "reuse" and "recycle" are based on complex systems involving several kinds of elements such as institution, business, and people's behaviour. Therefore, it is difficult to achieve "reuse" and "recycle".

This chapter presents potential solutions that can help the progression of 'reuse' and 'recycling' in society. First, some key issues lying behind reuse and recycling systems will be discussed: the lack of management during usage stage, invisible flow caused by discrepancy of personnel expenses between countries, the harmful impact of long-time product life-time, and the purchasing behaviour of people as agents of over-consumption. After such issues have been addressed, a possible solution will be presented which can potentially improve the current situation of "reuse" and "recycle". This solution is linked to a new concept of

product ownership: Dual Traceable Ownership System (DTOS). Furthermore, Service Oriented Products (SOP) will be proposed as an example of products suitable for DTOS. Finally, the feasibility of implementing a system such as DTOS will be examined using survey results about consumer behaviour in Japan.

## 2. Some key issues lying behind recycling system

### 2.1 Recycling QCD

Business processes are based on a free economy system. In this system, supply and demand are adjusted to the market. If there is a particular demand, manufacturers will meet the demand immediately. On the contrary, in recycling, discarded products are supplied to society for the convenience of users, with or without demand. We cannot clearly recognize the size and stability of a “market” in recycling. Therefore, recycling is operated on like a socialist economy rather than a free economy. Thus, there exists an economic “Berlin Wall” between business processes and recycling (Figure 1).

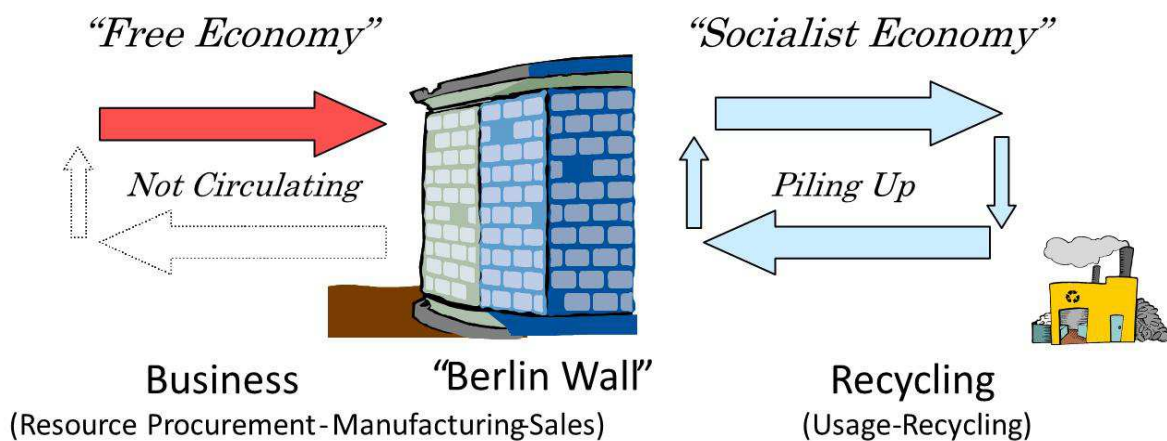


Fig. 1. Economic “Berlin Wall” between business and recycling

While, from the viewpoint of economics, this problem might be a form of economic externalities, from the viewpoint of manufacturing science one of the main causes is derived from the fact that the so-called quality, cost, and delivery (QCD) of recycling systems is not adequate to what manufacturing systems require (Fujimoto et al., 2003). Therefore, to break down this barrier and, as a result, to integrate recycling systems into manufacturing systems, it is essential to control quality, cost, and delivery of the recycling systems. Quality and cost of the recycling systems include the quality and cost of recycled materials and reused components. These need to be competitive relative to virgin materials or to newly manufactured components in order to be consistently used in the manufacturing systems. However, current recycling systems do not satisfy this condition. For example, material from the steel bodies of automobiles cannot be recycled into new automobile bodies because of quality problems, and clothes made of fibres recycled from PET bottles are often more expensive than those made from virgin fibres. Another problem is that the demands of the manufacturing process necessitate a quick response delivery of the recycling systems. The operation of recycling systems depends on the amounts of disposed and collected products (i.e., the push mechanism), while manufacturing systems depend on market needs (i.e., the

market pull mechanism). Thus, there is a mismatch in terms of delivery between the push mechanism and the pull mechanism. Table 1 summarizes the relationships between the ease of controlling QCD of recycled materials and types of recycling systems. It is difficult to control QCD of recycled materials within the conventional situation in which there are no recycling regulations and only economically profitable materials are recycled. By adding strengthened recycling regulations, the cost and delivery factors of recycled materials can be improved. By constructing information technology (IT) systems for managing the recycling systems, the quality factor can be improved. Finally, conducting business on a lease basis would make it easier to control QCD in recycling since a company or an alliance of companies can manage a whole product life cycle. To achieve this “recycling QCD”, it will be necessary to modify entire life cycle systems by introducing innovative product design, new sales and service patterns, and innovative reuse and upgrade strategies.

|          | Products owned by customers |                        |   | Products leased to customers |
|----------|-----------------------------|------------------------|---|------------------------------|
|          | Conventional situation      | +recycling regulations | +recycling regulations +ICT management system |                              |
| Quality  | poor                        | poor                   | acceptable                                    | good                         |
| Cost     | poor                        | acceptable             | acceptable                                    | good                         |
| Delivery | poor                        | acceptable             | acceptable                                    | good                         |

Table 1. Relation between QCD of recycled materials and Types of recycling systems

2.1.1 The dropped sausage

The difficulties of recycling in relation to quality management of discarded products can be illustrated in the following imaginary situation. If a “new” sausage drops outside a supermarket, can you pick it up and eat it? You may hesitate to eat it, because you doubt the “quality” of the sausage. It might contain some poison, or might be rotten. If you must eat it, you want to investigate the “quality” of the sausage further, perhaps by chemical analysis. However, this kind of analysis would be more expensive than the actual price of the sausage. You don’t doubt the quality of the sausage in a supermarket refrigerator because you believe the sausage is under the shop’s management. The difference in distance between a refrigerator in the supermarket and the area just beyond the entrance is only several meters. However, there is a huge difference with regard to “quality” management. Discarded products or recycled materials are under a similar condition in “quality” with the dropped sausage, i.e. out of management. All business processes from manufacturing parts, materials and assemblies to selling products are managed by individual companies. Information related to quality management is passed to the next step of businesses like a relay race. However, the relay of information is cut by consumers, i.e. product usage stage. Discarded products have not been “quality” managed during the usage stage, and nobody has information regarding the quality of discarded products.

2.2 Conflict between recycling and energy saving

The feature of long product lifetime has been recommended for various products as a waste reduction measure. The amount of waste from a product, which works for 10 years without

failure, becomes half in comparison with that which only works for 5 years. However, the best solution of one issue is not always good for the other. Some products, such as cars and home electrical appliances, consume a lot of energy at the product usage stage. Some LCA (life cycle assessment) researches revealed that energy consumption at the product usage stage showed the largest part of total power consumption for product life cycle. If energy consumption in the usage stage of products has been improved largely over the years, it may be necessary to replace an old product with a new good energy efficient product by suitable years from the viewpoint of energy saving in society. We proposed a new concept “rapid circulation of product”, (RCP) and estimated roughly the impact of RCP using product data of four kinds of products: cars, TVs, air-conditioners, and refrigerators. The following assumptions were used in order to simplify the estimation (Koshibu et al., 2003).

- 1. Conventional lifetimes of four products are similar, 10 years
- 2. 5 years lifetime was used in RCP
- 3. Estimation was achieved from 1991 to 2000 in Japan market.
- 4. Set one type of representative product for individual products, and it is assumed that almost all people in Japan use in same product which has the same specification and capacity.

Figure 2 shows the image of RCP concept. In the conventional case, the stock of products at 2000 consists of products manufactured in every year from 1991 to 2000. On the other hand, in the RCP, that consists of products manufactured in every year from 1996 to 2000. This means that the number of manufacturing and discarding product per year in the RCP was double in comparison with that of the conventional case.

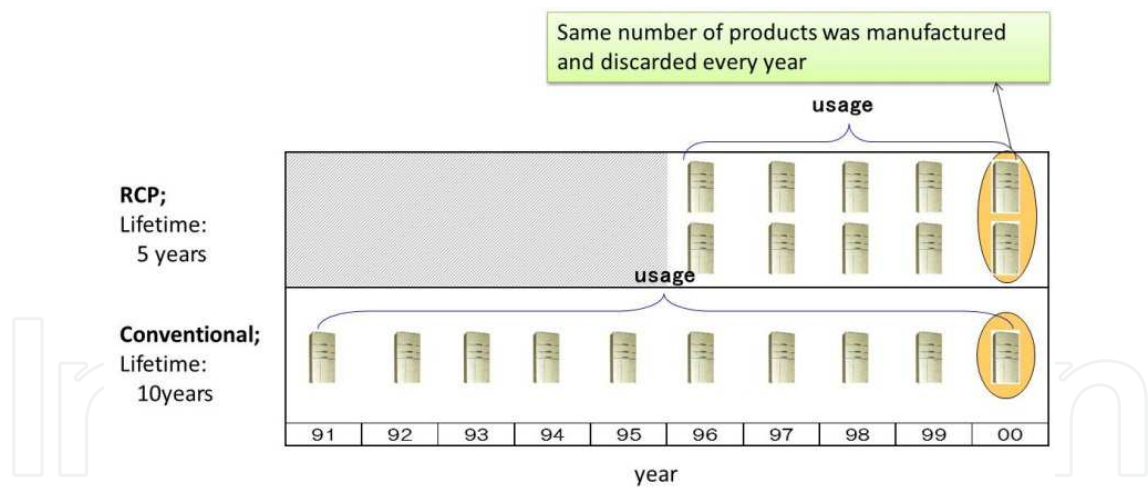


Fig. 2. Configuration of manufacturing year of products at 2000

Figure 3 shows the number of social stocks in the Japanese market and product types used in the estimation in 2000. The number of air-conditioners with both cooling and heating was around 71 million in 2000. The air-conditioner with a cooling capacity of 2.5 kW was assumed as a most popular product. This means the number of 71 million air-conditioners in Japan all occupied by those with 2.5 kW cooling capacity. There were 56 million refrigerators used in Japan 2000. Among these, refrigerators with over 300 liter capacity occupied about 54%, the number of 35 million. We chose the refrigerator with 400 liter capacity as a typical type of refrigerators, and calculated using the number of 35 million. Regarding TVs, 105 million TVs



were used in Japan 2000. Among these, TVs under the display size 29 inches were 76 million, and over 29 inches TVs were 29 million. Regarding TVs, we estimated the impact of RCP on the assumption that 76 million TVs were the same display size- 29 inches. There were 52 million cars in Japan 2000. Among these, the cars with the total amount of engine exhaust from 0.66 liter to 2 liter were popular in Japan- 28 million. Therefore, we selected the type of car with 1.5 liter, and 4 doors as an estimation model.

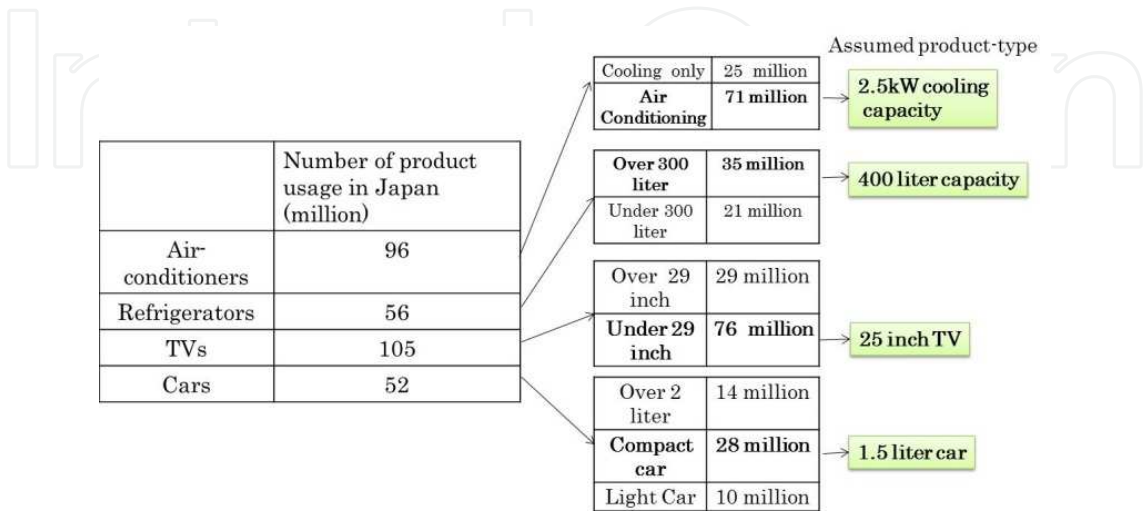


Fig. 3. Number of product usage at 2000 and assumed product-type

The energy consumption in the usage stage was estimated by average usage time per year and energy consumption of the “product model” of individual products, For example, in air-conditioners, the cooling period in summer was 3.6 month and heating period in winter was 5.5 month. In both cases, daily usage time was 18 hours. The energy consumption of the “product model” was obtained according to JIS (Japanese Industrial standards) C 9612 in 13 square meters room of Japanese typical wooden house at Tokyo. The model product was made by Toshiba with 2.5 kW cooling capacity. Figure 4 shows energy saving rate related to 1991 of the model products from 1991 to 2000. The power saving rate of cars do not decrease largely during this period. On the contrary, those of air-conditioners and refrigerators show under the half values of 1991s.

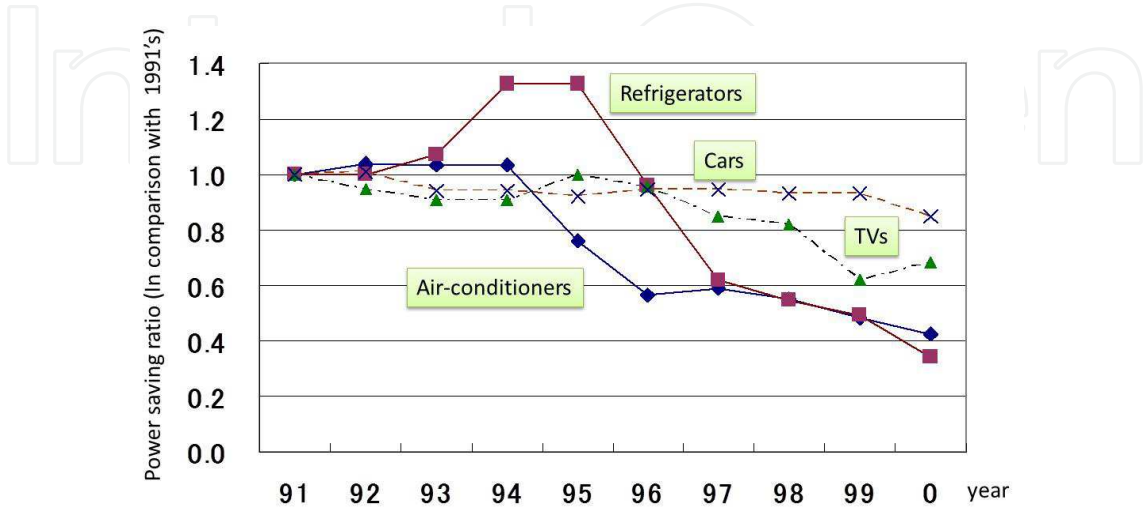


Fig. 4. Energy saving ratio to 1991's assumed product type

If four kinds of products had replaced new products every 5 years in 1990s, what has energy consumption from these products changed at 2000? The differences of the amount of CO2 emission calculated by energy consumption and final disposal amount of waste between conventional 10 years lifetime and RCP (5 years) are shown in Table 2. The minus values present CO2 emission reduction caused by RCP. The CO2 emission from product usage stage decreases in four kinds of products at 2000. However, the CO2 emission from manufacturing and discarding stages increases. Total CO2 emission decreases on air-conditioners and refrigerators, while increase on cars and TVs. The CO2 reduction adding that of air-conditioners and refrigerators is around 13.5 million tons, which is nearly 1% of total emission Japan 2000. On the other hand, RCP is not suitable for cars, because of 8.9 million tons increase. Of cause, final disposal amount of waste, which is a residue after material recycling, increase around 1 million tons, which is nearly 1.5% of total final disposal in Japan. These results suggest that equal 5 years lifetime assumed here is suitable some products, such as air-conditioners, and unsuitable for other products. Do individual products have different optimal replacing years regarding energy saving?

|                  | CO <sub>2</sub> emission at 2000 ( million ton per year) |   |                  | Difference of final disposal amount of waste (thousand ton) |
|------------------|--|---|------------------|---|
|                  | Difference in usage stage                                | Difference in manufacturing and discarding stages | Total difference |   |
| Air-conditioners | -11.2  | +0.9  | -10.3            | +110  |
| Refrigerators    | -4.2   | +0.7  | -3.5             | +150  |
| TVs              | -0.5   | +0.6  | +0.1             | +90   |
| Cars             | -1.0   | +9.9  | +8.9             | +600  |

Table 2. RCP impact on CO2 emission and final disposal waste at 2000

The general solution was derived for obtaining the optimal replacing years of various products. The following assumptions were used in order to simplify the calculation.

- 1. Improvement of energy-saving rate in product usage stages are constant every year
- 2. Energy consumption used in manufacturing and disposal are not changed each year
- 3. Number of shipped products and waste products are similar and does not change each year
- 4. Product lifetime are constant in an individual products

The average energy consumption per year in one product under the above assumptions can be obtained by the following equation (1).

$$T = \frac{\sum_{i=0}^{n-1} (1-\alpha)^{-i}}{n} + \frac{P}{n} = \frac{1-(1-\alpha)^{-n}}{n(1-(1-\alpha)^{-1})} + \frac{P}{n} \tag{1}$$

The individual parameters regarding product characteristics are defined as follows:

- n: lifetime of products (years):
- α : improvement rate of the usage stage energy consumption per year
- P: energy consumption required to manufacture and scrap product/ energy consumption required to work product per year

For example,  $\alpha=0.01$  means that the product of power consumption 200 W decreases 200  $W*(1-0.01)$  =198 one year later.

According to the assumption and definition, the average energy consumption per year (T) in one product can be obtained by the equation (1). However, this T value is a relative value when the annual energy consumption of usage stage at the year concerned is “1”. The n value to minimize T value can be obtained by differentiating equation (1) with n, and presents optimal replacing years of product regarding power saving during lifecycle of product. The results from the above calculation using various  $\alpha$  and P values are shown in Table 3.

| P\α | 1%   | 2%   | 3%   | 4%   | 5%   | 6%   | 7%  | 8%  | 9%  | 10% | 11% | 12% | 13% | 14% | 15% | 16% |
|-----|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 0.0 | -    | -    | -    | -    | -    | -    | -   | -   | -   | -   | -   | -   | -   | -   | -   | -   |
| 0.5 | 9.7  | 6.8  | 5.5  | 4.7  | 4.2  | 3.8  | 3.5 | 3.2 | 3.0 | 2.9 | 2.7 | 2.6 | 2.5 | 2.4 | 2.3 | 2.2 |
| 1.0 | 13.5 | 9.4  | 7.6  | 6.5  | 5.7  | 5.2  | 4.8 | 4.4 | 4.1 | 3.9 | 3.7 | 3.5 | 3.4 | 3.2 | 3.1 | 3.0 |
| 1.5 | 16.4 | 11.3 | 9.1  | 7.8  | 6.9  | 6.2  | 5.7 | 5.3 | 4.9 | 4.6 | 4.4 | 4.2 | 4.0 | 3.8 | 3.7 | 3.5 |
| 2.0 | 18.8 | 12.9 | 10.4 | 8.9  | 7.8  | 7.0  | 6.4 | 6.0 | 5.6 | 5.2 | 5.0 | 4.7 | 4.5 | 4.3 | 4.1 | 4.0 |
| 2.5 | 20.8 | 14.3 | 11.5 | 9.8  | 8.6  | 7.8  | 7.1 | 6.6 | 6.1 | 5.8 | 5.4 | 5.2 | 4.9 | 4.7 | 4.5 | 4.3 |
| 3.0 | 22.7 | 15.6 | 12.4 | 10.6 | 9.3  | 8.4  | 7.7 | 7.1 | 6.6 | 6.2 | 5.9 | 5.5 | 5.3 | 5.0 | 4.8 | 4.6 |
| 3.5 | 24.4 | 16.7 | 13.3 | 11.3 | 9.9  | 8.9  | 8.2 | 7.5 | 7.0 | 6.6 | 6.2 | 5.9 | 5.6 | 5.4 | 5.1 | 4.9 |
| 4.0 | 25.9 | 17.7 | 14.1 | 12.0 | 10.5 | 9.5  | 8.6 | 8.0 | 7.4 | 7.0 | 6.6 | 6.2 | 5.9 | 5.6 | 5.4 | 5.2 |
| 4.5 | 27.3 | 18.7 | 14.9 | 12.6 | 11.1 | 9.9  | 9.1 | 8.4 | 7.8 | 7.3 | 6.9 | 6.5 | 6.2 | 5.9 | 5.6 | 5.4 |
| 5.0 | 28.7 | 19.6 | 15.5 | 13.2 | 11.6 | 10.4 | 9.5 | 8.7 | 8.1 | 7.6 | 7.2 | 6.8 | 6.4 | 6.1 | 5.9 | 5.6 |

α: power saving rate of usage stage compared to previous year  
P: power consumption of manufacturing and disposal stage to  
that of usage stage per year ratio

Table 3. Optimal replacing year of product

Table shows that by decreasing P value and increasing  $\alpha$  values, optimal replacing years of product are shortened. When we calculated the impact of RCP of 5 years replacing from 1991 to 2000, we used  $P=2.39$  and  $\alpha=1.82\%$  of cars,  $P=1.45$  and  $\alpha=4.16\%$  of TVs,  $P=0.44$  and  $\alpha=9.10\%$  of air-conditioners,  $P=1.43$  and  $\alpha=11.2\%$  of refrigerators. These values reveal that optimal replacing years of product was around 15 years of cars, around 7 years of TVs, around 3 years of air-conditioners, and around 4 years of refrigerators in 1990s. The RCP 5 years shown in Table 3 is longer in air-conditioners and refrigerators, and shorter in cars and TVs in comparison with the optimal replacing years. Therefore, CO2 emission results shown in Table 2 can be improved by setting optimal years in individual products. To be exact, there are various products with different capacities and performances are used in actual society. Furthermore, annual usage time of products and operating condition are quite different depending on users. These suggest that the relation between energy saving and recycling show more complicated situation. However, this paradox between energy saving and recycling actually existed in some products which required high energy consumption at the usage stage. How can we solve this kind of paradox?

2.3 Invisible flow

According to ‘home appliance recycling law’ in Japan, advanced recycling for home appliances has been conducted from the year 2001. These home appliances are refrigerators, television sets, air conditioners and washing machines. What problems do we have with these practices? The number of reclaimed products using these recycling systems in the above four electric products was 11.2 million in 2004 fiscal year, including about 1.8 million



air conditioners, 3.8 million television sets, 2.8 million washing machines and 2.8 million refrigerators (Kuwatani et al., 2004). On the other hand, the total number of disposed products was estimated by using the number of shipped products for previous ten years. This was about 20 million and twice the number of reclaimed products. The number of illegally disposed products were estimated to be about 0.17 million products. What happened to the missing approximately 8 million products (see Figure 5)?

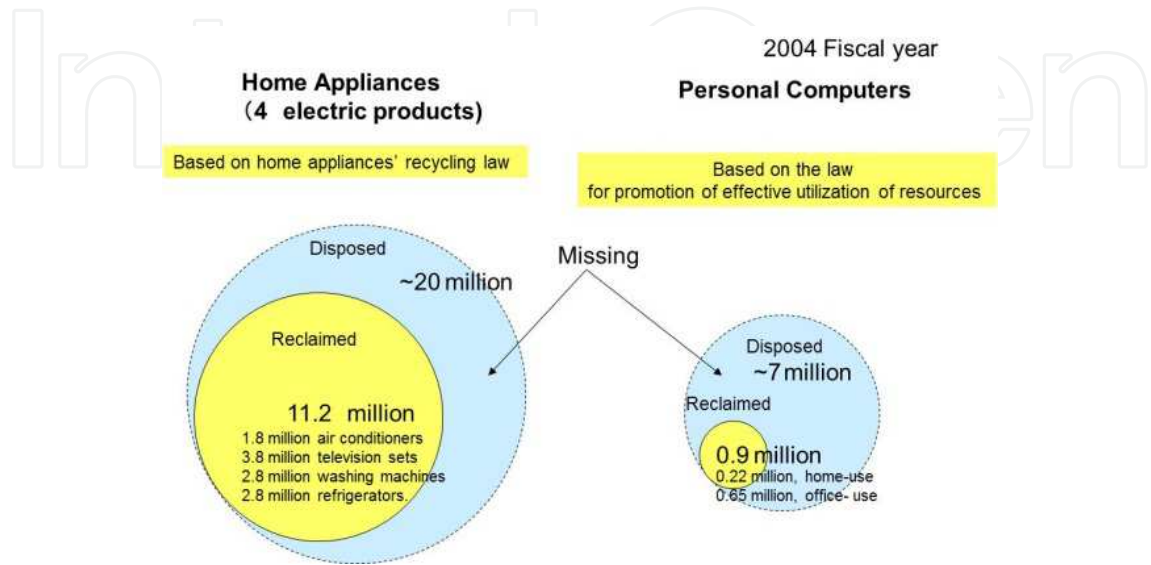


Fig. 5. Number of reclaimed and missing –products at 2004 fiscal year

As for Personal Computer (PC), there are two kinds of usage: office and home. The recycling of discarded PC used in the office has been conducted from April 2001 and that of home-use computer October 2003, based on the law for promotion of effective utilization of resources in Japan. The number of reclaimed products regarding home-use was 0.22 and 0.65 million regarding office-use in 2004 fiscal year (Kuwatani et al., 2004). The total number of disposed products was estimated by using the number of shipped products for the previous seven years. This was approximately 7 million in 2004 fiscal year. In this case, there is a great difference between the number of disposed products and that of reclaimed ones. More than 6 million computers were missing (see Figure 5). Some of the missing products may have been exported to Asian countries as ‘used products’ ; others may have been exported as used parts or materials after they were dismantled in Japan; the remaining ones may have been recycled using different recycling systems from regular recycling ones based on particular laws in Japan. These are chosen according to the economic factors rather than environmental benefits. However, the actual situations of missing products are still invisible. We tried to address these situations using the recycling profit analysis model and the trade statistics of Japan. This will make ‘invisible flow’ clear. Figure 6 shows a possible image of what happens to missing products.

The disparity in economic conditions among countries has a large effect on the benefits of material recycling. Figure 7 shows the benefit comparison of material recycling in Japan with that of Asia (Kondoh et al., 2009). These values were estimated under the assumption that material recycling would be achieved manually and the disassembly-flow strategy obtained by our analysis model would be chosen. This model presents the different recycling ratios between Japan and Asian countries. The values in Asia included the marine transportation

cost from Japan to China. The benefits obtained in Japan indicate all minus values regardless of products. The reason for large variations of benefits in Japan comes from configured disassembly times: from 10 to 20 min. This means that labour costs has a large effect on recycling benefits in Japan. The benefits in Asia are larger than those in Japan, in particular those obtained from PCs and Air conditioners indicate plus values. These show that lower labour costs and higher recycling-material sales in Asia make it possible to cover the extra marine transport cost. The product, which has small volume, consists of several kinds of materials, and takes a great deal of disassembly time, tends to fit the Asia recycling systems.

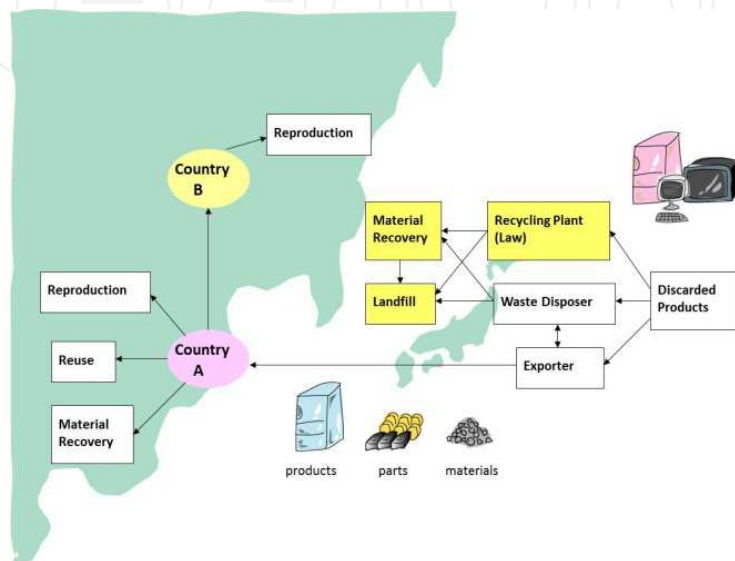


Fig. 6. Situation of missing products

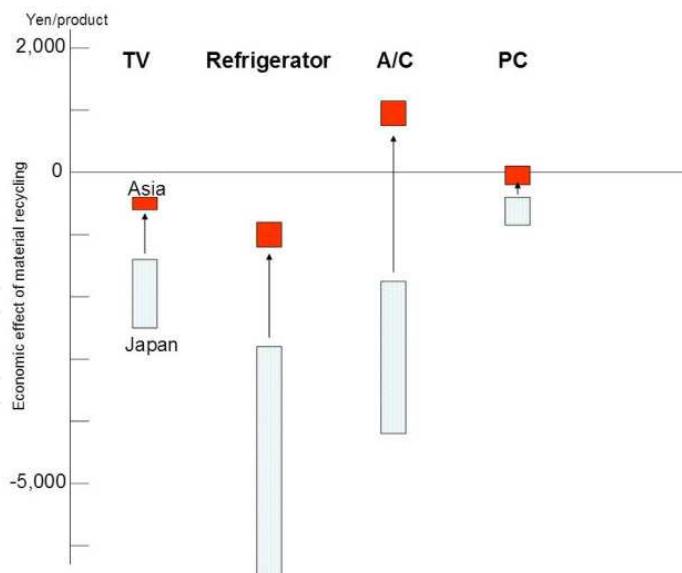


Fig. 7. Economic effect of material recycling

## 2.4 An unsustainable culture of ‘having’

In the societies of ‘developed’ countries, increasingly materialistic sensibilities and consumerist values have led people to believe that the ‘desirable’ lifestyle should be

founded upon the acquisition of material goods, and the unrelenting search for status and power. Unfortunately, this drive to purchase a 'desirable' lifestyle' is supported by high and unsustainable resource consumption.

Ironically, research also shows that this culture of 'having' does not actually have a positive impact on people's sense of Well-Being. Research has shown that levels of Subjective Well-Being (SWB) do not correlate with high GDP or personal wealth (Myers, 2000; Diener & Seligman, 2004).

If the culture of 'having' manifested in high level material consumption does not increase a person's well-being, then why do people do it? Why do people behave in ways that are unsustainable and seemingly irrational?

Although it is generally understood that overconsumption is not good for the well-being of people, society, the environment or even the world, research suggests that social and psychological mechanisms drive people to consume more and more, encouraging behavior that is both irrational and more importantly unsustainable (Boven & Gilovich, 2003). Furthermore, the institutional structures of modern society such as hierarchy, competition and advertising seem to play a large part in determining the lifestyles people lead. Such forces have been labelled 'weapons of influence', each of which play a part in manipulating peoples' behaviour (Cialdini, 2008). Indeed, the economic foundation of developed countries seems to be based on the principle that to consume, that is, contributing to the continuation of an affluent society, is a social responsibility.

But these ideas are by no means new. Decades ago, Erich Fromm in his seminal work 'To Have or To Be', labelled this kind of lifestyle a mode of 'having': "To acquire, to own and to make a profit are the sacred and the unalienable rights of the individual in the industrial society" (Fromm, 1976). Fromm concludes that ultimately the slogan of industrialized societies is: "I am what I have and what I consume." And it is this attitude of 'Having' in general which has contributed to the current situation of unsustainable consumption. Research by Winter and Koger showed that "Much of the irrationality of our environmentally unsustainable behaviour could be attributed to a 'false self' system" (Winter & Koger, 2004). In this system, external objects are used to express people's identity. The consumption of products function as symbols of some ones 'self' in relation to others. For example, cars not only have the function of transporting people from one location to another, but also make a statement to others about who they are. Winter and Koger conclude that much of our overconsumption may be driven by a 'false self' system. Striving for endless increases in material wealth; placing high value on social status and deriving our identity from what we 'Have' rather than who we 'are' or what we 'do' have all contributed to the creation of a mechanism of unsustainable lifestyle, and "constitutes a vicious circle of consumer-buying" (Fromm, 1976).

The condition of "Hyperphagia" i.e. over-eating disorder, the mechanism shown in Fig. 8, may serve as a useful analogy for many resource/energy over-consumption issues. Over-eating disorder requires "Excessive food" consumption. This leads to the problems of disease and obesity, and then creates "Excessive Demands". For example, medical and exercise services. The root cause of Hyperphagia could be said to be mental disorder. In order to suppress resources energy consumption, it would be essential to cure "Hyperphagia" (Fujimoto & Poland, 2009).



Fig. 8. Mechanism of resources and energy overconsumption

### 3. Concept of DTOS as a potential solution

#### 3.1 DTOS

As described in this article, the problem of 'invisible flow' is a key issue which must be solved if a multilateral recycling system is to be feasible. To prevent 'invisible flow', the root cause of this phenomenon must be addressed.

Ultimately, the root cause is connected to the concept of 'ownership'. What does 'ownership' mean for Japanese and Asian people? What does it mean to 'own a product' in today's society? In the current economic and cultural situation of Japan, ownership seems to mean freely possessing a product without taking responsibility for the products 'life cycle' especially with regard to the products 'end of life'. This style of ownership must be radically changed, if the problem of 'invisible flow' is to be solved. Against this background, the relationship between 'ownership' and 'responsibility' will be considered and grounded upon this new understanding, we will propose a new holistic approach: Dual Traceable Ownership System :DTOS (Fujimoto, et al., 2009).

DTOS is a system based on a different attitude towards 'ownership' which makes traceability of a product visible. In this system, there are two styles of 'ownership':

1. Individual consumer has complete ownership of the product.
2. Company has complete ownership and the consumer hires the product.

The first type differs in the level of responsibility for a products 'end of life' in comparison with the current practice of 'ownership'. In this style of ownership, the following requirements must be met:

1. An identification number is attached to individual parts of the product and this number corresponds to the owner.

2. When transferring ownership during product use, the owner has to follow a set of procedures laid down by law.
3. When discarding the product, the owner takes responsibility for the recycling process, for example choosing an appropriate recycling trader. In this case, an owner must consider and be responsible for such things as recycling cost, recycling processes and the legitimacy of the recycling company.
4. If the product which was owned by the consumer, i.e. now in a post-used state, is discovered in an unsuitable or illegal situation, such as a 'black market' recycling process, the owner will receive a severe penalty. The ownership can be easily traced by the identification code which was attached to the product during the time of purchase.

On the other hand, the second style of 'ownership', i.e. the company retains complete ownership responsibilities and the consumer hires the product have the following characteristics:

1. The consumer pays money not for the product itself, but for the services or functions which the product provides. Consumers may pay more money in comparison with the 'consumer ownership' style because of paying long-term monthly fees, but there are several advantages to be gained.
2. The consumer can enjoy the product without worrying about its disposal. The company or 'seller' will take responsibility for all the recycling duties that come with 'ownership.' Through the identification code system, the product and its parts can be easily traced back to the company. Therefore, the company will be liable to pay a large penalty if the product is disposed of inappropriately.
3. It may be possible for the consumer to receive new services quickly and at minimal or no extra cost. For example, consumers may update the product for a 'new model' without the inconvenience of disposing of the old model. Moreover, the consumer may be able to receive repairs and general maintenance of the product for no extra charge.

An increase in the number of consumers who choose the second style of ownership, may lead to manufacturers changing their style of manufacturing. Current products are designed based on the premise of consumer ownership. However, due to this new ownership style, manufacturers may consider a product design with easier functional upgrades or part reuse. Companies will have motivation to provide different styles of 'service-oriented products' (Fujimoto et al., 2003). They can provide consumers with selection of 'service courses' from a 'service menu', made on the basis of service contents that several types of products offer, and on a lease basis obtain new products that incorporate the selected service course. Manufacturers will be free to make various products according to their service menu, by combining functional components, the reuse of which enables them to be used up until the very end of their life cycle. Figure 9 presents prototype service-oriented facsimile products (Fujimoto et al., 2003)

Therefore, the DTOS system will not only give choice to the consumer who can choose one of the two styles of 'ownership' according to their personal preference, but also gives companies incentives to develop more innovative service plans and manufacturers to develop environmentally friendly product design.

The notion of 'hiring' a product rather than 'buying' a product is certainly not new.



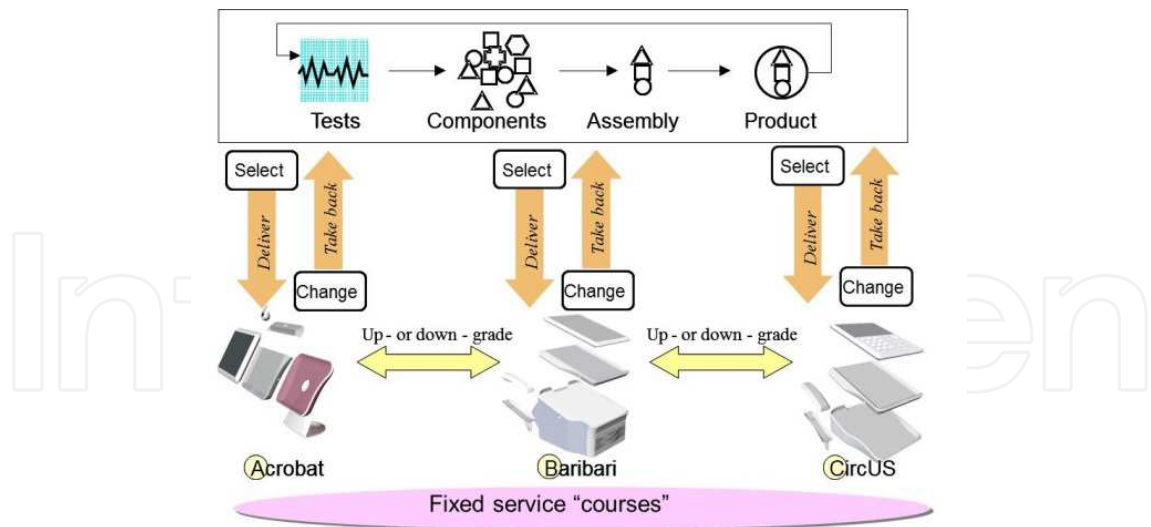


Fig. 9. Example of “Service-oriented products” applied to consumer fax

However, unlike previous systems DTOS emphasizes the notion of ‘ownership responsibility’. A key characteristic of DTOS is that the consumer will be confronted with a clear choice of ‘ownership’ styles on a wide range of products. When faced with the choice of privately owning or hiring a product, the consumer will have to consider the advantages and disadvantages of both styles. This will create an awareness of the impact of consumer behaviour on the environment, society and economy, thus creating social and environmental consciousness which will lead to a more eco-friendly lifestyle. This ‘consumer consciousness’ will hopefully reduce excessive and frivolous consumption. If DTOS is implemented, it may also have a large impact on social and lifestyle issues. The consumer can choose one of these two styles according to his or her life-style. For example, consumers may want to ‘own’ a computer and take on the responsibility that this new style of ‘ownership’ requires, but do consumers really want to own a Plasma TV or refrigerator? For a consumer ‘ownership’ of such impersonal and large products may not be appealing, and thus would rather take the ‘hiring and service’ path. The implications of such a system are far reaching and would have an impact on such areas as crime, dwelling styles, social behaviour, ethics and so on. There is no doubt that due to the ease by which products can be traced back to the owner, and the penalties that will accompany violations of the ‘ownership contract’, DTOS will help to solve the problem of ‘invisible flow’ in Japan. This means that upon this foundation, an adequate multilateral recycling system will be able to be constructed.

Furthermore, DTOS will increase the levels of social responsibility and the environmental consciousness of consumers. The key philosophy that underlies DTOS and that citizens will come to understand, is that ‘ownership’ equals ‘responsibility’.

**3.2 SOP**

To control QCD of product life cycles, one promising approach is to servicify products and operate the business on a lease basis by employing the concepts described previously (Brezet et al., 2001). We call such products service-oriented products (SOPs). SOPs can revise

traditional thought which holds that only products comprising new materials and components are valuable (Fujimoto et al., 2003). SOPs should be able to provide customers with new benefits not provided by ownership. Enabling customers to enjoy products they lease and to eventually exchange them for other products would be a good means of providing various services to customers. SOPs should also increase manufacturer profitability; the lease system would enable them to own the products they produce until the end of their product life. Purchasing and recycling cost reduction can be achieved by controlling product life cycles. Service of SOPs includes not only the service a product performs but also installation support, operation assistance, expendables delivery, maintenance, upgrading, and collection of post-use products. Required services differ according to usage pattern, the customer’s knowledge, awareness of the environmental issues, and so on. For example, one customer may require optimal performance, be able to repair a product by himself, but not care about environmental loads of disposed products. Another customer may want to use a product with minimal effort, have expendables provided, and care strongly about disposal. In anticipation of these differences, we prepare several “service courses” for a product group (e.g., facsimile machines) and call this set of service courses the “service menu” of the product group. A service course consists of a set of services covering all phases of a product life cycle. A service course, in one instance, consists of installation support, an easy-to-use product with basic performance, operation support, expendables delivery, maintenance support, and a post-use collection service. This idea is similar to so-called “mass customization”. However, while the mass customization focuses a variety of products, SOP offers a variety of services throughout a product life cycle that includes a variety of products.

In these service-oriented products, a customer selects a specific service course from a service menu and obtains, on a lease basis, a product incorporated into the selected service course. They can obtain many services in accordance with the course they select and also alter the service course, if desired, for an extra charge. Manufacturers create several kinds of products according to their service menu by combining functional modules. Reuse of functional modules enables them to be utilized until the very end of their lifetime. Table 4 summarizes the differences between conventional products and SOPs. With SOPs, a closer relationship, until the end of the service provision period, is maintained between the customer and the business. This closer relationship enables manufacturers to better understand customers’ needs, which are often difficult to ascertain because they tend to change dynamically, and to control the QCD of post use products.

|   |             | Conventional products        | SOPs                          |
|---|-------------|------------------------------|-------------------------------|
| Customer                                | choose      | product specifications       | “service” course              |
|   | purchase    | hardware                     | service(hardware rental)      |
|   | replace     | buy a new one                | change with extra charge      |
| Business                                | profit      | product sales                | service provision             |
|   | manufacture | assembling parts             | combining module              |
|   | Post-use    | disposal/recycling           | reuse/recycling               |
| Relation between business and customers |             | weak (in post-sales periods) | close (until use period ends) |

Table 4. Comparing SOP concept with conventional products

### 3.3 Is the implementation of DTOS feasible?

In a study by Van Boven and Gilovich it was shown that 'happiness' is increased when people focus more on the acquisition of life experiences than the acquisition of material possessions. They demonstrated that materialistic people tend to report lower levels of subjective well being than non-materialistic people; concluding that experiences make people happier because they play a more meaningful part of their identity and contribute more to social relationships (Boven & Gilovich, 2003). More recent studies have supported their initial findings. For consumers, satisfaction with experiential purchases such as going to a restaurant or taking family vacations starts high and increases over time, whereas spending money on material goods may feel positive at first but after time makes people feel less happy (Carter & Gilovich, 2010).

It is important to note that previous research in this area has pointed out the challenge of delineating between 'material purchases' and 'experiential purchases' (Boven & Gilovich, 2003). A useful way of illustrating this problem is if we look at the purchase of a car. On the one hand a car is a material object, a possession made of metal, plastic and so on, which has an impact on environmental and social issues. On the other hand, a car can facilitate certain experiences such as travelling. Therefore, in this case is a car an example of a 'material' or 'experiential' purchase?

Boven and Gilovich addressed this problem by focusing on a consumer's 'intention'. For example, a person might buy a car because it is an object of material desire: a status symbol, something to be possessed. Such a person would also likely have the desire to buy the latest model of a car, perhaps buying a different car every year in order to satisfy their desire 'to have'.

On the other hand, perhaps a nurse buys a car because she needs it for visiting her patients. She doesn't care about the car as a material object; her only concern is that the vehicle helps her meet the challenges of doing a satisfying job. In this case, she is likely to keep the car for as long as it serves her 'non-material' purpose.

To sum up, it seems a move from a materialistic 'having' to an experiential attitude towards purchasing could affect consumption levels in two ways:

- i. If consumers begin to purchase 'experiences' rather than material goods such as cars, TV's and so on, this may have a direct impact on levels of material consumption.
- ii. If experiential purchases increase levels of well-being, then this could disrupt the cyclical mechanism of overconsumption suggested by Fromm (Fromm, 1976) and expressed in the 'False Self' system (Winter & Koger, 2004)

Finally, we discovered that young Japanese are already moving away from material purchases such as a car, to a more experiential and communication based lifestyle.

#### 3.3.1 Questionnaire survey regarding Japan's people purchasing behavior

We conducted a questionnaire on over 1200 people in Japan on February 2010 via the Internet examining peoples purchasing behavior. Their age demographic was divided into four, 18~29, 30~37, 38~47, and 48~57. Each individual demographic had around 300 participants (Fujimoto & Poland, 2011).

The survey focused on what goods and services people want to have. The surveyed people chose their top 10 desired goods and services out of a selection of 34. The goods and services which people desired most was allocated “point 10”, and want to have 10th was allocated “point 1”. The total number of points of individual goods and services was obtained by multiplying the percentage of individual rank of goods with the previous points. Therefore, the higher values of products and services showed they wanted to purchase them strongly. Figure 10 shows the top ten ranking of goods and services which people wanted within each individual age demographic. In general, the trend was that a lot of services were ranked within the top ten, such as “domestic travel”, “eating out”, “international travel”, and “watching”. On the contrary, the choice of car, TV, AV, PC, and home appliances, which are often regarded as symbols of “material consumption”, were ranked lower. This suggested that Japanese society is maturing away from a materialistic attitude. When analyzing age demographic differences, material goods such as car, TV, AV, PC, and home appliances were desired by the older age range, as shown in Fig. 10. Particularly, the low rank of car in young generation was very impressive. The number of points regarding the desire to purchase a car in the age demographic 18~29 man was 2.6, that in 30~37 man was 2.5, that in 38~47 man was 3.3, and that in 48~57 man was 3.1. The Questionnaire Survey also asked about car possession in relation to age demographics. These results showed 58.6% of 18-29 males possessed their own cars. The same was true for 77.4% of 30~37 males, 82.2% of 38~47 males, and 84.2% of 48~57 males. Though 18~29 man had low car possession rate, their desire for cars was low. On the contrary, older males who already possessed a car, still desired a car.

|    | -29M                         | -29W                           | -37M                         | -37W                           | -47M                           | -47W                           | -57M                           | -57W                           |
|----|------------------------------|--------------------------------|------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| 1  | PC<br>4.4                    | Fashion<br>6.4                 | PC<br>5.5                    | Domestic<br>Travel<br>5.9      | Domestic<br>Travel<br>5.8      | Domestic<br>Travel<br>6.2      | PC<br>5.6                      | Domestic<br>Travel<br>5.9      |
| 2  | Domestic Travel<br>4.2       | Domestic<br>Travel<br>5.7      | Domestic Travel<br>4.7       | Fashion<br>5.5                 | PC<br>5.3                      | Eating Out<br>5.7              | Domestic<br>Travel<br>5.5      | Eating Out<br>4.8              |
| 3  | Game<br>3.4                  | Eating Out<br>5.3              | Eating Out<br>3.8            | Eating Out<br>5.2              | Eating Out<br>4.2              | Fashion<br>4.7                 | Eating Out<br>3.5              | Fashion<br>3.6                 |
| 4  | Music(CD,<br>Concert)<br>3.1 | Music(CD,<br>Concert)<br>3.3   | Game<br>3.1                  | International<br>Travel<br>3.0 | Car<br>3.3                     | Watching<br>Movie<br>3.5       | Car<br>3.1                     | Watching<br>Movie<br>3.5       |
| 5  | Animation,<br>Manga<br>2.8   | Cosmetics<br>3.2               | TV<br>2.7                    | Furniture,<br>Interior<br>2.7  | TV<br>3.1                      | International<br>Travel<br>3.1 | International<br>Travel<br>3.0 | International<br>Travel<br>2.9 |
| 6  | Fashion<br>2.7               | International<br>Travel<br>3.1 | Investment<br>2.7            | Domestic<br>Appliance<br>2.7   | AV<br>Equipment<br>2.7         | PC<br>2.8                      | TV<br>3.0                      | PC<br>2.8                      |
| 7  | Eating Out<br>2.6            | Book<br>2.6                    | Watching<br>Movie<br>2.6     | Book<br>2.6                    | Watching<br>Movie<br>2.4       | Book<br>2.8                    | Watching<br>Movie<br>2.7       | Book<br>2.7                    |
| 8  | Book<br>2.6                  | Watching<br>Movie<br>2.4       | Music(CD,<br>Concert)<br>2.5 | Cosmetics<br>2.6               | International<br>Travel<br>2.0 | Cosmetics<br>2.5               | Book<br>2.6                    | Music(CD,<br>Concert)<br>2.7   |
| 9  | Car<br>2.6                   | PC<br>2.0                      | Car<br>2.5                   | Watching<br>Movie<br>2.4       | Music(CD,<br>Concert)<br>2.0   | Music(CD,<br>Concert)<br>2.4   | Visiting<br>Famous Spot<br>2.3 | TV<br>2.5                      |
| 10 | Watching Movie<br>2.2        | Animation,<br>Manga<br>1.9     | AV Equipment<br>2.5          | Music(CD,<br>Concert)<br>2.4   | Book<br>1.9                    | Domestic<br>Appliance<br>2.4   | AV<br>Equipment<br>2.2         | Cosmetics<br>2.4               |

Fig. 10. Overall Chart of Purchasing Behavior



Our survey results were supported by previous research e.g. “2008 Passenger cars market trend investigation” (Japan Automobile Manufacturers Association, 2008). On the surface it seems young people’s consciousness is moving away from an interest in purchasing goods, especially with regard to purchasing a car. This suggests that more service oriented consumerism such as DTOS may be feasible in the future.

#### 4. Conclusion

Resources and energy have to be used effectively when considering future population growth, economy expansion in developing countries, and the preservation of natural resources for posterity. Furthermore, environmental issues, such as environmental pollution caused by the disposal of products across borders, and the paradox between energy-saving and waste are problematic. Against this background, “recycling” has become one of the essential solutions but recycling strategies and methods must become far more sophisticated. The conventional recycling system has serious defects from the viewpoint of “Recycling QCD”. Businesses stimulate people’s desire, sell a lot of products to people, and then lose their attention of the products after sale. These businesses are also supported by people’s overconsumption disorder. To improve these situations, we proposed a new holistic approach: Dual Traceable Ownership System (DTOS): a system based on a different attitude towards ‘ownership’ which makes traceability of a product visible. Moreover, we found DTOS would help suppress the invisible flow of discarded products. The fundamental style of ‘ownership’ proposed by DTOS is that companies have complete ownership and the consumer hires the product. In this style, the service oriented product was proposed. DTOS can be realized depending on whether the company creates an attractive service model or not. In addition to this, it would be necessary to reduce people’s attachment to the notion of “owning” consumer goods. Regarding consumer behavior, data suggested a departure from the materialistic notion of “owning” consumer goods in Japanese young people, suggesting a system such as DTOS may be feasible in the future.

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## **Post-Consumer Waste Recycling and Optimal Production**

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This book deals with several aspects of waste material recycling. It is divided into three sections. The first section explains the roles of stakeholders, both informal and formal sectors, in post-consumer waste activities. It also discusses waste collection programs for recycling. The second section discusses the analysis tools for recycling system. The third section focuses on the recycling process and optimal production. I hope that this book will convey both the need and means for recycling and resource conservation activities to a wide readership, at both academician and professional level, and contribute to the creation of a sound material-cycle society.

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Phone: +86-21-62489820  
Fax: +86-21-62489821

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