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Markets for used motor oil in California under a controversial deposit-refund system

Abstract

This paper explores the used motor oil markets in California under the regulatory scheme along with potential distortions introduced from elements of SB 546. California Senate Bill (SB) 545 modified the requirements of the deposit-refund system (DRS) for used oil outlined in the California Oil Recycling Enhancement Act (COREA) by introducing a differential fee and incentive system. The motivation behind the deposit-refund system is to assign a fee equal to the consumption externality of disposing used oil into the environment. This fee is refunded when consumers return their used oil for recycling. The DRS system in California is problematic, operating more closely to a consumption tax on motor oil. When the policy design no longer reflects the intention, it alters the price signals and introduces distortions in input markets. Furthermore, since the policy is operating at the state level, it inadvertently introduces through rent-seeking behavior non-tariff barriers to trade with other states. This adds additional distortions to the functioning of the the relevant markets.

Keywords: environmental externality, used oil, deposit-refund system, Pigouvian tax, non-tariff barriers to trade.

JEL Classifications: Q58, H23.

Introduction

The debate over how to dispose of used oil in California is ongoing. Early estimates by Sigman (1998) suggest that a significant amount of used oil in California has not found its way into appropriate disposal channels. The California Oil Recycling Enhancement Act (COREA) was implemented to provide requirements for the responsible management of used oil. Senate Bill (SB) 546 modified those requirements to include a fee of \$0.26/gallon of motor oil sold in the state of California through December 31, 2013, after which time the fee is reduced to \$0.24/gallon. Re-refined motor oil will be subject to a smaller fee of \$0.12/gallon beginning from January 1, 2014. COREA also provides payments of \$0.16/gallon to Certified Collection Centers and curbside operators, and \$0.40/gallon to Do-It-Yourself oil collectors.

The California used motor oil disposal system resembles the Deposit-Refund system (DRS) described by Fullerton and Wolverton (2000)¹. DRS is intended to reduce the environmental cost of the inappropriate disposal of items that create negative externalities. In theory, the optimal level of externality is generated by setting the deposit and refund amount equal to the cost of the environmental damage. If the cost of recycling is lower than the cost of the environmental damage, consumers will recycle the item in question; if the cost of recycling is higher than the cost of the environmental damage, the consumer will choose to forego the refund. In this case, setting a refund equal to the environmental damage does not result in the optimal collection of used motor oil. Because of the nature of used motor oil, designing an optimal refund sys-

tem is extremely complicated. The collection of used motor oil is only part of a well-designed DRS system. The value of used motor oil and the environmental consequences of its disposal and use are affected by the type of products created from the used motor oil².

The optimal policy for the disposal of used oil is complicated for several reasons. First, there are very few published estimates of the environmental damage created by the inappropriate dumping of used motor oil. This makes it extremely difficult to determine the optimal tax in a DRS for used motor oil. Second, changes in magnitude of the amount of the tax refund may result in a tax to those who use commercial oil changing services. Third, what does society do with the additional used motor oil collected as a result of a policy change that encourages increased used oil collection? Fourth, since used oil is processed into several product forms, one has to know the externalities attached to each product (in terms of production and consumption of each product). Such estimates are unavailable. Fifth, from an international trade perspective, opening up trade would increase the value of used oil, thus reducing the need for an incentive to collect used oil. Finally, because what was once a waste product could become a valuable commodity, under the proper pricing of used motor oil, there would be little need for governmental incentives (such as DRS) to collect all the used motor oil in California.

² One of the basic problems is that the COREA program contains conflicting policy goals. If the goal of the program is to address the externality associated with used motor oil, the deposit fee imposed should represent the environmental damages of dumping used motor oil. However, if the objective is to collect all used motor oil in California, a higher deposit would guarantee the collection of all used motor oil in the state. If eliminating the illegal disposal of used oil was the primary focus of the policy, then clearly the refund system has to be made more lucrative since, according to Sigman (1998), the percentage of uncollected used motor oil is large.

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¹ Some additional literature on price externalities can be found in Matthews and Lave (2000) and Tideman and Plassmann (2010).

In the ongoing debate on used motor oil disposal in California, SB 546 was passed in October 2009. In 2012, there was a review of COREA to evaluate the effectiveness of the recycling program in reducing the environmental damages from used motor oil and facilitating the responsible management of recycled used oil. One point of contention is that the legislation encourages the remanufacture of motor oil from used motor oil by reducing the deposit required on remanufactured motor oil (motor oil containing at least 70 percent recycled used motor oil). However, others contend that the differential system of producer incentive payments (i.e., the subsidy for recycling motor oil into new/re-refined motor oil) undermines the goal of facilitating the efficient collection of used motor oil in California. The debate highlights the fact that other products produced from used motor oil (i.e., marine diesel oil and recycled fuel oil) have additional environmental consequences, and hence the responsible management of used oil necessitates a study of a wider variety of environmental consequences associated with used oil disposition.

This article considers the management of used oil in the context of SB 546. It provides an overview of the California used motor oil market and the incentives to encourage the collection of used oil. It illustrates from an environmental perspective that not only does one have to consider the impact of increasing the collection of used oil, but also the environmental consequences from the production and use of products made from used motor oil. This requires that the DRS system be expanded beyond merely an examination of the optimal policy needed to collect used oil. In addition, under a general equilibrium approach to the collection and disposal of used oil, the incentives under SB 546 should be redirected to generate a different mix of products made from used oil. Trade also plays a major role in the optimal design of a DRS system. Unlike, for example, in Alberta, Canada, for various reasons used oil from California is not shipped out of the state. This lowers the value of the used oil and thus adds to the cost of a properly designed DRS system.

1. The “market” for motor oil

The primary market for motor oil is dependent on consumer demand for automobiles for transportation. As a part of maintaining reliable service from their automobiles, consumers either purchase oil and oil filters directly from a retailer (an auto-parts store or general retailer), or hire a service provider for these inputs and labor. The demand curve for this service is a function of a variety of mechanical factors (the miles driven each year, the manufacturer’s recommendations for the automobile, etc.) and general economic factors (periods of recession could

either reduce the level of oil demand as people postpone maintenance or increase the demand for motor oil as individuals take better care of their automobiles to postpone a major purchase). The demand curve for motor oil in Figure 1 is then the sum of the derived demand for oil by service providers (D_S) plus the demand for used motor oil by Do-It-Yourselfers (D_{DIY}). Given the supply curve of used motor oil S_O , the price of used motor oil is P_O , the quantity of oil used by service providers is Q_S , and the quantity of motor oil used by Do-It-Yourselfers is Q_{DIY} .

The market equilibrium presented in Figure 1 (Appendix) does not account for the potential externality resulting from the improper disposal of the used motor oil Q_O . A variety of policy instruments have been suggested to overcome this externality. The one implemented by COREA follows the general DRS. Under this policy, the purchase of an item (say a beverage in a glass bottle) implies a potential externality (i.e., the improper disposal of glass bottles).

2. The DRS as an extension of the Pigouvian tax

The DRS is an extension of the standard Pigouvian tax on an externality. The concept of an externality has become popular in economics to describe the scenario a decision maker does not bear the complete cost of his action. Under this scenario a market price based on the direct cost of production and consumer preferences implies an economic cost. Intuitively, externalities may result either from the actions of producers (i.e., the production process results in some environmental degradation for which the producer does not have to pay) or from consumption (i.e., in the present scenario the consumer could improperly dispose of the oil). One policy alternative is the imposition of an ad valorem tax on the market transaction (typically paid by the producer) to equate the marginal social cost and the marginal social benefit (Just, Hueth, and Schmitz, 2004, pp. 535-536), referred to as a Pigouvian tax. This tax can be represented as either a downward shift in the demand curve (the amount that a consumer is willing to demand, given the price less the amount of tax paid) or an upward shift of the supply curve (the quantity of product supplied for a price paid by the consumer less the amount of tax). The DRS can be viewed within the context of a Pigouvian tax in that the deposit can be set equal to the cost of the externality.

Figure 2 (Appendix) presents a slight modification of the market for motor oil presented in Figure 1. D_O is the total demand for motor oil (i.e., the sum of the demand for motor oil through service providers and the demand for motor oil from Do-It-Yourselfers). This demand represents the marginal private benefit of motor oil to consumers (MPB_O). The presence of an externality implies that consumption of any amount

of motor oil imposes a cost on society not borne by the primary consumer. In this case, improper disposal of used motor oil (which is part of the consumption of new motor oil) imposes an environmental cost either through reduced water quality or destruction of the ecosystem. Hence, the marginal social benefit (MSB_o) from the consumption of motor oil lies to the left of the marginal private benefit. The Pigouvian tax (ϕ) imposed on the consumption of the motor oil results in the optimal quantity of consumption (i.e., the equilibrium where the marginal social cost of production [implicitly S_o] equals the marginal social values of the consumption [MSB_o]). Under the traditional Pigouvian tax, society bears the cost of the externality (motor oil negatively affects the environment), but those that benefit from the consumption of motor oil balance the gains from the use of motor oil against the environmental cost. The DRS provides a self-enforcing mechanism for preventing the environmental cost from occurring in the first place. Specifically, suppose that the used motor oil can be collected at a price of γ (i.e., an equivalent increase in the price of new motor oil) which is less than the Pigouvian tax. Society will be better off by the collection of the used motor oil than by the imposition of the Pigouvian tax. Through the DRS, the consumer will expend $\gamma \leq \phi$ to recycle the oil. However, if $\gamma > \phi$, the DRS acts as a Pigouvian tax. This system is predicated on the concept that ϕ is set equal to the marginal environmental damage cost associated with improper disposal. If ϕ is set above the true cost of the environmental harm, we would expect that all motor oil would be collected and returned, but that the government program cost might exceed the value of the potential environmental damage it sought to avoid. If ϕ is set too low, collectors could be expected to prefer illegal disposal of used oil to the refund, and society would experience too little environmental improvement from the program. In California, with the value of the deposit, or tax at \$0.16-\$0.26/gallon, the value is not likely to approach the per-gallon cost of environmental damage. Assuming this is the case, the DRS does not appropriately deal with the optimal collection of used motor oil by virtue of the fact that the tax or deposit is too low. Also, under SB 546, the DIY refund no longer needs to be advertised, nor even mentioned by the certified collection centers (CCCs), although they are required to pay it if the DIY oil changer requests the refund.

3. Disposal and management of used oil

The DRS system is only part of the story since it focuses primarily on collection and not actually on the disposal and management of used oil. Once the

used motor oil is collected (either by collection centers and curbside pickup entities or directly from Do-It-Yourself consumers), the question is: What does one do with the oil?¹ Figure 3(a) in Appendix presents a scenario where u^* gallons of used motor oil are collected for potential use by refiners for the production of remanufactured products. Assume, however, that only the quantity B can be profitably used in the manufacture of recycled products and that quantity A must be either stored (indefinitely) or dumped (causing further environmental damage). As depicted in Figure 3(b), given a price of used oil $p_o + \tau$ (where p_o is the price paid for the used motor oil and τ is the cost of collecting the used oil from the various sources) the supply of the used oil (S_U) is equal to the derived demand for used oil (D_U) which is equal to the value of the marginal product of used motor oil (VMP_U) used in the production of other goods. In the scenario depicted in Figure 3(b), the price offered for used motor oil is zero ($p_o = 0$) because the used motor oil is not scarce (i.e., not all the used motor oil is used). This allocation leads to a profit of $ab[p_o + \tau]$ (the area under the derived demand curve) to the remanufacturers of used oil products.

The remaining question is what to do with the quantity of oil that cannot be profitably used in the production of remanufactured products (quantity A in Figure 3(a)). Following the popular debate of what to do about nuclear waste, A can forever be stored in an environmentally costly safe storage facility. Alternatively, the oil firms could be forced to recycle the used oil resulting in an economic loss of $p_c d\bar{p}$ as depicted in Figure 3(b). While these alternatives may be feasible in the short run, a market-oriented solution to the problem involves shifting the derived demand for used motor oil (or its value of marginal product) to the right to $D'_U = VMP'_U$.

4. Policy focus on increasing the overall value of used oil

Most of the policy questions regarding COREA involve secondary externalities. Figure 4 (see Appendix) presents the production relationships underlying the derivation of the derived demand for used motor oil presented in Figure 3(b). Figure 4(a) depicts the possible combinations of products that

¹ According to industry sources, if all the used oil were collected, likely most of it could be processed under the right incentive system. However, given the capacity and constraints of the existing processors, if this were to happen, most of the 30% uncollected oil would be processed as RFO. This is primarily due to the capacity constraints for re-refining and producing MDO. As discussed later, unfortunately the negative externalities associated with RFO production and use are relatively high.

can be manufactured given any level of used motor oil (Q_U) used as an input. In this analysis, we consider three alternative products that can be created from used motor oil: Re-refined Lubricants (RR), Marine Diesel Oil (MDO), and Recycled Fuel Oil (RFO is not pictured in Figure 4). The profit maximizing level of each output is determined by the tangency of the production possibility frontier with the ratio of relative output prices. The question of secondary externalities is presented in Figure 4 using the same basic formulation used to develop the effects of externalities on the consumption of motor oil (Figure 2).

As a starting point, consider the scenario where only one of the outputs generates an externality. In Figure 4(a), we assume this to be Marine Diesel Oil (MDO) which implies an externality. To maximize overall welfare, the state of California could choose to impose a Pigouvian tax on the consumption of MDO of ϕ_{MDO} . Again, by optimally selecting the level of tax, society is made better off since the marginal social benefit from the consumption of MDO (including the externality) is now equal to the marginal social cost of production. However, as indicated in Figure 4(c), the Pigouvian tax has the secondary effect of increasing the production of Re-refined Lubricants (RR). It is also important to note that this increase is optimal in the sense that the allocation between MDO and RR is optimal under the imposition of the Pigouvian tax.

Setting aside the assessment of which of the outputs will generate greater or lesser externalities, the current and post SB 546 management systems both impose the equivalent of a Pigouvian tax on one output – re-refined motor oil – and not on the other two outputs. Consequently, if all three outputs produce equal environmental externalities, the current system will be sub-optimal because the tax on RR would serve to shift production away from the optimal quantity of RR. If instead, the externality is greater for the combined MDO and RFO than for RR (which are both burned and produce more greenhouse gas [GHG] when used than would RR), the current system would represent an even further distortion from optimal resource allocation.

5. Comparing used and virgin oil markets – consumption externalities

Each product that can be produced from recycled motor oil can also be produced from virgin oil. Figure 5 (Appendix) extends the analysis presented in Figure 4 to include the supply of each product from recycled and virgin oil. In each case, the externality is directly accounted for by a Pigouvian tax on consumption. This approach emphasizes the formula-

tion which the consumption (i.e., the purchase and potentially illegal disposal of motor oil) is responsible for the environmental effect and not the production. Consider the effect of expanding the production of lubricants from recycled oil (Figure 5(a)). We assume that DRS results in an increased supply of lubricants (i.e., from the additional collection of used motor oil) from S_{RR} to S'_{RR} . This shifts the total supply of lubricants from S_L to S'_L which increases the quantity of lubricants supplied and demanded from q_L to q'_L , consumers gain $p_L \text{ eff } p'_L$. The net effect of this increase on the profit for recyclers is $p'_L ca - p_L ba (> 0)$. Producers who manufacture lubricants from virgin oil lose area $bea - cfa$. Similar results can be derived for the marine diesel oil and fuel oil markets; however, certain characteristics of each market affect the magnitude of each effect. First, the more elastic the demand curve for the final market, the larger the increased profitability to additional recycling (the more elastic the demand curve, the smaller the price effect). Comparing the results in 5(a) with the results depicted in 5(b), we assumed that the demand for lubricants is more elastic than the demanded for marine diesel oil. As a result, the relative increase in lubricants supplied and demand is larger than the relative increase in marine diesel supplied and demanded (i.e., comparing the increase in the marine diesel in Figure 5(b) of $(q'_{MDO} - q_{MDO})/q_{MDO}$ with the percentage change in the lubricant market of $(q'_L - q_L)/q_L$ in Figure 5(a)). However, the percentage change in price appears roughly similar (i.e., comparing $(p'_{MDO} - p_{MDO})/p_{MDO}$ in Figure 5(b) with $(p'_L - p_L)/p_L$ in Figure 5(a)). Intuitively, the percentage change in quantity for a given percentage change in price in the MDO market depicted in Figure 5(b) is smaller (or less elastic) than is the percentage change in the quantity of RR depicted in Figure 5(a) for the observed percentage change in the price of lubricants. Of course, the exact magnitude of the effect is an empirical question. Second, the relative share of recycled product used in supplying the total demand is important. A comparison of the results in Figures 5(a) and 5(b) with the results for the RFO market presented in Figure 5(c) demonstrates the importance of the relative share of recycled product in each market. The increase in quantity of RFO resulting from the increase in used oil presented in Figure 5(c) is smaller than is the percentage change in the quantity of either the RR or the MDO market. While the demand curve for RFO is less elastic than either the demand for lubricants or marine diesel, production from used oil is a much smaller component of overall production. Thus, the change in the percen-

tage increase in the quantity consumed (i.e., $(q_{FO} - q_{FO})/q_{FO}$ in Figure 5(c)) is smaller than it is in the other markets and the percentage change in the price is also smaller in that market (i.e., $(p'_{FO} - p_{FO})/p_{FO}$). Third, the equilibrium in each market is affected by the externality caused by the consumption of each product. The larger the potential externality, the greater is the required Pigouvian tax to balance the environmental cost of consumption with the marginal private benefits. Finally, differences in these Pigouvian taxes will cause differences in the distribution of recycled product across markets.

As a final point, we consider the differential treatment of recycled products under SB 546. Under SB 546, remanufactured motor oil is charged a reduced deposit, unlike motor oil created from virgin oil. Specifically, the deposit on lubricants containing at least 70 percent recycled oil is taxed at \$0.12/gallon (compared with the tax of \$0.26/gallon on motor oil from virgin material). In addition, there is a subsidy of \$0.02/gallon to encourage re-refining of used motor oil. This subsidy changes the combination of outputs as depicted in Figure 6(a), similar to the effect developed in Figure 4. Figure 6(a) depicts the combination of re-refined motor oil and marine diesel that will be produced given a set of inputs. The combination of each output produced is determined by the tangency of the ratio of output prices to the production possibility frontier. The relative price line before the subsidy is P_{MDO}/P_{RR} , which results in an output of marine diesel of $Q_{MDO}(P_{MDO}, P_{RR}, \tilde{Q}_U)$ and an output of re-refined motor oil of $Q_{RR}(P_{MDO}, P_{RR}, \tilde{Q}_U)$. Adding a subsidy of ψ_{RR} to the price for re-refined oil yields a relative price ratio of $P_{MDO}/(P_{RR} + \psi_{RR})$. With this subsidy, the output of re-refined motor oil increases to $Q_{RR}(P_{MDO}, P_{RR} + \psi_{RR}, \tilde{Q}_U)$ while the quantity of marine diesel declines to $Q_{MDO}(P_{MDO}, P_{RR} + \psi_{RR}, \tilde{Q}_U)$. Thus, the subsidy increases the overall quantity of used motor oil re-processed into new/re-refined motor oil. However, it is important to note that if this subsidy is removed, the quantity of used motor oil demanded will decline, as depicted by the derived demand curve in Figure 6(b).

6. Comments

Some have suggested that providing incentives for re-refining used oil reduces “the value of recycled material sold by CCCs which, in turn, hampers the effectiveness of the DRS in targeting used oil collection.” However, they offer no examples to show that providing incentives for re-refining oil reduces used oil collection rates. As our model suggests, this result is counterintuitive because providing incen-

tives to re-refiners should make re-refiners able to bid more for used oil, making it more (not less) valuable. Finally, the experience in Australia (among other places), where incentives for re-refining increases used oil collection rates, completely disproves these arguments.

Some argue that re-refined oil and virgin oil should be taxed the same. However, taxing re-refined oil is, in essence, a double-tax: the virgin oil that generates the used oil has already been taxed once. Also, taxing re-refined oil is, in essence, an indirect subsidy of other uses of used oil (i.e., *MDO*) which go untaxed. In other words, some argue that *RR* should be taxed because it creates an environmental impact, namely, some used oil ending up in the environment. But, the question raised by our theory is: Where are the taxes on the *MDO* and *RFO* sectors that account for negative environmental impacts?

As background, under California law, \$0.40/gallon is paid to Do-It-Yourselfers for their oil, but only \$0.16/gallon is paid to the Do-It-For-Me (DIFM) oil change companies. The California Integrated Waste Management Board actually wanted to eliminate all payments to the DIFM oil change companies because only a small percentage of that \$0.16/gallon payment goes to the customer. The fee simply fattens the bottom line of the DIFM oil change companies that charge the customers for the oil change. This is an additional reason why the current DRS can be described as defunct. The customers pay the deposit, but do not receive the refund, and for this reason we have analyzed the deposit as a tax. Under SB 546, the DIY refund no longer needs to be advertised nor even mentioned by the CCCs, although they are required to pay it if the DIY oil changer requests the refund. It does not follow that more customers will change their own oil unless the DIFM oil change companies are also paid \$0.40/gallon.

7. The environment

Some basic points of environment are the following:

- ◆ Some major conclusions on environmental costs of uncollected used oil and benefits from re-refining are as follows: (1) over a period of time the uncollected used oil is estimated to exceed the 2010 BP oil spill by over 100 million gallons; (2) the estimated reduced carbon dioxide emissions benefit of re-refining 14.5 million gallons California’s used oil is estimated to exceed \$23 million over 10 years while the estimated reduced carbon dioxide emissions benefit of re-refining all of California’s generated used oil is estimated to exceed \$182 million; and (3) the estimated energy savings benefits from re-

refining 14.5 million gallons of California's used oil instead of reprocessing it into fuel is estimated to exceed \$435 million over 10 years. The estimated energy savings benefits from re-refining all of California's generated used oil instead of reprocessing it into fuel is estimated to exceed \$3.5 billion over 10 years. The additional 6.14 gallons generated through re-refining adds at least a \$24.56-\$33.77/gallon value to society¹. At the California re-refining rate of 14.5 million gallons in 2010, the additional base or blended oil that cycles through society 6.14 times is 89 million gallons valued at \$356.1 million or \$489.6 million, respectively.

- ◆ Re-refined base oils emit less greenhouse gas emissions and production lifecycle energy use. By comparing burning used oil versus re-refining, the noxious compounds are solidified and stabilized in the form of asphalt, one of the main byproducts of re-refining, which pose minimal environmental impacts. Burning used oil for energy results in air emissions; the magnitude which depends on the quality of air pollution control equipment. Burning used oil produces more adverse environmental impacts than does re-refining. The heavy metal emissions may cause up to 150 times the eco-toxicity impacts, compared to re-refining (Giovanna, 2011).
- ◆ Re-refining base oil causes across the board far less environmental impacts than does processing base oil from crude oil (Fehrenbach, 2005).
- ◆ Many of the benefits from re-refining oil are measured in terms of both reduced pollution and reduced energy use. However, re-refining introduces another benefit through the reduced need to extract non-renewable resources. Re-refining used oil means society enjoys the same level of lube oil in the market without the costs of extracting virgin oil to produce it.
- ◆ Table 1 (Appendix) gives the product rating of different products made from used oil. The most environmentally friendly of these products are the API-certified re-refined base lube and re-refined industrial base lube oils. Under SB 546, preferential treatment is given to these products. Lubricants made from at least 70 percent recycled materials pay a lower deposit than products manufactured from virgin materials. Such tax breaks are not given to either *MDO* or *RFO*. This is consistent with the environmental damage associated with each product.
- ◆ In view of Table 1 and the previous theoretical discussion, given that there are negative externalities associated with the production of products

made from used oil, the question then becomes: How does one correct for these externalities? Imposing taxes to correct these externalities, for example, has an impact on the value of the margin product of the used oil and, therefore, the price of the used oil. This in turn impacts the magnitude of the tax refund system needed to increase the collection of used oil.

- ◆ Under California law, \$0.40/gallon is paid to Do-It-Yourselfers for their oil, and \$0.16/gallon is paid to the DIFM oil change companies. But how are these numbers calculated since where is the evidence that they have any bearing on the magnitude of negative externalities that are generated from the dumping of uncollected used oil? In addition, how would one estimate the magnitude of the negative externalities associated with the various sectors in the production and marketing chain for used oil?
- ◆ Tables 2 and 3 (in Appendix) show the negative and positive externalities that conceptually exist in the collection and production of products from used oil based on the authors conjectures of market structure. Note that in Table 3, even though no oil is dumped into the environment, there still exist segments of the market with attached negative externalities.

8. Nontariff trade restrictions²

Very little of California's used motor oil is exported out of the state. However, in many regions of the world, this is not the case. As an example, Alberta's used oil collection system has been stable for more than a decade, principally because it permits trade in used oil with other Canadian Provinces and exports to the United States as shown in Table 4 (Fitzsimmons, 2009). This is not the case in California. As we show below, restricting trade can result in significant reduction in economic benefits from used oil recycling³. This is one reason why the price of used oil in California is low. Allowing for trade in used oil

² A discussion of some of the many non-tariff barriers follow: (1) The regulation of bulk transfers as a permitted activity is extremely complicated since used motor oil is listed as a hazardous waste. The underlying laws and regulations are quite complex. To load used oil from a tanker truck into a rail tank car requires a hazardous waste facility permit which is not cheap, easy, or practical. A discussion with Bill Cundiff of Riverbank Oil Transfer (209-765-0727) illustrates how difficult getting and maintaining one of these permits is within California just for a simple rail loading terminal for used motor oil. (2) The testing, manifesting, and reporting of used motor oil is required under SB 546, which went into effect on January 1, 2010 (as codified in Health and Safety Code, Sections 25250.29-25250.30, and Public Resources Code, Sections 48600-48691). (3) There is a virtual monopoly on used oil collections in California by the sponsors of SB 546 (Demunno/Kerdoon in Southern California and Evergreen Oil in Northern California).

³ Restricting trade in used oil increases economic activity for California since used oil is processed in that state. However, while used oil cannot be exported out of California, MDO can be exported which gives an advantage to the manufacture of marine diesel. A more detailed trade model should incorporate this observation.

¹ These calculations do not include the value of the byproducts derived from re-refining used oil or utilize the retail value of the products.

among states would increase the value of the marginal productivity of used oil and would reduce the subsidy needed to encourage the collection of used oil.

Under the title, rent-seeking behavior, firms often sway regulators to impose non-tariff trade barriers. This often leads to handsome payoffs to these firms or industries. Consider Figure 7, where there are two regions, 1 and 2. Before trade restrictions, Region 2 produces q_1 at a price p_1 given supply S and demand D . Suppose that firms in Region 2 import a product from Region 1 which is further refined that adds value (such an example is the importation of used oil from California that is further refined outside of California). Region 1 produces none of the goods given supply S_A (the high-cost producer), but it provides a basic input to Region 2, where Region 2 imports the product from Region 1. Under free trade between the two regions, Region 2 imports the raw product and produces a final product of quantity q_1 and charges a price p_1 . On net, the economic rents for Region 2 total (p_1ab) .

Consider now that Region 2 incurs an increase in production costs that shifts supply to S^* . This could be due to many costs, including an increase in the cost of one of its key production ingredients that it imports from Region 1. In this case, production falls to q_2 .

Suppose that costs increase further to the point where the supply schedule in Region 2 shifts to S' . If this is due to a rise in the cost from an input that Region 2 imports, given the supply curve S_A in Region 1, then distance (ca) represents a non-tariff trade barrier (if S_A is not affected by the non-tariff trade barrier). Note that production ceases in Region 2, but production does occur in Region 1. In this case, Region 1 produces q^* . As a result, Region 1's economic rents of (egf) are positive while Region 2's economic rents are zero. Region 2 loses (p_1ba) from the imposition of the non-tariff barrier (ac) .

Consider Figure 8, where the supply and demand for used oil is given by S_U and D_U . The corresponding price and quantity is p_1 and q_1 . All of the used oil is processed in Region 2, in which supply for the final product is given by S_F and demand by D_F (i.e., Region 2 imports q_1 of used oil). The free trade price and quantity are p_0 and q_0 .

Suppose due to non-tariff barriers, the cost of importing used oil from Region 1 to be processed in Region 2 increases. This causes supply in Region 2 to shift to S^* as the cost of production of refining increases. What are the effects? Used oil suppliers in Region 1 lose (p_1efp_2) and producers of the final product lose $(p_0ab) - p^*dec$.

Unlike the above models, Figure 9 assumes that under free trade, both Regions 1 and 2 produce the final

product. Supply of the final product in California is given by S_C and S_N for Nevada. At the free trade price p_f , California exports to Nevada total $(q_2 - q_1)$. Production in Nevada is q_1 and the remainder is produced in California. The total demand is q_2 .

Suppose a non-tariff barrier causes a shift in the cost curve in Nevada to N_T . The total supply also shifts to $S_C + N_T$. Total production declines to q^* . Production in Nevada falls to q_T while production in California increases to q_c . What are the effects?

- ◆ California producers of the final product gain (bcp_fa) .
- ◆ Nevada producers lose $(p_feh) - (aig)$.
- ◆ The price of the final product rises.
- ◆ The demand for crude oil falls and so do the rents to crude oil suppliers (Figure 4).
- ◆ Producers of the final product in California gain from both a price increase of the final product and a gain due to a fall in the price of used oil that they buy (the demand in Figure 4 shifts leftward).

We show that trade barriers can be initiated by exporters since producers of the final product, but not the suppliers of the input in exporting countries, can gain from trade barriers while those in importing countries can lose. This is because trade theory is generally based on trade in final products only, whereas this paper deals with trade in inputs. Like trade in final products, trade in inputs can generate significant economic gains.

Conclusions

This article discusses the importance of policy design in the context of the California used oil market. Policy makers have to deal with reducing the quantity of used motor oil that is being dumped into the environment. At the same time, policy affects the spillovers from the use of products created from the recycling of this used oil motor into other products. Because the value of used motor oil is negative or zero, without intervention there is an incentive to dump used oil into the environment. However, through policy design, the value of recollected oil can be increased, and the environmental problem created from used motor oil disposal can be eliminated. Expanded trade is one example of how the value of used oil can be increased. Opening the possibility for trade could result in a market that eliminates the environmental consequences without government intervention. As currently implemented, increasing the value of the marginal product (either through the DRS or by subsidizing the use of used motor oil in the manufacture of lubricants) reduces the quantity of used motor oil dumped into the environment. In design-

ing policy, one has to consider the externalities associated with all phases of the used motor oil industry. The externality from dumping used motor oil is only one component. Other externalities that have to be dealt with include those from the production and use of remanufactured products (i.e., *RR*, *MDO*, and *RFO*), from used motor oil, and the additional fuel consumption inherent in the collection

of the used motor oil. Further work is need in order to quantify the externalities associated with all segments of the used motor oil market.

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Appendix

Table 1. Overview of markets for used oil

Product	Treatment mechanisms	Relative contaminant concentrations	Product rating
Reprocessed fuel oil (<i>RFO</i>)	Dehydration Filtration	Highest heavy metal and sulfur concentrations	Single-use processing Downcycled product Results in heavy metals and sulfur emissions
Marine diesel oil (<i>MDO</i>)	Dehydration Filtration Distillation	Intermediate concentrations of heavy metals and sulfur Asphalts removed	Single-use processing Downcycled product Results in heavy metals and sulfur emissions
Re-refined industrial base lube	Dehydration Filtration Distillation	Intermediate concentrations of heavy metals and sulfur Asphalts removed	Closed-loop recycling Potentially downcycled product, depending on used oil source Results in a low environmental impact
API-certified re-refined base lube	Dehydration Filtration Distillation Hydrotreatment	Lowest concentrations of heavy metals and sulfur Asphalts removed	Closed-loop recycling Maintains original quality of oil Results in lowest environmental impact

Source: Lawrence Livermore (2008).

Table 2. Negative and positive externalities, 70% collected used oil

Dumped used oil	Stored used oil	Processors	<i>RR</i>	<i>RFO</i>	<i>MDO</i>	Virgin oil
(-E)*	(-E)*	(-E)*	(-E)*	(-E)*	(-E)*	(+E)**

Notes: * -E = negative externalities, ** +E = positive externalities.

Table 3. Negative and positive externalities, 100% collected used oil

Stored used oil	Processors	<i>RR</i>	<i>RFO</i>	<i>MDO</i>	Virgin oil
(-E)*	(-E)*	(-E)*	(-E)*	(-E)*	(+E)

Notes: * -E = negative externalities, ** +E = positive externalities.

Table 4. Canadian collected oil end-use and destination in 2007 (gallons)

Used oil end uses	Within Alberta	Outside Alberta	% sent out of province
Recycled as base oil	33,893	3,854,844	99.1%
Other lubricant products (lessor process)	3,802,092	1,581,179	29.4%
Fuel for industrial burner	380,303	2,492,921	86.8%
Fuel for asphalt plants	7,114,286	3,563,845	33.4%
Fuel for small space heaters	532,225	704,439	57.0%
Total	11,862,799	12,197,228	50.7%

Source: Fitzsimmons (2009).

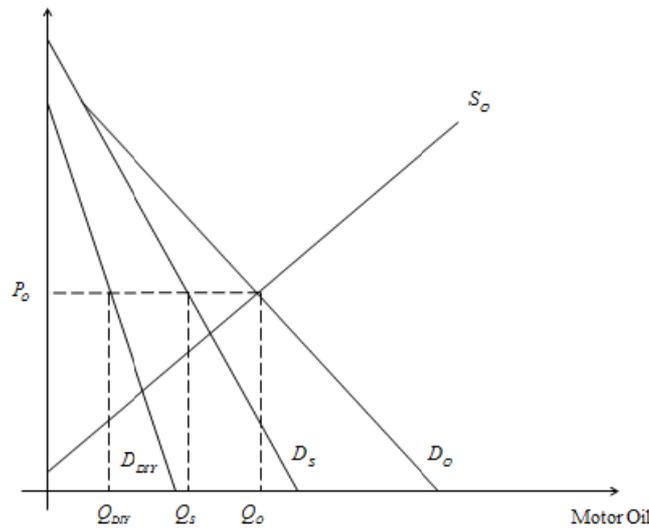


Fig. 1. Market for motor oil

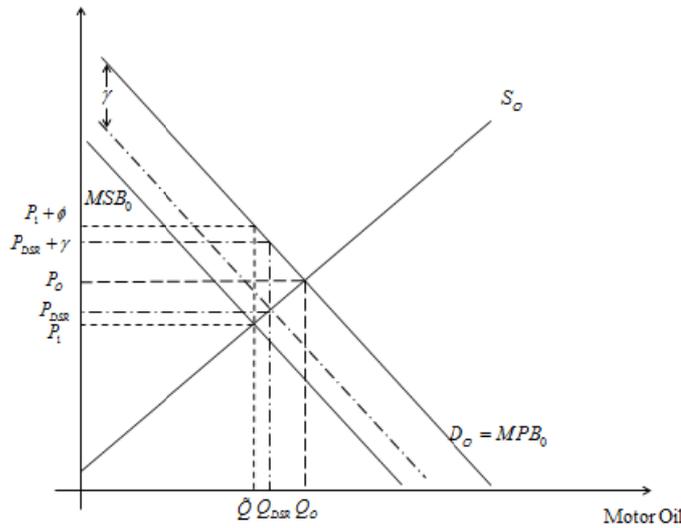


Fig. 2. Pigovian tax on an externality

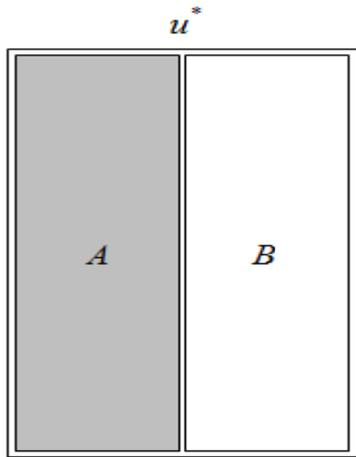


Fig. 3(a). Quantity of used oil

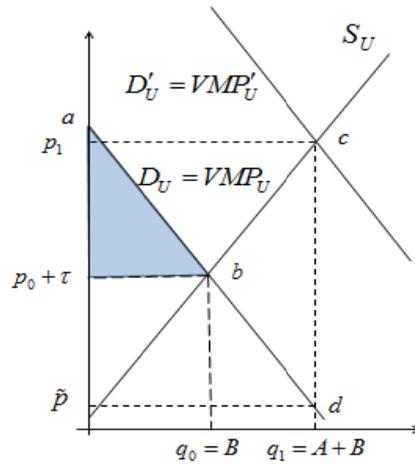


Fig. 3(b). Derived demand for used oil

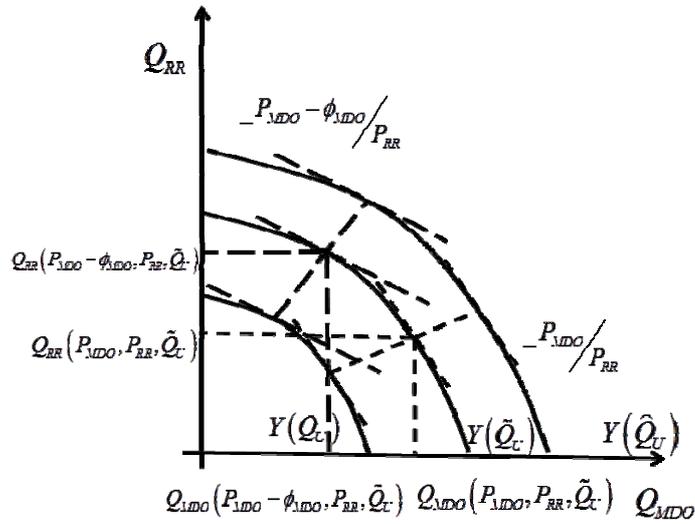


Fig. 4(a). Product choice for recycled oil

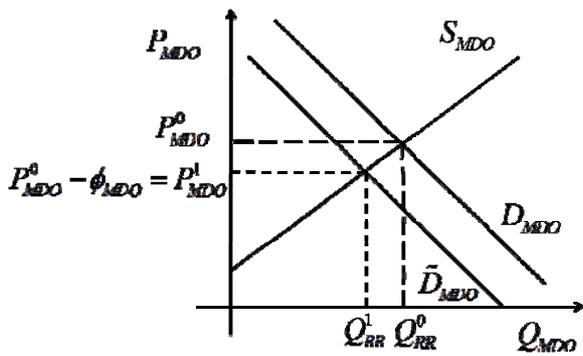


Fig. 4(b). Marine diesel oil

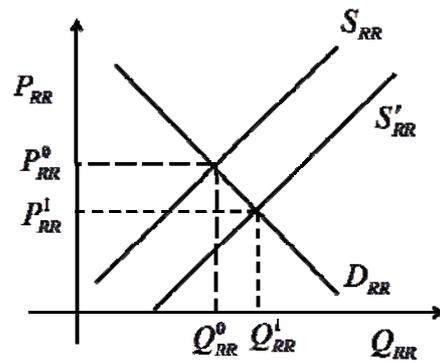


Fig. 4(c). Recycled lubricant market

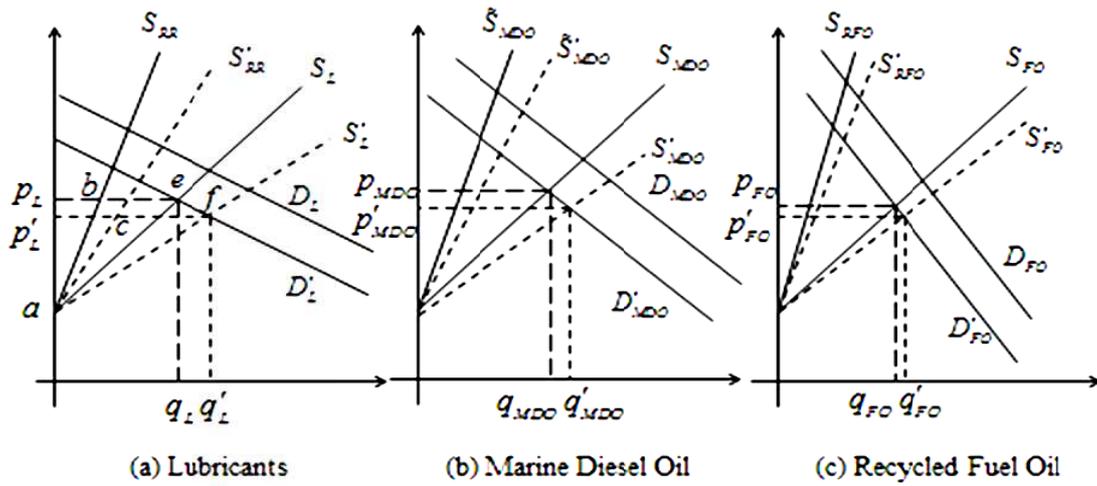


Fig. 5. Effect of increased supply from recycled motor oil

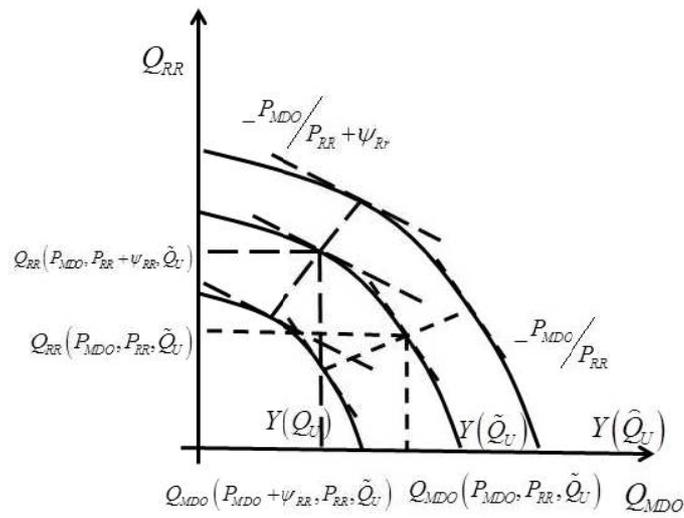


Fig. 6(a). Product choice for recycled oil

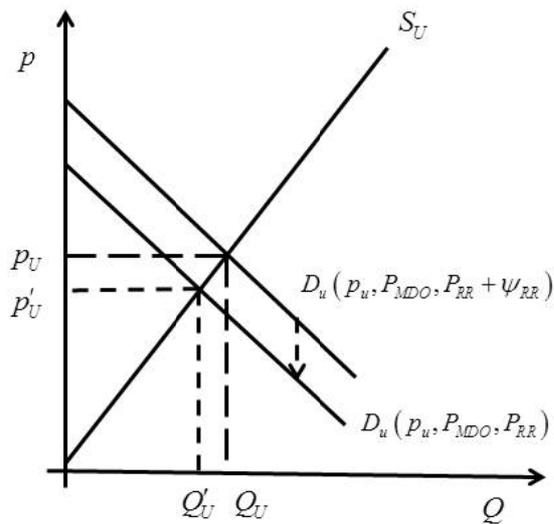


Fig. 6(b). Derived demand for used oil

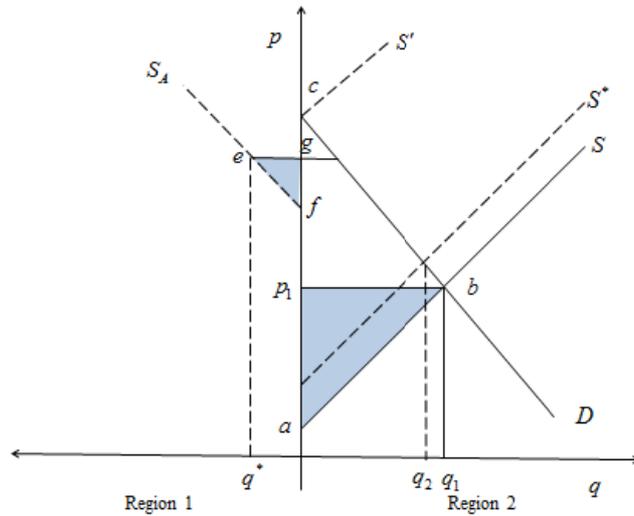


Fig. 7. Nontariff barrier

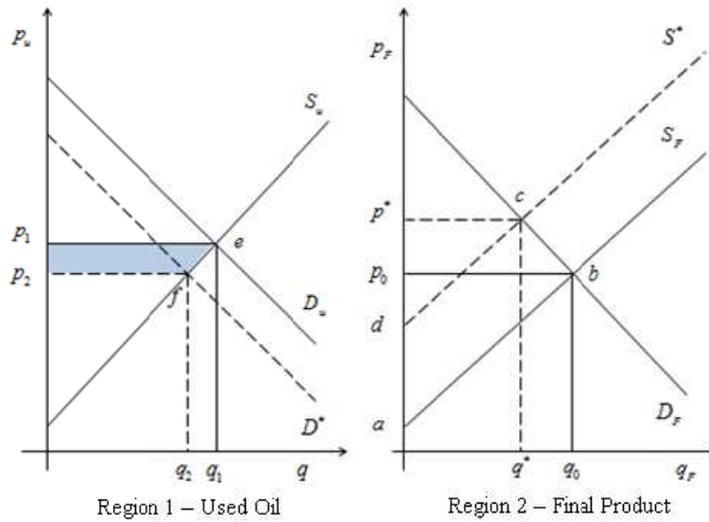


Fig. 8. Trade in input with non-tariff barrier

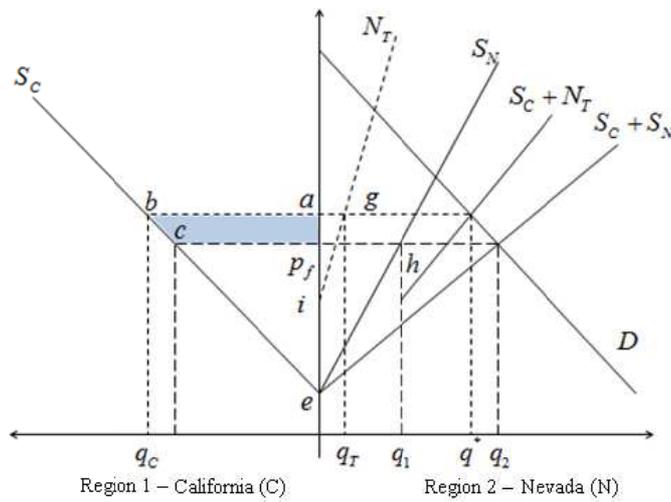


Fig. 9. Production in both regions