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EFFECTS OF THE AMERICAN ENERGY AND SECURITY ACT OF 2009 ON THE CHEMICAL INDUSTRY

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The American Clean Energy and Security Act of 2009, also known as the Waxman-Markey Bill or H.R. 2454, was passed by the House of Representatives on June 26, 2009, and is now awaiting approval by the Senate. If passed, this bill would create a renewable energy standard that requires utilities to obtain an increasing percentage of their energy from renewable sources such as wind, solar, and hydropower. In addition, the Waxman-Markey Bill would put a cap on the amount of greenhouse gas emissions in high-emitting industries. These industries would be required to possess one emissions allowance for each ton of carbon dioxide equivalent emitted. Some allowances would be given away freely, while others would be sold at auction. Firms in high-emitting industries could then buy and sell allowances through the cap-and-trade system to meet their individual needs (American Clean Energy and Security Act of 2009, H.R. 2454).

The chemical industry is considered a high-emitting industry, releasing about five percent of the United States' total greenhouse gas emissions according to the Environmental Protection Agency (EPA 2009). Thus, the Waxman-Markey Bill will directly affect the chemical industry and the industry will face the higher costs associated with either switching to cleaner energy production methods or buying carbon allowances once the bill is enacted. However, in its 2009 study, *Innovations for Greenhouse Gas Reductions*, the International Council of Chemical Associations (ICCA) found that emissions reductions caused by applications of chemical products are two to three times greater than the industry's own emissions (ICCA 2009). This is because chemicals are used in many important energy-saving products. For example, chemicals such as silicon are integral in the production of solar panels, polyurethane is used in energy-saving insulation products, and plastic polymers are being used to make cleaner, more efficient cars. As the demand for cleaner energy increases, the demand for these products produced by the chemical industry will also increase, offsetting some of harmful effects of increased costs on the industry's wellbeing. This study establishes why the Waxman-Markey Bill is important, examines both the direct and indirect effects of the bill on the chemical industry, and explains why H.R. 2454 may make the industry better off.

The main objectives of the Waxman-Markey Bill are to decrease greenhouse gas emissions and promote renewable energy in the United States through the cap-and-trade system as well as the renewable electricity standard. Decreasing greenhouse gas emissions is important for several reasons. The world is already experiencing the effects of climate change, which can be seen through changes in average temperature and weather patterns across the globe. Although a slight increase in temperature may not seem significant, it can severely impact biodiversity, shoreline erosion, and water quality (EPA 2009). In addition, M.L. Parry et al. argue that global warming is likely to increase respiratory illness and the spread of infectious diseases all over the world (Parry et al. 2007). For these reasons, it is in society's best interest to reduce greenhouse gas emissions, which are measured in tons of carbon dioxide equivalent (tons CO_2e), and limit the effects of climate change. However, regulation is needed to actually reduce greenhouse gas emissions because of a kind of open access resource problem. An open access resource is one for which no entity controls access to or use of that resource (Tietenberg and Lewis 2009). Open access resources are overused because the marginal costs to individuals of using the resources are less than the marginal costs to society in some situations. There is also underinvestment in maintaining open access resources because the marginal benefits of maintenance to individuals are often lower than the marginal benefits to society. These two factors both result in degradation of the resource over time. Because no entity owns or controls the air, it can be considered an open access resource. The efficient use of the resource occurs where the marginal benefit to society (MB^S) equals the marginal cost to society (MC^S). However, the markets clear where the marginal benefit to individuals (MB^I) equals the marginal cost to individuals (MC^I). Thus, the resource is overused in comparison to the allocatively efficient quantity. Individual polluters are emitting high levels of CO_2e, creating climate change effects past an efficient level for society. In addition, low levels of abatement activities correspond to underinvestment in maintaining a stable climate. A graphical representation of air as an open access resource can be seen in Figure 1. The deadweight losses indicate that the quantities of use and maintenance are not efficient, leading to the degradation of climate stability. Also note that emissions up to the Earth's natural absorption rate, x-hat, have no negative impact on society. According to the Intergovernmental Panel on Climate Change, the current global greenhouse gas emissions are between three and four times the Earth's natural absorption rate of carbon dioxide, which means that emissions significantly exceed x-hat and degradation of climate stability is occurring past an efficient level (ICCA).

The possible solutions to the open access resource problem include privatization, government regulation, and communal property management of the resource. The CO_2e emissions cannot be contained in a particular area, nor can their harmful effects be privatized. In this case, the most plausible solution to the open access resource problem is government regulation, which is why the Waxman-Markey Bill is so important. Without regulation to control the emissions of greenhouse gasses, they will continue to accumulate and the harmful effects of climate change will increase. However, even if the bill is enacted, it is important to consider that greenhouse gasses are uniformly mixed pollutants, or pollutants whose damage is global and depends on the total amount of pollution, not the location of the pollution source. This means that greenhouse gas reduction must be a global effort. According to the World Resources Institute's Climate Analysis Indicators Tool (CAIT), greenhouse gas emissions in the United States make up 20.63% of the world's total emissions (CAIT 2009). While this is a significant percentage for one country, it is only one-fifth of the world's total emissions. This means that the United States alone cannot reverse climate change. Without similar regulation in other countries, the reduction of greenhouse gas emissions in the U.S. will not be enough to stop global warming. Furthermore, regulation in the U.S. alone may cause industries to outsource their production to countries without greenhouse gas restrictions, where they can avoid the higher costs associated with the regulation. In this way, without participation against climate change from other countries, the Waxman-Markey Bill could have the opposite effect of what its creators intended. Although the bill contains provisions to limit "leakage" to other countries through carbon offsets and free emissions allowances, industry leaders are concerned that it will still occur (H.R. 2454 Sec 721, 734, Dooley 2009).

Even though it is important from a societal standpoint, reversing climate change is costly. If cleaner technology were not more expensive than the standard technology, there would not be an open access problem and governmental regulation would not be necessary. The Waxman-Markey Bill is expected to directly or indirectly affect most industries in the United States. Although only certain industries are subject to regulation under the bill, many other industries and their consumers will face higher prices as a result (Congressional Budget Office 2009). The chemical industry will be affected directly through the cap-and-trade part of the Waxman-Markey Bill. The cap-and-trade system works much like an emissions tax on pollution, except instead of setting the price, the government sets the total maximum amount of pollution through limiting the supply of allowances to a fixed quantity. The price of the allowances is flexible to meet the market demand. Just like a tax, an allowance trading system such as cap-and-trade leads to a cost-effective allocation of abatement and creates more incentives to adopt abatement technology than would a system of individual source standards tailored to differences in abatement costs.

The price of allowances is determined where market demand for allowances equals the supply, as shown in Figure 2a. The Congressional Budget Office (CBO) estimates the average price of greenhouse gas allowances over the period from 2011-2019. Specifically, the CBO indicates that the estimated 2011 price will be $15.00 and that it will increase yearly to $26.00 in 2019 (CBO 2009). The increase in price is caused by the decrease in the number of allowances available each year. Due to the expected increasing price of the allowances, firms might bank more allowances than they need in a given year and save them to apply to emissions in future years. The banking feature of the allowances has a price-smoothing effect by raising the demand for allowances and thus the price in the initial years. Banking reduces the range between the allowance prices at the beginning and end of the period and helps firms in estimating their expected expenditures.

The chemical industry will make abatement choices based on the costs of abating pollution versus the costs of buying allowances. To maximize profit, the industry will operate where the marginal cost of abatement, MC(a), equals the price of the allowances, P_E. One allowance is required for each metric ton of carbon dioxide equivalent emitted (H.R. 2454 Sec. 712). For example, one metric ton of nitrous oxide emissions is equal to 298 metric tons of carbon dioxide and would therefore require 298 allowances. If the marginal cost of abating one additional metric ton of carbon dioxide equivalent is cheaper than buying one additional allowance, then the industry will abate pollution until the marginal cost equals the price of the allowances. For additional abatement, the marginal cost of abatement is higher than the price of allowances and the industry will buy allowances to cover its additional emissions. The cost-minimizing equilibrium amount of abatement is denoted by a*, which corresponds to a level of pollution e*, in Figure 2b. Note that the level of abatement would be the same if a tax equal to the price of the allowances were put in place instead.

The chemical industry is an energy-intensive trade exposed (EITE) industry. EITE industries are industries whose output meets either a threshold greenhouse gas or energy intensity and trade intensity or a very high greenhouse gas or energy intensity (Schneck et al. 2009). The classification and recognition of EITE industries is meant to identify producers who would potentially lose the most under an emissions-capping system. EITE industries often have high abatement costs. Therefore, they would be forced to purchase large amounts of allowances under the cap-and-trade system. If the costs of doing so are too high, production might be outsourced to other countries with no emissions standards. The American Chemistry Council (ACC) believes that if leakage levels are high enough, H.R. 2454 may actually cause a net increase in global greenhouse gas emissions by shifting production to these countries (Dooley 2009).

Currently, the Waxman-Markey Bill treats EITE industries differently than other industries. While other sectors such as local oil distribution companies receive a fixed percentage of the free allowances under the bill, the percentage of free allowances for EITE industries changes over time. In 2014, 15% of free allowances will be given to EITE industries, but this percentage is reduced yearly starting in 2015 (H.R. 2454 Sec 782e). Although this provision is meant to help EITE industries and prevent leakage by initially giving them a higher percentage of the free allowances, the ACC and other EITE industries believe that it is not enough (Aluminum Association et al. 2009). The ACC believes that to achieve the bill's emissions reduction goals and simultaneously prevent leakage, EITE industries should be allocated a fixed yearly percentage of the annual free allowances (Dooley 2009). The reduction of the percentage of allocated free allowances to the chemical industry after 2014 has several basic implications. First, the chemical industry will face a relatively larger increase in costs compared to other non-EITE industries with similar marginal abatement cost curves. Although the total number of free allowances will decrease each year across the board, the percentage received by the chemical industry will decline at an even faster rate. This means that the industry will either have to buy additional allowances or increase its level of abatement at a faster rate than non-EITE industries. It can be implied from this that, holding everything else constant, the chemical industry loses compared to other industries on average. To see this, consider how the cap-and-trade system works. Suppose that there are two firms, Firm A and Firm B, with identical marginal cost of abatement functions. All the emissions allowances are initially given to Firm A. To maximize profit, Firm A would abate to the level where its marginal cost of abatement equals the market price of the allowances, and then sell the excess allowances to Firm B. This price is determined so the marginal costs of the two firms are equalized and the sum of each firm's level of abatement equals the total level of abatement necessary given the supply of allowances. Firm B would abate to the level where its marginal cost of abatement equals the price of the allowances, and use the purchased allowances to cover its unabated pollution. In this situation, Firm A would be relatively better off, receiving the revenue from the sale of its excess allowances. Firm B, however, would lose because it was not granted an initial entitlement of allowances and had to purchase them. Although both firms would have to invest in some level of abatement technology, which would increase their production costs in comparison with a no regulation scenario, Firm B faces relatively higher total costs because it must purchase allowances as well as invest in abatement technology. Figure 3 shows this concept, which applies to the chemical industry and other EITE industries. The chemical industry is like Firm B in this simplified model. Because the number of freely allotted allowances for the chemical industry is declining at a faster rate than it is for other non-EITE sectors after 2014, the costs of H.R. 2454 are disproportionately placed on the chemical industry and other EITE industries.

An analysis done by McKinsey & Company estimates the greenhouse gas abatement cost curve for the world chemical industry (ICCA 2009). This curve can be seen in Appendix 1. Although this curve is an estimate for the world industry and not the United States specifically, it can be used to approximate the costs of abatement in the U.S. for general purposes. This curve shows the abatement potential and the corresponding cost of a given abatement activity relative to the "business as usual" case in a given year. Because firms are facing the direct costs of abatement, the business view should be used, even though it estimates much higher costs. From the CBO yearly estimates, the average expected cost of allowances over the 2011-2019 period is $19.78, which is approximately €13.15. Assuming the abatement costs for the U.S. chemical industry are comparable to those for the world industry, the U.S. chemical industry can be expected to abate until the marginal cost of abatement is $19.78. In other words, the industry will adopt additional abatement practices until the cost of abating one additional metric ton of carbon dioxide equivalent is $19.78. According to McKinsey & Company's estimates, it appears that improving motor systems, shifting from oil to gas fuel, decomposing nitrous oxide from adipic and nitric acid, and level one process intensification and catalyst optimization are all cost effective abatement processes. This suggests that although the chemical industry will have to purchase allowances as well, it will undertake a considerable amount of abatement technology if the Waxman-Markey Bill is enacted.

Whether the chemical industry buys allowances, invests in abatement technology, or does some combination of the two, industry production costs will increase. Other things equal, as costs rise, profits decrease, and decreased profits are clearly harmful to industry producers. In his article, “Product Pricing in the Chemical Industry,” Paul Christopherson says that most economists have traditionally viewed the chemical industry as a perfectly competitive industry (Christopherson 1977). This assumption will be used to evaluate the effects of a cost increase. Recall that in a perfectly competitive market, economic profit is zero. This means that as costs increase and thus profits decrease, firms will be making negative profit in the short run. In the long run, this will drive some firms out of the market, shifting supply down. As supply decreases, the market price rises to restore long run equilibrium in the market, where the price is higher and the quantity is lower than at the original equilibrium. Note that even for a monopoly, an increase in costs or the imposition of an allowance system raises the marginal cost of production, shifting marginal cost up. Because monopolists produce where marginal cost equals marginal revenue, the same effect takes place: price increases and quantity decreases. Holding everything else constant, under the Waxman-Markey Bill most high-emitting industries should experience this increase in price and decrease in quantity regardless of the amount of market power present within the industry.

However, increased costs due to cap-and-trade might not have the effect of raising price and lowering quantity in the chemical industry. Many of the products that the industry produces are inputs for energy-saving products in other sectors. Some of the highest energy-saving products using chemical industry outputs are insulation materials, fluorescent lighting, automotive plastics, and synthetic fuel additives (ICCA 2009). By directly increasing the cost of energy in other sectors, H.R. 2454 will indirectly affect the chemical industry as well. If other sectors move towards more energy efficient production, the demand for intermediate chemical products used in energy saving final products will increase. If demand increases enough, the industry's short run profits could actually increase despite the higher production costs resulting from the cap-and-trade program. Figure 4 shows a situation where short run profits increase for a perfectly competitive firm. Under no regulation, the industry produces Q_0 output at price P_0. The firm, which has a marginal cost MC_0 and average cost AC_0, produces q_0 output and makes zero economic profit. Under cap-and-trade, the production costs of the firm will increase, raising the marginal and average costs to MC_1 and AC_1 respectively, and the firm's level of output will fall from q_0 to q_1'. Since firms produce where marginal cost equals marginal revenue, the firm is now making a negative profit, $\square_1$'. Because every firm in the industry faces higher costs and now produces a lower quantity, the industry supply will shift to S_1, and Q_1' will be supplied at price P_0. Demand at this price exceeds quantity supplied, so price and quantity supplied will increase until the market reaches the new equilibrium at (Q_1, P_1). At price P_1, the firm supplies quantity q_1 and is making zero economic profit. The increase in demand then raises the industry quantity supplied and price to (Q_2, P_2), and at price P_2, the firm produces quantity q_2. This results in positive profit $\square_2$, for the firm in the short run. In the long run, additional firms enter the market because of the prospect of earning positive profit. This shifts supply back to S_2 and decreases the market price to P_3, driving economic profit for the firm back down to zero. Note that not only are short run profits possible as a result of the Waxman-Markey Bill, but the long run market quantity of output has increased from Q_0 to Q_3 in spite of the increased price.

A specific example of a chemical product for which demand could increase due to H.R. 2454 is insulation. Insulation is one of the most important products in increasing energy efficiency. Insulation materials reduce heat loss, and therefore the use of fuel for heating. Insulation is by far the largest potential energy-saving product of the chemical industry. In addition, insulation foam has a ratio of emissions savings to emissions in production of 233 to 1 (ICCA 2009). Chemical based insulation products reduce the energy needed to heat and cool both commercial and residential buildings, and can be used throughout the country. One of the reasons that insulation has such a high potential for saving energy and reducing greenhouse gas emissions is that its use is not limited to one specific industry. Insulation is used in almost all new construction and can be updated in older buildings to maximize energy savings. Three important chemical insulation materials are expanded polystyrene (EPS), extruded polystyrene (XPS), and polyurethane (PU). These materials have an average carbon footprint of 2.8 kilograms of carbon dioxide equivalent per kilogram produced ($kgCO_2e/kg$). Over the 50-year average lifetime of insulation, 2.3 metric tons of carbon dioxide equivalent are saved from its use (ICCA 2009). Not only is insulation energy efficient, but it is cost effective as well. A study done by Texas A&M University found that updating existing buildings with PU foam pays for itself within three to four years from the decrease in energy bills (Scott 2009). Therefore, the use of insulation is efficient from a monetary standpoint as well as an emissions standpoint.

As specified industries are required to purchase allowances for their greenhouse gas emissions, there will be more incentives for them to curb emissions. Just like the chemical industry, other industries will adopt abatement technology until the marginal cost equals the price of the allowances. Because insulation often pays for itself in decreased energy costs as well as reduces the amount of greenhouse gasses produced, firms are likely to properly insulate their buildings as one of the first abatement measures taken. Because the bill will especially affect the price of energy, both firms and households will have incentives to increase their use of insulation. There are many different materials, thicknesses, and densities of insulation. Even though most buildings are already insulated to some extent, they are often not insulated to the efficient level for the prevention of excess energy loss. The types of insulation that contain chemicals are often more expensive or harder to install than other types of insulation, but they are also more effective and can be cheaper in the long run (ICCA 2009). In addition, Title 2 of the Waxman-Markey Bill establishes higher targets for buildings to meet energy-efficiency codes, which will serve as another reason for the demand for insulation to increase (H.R. 2454). Updating the insulation in existing buildings will not create a sustained increase in the demand for insulation materials, but its use in new buildings will.

Although the effect may be even less direct, the implementation of H.R. 2454 will benefit the chemical industry by increasing the demand for residential insulation materials as well.

Individual households will not be subject to a carbon tax. However, the increased energy costs that the bill is expected to cause through the renewable energy standard as well as the cap-and-trade system will be passed on to consumers. Households will bear a large part of these costs by paying higher prices for a variety of goods. Although the bill includes a provision for a refundable low-income energy tax credit, the increased costs are still expected to reach consumers (H.R. 2454 Sec. 431). If it is true that certain types of insulation can reduce energy needs enough to pay for themselves, then “sustainable building,” or the building of energy efficient structures, will become more popular and people will demand these types of energy efficient insulations in their homes to offset the higher energy costs. The bill also includes provisions in sections 202 and 203 to help low-income households retrofit their dwellings to be more energy-efficient by providing rebates for certain improvements (H.R. 2454). These factors will also increase demand for chemical insulation materials, which will be used more consistently when constructing and retrofitting homes.

Because the amount of carbon dioxide equivalent emitted from the production of insulation materials is relatively low, the chemical industry will not face a significant cost increase in the production of these goods under the Waxman-Markey Bill (ICCA 2009). Installing proper insulation is a cost-effective energy-saving option, so therefore the demand for insulation materials will increase. Because the ratio of avoided greenhouse gas emissions to those emitted in manufacturing is so high, under this bill, the demand should be expected to increase by more than supply decreases from the increased production costs. As previously explained for Figure 4, if the chemical industry is considered perfectly competitive, this will raise the equilibrium price and quantity, which will increase profits in the short run. In the long run, of course, additional firms will enter the market, increasing supply and driving economic profits back down to zero. If the chemical industry is not perfectly competitive and there are barriers to entry, then firms producing insulation materials will likely continue to see increased positive profits.

This situation is good for not only the chemical industry, but society as well. Although the increased demand leads to more insulation being produced and therefore more greenhouse gasses emitted by the chemical industry, overall emissions in the United States should decrease as insulation is installed in buildings and put to use. Although insulation has one of the highest emissions savings to emissions ratios, the use of other chemical products with ratios greater than one will also help decrease total emissions (ICCA 2009).

An emissions ratio greater than one does not guarantee positive short run profits for the chemical industry, however. Another example of a chemical product that will be affected by H.R. 2454 is the silicon used in solar cells. However, its effect on the industry is less clear. The renewable energy standard (RES) in the Waxman-Markey Bill requires that 20 percent of electricity come from renewable sources by 2020 (H.R. 2454 Sec. 103). Because of this, the ICCA expects the demand for solar cells to increase by twenty percent per year until 2020 and 10 percent per year in subsequent years (ICCA 2009). Various types of silicon processed by the chemical industry are key components of solar cells. Therefore, demand for silicon products should increase. However, the production of silicon produces more carbon dioxide equivalent than insulation does, and it has a lower emissions ratio of only 5.3 to 1 (ICCA 2009). This means that the production costs of silicon will increase by more than they will for insulation because of the need to purchase more CO_2e allowances. This will raise the price of silicon. And, although the expected increase in demand for silicon used in solar cells seems large, only a fraction of all silicon produced goes to the production of solar cells: it is also used in many other products including electronics, shingles, and even contact lenses (Maynard 2009). For these reasons, under current levels of technology the increase in demand for silicon is likely to be relatively small. This situation is shown in Figure 5. The same processes take place as explained above for Figure 4. However, at price P_1, the firm is still making a negative profit, $\square_1$. The small shift in demand raises the market quantity supplied and price to the new equilibrium (Q_2, P_2). At this price, the firm produces q_2 output but its profit, $\square_2$, is still negative. Therefore, in the long run firms exit the market and supply shifts to S_2. The new equilibrium is the point (Q_3,

P_3). At price P_3, the firm's economic profit is zero. In this case, the firm never makes positive profit and the end equilibrium for the industry is at the point (Q_3, P_3) where the quantity is lower and the price is higher than at the original equilibrium before the bill took effect.

This is only one possibility, however. Solar cell producers are investing in technology to make solar cells more efficient. As efficiency increases, energy suppliers will be more likely to choose solar energy over other forms of renewable energy. This will increase demand for solar cells and thus silicon products even further. If solar cells become at least 30 percent more efficient within five years as predicted, the chemical industry may benefit from the Waxman-Markey Bill in an area it otherwise may not (Maynard 2009).

Although it would be presumptuous to say from this analysis that the entire industry will benefit from the Waxman-Markey Bill, at least part of the chemical industry will. Despite the increased production costs that they will face as a result of the cap-and-trade program, the producers of insulation, silicon, and other energy-saving products are likely to benefit from H.R 2454. This is because many of the products that the chemical industry produces are inputs for energy-saving technologies produced and used by other sectors. As the incentives to reduce greenhouse gas emissions increase, the demand for these products will increase as well, offsetting the higher costs faced by the chemical industry. Although the products mentioned here do not represent the entire industry, they do represent the future of clean energy, and will play an important role in determining the viability of the chemical industry if H.R. 2454 takes effect.

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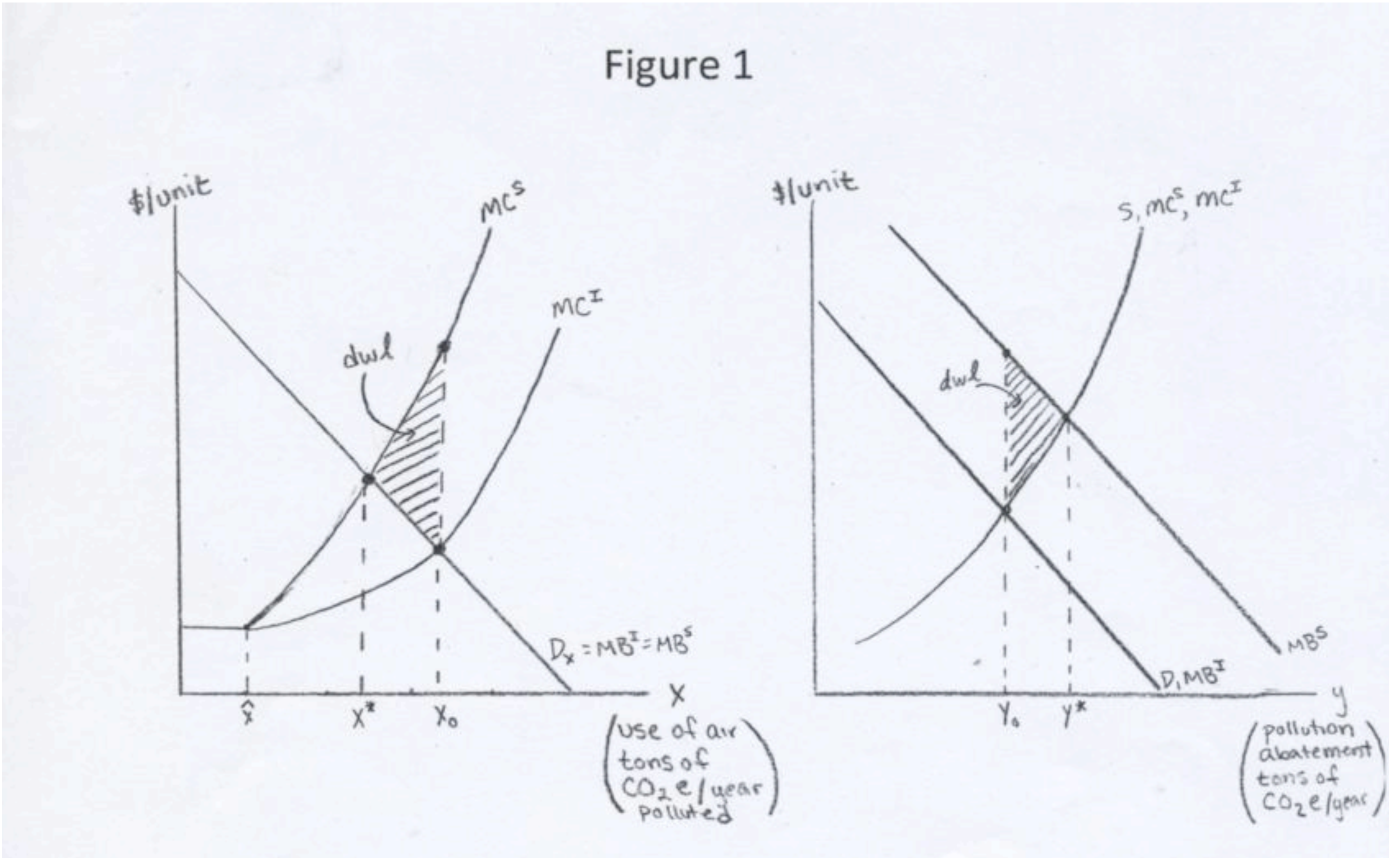


Figure 1: Air as an open access resource

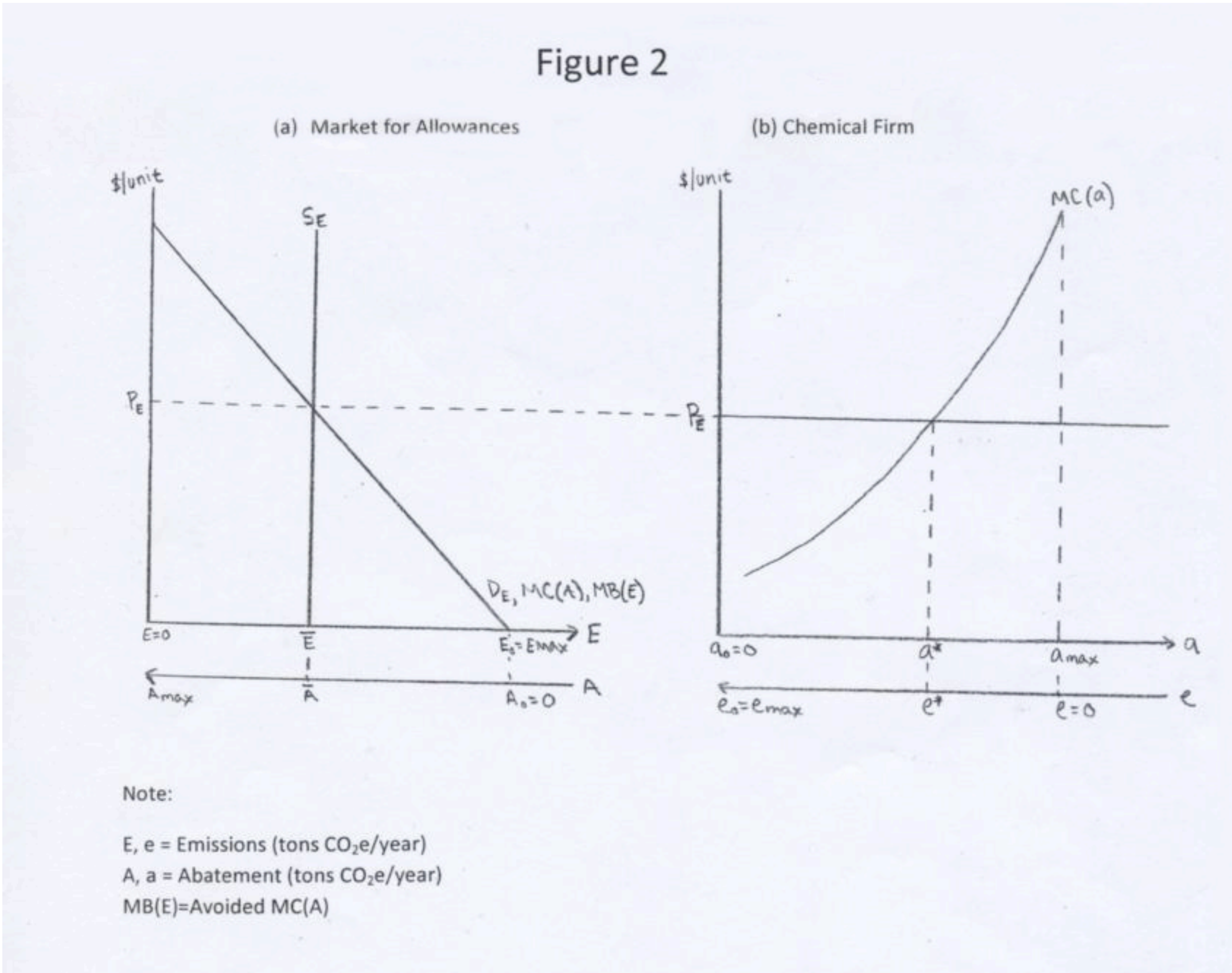


Figure 2a: The market for carbon allowances determines their market price.

Figure 2b: The amount of abatement undertaken by an individual firm is determined by the price of carbon allowances and the firm's marginal cost of abatement.

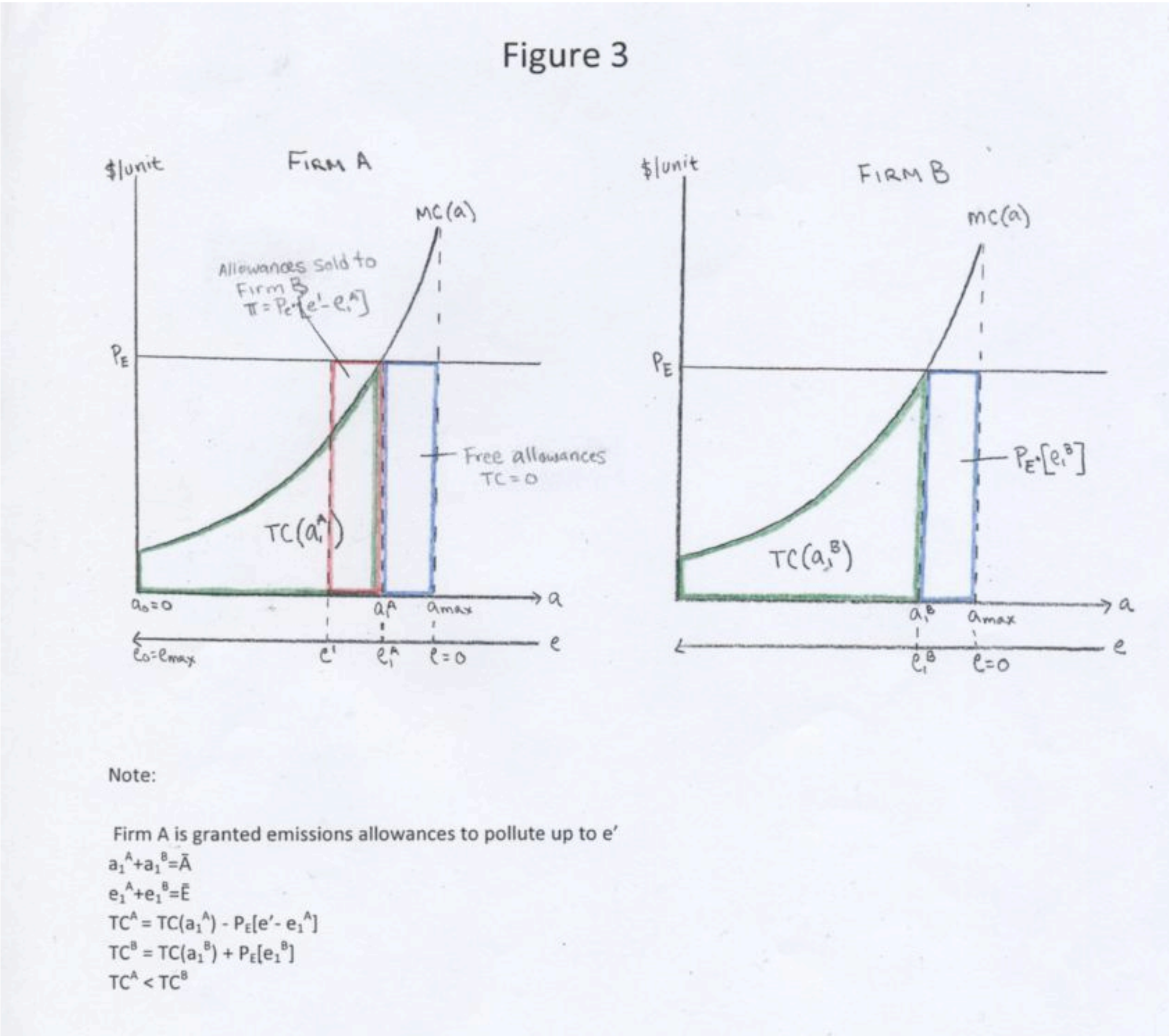


Figure 3: Total abatement costs of Firms A and B when the initial entitlement of carbon allowances is granted to Firm A.

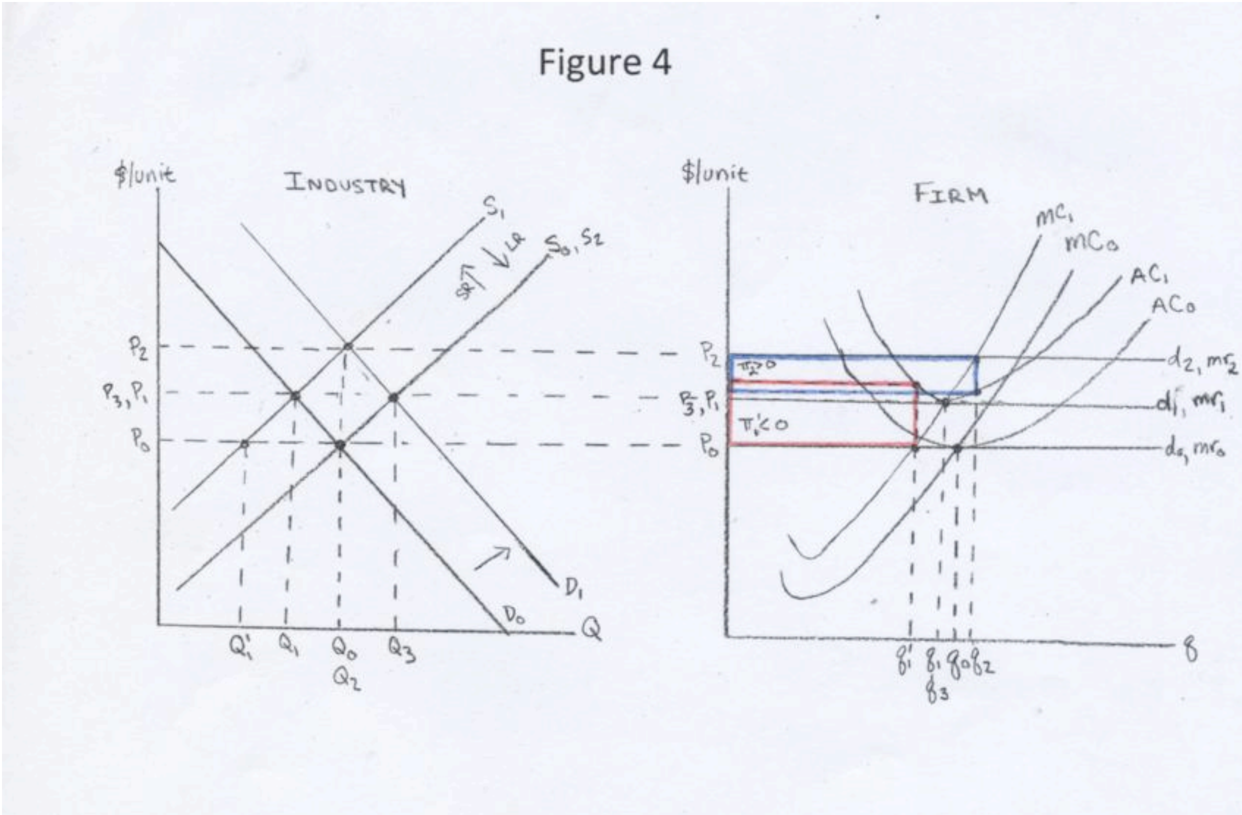


Figure 4: The effect of H.R. 2454 on the chemical industry if increased demand causes short run profits to increase for a perfectly competitive firm.

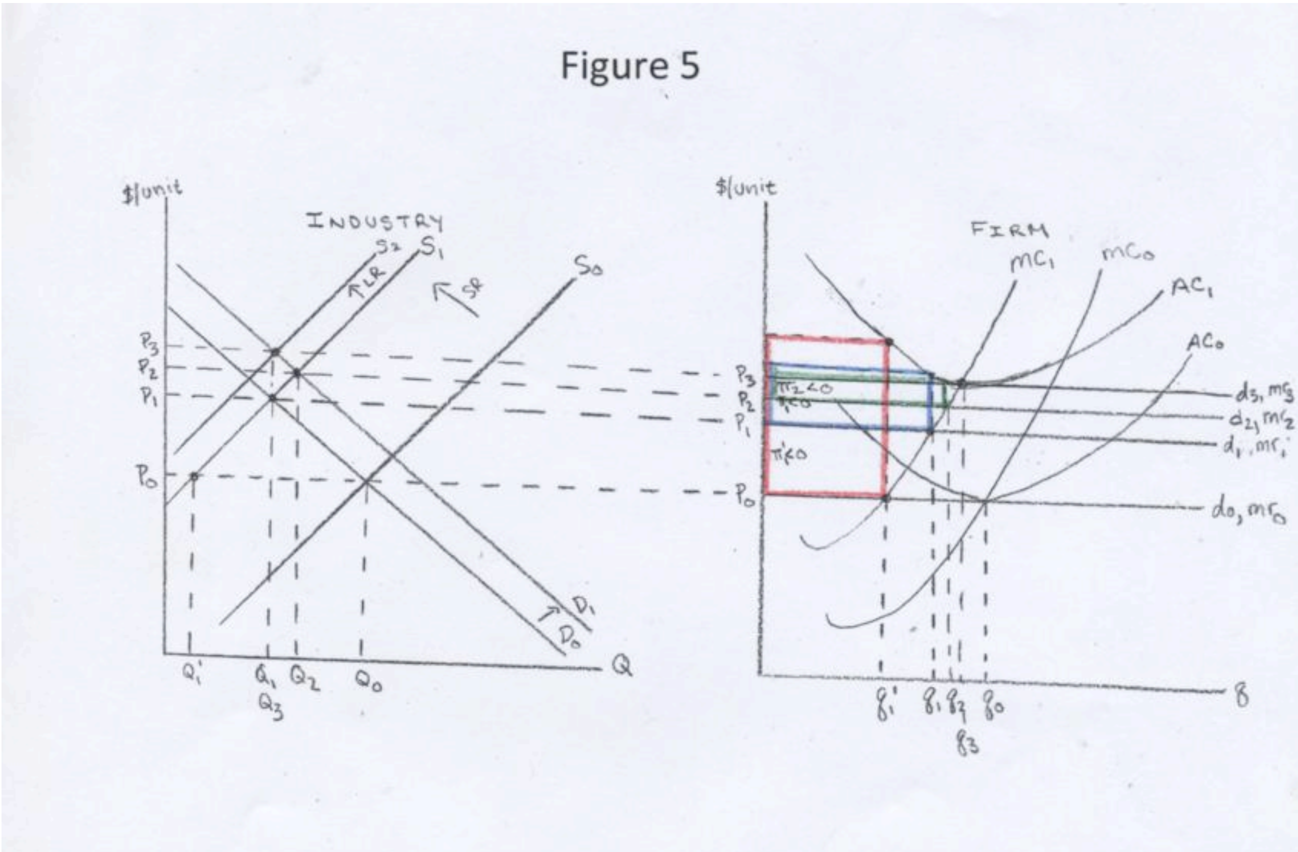
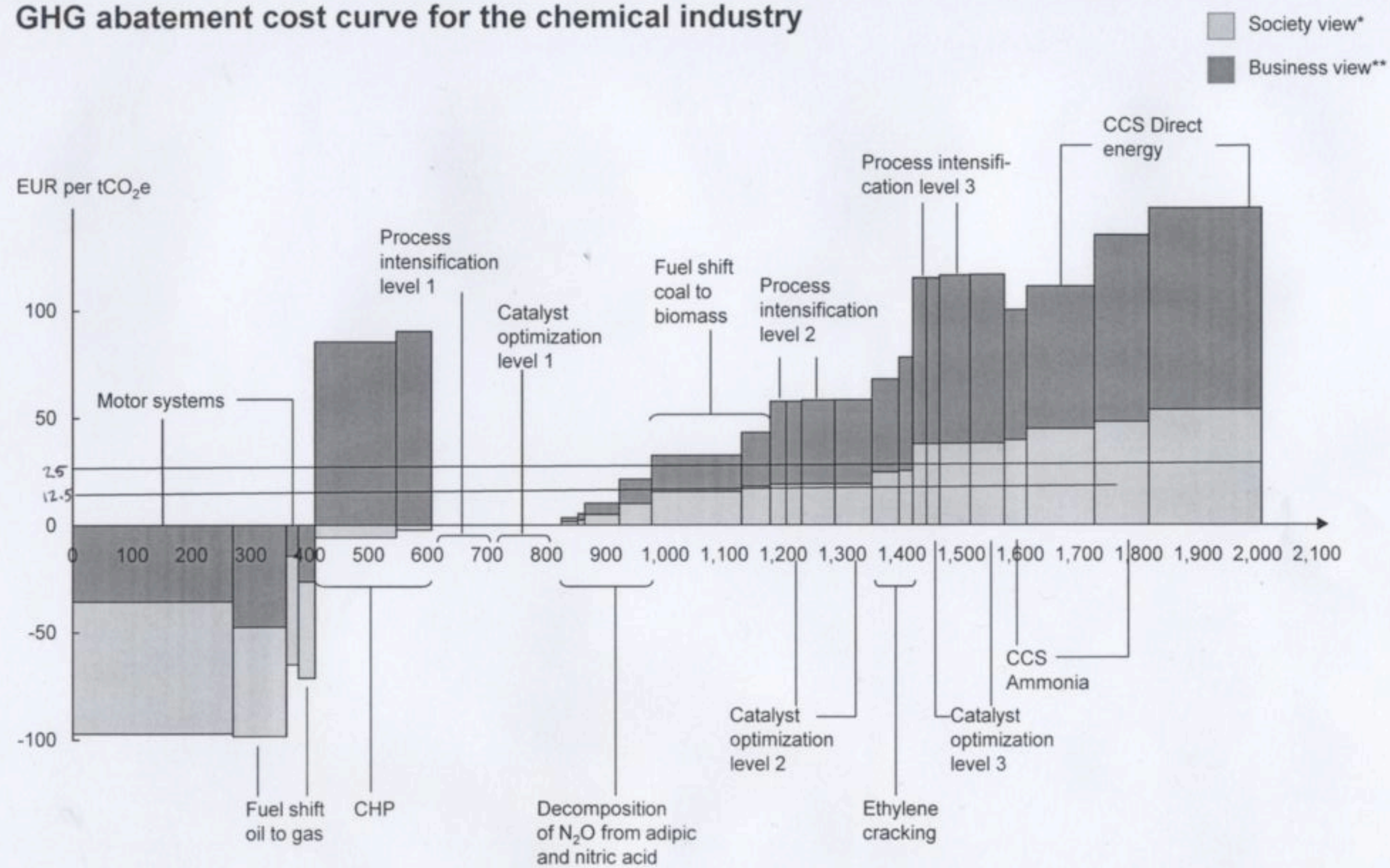


Figure 5: The effect of H.R. 2454 on the chemical industry if the shift in demand is relatively small compared to the shift in supply.

Appendix 1

GHG abatement cost curve for the chemical industry



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below EUR 60 per tCO_2e (society view) if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play

* 4% interest rate, depreciation over life time of equipment

** 10% interest rate, depreciation over 10 years

Source: ICCA/ McKinsey analysis