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Applying the Supply-and-Demand Model

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New Jersey's decision to eliminate the tax on Botox has users elated. At least I think they're elated. I can't really tell.

Challenge

Who Pays the Gasoline Tax?

U.S. consumers and politicians debate endlessly about whether to increase or decrease gasoline taxes, even though U.S. gasoline taxes are very low relative to those in most other industrialized nations. In 2016, the typical American paid a tax of 45¢ per gallon of unleaded gasoline, which includes the federal tax of 18.4¢ and the average state gasoline tax of 26.6¢ per gallon. The comparable tax is $1.12 in Canada, $3.63 in France, and $4.20 in the United Kingdom.

Regularly, at international climate meetings—such as the one in Paris in 2015—government officials, environmentalists, and economists from around the world argue strongly for an increase in the tax on gasoline and other fuels (or, equivalently, on carbon) to retard global warming and improve the air we breathe.

However, whenever gas prices rise suddenly, other politicians call for removing gasoline taxes, at least temporarily. Illinois and Indiana suspended their taxes during an oil price spike in 2000, as did Alaska in 2008. While running for president, Senators John McCain and Hillary Clinton called for a gas tax holiday during the summer of 2008. They wanted Congress to suspend the 18.4¢ per gallon federal gas tax during the traditional high-price summer months to lower gasoline prices. Then-Senator Barack Obama chided them for "pandering," arguing in part that such a suspension would primarily benefit oil firms rather than consumers. A similar debate took place in Britain in 2008. In 2011, Representative Heath Shuler proposed a 45-day federal gasoline tax holiday, as did legislators in Illinois, Indiana, New Hampshire, and New York. In 2013, the Indiana House minority leader proposed a tax holiday.

A critical issue in these debates concerns who pays the tax. Do firms pass the gasoline tax on to consumers in the form of higher prices, or do they absorb the tax themselves? Is the ability of firms to pass a gas tax on to consumers different in the short run (such as during the summer months) than in the long run?

We can use a supply-and-demand analysis to answer such questions. When an underlying factor that affects the demand or supply curve—such as a tax—changes, the equilibrium price and quantity also change. Chapter 2 showed that you can predict the direction of the change—the *qualitative* change—in equilibrium price and quantity even without knowing the exact shape of the supply and demand curves. In most of the examples in Chapter 2, all you needed to know to give a qualitative answer was the direction in which the supply curve or demand curve shifted when an underlying factor changed.

where i is your personal discount rate for a week. If today your discount rate is $i = 0.25$, then your present value of mowing in a week is $-22.5/1.25 = -18$, which is not as bad as -20, so you delay mowing. However, if you were asked six months in advance, your discount rate might be much smaller, say $i = 0.1$. At that interest rate, the present value is $-22.5/1.1 \approx -20.45$, which is worse than -20, so you would plan to mow on the first of the two dates. Thus, falling discount rates may explain this type of time-inconsistent behavior.

Falling Discount Rates and the Environment A social discount rate that declines over time may be useful in planning for global warming or other future environmental disasters (Karp, 2005). Suppose that the harmful effects of greenhouse gases will not be felt for a century and that society used traditional, exponential discounting. We would be willing to invest at most 37¢ today to avoid a dollar's worth of damages in a century if society's constant discount rate is 1%, and only 2¢ if the discount rate is 4%. Thus, even a modest discount rate makes us callous toward our distant descendants: We are unwilling to incur even moderate costs today to avoid large damages far in the future.

One alternative is for society to use a declining discount rate, although doing so will make our decisions time inconsistent. Parents today may care more about their existing children than their (not yet seen) grandchildren, and therefore may be willing to significantly discount the welfare of their grandchildren relative to that of their children. They probably have a smaller difference in their relative emotional attachment to the tenth future generation relative to the eleventh generation. If society agrees with such reasoning, our future social discount rate should be lower than our current rate. By reducing the discount rate over time, we are saying that the weights we place on the welfare of any two successive generations in the distant future are more similar than the weights on two successive generations in the near future.

Application

Falling Discount Rates and Self-Control

If people's discount rates fall over time, they have a *present bias* or a *self-control problem*, which means that they prefer immediate gratification to delayed gratification.[8] Several recent studies argue that governments should help people with this bias by providing self-control policies.

Shapiro (2004) finds that food stamp recipients' caloric intake declines by 10% to 15% over the food stamp month, implying that they prefer immediate consumption. With a constant discount rate, they would be more likely to spread their consumption evenly over the month. Governments can help people with a present bias by delivering food stamps at two-week intervals instead of once a month, as several states do with welfare payments.

Cigarette smokers often have inconsistent preferences with respect to smoking. Individuals with declining discount rates lack self-control and perpetually postpone quitting smoking. A 2013 Gallup poll found that 74% of U.S. smokers would like to give up smoking. According to a 2015 survey, 56% of Beijing smokers said they want to kick their habit. Consequently, a smoker who wants to quit may support the government's impositions of control devices. Based on a survey in Taiwan, Kan (2007) finds that a smoker who intends to quit is more likely to support a smoking

[8] In the famous marshmallow test, small children are offered one marshmallow now or a second one if they wait. See an excellent reenactment at **https://www.youtube.com/watch?v=QX_oy9614HQ**. Children who could delay gratification did better later in life: **http://www.newyorker.com/magazine/2009/05/18/dont-2**.

dumps its waste product into the water, harming a firm that rents boats for use on that waterway. Government officials in Sydney, Australia, used loud Barry Manilow music to drive away late-night revelers from a suburban park—and in the process drove local residents out of their minds.[1]

A *positive externality* benefits others. A 2016 report by the U.S. Forest Service estimated that trees lining Californian streets and boulevards provide $1 billion in benefits to municipalities and residents, including carbon storage, the removal of air pollutants, the interception of rainfall, energy savings in heating and cooling homes, as well as aesthetics.

A single action may confer positive externalities on some people and negative externalities on others. The smell of pipe smoke pleases some people and annoys others. Some people think that their wind chimes please their neighbors, whereas anyone with an ounce of sense knows that those chimes are annoying! It was reported that efforts to clean the air in Los Angeles, while helping people breathe more easily, caused radiation levels to increase far more rapidly than if the air had remained dirty.

Application

Negative Externalities from Spam

Spam—unsolicited bulk email messages—inflicts a major negative externality on businesses and individuals around the world by forcing people to waste time removing it, by inducing people to reveal private information unintentionally, and infecting computers with malware, which is malicious software. Spammers take advantage of the open-access nature of email. A spammer targets people who might be interested in the information provided in the spam message. This target group is relatively small compared to the vast majority of recipients who do not want the message and who incur the costs of reading and removing it. (Moreover, many spam messages are scams.) In 2016, people around the world receive 400 billion spam messages daily, which is 86% of global email traffic according to Talos.

The worldwide cost of spam and malware is enormous. Global spending on cyber-security technology alone exceeded $84 billion in 2015. Firms incur large costs to delete spam by installing spam filters and using employees' labor. A study at a German university found that the working time losses caused by spam were approximately 1,200 minutes or $2\frac{1}{2}$ days per employee per year (Caliendo et al., 2012). Various estimates of the cost range from $20 billion to $50 billion per year. Yahoo! researchers, Rao and Reiley (2012), concluded that society loses $100 for every $1 of profit to a spammer, a rate that is "at least 100 times higher than that of automobile pollution."

18.2 The Inefficiency of Competition with Externalities

Competitive firms and consumers do not have to pay for the harms of their negative externalities, so they create excessive amounts. Similarly, because producers are not compensated for the benefits of a positive externality, too little of such externalities is produced.

To illustrate why externalities lead to nonoptimal production, we examine a (hypothetical) competitive market in which firms produce paper and by-products of the production process—such as air and water pollution—that harm people who live near paper mills. We'll call the pollution *gunk*. Producing an extra ton of paper

[1]"Manilow Tunes Annoy Residents," **cnn.com**, July 17, 2006.

Good news. Production's up 13%!

the competitive output rather than the socially optimal quantity is $-D - E - H$.

The main beneficiaries from producing at the competitive output level rather than at the socially optimal level are the paper buyers, who pay \$240 rather than \$282 for a ton of paper. Their consumer surplus rises from A to $A + B + C + D$. The corresponding change in private producer surplus is $H - B - C$, which is negative in this figure.

The figure illustrates two main results with respect to negative externalities. First, *a competitive market produces excessive negative externalities*. Because the price of the pollution to the firms is zero, which is less than the marginal cost that the last unit of pollution imposes on society, an unregulated competitive market produces more pollution than is socially optimal.

Second, *the optimal amount of pollution is greater than zero*. Even though pollution is harmful and we'd like to have none of it, we cannot wipe it out without eliminating virtually all production and consumption. Making paper, dishwashers, and televisions creates air and water pollution. Fertilizers used in farming pollute the water supply. Delivery people pollute the air by driving to your home.

Application

Global Warming

A 2014 United Nations (UN) report concluded that global warming is occurring and the situation is becoming more serious. This report reflected the work of 800 scientists on a UN panel, which had previously won the Nobel Peace Prize for its work on the environment.

According to the UN report, human activity—pollution—is causing temperatures to rise. At least 97% of actively publishing climate scientists agree that the climate-warming trends over the past century are likely due to human activities, as do the Academies of Science from 80 different countries. Nonetheless, some non-scientists are skeptical. A 2015 Pew Research Center poll of U.S. adults found that 68% say that solid evidence exists that the planet has been warming over the last several decades, while 25% think that such evidence does not exist.

The UN report found that continued emission of greenhouse gases will cause further warming, increasing the likelihood of "severe, pervasive and irreversible impacts for people and ecosystems." Island nations and coastal cities face inundation due to rising sea levels. Pal and Eltahir (2015) predicted that, by the end of this century, areas of the Persian Gulf could be hit by severe waves of heat and humidity that would be "intolerable to humans." The global volume of weather-related insurance losses has more than tripled since the 1980s. A 2016 World Bank report predicted that more than 100 million people could be driven into extreme poverty by 2030, unless actions are taken to protect the world's poor from climate change catastrophes such as crop failures, natural disasters, and waterborne diseases.

18.3 Regulating Externalities

Because competitive markets produce too many negative externalities, government intervention may provide a social gain. In 1952, London suffered from unusually thick "peasouper" fog—pollution so dense that people had trouble finding their way home—that killed an estimated 4,000 to 12,000 people. Those dark days prompted the British government to pass its first Clean Air Act, in 1956.[3] The United States and Canada passed Clean Air Acts in 1970.

Now virtually the entire world is concerned about pollution. Carbon dioxide (CO_2), which is primarily produced by burning fossil fuels, is a major contributor to global warming, damages marine life, and causes additional harm. China and the United States are by far the largest producers of CO_2 from industrial production, as Table 18.1 shows. The amount of CO_2 per person is extremely high in Australia, Canada, Russia, and the United States. China and Russia have a very high pollution to gross domestic product (GDP) ratio. The last column of the table shows that China and India at least doubled their production of CO_2 since 1990, while only a few countries—such as France, Germany, Russia, and the United Kingdom—reduced their CO_2 production.

China produces 27% of the world's CO_2, the United States spews out 17%, and India and Russia are each responsible for 5%. Thus, these four countries are responsible for half of the world's CO_2.[4]

Developing countries spend little on controlling pollution, and many developed countries' public expenditures on pollution regulation have fallen in recent years. In response, various protests have erupted. China and India now face regular pollution protests.

Nonetheless, politicians in countries around the world disagree about how and whether to control pollution. Most U.S. Congressional Democrats favor stronger pollution controls but most Republicans call for reducing such regulations. Australia imposed a tax on carbon in 2012, repealed it in 2014, and may reinstate it. Similar fights occur in Canada and European nations. Clearly, pollution control will be a major bone of contention throughout the world for the foreseeable future. The one bright spot is that

Table 18.1 Industrial CO_2 Emissions, 2011

	CO_2, Million Metric Tons	CO_2 Tons per Capita	CO_2 kg per \$100 GDP	Percentage Change in CO_2 Since 1990
China	9,020	6.6	65	267
United States	5,306	16.8	34	10
India	2,074	1.7	35	200
Russian Federation	1,808	12.6	56	−13[a]
Japan	1,188	9.3	27	9
Germany	729	8.8	21	−22[b]
Canada	485	14.1	36	12
United Kingdom	448	7.2	19	−19
Mexico	467	3.9	25	48
Australia	369	16.2	40	40
France	339	5.3	14	−10

[a]Since 1992; [b]Since 1991.

Source: CO_2 emissions in metric tons (CDIAC): **http://mdgs.un.org/unsd/mdg/Data.aspx** (viewed July 17, 2016).

[3]King Edward I established an air pollution commission in 1286 to reduce London's smog. At the commission recommendation, he banned burning coal in the city, with a punishment of torture or death. **https://www.epa.gov/aboutepa/londons-historic-pea-soupers**.

[4]**http://www.ucsusa.org/**.

the 195 countries that attended an international meeting on climate change in Paris in 2015 agreed to national goals to restrict emissions. The agreement was ratified in 2016. However, with the election of President Trump, the participation of the United States is in doubt.

Suppose that a government wants to regulate pollution and it has full knowledge about the marginal damage from pollution, the demand curve, costs, and the production technology. The government could optimally control pollution directly by restricting the amount of pollution that firms may produce or by taxing the pollution they create. A limit on the amount of air or water pollution that may be released is called an *emissions standard*. A tax on air pollution is an *emissions fee*, and a tax on pollution discharges into air or water is an *effluent charge*.

Frequently, however, a government controls pollution indirectly, through quantity restrictions or taxes on outputs or inputs. Whether the government restricts or taxes outputs or inputs may depend on the nature of the production process. It is generally better to regulate pollution directly than to regulate output, because direct regulation of pollution encourages firms to adopt efficient, new technologies to control pollution (a possibility we ignore in our example).

Regulation can effectively reduce pollution. Shapiro and Walker (2015) observe that emissions of the most common air pollutants from U.S. manufacturing fell by 60% between 1990 and 2008 even though U.S. manufacturing output increased substantially. They estimated that at least 75% of the reduction was due to environmental regulation.

Emissions Standard

We use the paper mill example in Figure 18.1 to illustrate how a government may use an *emissions standard* to reduce pollution. Here the government can achieve the social optimum by forcing the paper mills to produce no more than 84 units of paper per day. (Because output and pollution move together in this example, regulating either reduces pollution in the same way.)

Unfortunately, the government usually does not know enough to regulate optimally. For example, to set quantity restrictions on output optimally, the government must know how the marginal social cost curve, the demand for paper curve, and pollution vary with output. The ease with which the government can monitor output and pollution may determine whether it sets an output restriction or a pollution standard.

Even if the government knows enough to set the optimal regulation, it must enforce this regulation to achieve the desired outcome. The U.S. Environmental Protection Agency (EPA) tightened its ozone standard to 0.075 parts per million in 2008. As of 2015, 36 areas were marginally out of compliance with this rule, three moderately, three severely, and two extremely (the Los Angeles-South Coast Air Basin and the San Joaquin Valley, California).[5]

Emissions Fee

The government may impose costs on polluters by taxing their output or the amount of pollution produced. (Similarly, a law could make a polluter liable for damages in court.) In our paper mill example, taxing output works as well as taxing the pollution directly because the relationship between output and pollution is fixed. However, if firms can vary the output-pollution relationship by varying inputs or adding pollution-control devices, then the government should tax pollution.

[5]See **http://www3.epa.gov/airquality/greenbook** for details on noncompliance with EPA standards, and go to **http://scorecard.goodguide.com/** to learn about environmental risks in your area.

Application

Why Tax Drivers

Driving causes many externalities including pollution, congestion, and accidents. Taking account of pollution from producing fuel and driving, Hill et al. (2009) estimated that burning one gallon of gasoline (including all downstream effects) causes a carbon dioxide-related climate change cost of 37¢ and a health-related cost of conventional pollutants associated with fine particulate matter of 34¢

A driver imposes delays on other drivers during congested periods. Parry et al. (2007) estimated that this cost is $1.05 per gallon of gas on average across the United States.

Edlin and Karaca-Mandic (2006) measured the accident externality from additional cars by the increase in the cost of insurance. These externalities are big in states with a high concentration of traffic but not in states with low densities. In California, with lots of cars per mile, an extra driver raises the total statewide insurance costs of other drivers by between $1,725 and $3,239 per year, and a 1% increase in driving raises insurance costs 3.3% to 5.4%. While the state could build more roads to lower traffic density and hence accidents, it's cheaper to tax the externality. A tax equal to the marginal externality cost would raise $66 billion annually in California—more than the $57 billion raised by all existing state taxes—and over $220 billion nationally. As of 2015, Germany, Austria, Slovakia, the Czech Republic, Poland, Hungary, and Switzerland have some form of a *vehicle miles traveled tax* (VMT), which is more clearly targeted at preventing congestion and accidents.

Vehicles are inefficiently heavy because owners of heavier cars ignore the greater risk of death that they impose on other drivers and pedestrians in accidents (Anderson and Auffhammer, 2014). Raising the weight of a vehicle that hits you by 1,000 pounds increases your chance of dying by 47%. The higher externality risk due to the greater weight of vehicles since 1989 is 26¢ per gallon of gasoline and the total fatality externality roughly equals a gas tax of between 97¢ and $2.17 per gallon.

Taking account of both carbon dioxide emissions and accidents, Sheehan-Connor (2015) estimates that the optimal flat tax is $1.14 per gallon. In 2014, the International Monetary Fund (IMF) estimated the optimal tax for the United States as $1.60 per gallon for gasoline and $2.10 for diesel.

To reduce the negative externalities of driving, governments have taxed gasoline, cars, and the carbon embodied in gasoline. However, such taxes have generally been much lower than the marginal cost of the externality and have not been adequately sensitive to vehicle weight or time of day.

Benefits Versus Costs from Controlling Pollution

The Clean Air Act of 1970 and the Clean Air Act Amendments of 1990 cleansed U.S. air. Between 1980 and 2015, the national average of sulfur dioxide (SO_2) plummeted 84%, carbon monoxide (CO) fell 84%, lead dove 92%, nitrogen dioxide (NO_2) tumbled 59%, and ozone dropped 32%.[6]

The EPA believes that the Clean Air Act saves over 160,000 lives a year, avoids more than 100,000 hospital visits, prevents millions of cases of respiratory problems, and saves 13 million lost workdays. The EPA (2011) estimated the costs of complying with the Clean Air Act were $53 billion, but the benefits were $1.3 trillion in 2010. Thus, the benefits outweighed costs by nearly 25 to 1.

Application

Protecting Babies

Some policy changes raise benefits and *lower* costs. For example, E-ZPass reduces congestion and pollution and increases babies' health. The E-ZPass, an electronic toll collection system on toll ways in New Jersey, Pennsylvania, and 12 other states, allows vehicles to pay a toll without stopping at a tollbooth.

[6] According to **https://www.epa.gov/air-trends** (viewed July 21, 2016).