# Teaching Innovation in Principles of Microeconomics Classes

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October 15, 2008

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## ABSTRACT

The author presents multiple ways of integrating innovation theory into many of the topics typically covered in Principles of Microeconomics classes.

## INTRODUCTION

Few Principles of Microeconomics instructors spend anywhere near as much time on innovation as they do on, say, perfect competition or elasticities.[1] Yet understanding innovation undoubtedly gives students a much greater understanding of our economy than understanding perfect competition or elasticities does, and surely most students would find innovation far more interesting than such subjects. Innovation, I believe, is often neglected in Principles of Microeconomics classes because it's challenging to work the topic into the material traditionally covered in the course.

In this paper I show how Principles of Microeconomics instructors can integrate the teaching of innovation into many of their lectures. This paper is user friendly for instructors. It lists many topics that are often covered in Principles of Microeconomics classes. After each topic the paper provides innovation-related theory and often provides examples that an instructor could use when covering the topic. I wouldn't expect any instructor to use all of the information in this paper; rather, this paper provides a menu of innovation material an instructor can choose from to enrich the course.

## TOPICS

### 1. Positive Externalities and Spillovers

**Theory for students:** Technological spillovers are an example of a positive externality. Technological spillovers result in markets producing a socially sub-optimal amount of innovation.

The "rate of diffusion" of an innovation refers to how quickly it spreads throughout an economy. A high rate of diffusion produces both costs and benefits to an economy. Under a high rate existing innovations spread quickly. And such a rapid

[1] As a recent Principles of Microeconomics textbook author I have come to be very familiar with what is covered in Principles of Microeconomics classes in part because of the extensive surveys of Principles' instructors that my publisher conducted and often shared with me..

spread helps new innovators build upon existing innovations. But a high rate of diffusion also reduces the profits that innovators capture from their works and so reduces incentives to innovate.

**Applications and Examples:**

(a) Because innovators have difficulty capturing the gains from basic research, most of the gains from such research are spillovers. Point to these spillovers to justify government funding of college professors' research.

(b) Xerox developed the first graphical user interfaces for computers. These interfaces allowed people to interact with computers by clicking on visual icons rather than by typing in text. Xerox captured very little of the gain from developing graphical user interfaces because it didn't understand their full value. Microsoft and Apple, however, did see the potential of graphical user interfaces and used them to build business dynasties.

Interestingly, Apple co-founder Steve Jobs accused Bill Gates of stealing the concept of the graphical user interface from Apple. Gates supposedly retorted: "Well, Steve, I think there's more than one way of looking at it. I think it's more like we both had this rich neighbor named Xerox and I broke into his house to steal the TV set and found out that you had already stolen it." (Smith and Kiger 2004, 184)

(c) Everything you have used that was invented more than 50 years ago is a technological spillover since you have paid nothing to the inventor.

(d) Hall (2005, 459) presents an interesting example of technological diffusion[3]:

> In 1953, a young female Macaque monkey in the south of Japan washed a muddy sweet potato in a stream before eating it. This obvious improvement in food preparation was imitated quickly by other monkeys and in less than 10 years it became the norm in her immediate group; by 1983, the method had diffused completely. In 1956, the same monkey innovated again, inventing a technique in which handfuls of mixed sand and wheat grains were cast upon the sea, so that the floating cereal could be skimmed from the surface. Again, by 1983, this method of gleaning wheat had diffused almost completely throughout the local populations of Macaques.

## 2. Intensely Competitive Markets

**Theory for students:** Successful innovations made by firms in intensely competitive markets will be copied quickly. By definition there are few barriers in these markets that in the long run prevent firms from copying each other's innovations. Also, any firm that doesn't copy a successful innovation will be forced to exit its industry.

Because successful innovations are so quickly copied, firms in extremely competitive markets have low incentives to develop their own innovations. A firm in such a market knows that if its innovation fails it alone will bear the cost, whereas if the innovation is successful all firms in its industry will copy it and so eliminate the competitive advantage to the innovating firm. Consequently "few, if any, economists maintain that perfect competition efficiently allocates resources for technical advance" (Kamien and Schwartz 1975, 2). Although perfectly competitive markets maximize the sum of consumers' and producers' surplus they are often not the best market structures for promoting economic growth because they produce limited incentives for innovation by firms.

**Application:** No single innovation can result in a firm in an extremely competitive industry making a positive long run profit. If, for example, an innovation reduces a firm's costs, then for a short period of time this firm's average total cost will be below the market price and consequently the innovating firm will make a positive economic profit. But as the innovation is copied all other firms' costs will fall, which will cause output to expand, which will eventually lower the market price to the point where it is again equal to the innovating firm's average total cost. The only way a firm in an intensely competitive market could earn a long run positive profit from innovation would be if it continually innovated.

## 3. Profit-Maximizing Monopolies' Incentives To Innovate

**Theory for Students:** Profit-maximizing monopolies keep more of the gains from their innovations than firms in competitive markets do, meaning that monopolists' innovations result in fewer technological spillovers than do the innovations undertaken by other types of firms. Consequently, innovation would be increased in many intensely competitive markets if a single firm acquired a monopolistic position in the market. Students are usually taught that monopolies harm an economy, but when incentives to innovate are considered the net welfare consequences of monopolies become theoretically ambiguous.

**Example:** Consider the market for Vitamin D. Some scientists believe that taking large doses of Vitamin D greatly reduces your risk of cancer. But nobody is sure if this is true, and it's certainly possible that consuming mega-doses of the vitamin could overall harm your health. Pretend that it would cost $50 million to run the clinical trials necessary to determine the net health benefits of Vitamin D. If one firm had a monopoly on the sale of the vitamin it would almost certainly spend the $50 million because if the vitamin proved to be a strong cancer fighter the firm would reap billions in revenue from selling the vitamin.

But now, realistically, assume that anyone has the right to sell Vitamin D. Let's say that one firm did spend $50 million on clinical trials and these trials did show that taking mega doses of Vitamin D had tremendous health benefits. The demand for Vitamin D would skyrocket. But many firms would meet this demand and competition among them would likely drive the price of Vitamin D down to its marginal cost of production. The firm that spent the $50 million, therefore, would probably never recover

its investment. Predicting all of this, no firm would undertake the innovative research necessary to determine the health properties of the vitamin.

## 4. Monopolies and Innovation Suppression

**Theory for Students:** A profit-maximizing monopolist should almost never suppress one of its own innovations if the monopolist doesn't have a product that is "better" than the innovation. A monopolist, however, has somewhat diminished incentives to spend money to improve one of its existing products. As Apple co-founder Steve Jobs said, "What's the point of focusing on making the product even better when the only company you can take business from is yourself?" (*Business Week* 2004).

**Clarifying Example:** Imagine, for example, that a firm develops a superior battery that lasts ten times longer than an ordinary battery does but costs the same to produce. Further assume that the firm successfully patents this superior battery. Those unfamiliar with economics might argue that the firm wouldn't release the battery because it would decrease the total number of batteries a consumer must buy. But an economics student should understand that the monopolist could charge much more for this battery since consumers should be willing to pay (roughly) ten times as much for this superior battery as it would for a regular battery. Furthermore, since it's cheaper to make one superior battery than ten ordinary batteries the monopolist will earn greater profits by selling its superior batteries.

If a monopolist accidently discovered the superior battery mentioned in the last paragraph , it would market the battery. But a firm that already had a monopoly on batteries would be willing to spend less, compared to other firms, to develop such a superior battery. This is because the superior battery would reduce the profits that the monopolist earned from its existing product line.

## 5. Monopolists and Employee Laziness

**Theory for Students:** The barriers to entry protecting a monopoly's profit can reduce employees' incentives to innovate. Imagine that if the employees of some firm work extremely hard for one year they will develop an innovation that improves the quality of their firm's products. First let's assume that this firm is in a competitive market. The innovation will boost the firm's profits. Also, if this firm doesn't innovate, its competitors might. And in competitive markets, firms that fall behind often lose customers and must fire employees.

Now imagine that our firm is a profitable monopolist. The innovation will bring the monopolist higher profits. But if the monopolist doesn't innovate, it will still keep its old customers. Lack of innovation, therefore, won't compel the firm to fire any workers. The monopolist's employees, consequently, don't have the same personal incentives to work hard developing the innovation as they would if their firm were in a competitive market.

**Analogy:** Consider a studying analogy involving two students, each with a 70 percent grade point average. Both attend a college where you lose all financial aid if your average goes below 70 percent. One student, Oliver Twist, is on financial aid and will have to drop out if his grade point average falls below 70 percent. The other student, Richie Rich, doesn't receive financial aid. Richie Rich probably won't work as hard as Oliver Twist because he has less to lose if his grade point average falls. Similarly, employees working for a monopoly protected by strong barriers to entry know that even if they are lazy their firm won't be forced to shut down.

## 6. Monopolists and Potential Competition

**Theory for Students:** The possibility of innovation should scare even the most seemingly secure monopolist.

**Example:** In 1877 Western Union dominated the telegraph market. The firm failed to recognize the threat from telephones and so turned down the opportunity to buy the key telephone patent for $100,000 (Rosenberg 1994, 219).

**Application:** Failure to anticipate innovation has caused antitrust regulators to overestimate the staying power of monopolies. For example, in 1998 the U.S. filed an antitrust suit against Microsoft. Lawrence Lessig, then a Harvard law professor who was to be appointed a Special Master by the judge presiding over the antitrust case, believed that the government had to regulate Microsoft because the software giant faced no serious competition to its operating system. Lessig was aware of the open-source operating system Linux, but didn't think that it could ever seriously compete with Microsoft because, as Lessig has written about his beliefs at the time, "only crazies imagined that volunteers outside the control of a corporation could successfully create a system over which no one had exclusive command" (Lessig 2007). Showing a degree of honesty uncharacteristic of government agents (or college professors), Lessig now admits he greatly underestimated the competitive threat that Linux would, or even could, pose to Microsoft.

## 7. Price Discrimination

**Theory for Students:** By increasing the total revenue a firm might receive from a new product, price discrimination increases incentives for innovation.

**Example**: Price discrimination causes firms to sell low marginal cost goods at very low prices to poor people in poor countries. Although it might cost hundreds of millions to develop a new AIDS drug, the marginal cost of making a copy of the drug might be only a few cents. If the drug's developer could price discriminate it would profit from selling the drug to poor Africans for any amount above the drug's marginal cost. And pharmaceutical companies are more willing to develop a drug if they know that through

price discrimination they can profit by selling the drug to poor Africans. Of course, if governments in rich countries complain about Africans paying much lower prices for drugs than their citizens do, companies might feel compelled to stop selling the drugs to poor Africans, and so would be less willing to create new drugs.

## 8. Unions

**Theory for Students:** Innovations often reduce a firm's demand for labor. For example, because of innovation in the textile industry "[i]n spinning the number of direct labor hours required to process 100 pounds of cotton declined from 300 in 1790 to 135 in 1820" (Bruland and Mowery 2005, 353). Unions often object to labor saving machines. Sometimes, however, a powerful union won't resist innovation because it raises workers' productivity and so increases the union's negotiating strength.

If only a few firms in an industry are unionized then unions will have difficulty suppressing innovation because if they do non-unionized firms will have lower costs and so may drive the unionized firms out of the industry.

**Examples:** John L. Lewis, the head of the United Mine Workers union until 1960, "gave the employers a free hand in [implementing new innovations]… and then [compelled] them to pass on much of the gains to workers in the form of higher wages"(Mansfield 1968, 150).

In 1960 the longshoremen allowed port operators to implement labor saving technologies in return for guaranteeing all longshoreman a level of pay "even if there was not work for everyone" (Greenhouse 2002). As an expert on labor relations said "the productivity gains were so phenomenal that it was easy for the employers to pay high salaries" (Greenhouse 2002).

Firms sometimes compensate union members in return for the union allowing them to implement labor saving innovations. For example, in 1958 workers at the Columbia Broadcasting System (CBS) went on strike over fears that the introduction of videotape would eliminate jobs. The union agreed to end the strike after CBS agreed to make "severance pay of up to thirteen weeks' wages for layoff or dismissal due to automated processes" (Mansfield 1968, 152).

## 9. Oligopolies

**Theory for Students:** Oligopolists often capture fewer of the gains of their innovation than monopolists do, giving the oligopolists lower incentives to conduct some types of innovation. Oligopolists, however, are much more willing than monopolists are to engage in disruptive innovation, innovation that reduces the value of existing products.

**Examples:** Imagine that Toyota is considering spending $7 billion to create a computer-controlled car. Toyota, let's say, figures that after spending the $7 billion it could generate $10 billion in profits from sales of these cars, giving it a net profit of $3 billion. But Toyota realizes that sales of computer-controlled cars would greatly reduce sales of

human-operated cars and, say, reduce the world-wide profits from selling this type of car by $4 billion. If Toyota were a monopoly seller of cars it would never develop the computer cars. But since most human-controlled cars are not sold by Toyota most of the harm caused by the sale of computer-controlled cars would fall on other firms. As a consequence, because Toyota is not a monopoly provider of cars, it *will* spend the $7 billion needed to create the computer-controlled vehicles.

Some politicians call on oil companies to find alternatives to fossil fuels that would greatly reduce the demand for fossil fuels. But such alternatives would be a disruptive innovation that would decrease the value of oil companies' existing assets. Consequently, oil companies have fewer incentives, compared to other firms, to develop energy alternatives.

Disruptive innovation could, theoretically, result in too much innovation compared to what is socially optimal.

Examples of disruptive innovations include:[4]

| **Innovation or Innovating Company** | **Disrupted the Market for** |
|---|---|
| Telephone | Telegraph |
| Dell Inc. | Retail computer sellers |
| Email | Mail |
| McDonald's | Mom-and-Pop diners |
| Craig's List | Newspaper classified ads |
| Expedia.com | Travel agencies |
| Amazon.com | Physical book stores |
| Linux | Microsoft's operating system |
| Word processors | Typewriters |
| Online dating sites | Singles' bars |
| Wikipedia | Encyclopedias |
| Cell Phones | Land line phones |
| Online pornography | Offline pornography |

## 10. Prisoners' Dilemma and How Oligopolistic Collusion Can Decrease Innovation

**Theory for Students:** Oligopolies can end up in a prisoners' dilemma in which competition forces them to innovate more than they would if they could come to a binding agreement with other firms not to innovate.

**Example:** Consider an industry with two firms. Assume that if just one firm innovates it will capture the entire market, but if both firms innovate each will keep the same market share as before and the total size of the market will increase by only a trivial amount. Absent collusion, the logic of the prisoners' dilemma will compel both firms to innovate.

The firms, however, could potentially come to a collusive agreement to avoid innovating. But it's often harder for oligopolies to escape from an innovators' prisoners' dilemma than it is for them to escape from a pricing prisoners' dilemma.

In the traditional two firm pricing prisoners' dilemma game each firm has a dominant strategy of setting a low price but both firms are better off if they both set a high price than if they both set a low price. In a one period game rational firms will always play their dominant strategy. But in a repeated game each firm might choose a strategy of setting a high price this period so long as the other firm sets a high price in all the previous periods. Each firm will reason that its rival could gain a temporary advantage from setting a low price. But since it's quick and easy to match a price cut, this advantage will be temporary. And neither firm is likely to risk upsetting an implicit agreement to maintain high prices for a mere momentary advantage.

But now imagine that two firms must decide whether or not to innovate. Analogous to the pricing prisoners' dilemma, assume that each firm has a dominant strategy of innovating but both firms are better off if neither innovates than if both innovate. It would be very dangerous for any one firm to follow a strategy of not innovating so long as it observes its rival not innovating. This is because although a price cut can be matched quickly it takes much longer to match a rival's innovation. So let's say both firms agree not to innovate. One firm could secretly spend three years innovating and then capture much of its rival's market share by releasing a superior product. This market share would be kept until the rival had time to innovate. Fearing such a long-term loss, the firms would find it extremely challenging to come up with a credible agreement not to innovate.

## 11. Prisoners' Dilemma and How Oligopolistic Collusion Can Increase Innovation

**Theory for Students:** The free rider problem created by technological spillovers might cause oligopolists to engage in less innovation compared to what would maximize their collective profits.

**Examples:** Imagine that in some two firm industry each firm has the option of spending $3 million on innovation. Pretend that such spending would reduce the innovating firms' costs by $2 million, and also reduce its fellow oligopolists' costs by $2 million. Regardless of what the other firm does, each firm is better off not innovating. But both firms are better off if they both innovate than if neither innovates. The firms, therefore, would benefit from a binding agreement in which they both innovated.

A real-life example of such pro-innovation collusion is SEMATECH, which is an organization founded by 14 U.S. semiconductor firms and the U.S. government to engage in basic research on semiconductor manufacturing.

## 12. Innovation and Existing Oligopolistic Collusive Arrangements

**Theory for Students:** It's often challenging for oligopolies to come up with effective agreements not to compete on price. New technologies can upset such arrangements and so might be shunned by oligopolies.

Oligopolies often use innovation to engage in product differentiation in the hopes of reducing price competition. Such product differentiation reduces the benefits to oligopolists from undercutting its rival and thus increases the stability of existing collusive arrangement

**Example:** In the 1950s large steel firms were surprisingly slow to adopt superior steel making technologies and instead these new technologies were first implemented by small firms. Drawing on this, two economists concluded that sometimes "small firms may be the innovators because, unlike their giant rivals, what they do in the way of cost reductions is unlikely to cause so violent a disturbance of the status quo" (Adams and Dirlam 1966, 188).

## 13. Expectations and Demand Curves

**Theory for Students:** Expectations about future innovations influence demand curves. Quality improving innovations on a substitute or complement for a good also influence a good's demand curve.

**Example:** When the first gasoline cars became commercially available many consumers were reluctant to buy them because they expected Thomas Edison would soon invent a "superior and cheaper electric automobile" (Stern 1937, 43).

## 14. Elasticities

**Theory for Students:** The potential for innovation increases a good's long run price elasticity of supply because as the price of a good goes up firms have increased incentives to find ways of lowering the cost of making the good.

Innovation also increases a good's long run price elasticity of demand because as a good's price goes up consumers will find innovative ways of substituting new goods for the now more expensive good. Furthermore, as the price of a good goes down innovative consumers will eventually find additional uses for the good. For example, if the price of shrimp falls innovative cooks will develop new shrimp recipes and so use more shrimp than they would have absent innovation.

## 15. Market Efficiency

**Theory for Students:** Although (absent externalities) unfettered perfectly competitive markets squeeze the most possible wealth out of the production and sale of a good, what really matters for the long-term performance of an economy is innovation that improves existing goods and creates new goods.

## 16. Adam Smith's Invisible Hand

**Theory for Students:** If an innovator can capture much of the gains from his innovations then he will seek to create the innovations that consumers are willing to pay the most for. Consumers might not even be aware of how much they would value a new good. Innovators therefore must seek to satisfy desires consumers don't even realize they have.

## 17. Costs

**Theory for Students:** Many technology-intensive products such as software and pharmaceutical drugs have high fixed costs. Firms will incur the fixed costs of developing such products only if they can potentially sell the products to many customers. International trade, population growth, and (for normal goods) economic growth increase the number of customers who might buy a new product. These three factors, consequently, all produce incentives for innovators to create new high fixed cost goods.

**Example:** Imagine that consumers will pay $3 a pill for a new drug. Further assume that the fixed costs of developing the drug are $2 billion, whereas the marginal cost of making each drug is $1. A firm will create this drug only if its average total costs are below $3, which will occur only if the firm could sell more than one billion pills.

## 18. Learning By Doing

**Theory for Students:** As workers build more copies of a product they often figure out better ways of doing their required tasks, These micro-innovations induced by workers' "learning by doing" often cause marginal costs to fall as output increases.

**Examples:** Liberty Ships were cargo vessels produced in the United States between 1941 and 1945. Although the design of these ships stayed exactly the same, the amount of labor needed to build a Liberty Ship in a given ship yard greatly decreased after the production of each ship (Searle 1945).

## 19. Trade

**Theory for Students:** Countries import technology through trade. Chinese firms, for example, have gained significant knowledge by thoroughly studying factories that rich nations have set up in China. Trade enhances incentives for innovation by increasing the number of customers who might buy a new product and so lowering that product's expected average fixed cost. Trade in people (immigration) allows human brains to travel to more productive lands for innovation.

## 20. Specialization

**Theory for Students:** The greater the division of labor, the more workers become experts in their area and so the more likely they are to innovate. As Adam Smith (1776) wrote:

> Men are much more likely to discover easier and readier methods of attaining any object, when the whole attention of their minds is directed towards that single object than when it is dissipated among a great variety of things. But in consequence of the division of labour, the whole of every man's attention comes naturally to be directed towards some one very simple object. It is naturally to be expected, therefore, that some one or other of those who are employed in each particular branch of labour should soon find out easier and readier methods of performing their own particular work, wherever the nature of it admits of such improvement. A great part of the machines made use of in those manufactures in which labour is most subdivided, were originally the inventions of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts towards finding out easier and readier methods of performing it. Whoever has been much accustomed to visit such manufactures, must frequently have been shewn very pretty machines, which were the inventions of such workmen, in order to facilitate and quicken their own particular part of the work. In the first fire-engines, a boy was constantly employed to open and shut alternately the communication between the boiler and the cylinder, according as the piston either ascended or descended. One of those boys, who loved to play with his companions, observed that, by tying a string from the handle of the valve which opened this communication, to another part of the machine, the valve would open and shut without his assistance, and leave him at liberty to divert himself with his play-fellows. One of the greatest improvements that has been made upon this machine, since it was first invented, was in this manner the discovery of a boy who wanted to save his own labour.

## 21. Property Rights

**Theory for Students:** Patents and copyrights are a means of internalizing some of the positive externalities of innovation, but by creating monopolies they also create some deadweight losses. Patents and copyrights reward innovators in proportion to the market value of their innovations without requiring the government to determine the worth of the innovations.

**Examples:** Widespread Internet piracy of copyrighted movies, music and software may have reduced innovation in these sectors. Interestingly, significant innovation has occurred in free software projects such as Wikipedia and Linux even though they purposefully reject property rights.

A country that doesn't have strong patent protection has less innovation in industries in which patent protection is important. A study of 15,000 innovations in the

catalogues of the 1851 and 1876 Worlds Fairs showed that "innovation in countries without patent laws [focus] on industries where alternative mechanisms to protect intellectual property are effective" (Moser 2005, 1214).

## 22. Public Goods

**Theory for Students:** Many types of innovation are public goods and so may not be produced by the marketplace.

**Example:** A justification for government support of college research is that much of said research constitutes public goods that wouldn't come into being without government subsidies.

## 23. Natural Resources

**Theory for Students:** The earth does contain a finite amount of natural resources such as oil. But as the price of oil goes up, innovators gain more from finding (1) substitutes for oil, (2) technologies that allow for the acquisition of oil from previously inaccessible sources, and (3) ways for existing products to use less oil. Rising market prices, therefore, induce innovators to lessen the harm of dwindling natural resources.

**Past Predictions:** In 1865 economist William Stanley Jevons predicted that the English economy was doomed because it would soon run out of coal, and there could be no good substitute for coal. Because of this Jevons wrote that England's "present happy progressive condition is a thing of limited duration "(Jevons 1865). Jevons believed that the only solution was to drastically slow down the English economy. Jevons underestimated the power of innovation to compensate for the continued consumption of earth's finite quantity of coal.

In 1980 many intellectuals such as ecologist and best-selling author Paul R. Ehrlich believed a growing scarcity of natural resources would someday cause the world's economy to crash. These intellectuals thought that since (1) the total quantity of any natural resource was fixed, and (2) we don't get back the natural resources that have already been consumed, and (3) the human population is increasing thereby putting greater demands on natural resources, then natural resources would continually become scarcer and scarcer. Economist Julian L. Simon, however, disagreed. Simon thought that market incentives and human innovation would make natural resources more abundant in the future.

In 1980 Ehrlich and Simon agreed to bet money on their respective beliefs. Ehrlich chose 5 metals — chrome, copper, nickel, tin and tungsten, and bet that their average inflation adjusted prices would be higher in 1990 than it currently was. Unfortunately for Ehrlich, the price of all five metals fell and Ehrlich had to pay $576.07 to settle the bet. Ehrlich, however, didn't believe that the bet's outcome held any significance for the future as he said (Tierney, 1990):

> The bet doesn't mean anything. Julian Simon is like the guy who jumps off the Empire State Building and says how great things are going so far as he passes the 10th floor. I still think the price of those metals will go up eventually, but that's a minor point. The resource that worries me the most is the declining capacity of our planet to buffer itself against human impacts.

## 24. Pollution Control

**Theory for Students:** When governments use command and control methods for reducing pollution they create no incentives for innovation. After all, if a firm is told exactly what type of pollution-reducing technology it must use, the firm has no incentives to find better technologies. In contrast, when governments reduce pollution by implementing Pigouvian taxes or tradable permits they create significant incentives for innovation. A firm that must pay a pollution tax obviously pays less if it can figure out how to pollute less. Similarly, under a tradable permit system a firm that pollutes less need buy fewer permits. Most importantly, however, when firms face a positive marginal cost for polluting they will pay for pollution-reducing technologies developed by others and so will create a market for such technologies.

## 25. Inequality

**Theory for students:** Innovation can increase or decrease inequality. Much income inequality is caused by inequality in skills. When innovation "deskills" jobs it therefore reduces inequality. As Richard Posner (2008) has written:

> Fifty years ago, a driver had to know how to change a tire and put chains on a tire, how to check the engine's oil level and the water level in the radiator, and how to start a car in freezing weather. These skills are no longer required. Most cashiers no longer need to know how to make change; the cash register tells them how much change to give the customer. Printers no longer need to know how to set type upside down. With advances in neuroscience, artificial intelligence, computer science, robotics, and nanotechnology, many jobs that require a college education today will require little in the way of education tomorrow.

Innovation can likewise increase inequality by creating demand for tasks that can be completed only by high skilled laborers.

## 26. The Future of the Economy

Where will innovation take the economy over our students' lifetimes? Innovation is driven by intelligence. Innovation, however, is improving the intelligence available to

humanity. Pharmaceutical companies are currently working on drugs that improve human intelligence. How will these drugs influence future innovation? And, perhaps more importantly, within 40 years computers may vastly exceed humans in intelligence. No doubt these smart machines will be put to work increasing their own intelligences. What innovations will these super-smart machines create?

## NOTES

1. A draft of this paper was presented at the 2008 Association of Private Enterprise Education conference.

2. As a recent Principles of Microeconomics textbook author I have come to be very familiar with what is covered in Principles of Microeconomics classes in part because of the extensive surveys of Principles' instructors that my publisher conducted and often shared with me.

3. Footnote omitted. Material cited to Kawai, Watanabe, and Mori (1992).

4. Many of these examples are taken from Christensen and Raynor (2003).

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