1. Environment-oriented, product registration, and product oversight.
2. Environment-oriented statutes are the most common, and they are focused on the level of contamination of some aspect of the environment.
3. Product registration statutes require that particular kinds of products be approved by the government before they can be manufactured or marketed. The Federal Food, Drug, and Cosmetic Act' and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) are the only two health and safety statutes in this category.
4. Product oversight statutes focus on particular products but do not require government approval for new products. The Hazardous Substances Act, the Consumer Product Safety Act, the Flammable Fabrics Act, and the Toxic Substances Control Act are examples.
5. The Standard Industrial Classification Manual contains eight major divisions of chemicals and allied products: industrial inorganic chemicals; plastics, synthetic rubber, and man-made fibers; drugs; soaps, detergents, and cosmetics; paints, varnishes, and allied products; agricultural chemicals; industrial organic chemicals, and miscellaneous chemical products.
6. To understand chemical innovation, three interrelated levels or models must be considered: the industry level, the company level, and the product level.

A. Industry-Level Effects: Market Concentration

Government regulation may have the effect of increasing concentration in an industry by increasing the cost of developing and marketing products and thereby eliminating all but large firms from the market. This effect, if it occurs, will probably influence the rate and type of innovation that takes place in the industry, although the existing literature contains contradictory findings on the relationship between innovation, on the one hand, and industry concentration and the size of a firm, on the other.

B. Company-Level Effects: Research and Development

There are two types of innovation-related decisions that are applicable to an entire company, not just to an individual product. The first is the philosophy or strategy that the firm wants to pursue with respect to innovation. The second is the annual decision of how much to invest in research and development. The specific decisions within a firm regarding innovation are governed, implicitly or explicitly, by the corporate strategy of innovation. Such strategies are of great importance, but they are also elusive because they can take a variety of forms, and only rarely are they explicitly documented. The most basic strategy choice, in the realm of innovation, is whether a firm wants to engage in innovative product activity at all.

C. Product-Level Effects: The Commercialization Decision

The analysis done by a firm to decide whether or not to commercialize a new product depends on the type of product line, the size of the firm, and the amount of investment necessary to bring the new product to market. A specialty chemical firm deciding to make fifty pounds of a new chemical may not do much more than a back-of-the-envelope calculation to determine the selling price. At the other extreme, a large firm may spend months analyzing alternative scenarios of cash flow, return on investment, etc., before deciding to proceed with a major new product.

1. FAVORABLE EFFECTS OF REGULATION ON INNOVATION

Although the negative effects of regulation on innovation have received the most attention, there are major favorable effects as well. The most obvious favorable effect is the shift in corporate strategies and procedures so that new products and new plants are safer and healthier. Pollution control at new plants and toxicological testing of new products are now important considerations which have been institutionalized in the structure of most major corporations. The effect may

not be to increase the number or dollar value of new products or processes, but the quality of innovations has been changed and the decision making processes leading

to innovations also have been changed.

1. A. Process Innovations

Pollution control and other environmental or health regulations have stimulated the development and adoption of a number of innovative production processes. For example, a number of electrolytic caustic soda-chlorine plants have converted from using mercury cells to diaphragm cells, and from using graphite anodes to dimensionally stable anodes. Although costly, these changes have substantially reduced pollution problems and control costs and have increased plant efficiency within the industry. The new processes have helped domestic producers remain competitive with foreign producers and have reduced pressures for manufacturers to relocate abroad.

Many industries have found that the cost of complying with new regulations can be reduced through reclaiming and recycling material that previously was discharged into the air or water. The electroplating industry, for example, was expected to be one of the industries hit hardest by regulations covering toxic water effluents. Since the industry consisted primarily of small, local operations and, at the same time, was the largest contributor of toxic metal wastes into public sewage treatment plants, the EPA estimated that up to 20% of all electroplating firms would be forced out of business by the water regulations. This has not happened because technological advances, both in production processes and recycling techniques, have enabled many electroplaters to reduce their discharges of toxic wastes. This has not only reduced the toxic waste problem but has also led to major cost savings through the recycling of expensive metals.

Many chemical firms have introduced process changes in response to environmental regulations. A number of these changes have led to more efficient production. However, it should not be implied that firms typically save money bycomplying with pollution control regulations.

B. Product Innovations

Regulations can also result in product innovations. This innovation can happen in three ways. First, new markets may be opened because regulatory action removes existing products from the market or threatens to do so. The banning of DDT and the likelihood that other chlorinated hydrocarbon pesticides would be removed from the market encouraged the development and commercialization of alternative kinds of pesticides. Proposed regulations to limit the uses of

asbestos have led to a search for alternative materials. Second, apart from any direct regulatory action or threat, the existence of health and safety regulatory mechanisms may encourage companies to develop and market products whose commercial superiority rests in part on their being less hazardous for humans and the environment. The development of so-called biorational

pesticides is an example. Third, regulation can encourage the development of products necessary for implementing regulatory action. A wide variety of new pollution control products has been developed over the past fifteen years. Also, a number of devices for monitoring and analyzing chemicals have been invented and marketed because of the demand created by regulations.