

Technology: Tomorrow's Determinate^{1, 2}

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DEFENSE CONVERSION POLICY FOR OHIO

Defense Conversion

By 1996 more than 2,000,000 people directly employed in defense related work in the United States will become redundant, and will lose their jobs. About 150,000 will be Ohio residents. Congress has passed into law a defense conversion act in an effort to alleviate the negative effects of the lay-offs and to enhance the positive effects. Obviously, the social benefit occurs when these citizens are employed in useful occupations rather than in military occupations no longer necessary. More than one billion dollars has been allocated in order to accomplish the goals of defense conversion. This act of Congress is of unusual interest to Ohio scientists and engineers.

The goals of the program can be summarized as follows: 1) to minimize the adverse economic effects of the shift in public expenditure; 2) to assist the transition of defense production to civilian commercial production; 3) to enhance the competitiveness of industry by applying defense technologies; 4) to maintain the defense production capability; and 5) to enhance the quality of life.

The Ohio Department of Development is undertaking a coordinated, high level, serious, substantial effort to comply with federal guidelines established under the aegis of the act in order to assure that Ohio shares in the defense conversion effort.

The Ohio program goals encompass our entire state, and the program will use existing networks of services. The focus will be on technologies and product areas that are appropriate for Ohio. The Ohio Edison Program will be at the heart of the effort along with many other players. The principal Ohio objective is to provide technical manufacturing outreach to a number of Ohio cities in order to deploy advanced manufacturing technology throughout the state. The goals include work force training, business development, and the augmentation of electronic commerce. Ohio's plan for the science based military conversion program includes manufacturing extension programs using a model similar to the extension services of the Department of Agriculture.

The federal program envisions several dozen demonstration facilities placed at nodal locations, along with related technology transfer programs staffed by highly trained engineers to assist in the implementation of advanced manufacturing methods. These facilities will be teaching factories or demonstration factories that incorporate state-of-the-art technologies. The centers will be located at sites that combine comparative economic advantage based on historical presence of industrial sectors in the subregion, and strengths in university and corporate research and other activities related to the focus of the advanced manufacturing extension units. The technology focus is the relevant consideration. As outlined above the centers mirror the philosophy of the Thomas Edison Program of Ohio, and it is a fair conclusion that the federal government drew substantially from the Ohio success in defining the policy. The major focus is directed toward plants that are of small or medium size. Of course, training and retraining the skilled work force required for advanced manufacturing methods is an integral part of the overall program.

Defense Conversion is an industrial policy for the United States that addresses the layoffs caused by the shrinkage of the defense budget. The legislation is an initiative of several federal departments, including the Department of Commerce (National Institute of Science and Technology), the Department of Defense (Advanced Research Projects Agency), the Department of Energy, and the National Science Foundation (NSF).

Competitive Context

Fierce competition is the hallmark of contemporary markets. This observation applies to all kinds of businesses from retailing to high-tech manufacturing; and applies from very small operations to global adversaries. The reasons for the enhanced competitive nexus in which firms compete has many causes among which are: 1) the rise of international communication; 2) the increase in world population (doubling in 50 years or less), which promotes new entry by foreign entrepreneurs; 3) the general rise in educational achievement worldwide; 4) the deliberate policy initiatives by governments to promote entrepreneurship; and 5) the dynamic aspect of modern industrialism that offers new opportunities with new technologies (Gage 1993).

The interconnections of the world regions, including movements of commodities (both goods and services) and of people has opened opportunities to many. The widespread practice of students getting higher education in foreign countries, especially the United States, has augmented the possibilities for interregional trade across international boundaries. Likewise, the practice of bringing

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foreign military officers to the United States for training has also diffused the awareness and opportunities of enterprise. Of overwhelming significance, the multinational firm has been an engine for diffusion of technology, techniques, and organization to far-flung regions—regions linked by transport modes, telephone communications, data transmissions, satellite television broadcasts, and work station networks.

In retail sectors competition is so fierce that reports of bankruptcy, reorganization, and default are covered daily in the financial news. In manufacturing it is not unusual to be impacted by a new competitor whose very country is a surprise.

In the period before the 1970s, for many industries, very large capital investment was enough to assure an oligopolistic situation for the few firms sharing a national market. In today's world many foreign firms have capital resources of great magnitude. This factual condition suggests two other implications (*The Economist* 1993a).

International companies in manufacturing have typically multiple product lines and the entry of a company of very large scale into a new product line does not require the same degree of risk as a new entry by a single product firm. The organizational structures for analysis, implementation, and operation already exist within the multinational firm and many costs do not have to be attributable to a new product line. The threat of easy entry by multinational firms limits the price attainable by those already in the market. Another difference from earlier times is the existence of infrastructure that simplifies greatly foreign trade operations. Commercial export facilitation, departments of government, container shipping, satellite telephone communication, air passenger travel—all bear on the issue.

Product differentiation, advertising, and goodwill are all important aspects of marketing, but the price attainable is closely constrained in almost all important global mass markets. New entry is pervasive; no region is sacrosanct; no region is protected from competition. These comments are tantamount to stating that the long run demand curve perceived by many interacting firms in the contemporary world is nearly horizontal. The cost functions of the individual firms become the critical issue for regional development. This is true in Ohio and around the world (*The Economist* 1993b).

Diffusion Strategy

Because cost functions are the critical target in the contest for regional superiority, a conclusion is warranted. The State of Ohio should continue in the resolve to promote science based, best technology (in a minimum cost sense) for all of the firms that have establishments in Ohio. This implies technology transfer policy, that is, a technology diffusion strategy for Ohio. The policy can be articulated easily, but the implementation is difficult. These transformations of production techniques are expensive. The total cost exceeds the out-of-pocket charges that small and medium size firms are willing to pay for new technology. Nevertheless, it is of crucial importance for the future of Ohio that these technology transfers be made as rapidly as possible. The alternative—to use our

work force in obsolete techniques—will condemn the industrial work force of Ohio to successively lower remuneration as Ohio firms compete globally with firms from lesser developed regions.

Implementation of new technology requires research and development in process and product. Then, substantial private investments must be made to embody the new technologies in plant and equipment. The social good is enhanced by rapid deployment of the best techniques among our Ohio factories. The determinants for sustained economic growth in Ohio will be realized by conversion of production functions in our factories, and farms, and mines, and offices from state of practice to state-of-the-art. This is a viable, science-based industrial policy for Ohio to achieve a bright future for those who come after us.

ROLE OF TECHNOLOGY

Key Technologies

Key technologies are defined as pervasive technologies that increase productivity across a spectrum of industries. The definition has a time-based reference. For example, in Ohio today, one key industry is software. Computer programs can increase efficiency or reduce costs to every firm in Ohio. The applications are at every work station, from the check-out counter to the locomotive engine, to the teacher's desk. This industry in Ohio will have tremendous leverage to raise productivity. This is true even if the industry is small in terms of employment in each subregion. Software is clearly a key industry in every subregion of the nation. The relative simplicity of manufacturing automation based on software can be compared to the old method that required wheels, and drives, and gears, and cams, and reversing relays to connect machines together. The pay-off to Ohio is implied with every application of software programs. Moreover, software does not have to be invented here.

Ohio is fortunate to be a world leader in several key technologies that are heavily based on science. The reference is to materials technologies, such as casting and plating and including composites; joining technologies such as welding; and polymer technologies—plastics of all kinds, including molecular modeling, sheet extrusion, injection molding, and vacuum casting. Polymers also represent a high employment industry in Ohio—our fastest growing industry.

High Employment Industries

Industries that have the highest proportions of employment within a subregion are denoted "high employment industries." The significance of these industries to the subregion is manifest. Substantial employers are the most valued companies to most development directors because of the opportunities afforded to local citizens. The job base of a community is the most important basis for community economic health. If the proportion of jobs to work force is high then opportunities are high. In contemporary industrial states equity means having a job.

Tradeable goods that can be exported from the subregion are the basis of prosperity in Ohio, and have been since the development of Ohio canals. After the Civil War,

steel was a key industry for the nation and the industry was located in Pittsburgh in those early years. Iron was being replaced with a superior material. In a number of cities—Mansfield, Akron, Canton, Massillon, for example—steel was being used for the manufacture of high quality farm machinery. Productivity on the farms was spectacularly increased with the introduction of the new machinery made from steel—reapers, cultivators, plows. The farm machinery factories of northern Ohio were linked to Pittsburgh with customer/vendor relationships, and farm machinery was the “high employment industry” in a number of cities. Later the same cities attracted the steel industry, which became the most characteristic high employment industry of Northern Ohio cities—Cleveland, Lorain, Conneaut, Warren, Canton, and especially Youngstown. The largest coal port on the Great Lakes is still Toledo, made great by the enormous appetite of the coke furnaces providing the fuel for the blast furnaces, and the fuel for the steam engines in factories and power plants. Today the steel industry that remains is characterized by high chemistry production methods and massive investments, but the polymer industry now employs more people in northern Ohio than the steel industry at its zenith.

Ohio's Biomedical Industry

In 1992 the Edison Biotechnology Center (EBTC) published a directory of biomedical and biotechnology companies in Ohio. More than 250 firms were identified, not including agricultural and environmental biotechnology companies. The firms included in the catalog are focused on manufacturing, or research and development, or support services for biomedical applications. More than one third of the firms have sales between one and 10 million dollars, and about 42% have been in existence less than 10 years. The firms are small, but growing, and the picture is clearly that of an evolving industry, but an industry that is established in Ohio. This is important, because the next century will be the century of gene therapy (Baunach et al. 1993, Jaroff 1992).

Discovery in genetic engineering is accelerating around the world. The human genome project is on target. The situation is comparable to that of chemistry after the periodic table was enunciated. A century of basic research was required to fill in the cells of the table which led to an outburst of applied chemical science at the turn of the century. Dyes, aspirin, plastics, alloys, refining—all are chemical based discoveries that underlie great twentieth century industries. It can be persuasively argued that Germany's power and misuse of power in the first half of this century combined the industrial technologies for war making (solidly based on science) with an hysterical, programmatic, propaganda for racial superiority.

Gene therapy in the early part of the twenty-first century will be as far reaching for human health as the chemical industries were for war making. The human genome is being filled-in and the print-outs of our genetic make-up will follow soon listing our individual genetic health for a preponderance of all 100,000 genes. The knowledge being learned daily in our research laboratories will allow genetic intervention to alter and correct genetic defects in the living person. Any muscle will

function as an organ when the therapeutic DNA is injected. Gene therapy may largely replace chemical drug therapy (Financial Times Survey 1993b). Intervention in the womb is another obvious application in order to correct malfunctions before birth.

Some of the mini- and micro-firms of Ohio's biomedical industry will grow to become global players in the genetic revolution in human health; we are on the threshold.

Digital Communication

Ohio is not a significant player in the manufacture of digital communications equipment, nor does Ohio need to be. The power of digital communications is in the use of the technologies, which are certain to embrace and propel some efficient companies into global markets. Economies of scale will be measured by a worldwide standard and the significance of national borders to trading nations will continue to decline. Many observers have commented on the convergence of computers and communications. Driven by falling costs for microchips and exponential increases in speed of computation (now 200 million bits per second), the practicality of transmitting sound, video, still pictures, and data—all the features of multimedia—is now apparent. The recabbling of America with fiber optic lines is underway. Interactive communication and access to data bases and library information will have profound effects on producers and on society as a whole (Financial Times Survey 1993a, *Newsweek* 1993b).

Innovation occurs when new technology is successfully marketed. In the general case innovations are used in industries that have not created the new technologies. For example, large earth moving equipment is used in road-building and mining industries. It is in these using industries that successful early adopters reap very large commercial rewards. Ohio manufacturers have large stakes in international business. By early adoption of global digital communications the manufacturers of Ohio will utilize information more successfully and will more successfully compete in distant markets. Information networks for producers will characterize all aspects of business. For example, the stream of interactions with customers and design groups at both vendor sites and customer sites will be accomplished daily in real time measured in mips (millions of instructions per second) (*Newsweek* 1993a).

Personal communicators are already in use by some courier companies in order to track customers' shipments and their own personnel. Data transfer and fax communication from non-fixed locations are routine. Applications by Ohio companies will reduce costs, eliminate some middle management functions, devolve decision making, and at the same time increase control because operations will be transparent.

Environmental Issues

Hundreds of statutory and regulatory mandates have resulted from federal laws to protect the environment. These mandates require corporate behavior to assure clean water and clean air. By now the regulations require more than 11,000 pages of printed text. The requirements for clean (non-polluting) manufacturing processes have

changed relative cost structures in almost every industry and every product line produced in the United States. The entire interindustry fabric of inputs and outputs has been changed, but not uniformly. In this sense pollutants are final outputs like multiple product lines that are typical of contemporary factories, except that these outputs have negative prices. The result of this environmental legislation, which is deemed desirable by almost everyone, will be continuous industry adjustments to the new conditions. The social costs of bad safety practices and the social costs of respiratory disease and carcinogenic disease have been internalized and are now included in the price of the economic output instead of being externalized with the cost mainly borne by individuals that succumb to pollution related disease.

The process of addressing environmental problems associated with our factories, mines, farms, and households will take several decades (*Economist* 1992). The research agenda has not been defined but the research horizons are vast; and the potential for waste of both private and public funds is vast, also. Much of the money spent on superfund clean-up has been wasted (already billions of dollars) because of bad science. Production functions should be changed to the extent possible in order to design out of the process noxious, toxic, harmful outputs. At the same time we have to recognize that our high standards of living often depend on these toxic processes. For example, the beautiful skylights and window walls of our malls and super hotels have transformed the architectural landscape by use of a virtually unbreakable transparent plastic that has nasty by-products. On the other hand, nearly all of these nasty organic by-products break down to CO₂ and H₂O if incinerated at very high temperature. If we cannot design the pollutants out of the process then science should be marshalled to maintain our quality of life.

The necessary research to implement the missions of the Environmental Protection Agency (both U.S. and Ohio agencies) will cost billions of dollars. For example, the clean-up of the Fernald nuclear plant near Cincinnati will cost U.S. taxpayers 15 to 20 billion dollars, and will take to the year 2017, more or less. Scientists, like other professionals, have extensive purviews, specialist strengths, and regional contacts. Gathered together as a network the environmental research capability is augmented by other specialists in chemistry, biology, ecology, agriculture, health care, advanced manufacturing, and other disciplines. The implementation of corrective environmental actions will be enhanced by networks of researchers possessing a vast array of skills. Some of our third-world competitors will not have included the social costs of pollution in their prices. Nevertheless, we will have to compete in the same markets using production processes that are environmentally sound in a scientific sense and that are simultaneously least-cost in a competitive sense.

DEVELOPMENT POLICY IMPLICATIONS

Corporate Down-Sizing

Many large manufacturing corporations have devoted two decades to re-engineering production processes in order to increase productivity. The efforts have been successful from the corporate perspective, and labor

productivity in the United States is now the highest in the world. The inevitable result has been a down-sizing in employment in many of our most important manufacturing industries. The turmoil, unemployment, and insecurity within the labor force has resulted in unparalleled economic duress. The defense conversion initiative of the U.S. Congress addresses some of these concerns. Small and medium size manufacturing firms must make the same conversions to modern manufacturing methods that are already underway in our large companies. Modern automated methods using large inputs of science based technology will allow sustained competition in global markets. The labor force in the United States receives multiples of the wages in developing countries, often for the same skills and education required to perform the work. An imperative of high relative wages for Ohio citizens underlies the necessity for Ohio's newest industrial policy—defense conversion—and underlies radical proposals to make education establishments accountable for the output stream.

Once a firm establishes low cost output on a global comparative basis the regional income rises. The firm shares gains in real income with the residentiary population. The basis for high real income in the subregions of Ohio is the successful manufacturing establishment. Moreover, one job in the export industry sustains two or more jobs in other firms within the subregion. These multiplier effects are crucial. Today three-fourths of U.S. employment is in non-goods industries, such as health services and retailing. These are equally crucial to high real incomes for citizens. In fact, the real gain in social welfare occurs when the displaced workers in down-sized manufacturing firms find alternative employment, especially in non-goods service industries where their contribution to society is real and useful. When full employment is obtained in this sense, then the subregion is optimizing social welfare by maximizing real income within the region. This is true even though income to individual workers may be lower than before.

Wage Determination

Wage determination in a global free market economy for competitive products is established by the value of the marginal product. For this reason, activities that require low skills are remunerated correspondingly. For jobs that require higher skills, the value of the marginal product will be higher and the wage correspondingly higher. Of course increased real capital investment per worker-hour will also enhance the productivity of the worker. Very often leading edge technology coming out of our university and corporate research laboratories is germane, because of lower unit costs derived from use of the new technology. Either output is increased or product is improved, and the wage can be correspondingly larger.

In fact, where there are sluggish changes in technology in mass industries with large classes of low-paid, unskilled labor there may be little incentive to improve processes. Some historians suggest that slavery in the Roman Empire inhibited the discovery and application of science. Ohio culture assiduously promotes innovation within the context of a market system. This has been Ohio public policy since the early 1980s and is still Ohio industrial policy.

When re-engineering increases productivity and downsizing occurs as a result, there is a public obligation to retrain the discharged workers. Of course, there is no point in retraining for non-existent jobs. Billions of dollars will be wasted in the United States by non-focused, well-intentioned training programs. For this reason training programs should be tied as closely as possible to Ohio's Thomas Edison Technology Centers, where industrial companies and university partners are participating in the research and development activities that represent sunrise technologies. Industrial training programs including apprenticeships should be connected to specific industry needs, preferably by contract, or to technical colleges that offer courses specifically requested by area firms. Of course, higher level college courses, including engineering and mathematics, do not need to have a well-defined focus. Skills in science, engineering, mathematics, computer technologies, and business management are of wider scope and can be applied in almost every business entity.

Innovation as Development Policy

Technological evolution is the social process that has allowed mankind to aspire to ever higher standards of living. The historical basis for Ohio prosperity has been manufacturing. We must assure the continuation of this engine of economic growth through excellent science continuously applied to the ever-changing problems of production. Incremental changes in process technology have profound cumulative effects. In mass production industries these effects are quickly observable as increasing exports (both domestic and foreign) from the innovating region. The gains to the region are captured as increasing increments to real income. The United States has had a

1.5% increase in real income per person employed per year for more than a half century, interrupted in the late 1970s. When this long run economic growth is analyzed, over 50% is attributable to advances in knowledge (both technical and organizational). In addition, the direct effect of education inputs per worker is about 25%. There is also an indirect effect of educational expenditures which are a function, primarily, of the quality of the higher education establishments, their links with business and industry, and the quality of teaching, especially in science, engineering, mathematics, and marketing. The implications to Ohio economic development policy are clear. Ohio must maintain a leadership role in technologies significant to Ohio industry. Rapid implementation of leading edge, cost-cutting technologies are the determinants of tomorrow's prosperity.

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