III.

Social Issues

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In addition to the technology and market issues above, the workshop panel identified a number of social impacts. This list is provided in appendix A. Many of the issues on the list were offered without much comment; and, as would be expected, the panel members differed in their opinions of the priority of the various issues and their importance to the Federal Government.

Combining the workshop results with other information collected and evaluated in terms of congressional interests, OTA identified five sets of issues.

- Productivity and capital formation
- Labor
  - –Unemployment, displacement, or job shifting
  - –Positive or negative effects on the quality of working environment (such as exposure to hazards, job boredom, and employer/employee relations)
- Education and training
  - –Need for technological specialists
  - –Need for a technologically literate work force
  - —Need for retraining workers
- International impacts
  - –Import/export of robotics technology
  - –Contribution to economic competitiveness
- Other applications
  - –Military
  - –Space
  - –Oceans

Each of these sets of issues is discussed briefly below.

Productivity and Capital Formation

As stated in the introduction, much of the literature on robotics contains reference to the contribution robotics can be expected to make toward improving industrial productivity. Since a major national concern is the strengthening of U.S. industry, it is important to examine this question.

No answers were agreed on by the workshop participants. However, some experts did warn about making simplistic assumptions that exaggerate the importance of robotics, by itself, in improving productivity. Two reasons were offered:

1. Robotics is only one part of a wide array of technologies available to automate manufacturing and to increase industrial productivity.
2. Productivity is a subtle and complex concept with several definitions and measurements. (This is developed in some detail in the paper by Gold; see app. B, item 3.) Furthermore, even after some specific definition is chosen, industrial productivity depends on many factors that interact with one another. It is difficult, hence, to attribute productivity improvements to any single technology.

These warnings do not suggest that robotics is not an important production technology. Most experts seem to feel that it is. However, they stated that there are dangers inherent in taking an overly narrow definition of the technology when assessing impacts on industrial productivity.

While most applications of robots to date have been made by large firms, the future diffusion of robotics and related technologies can also affect small businesses in several ways. For example, there are likely to be many new business opportunities for small firms to develop and produce software and specialized types of equipment. Secondly, it can be argued that robotics and flexible automation may in some cases lower the minimum scale for efficient production, and therefore that new manufacturing opportunities could be created for small businesses. Third, the adoption of robotics and related technologies by large firms may foreclose some manufacturing opportunities for small firms that cannot afford to invest in new equipment. This situation frequently arises when major equipment technologies change.

Capital formation is another issue that was raised in the workshop and is discussed in the appended Lustgarten paper. The important questions seemed to be whether there would be adequate capital for three purposes:

1. To fund the modernization of industrial plants for the use of automation technology. The financial need would be particularly great if it were necessary to rebuild entire plants in order to make the most effective use of robotics.
2. To fund the construction and expansion of plants to produce robots in quantities necessary to have a significant economic impact.
3. To fund entrepreneurs who wish to develop new types of robots for new applications. The importance of the availability of this type of capital depends on how important it is that the technology be pushed forward rapidly.

No one in the workshop expressed the view that lack of capital is an important impediment to the growth of the robotics industry or to the expansion of the use of robots in manufacturing. However, some panelists observed that a tax policy that encourages such investment would be an important stimulus.

There was some disagreement about the availability of private capital to fund R&D. Robot manufacturers maintained that they were investing large amounts of money in R&D. Other experts suggested that these expenditures were principally aimed at short-term product development and adapting existing products to specific tasks. There was a difference of opinion about the definition of R&D and concerning the amount of emphasis that needs to be placed on long-term research v. short-term product development.

Labor

Unemployment is an issue that is constantly raised in discussions about the social impact of robots, but that seems in this context not to be well understood as yet or even to have been widely studied by labor economists in the United States (8). The discussion at the workshop reflected a wide variety of opinion about the effects on jobs, differences that seemed to be confounded by a number of conceptual problems.

Productivity improvements resulting from the use of robotics and related technologies can affect labor in a number of ways. These effects depend on factors such as the following:

- The effects of new technology on the relative proportion of machinery to workers (the capital-labor ratio) in a given industry.
- The extent of change in prices and production volumes for U.S. firms once the new technology is in use.
- The supply of qualified workers with specific job skills in a given industry.

U.S. employment in a given industry may fall because of productivity improvements, which, by definition, enable fewer workers to produce a given volume of product. U.S. employment in a given industry may remain constant or rise, however, if productivity improvements are combined with increases in production volume. Effective labor compensation may rise or fall if productivity improvements lead to shorter workweeks and/or new product prices, depending in large part on production volume and profitability. Finally, average wage levels will change with changes in the necessary mix of worker skills resulting from the implementation of robotics and related technologies.

Definitions of unemployment, like those of productivity, require distinctions between short-term and persistent job loss, or between true unemployment (job loss) and displacement (job shift).

For some time, most experts in the United States have argued that more jobs are created by new technology than are eliminated. However, if these jobs are in different industries and/or require different skills, the effect on an individual who has been replaced by automation can be traumatic.

Production and servicing of robots and related technologies will create new jobs. The number of jobs created and the rate at which they appear will depend both on the growth rate of the robot industry and the degree to which robot manufacture and repair are, themselves, automated.

Additionally, the effects of modern microelectronics will be to lower cost, improve performance, and widen the availability of automation technology substantially. Negative impact on employment that, in the past, has been small enough to be insignificant or undetectable may be much larger in the future.

In order to assess the effects of automation on future employment levels, a baseline must be established against which job loss or gain can be measured. This baseline could be a simple extrapolation of current trends. But it may also need to be adjusted to reflect two other effects:

- *Virtual employment,* domestic jobs that were not explicitly eliminated, but that would have existed were robots not installed.
- *Virtual unemployment,* domestic jobs that would have-been lost if the plant had not responded to domestic and international competition by automating.

As the case with productivity, it is difficult to attribute employment effects to any single component of an entire range of improvements in the manufacturing process, in this case robotics. Any examination of the effects of robots on jobs would need to consider, at least in part, a much broader context of automation technology.

There seemed to be two principal sets of questions concerning unemployment. These questions are different in their focus, in their implication for Federal policy, and in the data collection necessary to analyze them:

1. Will the United States experience a long-term rise in the real unemployment rate due to the introduction of robotics and other automation? If so, will these effects be differentially severe by geographical location, social class, education level, race, sex, or other characteristics? What might be the employment penalty of not automating?
2. Will the use of robots create displacement effects over the next decade? In what ways will these effects be specific to particular industry classes, geographical locations, or types of jobs? How will they effect labor/management negotiations?

Quality of working environment is another issue that was identified. If robots are employed principally for jobs that are unpleasant or dangerous and if the new jobs created by robotics are better, the quality of worklife will improve. Productivity increases may also, in the longer term, result in a shorter, more flexibly scheduled workweek.

New forms of computer-based automation may in many cases relieve job boredom and resulting worker dissatisfaction that many management experts have been concerned with. Workers may be able to make use of more complex skills and perform a greater variety of tasks. For instance, they may be able to follow the assembly of a product from beginning to end and assume greater individual responsibility for the quality of the result.

The human working environment can also be improved by segregating processes that create hazardous working conditions (such as heat or exposure to chemicals) from the section of the factory occupied by humans, and staffing them with robots. Furthermore, equipping a worker with a robot helper for strenuous activities not only eases job stress, but opens up employment opportunities to those who have physical handicaps or other limitations.

Whether these benefits are realized depends, in part, on the particular ways in which industry uses the technology. Many labor experts are concerned that some uses of robots will produce effects on the working environment that will not be so salutary. For example, some argue that one long-term effect of robotics may be to "deskill" labor, requiring less ability on the part of humans as they are incorporated into a mechanized environment.

Some labor experts and others have also expressed concern that automation provides increased opportunities for employer surveillance of employees. Some unions also fear that automation could be used by employers to "downgrade" jobs that require working with automated systems, or that robots might be targeted to replace unionized jobs first.

Education and Training

A number of education and training issues are raised by robotics. Some of them will be addressed in the current OTA assessment of the impact of information technology on education, in the context of vocational education and industrial training.

According to the workshop participants, there is a shortage of trained technical experts in the field of robotics. If there is to be any significant expansion in the pace of automation including robotics, many more computer scientists, engineers, software programers, and technicians will be needed in the next decade.

A shortage already exists in many fields of engineering and science. It seems to be particularly critical in areas of computer software design and programing, according to findings of the recently released National Information System study by OTA (9). Hence, the issue is not peculiarly unique to robotics technology, at least in the case of very highly skilled jobs.

At the same time, the use of robots has already created some new technical jobs. A few programs have been started at the community college level to train workers in robot installation, programing, and maintenance.

Some participants and observers suggested that there was a need for a more technologically literate work force, one that has a basic understanding of technology and mathematics. In their view, improved technological literacy would provide the following benefits:

1. To the extent that workers would be expected to instruct, oversee the operation of, or repair robot units, they would need some basic understanding of computers and systems, both mechanical and electrical.
2. A technologically literate work force would be less likely to resist the introduction of robots and other automation technology.

3. A knowledgeable, technologically skilled worker would be easier to retrain for some other job, somewhere else in the plant.

One observer at the workshop suggested that the reason the Japanese work force seemed to welcome robots in their plants was the high level of technological literacy reported for the average Japanese employee. This characteristic, accordingly, would give the employer greater latitude in finding another and possibly even more skilled job for a displaced worker.

If the introduction of robotics into a plant is not to result in unemployment, a program of retraining displaced workers to take on new jobs may be necessary. Retraining may also be required for those workers who remain, for their existing jobs will change in form and function even if their job title remains the same.

International Impacts

Concern about economic competition in this technology from Europe and Japan was repeated often. Panelists pointed to large investments abroad both for research and development and for encouraging the use of robots. This potential competition exists on two levels: 1) developing and selling robotics technology, itself, and 2) using robots to produce goods more competitively (for example automobiles).

Some experts felt that the directions of robotics-related research were significantly different between the United States and other nations, notably Japan. U.S. researchers emphasize software and highly flexible systems while many foreign laboratories are concentrating on hardware. No one maintained that the foreign state of the art in robotics was superior to that in the United States. "Technological leads" are hard, in general, to either prove or disprove.

There was a general feeling that the utilization of robots was further advanced in several nations (possibly including the Soviet Union) compared to the United States. Some analysis of the Japanese and Soviet picture is presented in the background paper by Aron (app. B, item 1).

The issue of international competition creates conflicts in import/export policy. Controls might be placed on exports of industrial robots either for national security reasons or to limit foreign access to domestic high technology that increases the competitiveness of U.S. firms. However, such controls also deny U.S. robot manufacturers access to foreign markets. Even if the total international market in robots, per se, were to remain relatively small, robot technology would be a vital component in the much larger international market for sales of complete automated factories.

Some issues of export controls are examined in the context of East/West trade in a recent OTA study (10).

Other Applications

Some panelists and other consultants expressed *concern* that an examination of the impacts of robotics not be restricted only to applications to traditional industrial automation. Because of their ability to work in environments that are hazardous, difficult, or even impossible for a human to enter or survive, there may be future uses of robots that represent new opportunities.

For example, several defense applications were mentioned. While there is work on direct military applications of robots, much of the interest on the part of the defense community in robotics is focused on manufacturing. Improved productivity in the manufacture of weapons and associated military hardware could offer significant savings to the defense budget. Flexible, automated factories, even those not normally involved in military production, could be more easily and quickly mobilized in times of national crisis.

The National Aeronautics and Space Administration is exploring the expanded use of robots for such tasks as planetary exploration, repairing satellites in space, and aiding mining expeditions. Some researchers are interested in the use of robots for ocean exploration and seabed mining.

These examples suggest that, depending on the capabilities of robots in the next decade, there may be important applications that are not now imagined. The nature of these new capabilities, and hence of the applications, will depend in part on Federal policies in such broad areas as R&D, technical education, and reindustrialization.