Appendixes

Appendix A

A National and Regional Analysis of the Adoption of bovine Somatotropin

Chapter 5 presented the summary results of the national, regional, and farm-level impacts of emerging technologies and public policies on the U.S. dairy industry. A crucial assumption in the analyses is the rate of adoption of bovine somatotropin (bST). This appendix discusses the results of the analysis supporting OTA's adoption rates for bST. For more detail than is provided in this appendix the reader is advised to read the background paper on which this analysis is based.[1]

Review of Previous Studies

There have been numerous studies dealing with the introduction of bST into the dairy industry (1,2,5,6,7,9). Lesser, Magrath, and Kalter (7) estimated the rate of adoption of bST based on a primary survey of producer attitudes towards the technology. This estimate has been used in simulation studies of bST (6), which predict the relatively rapid adoption of bST after it is introduced. Fifty percent of dairy herds adopt bST technology within the first year and over 80 percent within 3 years.

Other studies (i.e., Fallert et al. (2) and Sellschopp and Kalter (9)) reviewed the impact of bST under alternative policy scenarios. Their conclusions were that with the introduction of bST, inflexible support prices would result in large Commodity Credit Corporation (CCC) purchases during the 1990s. To reduce government purchases, the government would need to continue reducing the support price by $0.50 increments.

Using a structural model, Kaiser and Tauer also analyzed the impact of bST on the national dairy market during the 1990s under a number of government policy options. Under one, CCC purchases are held stable by adjusting the U.S. herd inventory through repeated implementation of the dairy termination program. The authors note that such adjustments may be difficult to accomplish if farmers recognize the intent of the government and raise their dairy termination program bids. Without these adjustments, CCC purchases rapidly increase with bST even with lower support prices. The authors conclude that a combination of price support reductions and dairy termination programs would be the most effective policy for balancing the conflicting interests of dairy producers, taxpayers, consumers, and beef producers.

The previous analyses have relied on surveys and hypothetical estimates for the adoption rates of bST. The studies have generally lacked a consistent economic foundation for predicting adoption. This is in part because a model that systematically explains technological change and/or the consequences for agricultural policy has been elusive. As Feder (3) and Just and Zilberman (4) observe, conventional economic models have not consistently explained adoption patterns of agricultural innovations or why seemingly profitable technologies are slowly adopted by specific classes of farms (i.e., small farms). The analysis here attempts to predict adoption of bST.

Technological Change

Technological change refers to change in production processes that results from the application of scientific knowledge. At the firm level, technological change can be **realized in several ways. It can be** *embodied in* inputs (changes in input quality); it can be *disembodied,* and involve improved use of existing resources such that a higher output rate per unit of input is obtained; or it can arise from entirely new processes and new inputs (e.g., bST). A combination of these three phenomena underlies many innovations. For example, the development of hybrid corn varieties represented the embodiment of scientific knowledge in corn seed. Disembodied management knowledge was then needed for its successful use, and eventually a set of new inputs in the form of pesticides was developed for use with the hybrids.

These definitions apply to the analytical framework presented here. The adoption of bST is both the consequence and cause of technological change. To use bST successfully, farmers must adjust to new, higher production levels by increasing technical efficiency. Farmers with low levels of efficiency are less likely to adjust inputs to meet the requirements of higher milk production. Conversely, the higher the current productivity of the farmer, the more likely he or she will adopt bST technologies.

Operational Model of bST Adoption

In a theoretical model outlined by McGuckin (8), changes in technical efficiency (ratio of milk output to farm resources) drive the adoption of new technologies. Milk output per cow (a productivity measure) and changes in scale (size of the dairy unit) are strongly

[1]This appendix is based on the OTA commissioned background paper "Adoption of bovine Somatotropin: A National and Regional Analysis'' prepared by J. Thomas McGuckin, New Mexico State University. It is available through the National Technical Information Service.

correlated with technical efficiency and thus technology adoption. As productivity increases over time so does adoption of new technologies.

The linkages between productivity change, technical efficiency, and adoption of bST are the cornerstone of this analysis. However, because of data limitations, only general trends in productivity over time can be obtained. Increasing farm productivity is equivalent to increasing farm technical efficiency, which drives adoption: as productivity increases because of improved technical efficiency, so does the willingness to adopt new technologies such as bST.

The operational model used in this analysis assumes that a farm's likelihood of adopting bST is a function of its scale and technical efficiency (measured by total factor productivity (TFP)). Because predicting adoption of bST is ex ante, an index of adoption of previous technologies (outlined in the data section) is used as a proxy measure. The empirical model used is the following general representation:

$$IA_f = g(S_f, TFP_f), \text{ for } f = 1..\ N$$

where IA is an index of adoption of previous technologies, S is scale or size of the dairy, TFP is total factor productivity and f represents a cross section of dairy farms.

Data

The analysis used cross sectional representative farm data from the 1985 U.S. Dairy Farm Costs and Return Survey. Detailed data sources and the types of information collected through the survey are reported in the USDA report by Fallert, McGuckin, Betts, and Bruner (2). The data include dairy farm milk production, amount of labor (both hired and family), amount of capital (converted to a cow capacity basis—parlor, housing, and feeding system can berated by the number of cows milked per day) and respective prices. As the index for the technological adoption, five type of technologies were weighted according to their relevance to bST adoption. The five technologies include:

1. automatic grain feeding system (parlor or otherwise),
2. automatic milking unit takeoff,
3. three times a day milking,
4. herd production records (DHI), and
5. artificial insemination.

The most heavily weighted (45 percent) measure was 3x milking. Use of this technology indicates that a farmer can adjust feed, breeding, and herd health practices to a higher level of production. However, 3x requires additional labor while bST would not. Artificial insemination, an improved method of breeding that directly affects milk production, is weighted 20 percent. DHI is a management information system, known as Dairy Herd Improvement, that is weighted 15 percent. Automatic takeoffs are representative of automated milking systems (weighted 15 percent); automatic grain feeders are similar to automatic takeoffs, though not universally used by factory style operations.

The rate of change in the index of technological adoption indicates the change in use of the bST technology over time and across dairy production regions of the United States. Because the estimated functions are indices, an initial starting point was derived. A range of initial adoption levels (low, medium, and high) were identified for each region.

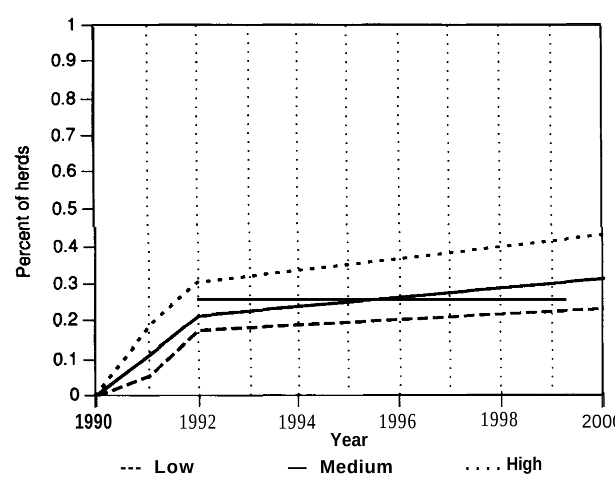
Results

To predict the adoption of bST, a regression analysis was used based on historical rates of change in capital, labor, and feed efficiency in the dairy industry. The results for each region contain a low, medium, and high scenario for the initial adoption of the technology in 1991. After 1991, all regional growth in adoption is based on the relative impact of production efficiency change on the technological index. The results are presented by region.

The Corn Belt region is one of the lowest adoption regions (see figure A-l). By 1995, between 20 and 35 percent of herds will receive bST (low and high scenarios, respectively). By 2000, these percentages rise to 25 and 45 percent, respectively. A medium scenario is 31 percent.

The Southeast is also relatively slow to adopt (see figure A-2). By 1995, between 24 and 42 percent of herds will receive bST (low and high scenarios, respectively).

Figure A-l—Projected Adoption Rate of bST Corn Belt Region



SOURCE: Office of Technology Assessment, 1991.

Figure A-2—Projected Adoption of bST Southeast Region

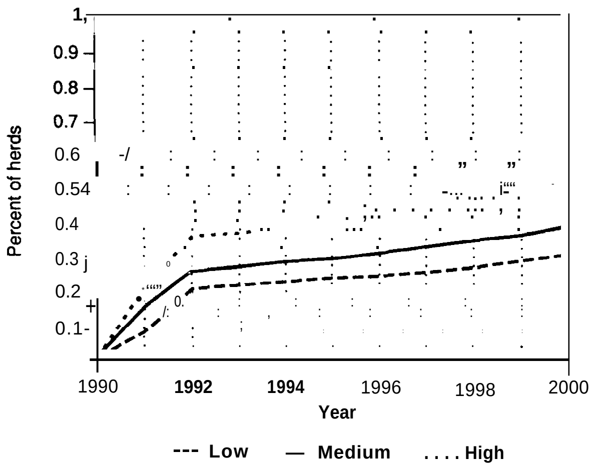


Figure A-3-Projected Adoption Rate of bST Southern Plains Region

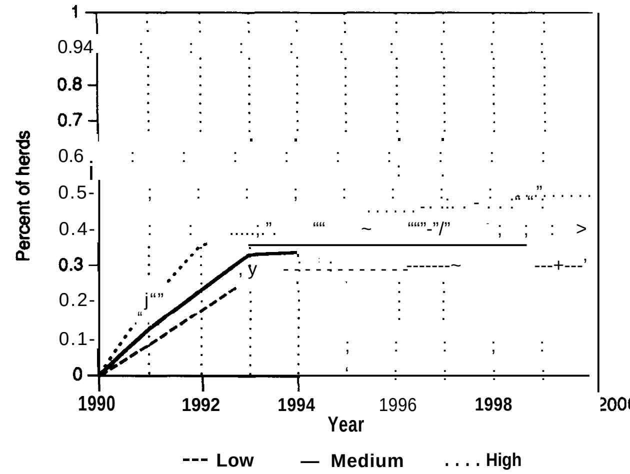


Figure A-4—Projected Adoption of bST, Lake States Region

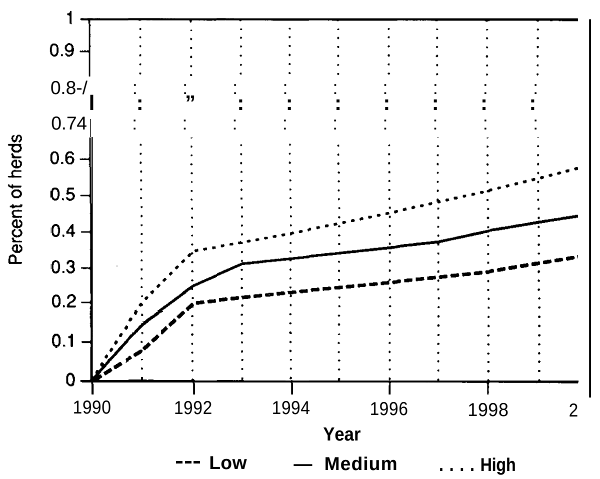


Figure A-5-Projected Adoption Rate of bST, Appalachian Region

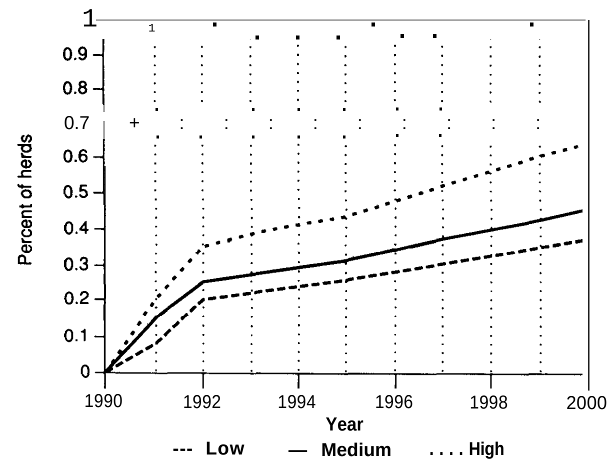


Figure A-6—Projected Adoption of bST Northeast Region

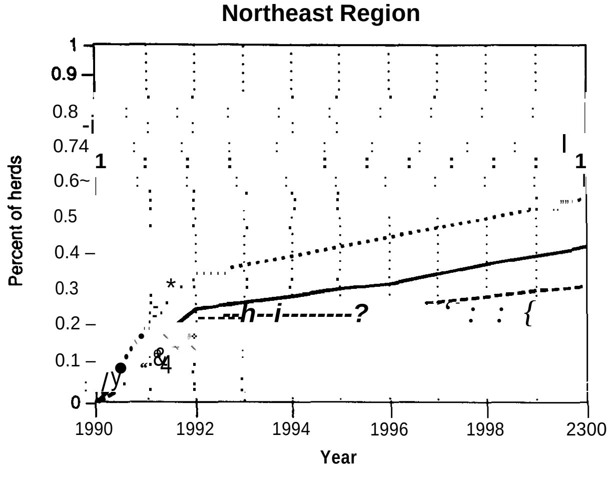
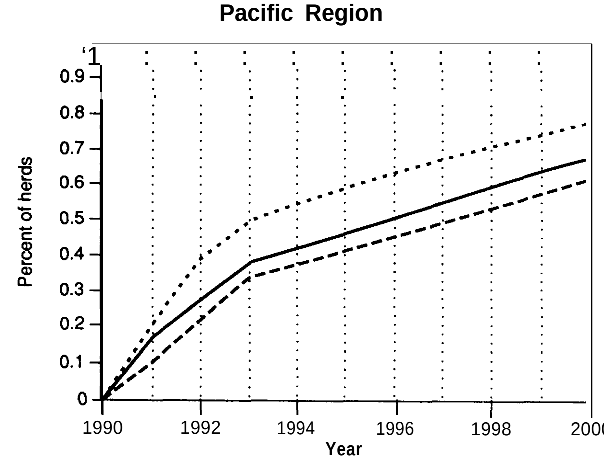


Figure A-7—Projected Adoption Rates of bST, Pacific Region



SOURCE: Office of Technology Assessment, 1991.

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By *2000, these* **percentages rise to 32 and 55 percent, respectively. A medium scenario is 39 percent. (However, confidence in these predicted rates is low, respectively.)**

Like the Southeast, the Southern Plains is a low adoption region (see figure A-3). By 1995, between 28 and 44 percent of herds will receive bST (low and high scenarios, respectively). By 2000, these percentages rise to 35 and 53 percent, respectively. A medium scenario is 42 percent.

Adoption rates are slightly higher in the Lake State region (see figure A-4). By 1995, between 26 and 46 percent of herds will receive bST (low and high scenarios), respectively. By 2000, these percentages rise to 37 and 64 percent, respectively. A medium scenario is 46 percent.

Relatively high rates of adoption are also predicted for the Appalachian region (see figure A-5). By 1995, between 27 and 48 percent of herds will receive bST (low and high scenarios, respectively). By 2000, these percentages rise to 40 and 70 percent, respectively. A medium scenario is 46 percent.

Adoption rates in the Northeast are similar to those in the Lake States (see figure A-6). By 1995, between 25 and 44 percent of herds will receive bST (low and high scenarios, respectively). By 2000, these percentages rise to 34 and 59 percent, respectively. A medium scenario is 43 percent.

The adoption pattern in the Pacific Region, the fastest growing dairy region of the United States, is accelerated relative to that of all other regions (see figure A-7). By 1995, between 45 and 63 percent of herds will receive bST (low and high scenarios, respectively). By 2000, these percentages rise to 66 and 81 percent, respectively. A medium scenario is 67 percent. The strong coefficients of size and milk output per cow drive the adoption of bST in this region at a high rate.

Overview of Results

The dairy industry has one of the highest rates of productivity increases in U.S. agriculture. Yet, adoption of existing proven technologies is **not universal among dairy** producers. Though **technologies such as** artificial insemination and herd record systems have existed for many years, these technologies have only been adopted by 30 to 40 percent of producers in several major dairy regions. The most technically efficient producers (highest ratio of milk output to farm resources) are the most likely to adopt new technologies. Using regression techniques, this analysis establishes that producers with high levels of milk per cow and large operations are more likely to adopt new technologies (a finding consistent with scientific literature on adoption of new technologies).

Given that bST has similar characteristics to previous dairy technologies, improvement in productivity from an increasing knowledge base will drive its adoption. Analysis of productivity measures in the major dairy regions suggest that between 50 and 70 percent of dairy producers in the United States will adopt bST by the year 2000. The Pacific region will lead all regions in adoption, possibly reaching 80 percent by 2000.

The projected rates of adoption in this analysis are lower than other studies based on differing methodologies. Rather than basing predictions on historical trends, for example, Lesser, McGrath, and Kalter use contingent surveys of producers and arrive at higher adoption rates. There is little to suggest that the adoption of bST will vary from past adoption practices by dairy operators. bST is simply a continuation of numerous other productive technologies in the dairy industry. The lower projected rates of adoption are, therefore, the more realistic projections of actual adoption rates.

Appendix A References

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