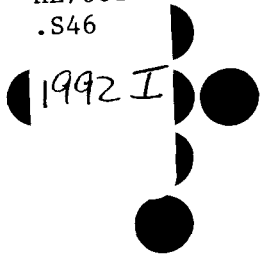




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COMMUNICATIONS
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**Evolution of the Telecommunications
Industry: Echoes and Projections**

October 15, 1992

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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COMMUNICATIONS FORUM**

**Evolution of the Telecommunications Industry:
Echoes and Projections**

**October 15, 1992
4:00 to 6:00 p.m.
Bartos Theater
20 Ames Street
Massachusetts Institute of Technology
Cambridge, Massachusetts**

Speaker:

**Morris Tanenbaum, Vice Chairman (Retired)
AT&T**

Respondent:

**Peter Temin, Professor of Economics
MIT**

Rapporteur:

**Amy Blitz, Ph.D Candidate
Political Science Department
MIT**

Introduction by Professor Jack Ruina: I think everybody involved in the communications business knows who Morry Tanenbaum is and everybody at MIT in communications or economics knows who Peter Temin but nobody knows who I am. I am Jack Ruina and I am in the electrical engineering department and at the Center for International Studies.

It is a special privilege for me to introduce Dr. Tanenbaum to the forum. Morris Tanenbaum has had a long and distinguished career in many professional areas: first in science and technology, second as an industrial leader, and third in public service. He started out as a chemist with a Ph.D. from Princeton and then went to work for the Bell labs and then for the other companies within the Bell system. The public service work, he has been involved in a variety of philanthropic organizations but, by far, the most important work he has done has been as a member of the MIT corporation. He has been a member of the corporation here and of the executive committee. He has been a member of several visiting committees, and most importantly now he is a speaker at the Communications Forum.

The respondent is Peter Temin, head of the MIT Economics Department. He has been a member of the MIT community for 25 years. We could not find a more appropriate respondent than we found right on our own campus. Peter is the author of many pieces but the piece that is most important for our purposes here is a book he wrote recently called **The Fall of the Bell System: A Study in Prices and Politics**. Dr. Temin will follow Dr. Tanenbaum.

Tanenbaum: It is an honor to be invited to speak to such a distinguished audience and in the well known venue of the Communications Forum. Along with the honor, is the challenge of what to say to such a learned group. Since I have only been a player in the field of telecommunications and neither a student nor a scholar, I would not presume to give a lecture. Instead, I will make some observations about the events of the past decade in the part of telecommunications in which I have been permitted to play a role. I will then suggest some aspects of the future of the industry that this past player believes might concern the current and future players.

I will not consume too much of our time in this exercise but hope that one or more of my observations will be, if not provocative, at least suggestive enough to stimulate some dissent, support or other comments from you. My fondest hope is that I might serve in some way as a resource to those of you with interest in the past and hope for the future of the industry. I also thank you for the excuse that your invitation has given me to indulge in a bit of nostalgic recollection of an exciting and very interesting period of my life. I want to acknowledge that I was aided in nostalgic reminiscences by rereading Peter Temin's and Lou Galambos' excellent book: **The Fall of the Bell System**. I must admit that I have always been somewhat troubled by the title, though. I cannot quite equate the Bell system with the Roman Empire, though I suspect there are some arguable similarities.

From my viewpoint, their description of events is the most complete and accurate that I have encountered. Their judgments about the driving forces and their speculation about alternative outcomes that might have occurred are generally consistent with mine, with a few exceptions. With full disclosure in mind, important at these times in all organizations, I must also note that Peter and Lou are associated with two educational

institutions where I also have close associations; thus, my endorsement may only signify a similar set of biases. Of course, I don't object to biases when they are close to my own - but you should be forewarned!

To cite an example of our similar viewpoint, I also believe that the seeds of the AT&T divestiture were irreversibly planted during Bernie Strassburg's time as chief of the Common Carrier Bureau of the FCC, and that Bernie and the FCC were not sensitive to the enormous forces that they were unleashing. For that reason, I frequently find myself in the unexpected position of defending Judge Greene when he is accused as the person responsible for the break-up of the Bell system, although clearly he found it a completely acceptable idea. At the same time, I have wondered from time to time if Judge Greene realized the morass he had created for himself, his court and the industry with the invitation he inserted in the decree for the parties to seek waivers of decree restrictions whenever they thought it appropriate.

I am also often asked about Bell labs. What has happened to it? Will it survive? Will it retain its quality? Or will it be, perhaps, one of the most serious casualties of divestiture? I am happy to report that AT&T Bell Labs, the new name, is alive and well. At divestiture, about 25% of Bell Labs was split off to help form Bellcore. For those of you who may not be familiar with Bellcore, it is an organization that is owned by the divested Bell companies and set up to provide a centralized source of technical and administrative advice of the kind provided by AT&T before divestiture.

There have been a few other minor resizings of AT&T Bell Labs but overall it has now regrown to about its original size. The 90% of AT&T Bell Labs that was devoted to development has remained strong. In fact, it has expanded its capabilities by learning how to operate in a competitive and international environment. The 10% that was devoted to basic research has continued to be supported at about the same level as before divestiture although the research is more sharply focused on areas judged to have the greatest long range promise for AT&T's business. That, by the way, is the kind of focus that led to the invention of the transistor and that stimulated much of the work, including the Nobel Prize work, for which AT&T Bell Labs is best known. While there is no doubt that AT&T Bell Labs has changed, I believe it remains one of the world's premier industrial R&D organizations and will continue to remain so.

Frequently, I am told by friends and acquaintances that divestiture was one of the worst things that the U.S. government has ever perpetrated on the American public. Alternatively, I am asked if I think that divestiture was the right direction for the country to take. Of course I had given that question a good deal of thought before divestiture. I confess that afterwards, I have not thought about it much.

I do believe though that it is apparent to most observers that the answer depends on one's position as a stakeholder. If you were a more than average user of long distance service, not only do you now have a choice of carriers but your total costs are also lower. For very heavy users, these costs are much lower. If you were a manufacturer or distributor of telecommunications equipment, there are many more opportunities now; but in a highly competitive market, these are often only marginally profitable if at all. One industry that must have profited handsomely was advertising. A new market measured in hundreds upon hundreds of millions of dollars annually was suddenly created and continues to flourish.

And if you were a pre-divestiture stock holder and held on to all of the pieces, you did very well indeed.

However, if you were an employee of AT&T or one of the regional Bell companies, you had a significant chance of finding yourself without a job - about one chance in four at AT&T. Also, if you were a light user of long distance service, your total costs are noticeably higher, albeit for most not at levels that are too burdensome. If you moved frequently or had significant telephone troubles, you were also inconvenienced and probably found it much more expensive. Indeed, according to a few polls taken a short time after divestiture, a majority of the general public expressed a negative opinion of the action. I have always felt that if you had a national referendum on the issue, very few people would show up to vote.

Thus, there were winners and losers. Among the losers about whom I have felt particularly bad were the U.S.-based telephone equipment manufacturers. Divestiture instantly forced open the Bell equipment market, primarily to foreign-based equipment manufacturers. Our national balance of payments in telephone equipment fell dramatically from over \$1 billion positive to negative \$1 billion. That kind of swing had been predicted by AT&T, not believed by the congress or the court; but it happened. At the same time, many positive things also happened. Competition bloomed. Choice in the long distance business expanded enormously. Some 500 new companies appeared, mostly local and regional resellers, many of whom have since disappeared. While almost all of the consumer choice that appeared was in providers, prices and pricing plans rather than new types of services, the provider choice remains wide. The price choice is much more complex and it has become much more narrow for the informed buyer.

There was a similar choice in equipment for residential users, business users and the telephone companies themselves. Here the variety of equipment was extensive. Junk telephones flooded the market for a while, but consumers became knowledgeable and the junk quickly disappeared. In that instance, the regulators were right and the industry was wrong about the damage to the network that we forecasted. The quality of telephone service has continued to improve and its availability in the U.S. remains essentially universal. We still have the highest quality, most widely available service in the world. Indeed, transmission quality probably improved more rapidly with competition than it would have otherwise, as carriers accelerated the digital conversion of their networks. That occurred at some significant cost, but not enough to cause anguish.

All that is in the past, though. While the past is easier to forecast than the future, it is not nearly as much fun to debate. In addition, since I am unlikely to play a role in that future, I can be more relaxed as I speak of it. First, I believe that competition in telecommunications is here to stay. We have demonstrated that it can work and, in our economy, we will not retreat to monopoly if a competitive industry is possible. By the way, I applaud that!! That forecast may be contestable in view of the recent action in Washington to re-regulate some aspects of cable. I would note, however, that there is a path similar to that taken in the telephone industry that would comparably expand the role of competition in cable. I refer to a structure with a regulated local distribution network with open access for competitive program providers.

I do not recommend or even suggest that that is the proper route for the cable

industry. In fact, I expect that competition will increase in both industries. Local telephone companies and cable companies are being encouraged to compete in each other's businesses and, while the technology is still a barrier, developments in wireless personal communications and in fiber optics continue to improve the possibilities. Having introduced another, albeit related, industry into the discussion, let me also mention one that is not so closely related. For those of you with strong interests in the tensions between regulation and competition, in case you haven't noticed, the electric power industry is in the opening phases of a potential transition with significant similarities to that experienced by the telecommunications industry. It merits close attention.

Returning to my principal theme, I believe that the forces for competition in telecommunications will continue to grow in other countries as well. They have been held in check to a degree by some of the negative experiences in the U.S. that I mentioned earlier. Our colleagues in other countries will likely find more graceful paths to arrive at competitive structures but they will arrive there. I am also convinced that the long-heralded, and disputed, merger of telecommunications and computing technologies and the resulting confluence of the related industries is advancing inexorably. Telecommunications and computer companies that do not recognize this will severely limit their abilities to be world leaders in the future information movement and management businesses. This does not mean that they will go out of business. There will be pure telecommunications and pure computer companies that will survive and prosper. I do believe, however, that their opportunities to serve the largest users and to exploit the most promising technologies will be significantly attenuated.

It has been suggested that this was one of the reasons that AT&T decided to negotiate the last consent decree. You may recall that the current decree is actually a modification of an earlier decree. The earlier decree restricted AT&T to the telecommunications business. The new decree eliminated that restriction. I will confirm that, while that was not the only reason, the belief in the eventual merger of much of communications and computing did carry significant weight in the minds of many of the decision makers. Beyond that, I see the information movement and management business as one of the most rapidly growing and promising business for the foreseeable future. It will provide the most important infrastructure for the industries of the 21st century, ranging from bio-technology to manufacturing to the great variety of services that the developed and developing world will demand. It will be the primary productivity engine of the next many decades, as well as a principal instrumentality for harmonizing the world's difficulties.

I occasionally have the stimulating experience that you at MIT enjoy with great frequency - the experience of being asked by a young person my opinion of the best choice for someone interested in a technology-based career. I generally tell them that if I were starting again, I would have a difficult choice between bio-technology and the information technologies. However, if I chose bio-technology, I know that I would need information technology. And I have a distant but tempting belief that if I started in information technology, I might find real opportunities awaiting in the use of biotechnology to construct components and sub-systems of great power in applications related to handling information. And with that prognostication, I turn the podium to Dr. Temin.

Temin: It is always a pleasure to hear from Dr. Tanenbaum; but, if I may, I will turn to my book since you were kind enough to refer to it, and I will review the talk I thought I was going to hear today. The sub-title of the book was the study in prices and politics, and the question is why prices and politics. This list does not include the influence of technology. The argument that I put forward was that the institutional changes were not really driven by technology. They are driven, of course, by the general thrust of technology which led to the increased importance of technology; but there are a lot of other people who cite specific technologies, starting with the transistor, which Morry mentioned, micro-wave radios, direct distance dialing, etc. There were a lot of different hypotheses floating around. Perhaps Morry might want to speculate since this an area that interested him very much: in hindsight, the effects of various specific technologies.

Morry said he would put the seeds of divestiture with Bernie Strassberg and the FCC. These were actions taken around 1970. I would put the seeds of the break-up of the Bell system twenty years earlier than that with a decision about prices. At that point, shortly after WWII, when the cost of long-distance service was falling much more rapidly than the cost of local service, the decision was made through a rather complex political process to keep relative prices within telecommunications constant. That put increasing strain on the system over the next thirty years. One of the things that we have seen, of course, is that that has changed.

Morry was talking about forecasting the present. I heard a definition recently that a historian is a person who can forecast the past with 90% accuracy. Looking back on what was forecast at the time of the MFJ, the Modification of Final Judgment, Morry has mentioned a couple; but I jotted down a few others. One was that there would be a clear separation between competitive and monopoly parts of the business. Another is that there would be deregulation of telecommunications. A third was that the fragmentation of the network would lead to coordination failures and difficulties. The fourth was that the relative price structure would be changed. If we look at that list and try to say what has happened in intervening years, competition v. monopoly has proven to be a bugbear of telecommunications in the past ten years as it was before. Either there is no bright line separating competitive and monopoly markets at any moment, or, more plausibly, the line is changing sufficiently rapidly these days that any attempt to fix an industry structure based on this kind of division is chimerical. The notion that we could fix a bright line and then live with it has proven to be illusory.

Deregulation is also fanciful. It is not clear to me why anyone thought that regulators would be unlike anybody else in the world and would simply fold their tents and leave when other people said they weren't needed. Morry will perhaps correct me, but it seems to me that the fragmentation of telecommunications has led to increased regulation rather than decreased regulation. Certainly as more of the regulation has gone to the state level, this has involved more and more people. Coordination failure does not seem to have been a problem. Those who thought about this from a theoretical perspective or looked at historical difficulties Bell had with such issues, and assumed this would be a problem. It is a problem, and there is a myriad of committees that devise and revise standards. The network does not, however, seem to be bothered by this in the sense that it has proven remarkably easy to reach agreements on questions of coordinations.

Fourth, the change in relative prices, as Morry mentioned, did occur. Local prices have gone up, while long distance prices have gone down. Finally, people were concerned that the local telephone companies were going to go down the tubes. They were going to become the back waters of telecommunications and would be starved of revenues. Those students of this will remember that Judge Green gave them the yellow pages as a kind of life preserver to keep them going. In the subsequent history, as Morry commented on their stock values, that has been the opposite of what has happened.

So the people at the time of the MFJ were not totally wrong. Just on the scorecard I had, they missed four out of five. Morry talked about some others. That is the problem with predicting the future. That should give us some humility as we think about the future. Morry said that competition is here to stay. It seems to me that that is true and, in fact, one should go further than that. Competition is coming ever closer to your door. The notion now that you have a single gateway, your local telephone company, to get to these various choices of long distance suppliers, etc., is something that may well change. It may change dramatically not just from cable TVs but also some non-wire line based companies as well. This is one of the most intriguing notions. I have always liked historical parallels, and this possibility echoes the earlier conflict over microwave radio. The thought then was that microwave transmission was going to replace all of the wireline transmissions. People wrote that the economies were there; that the cost would be lower; that it would be easier, etc. That is not what happened. Instead, the wires were replaced by fiber optics, largely due to the creativity bred by competition.

When I say that it looks promising that there will be some non-wire, non-cable based communications, this looks promising at the moment. We see in Eastern Europe, where people are trying to jump start their telecommunications, where they don't have the physical structure, the creation of a wire-based telecommunications system is very expensive so people are trying to avert this by going to mobile phones. Will this lead to developments that will then come back here, reducing the costs, or will the cost of wire cable will then fall dramatically as it did before?

The competition with cable TV does not strike me as a dramatic increase in the capabilities of the system. There is a lot of talk about cable TV. There has been much attention given to the technical capabilities of cable TV and how they can carry many channels, how they can introduce interactive communications; but I would like to draw your attention to the very different industrial structure of cable TV than of telephone companies. There are many telephone companies; but relatively few at the local level and they are large in scale. The cable companies are myriad and they are broken up in small areas. If they were going to make the investments needed to transform their system into an interactive system, it would require a lot of capital investment. Is their scale such that they could raise the funds to do this? This is one of the strengths of the Bell system. In the negotiations preceding the break-up of the Bell system, one of the things that Charlie Brown and others thought about was: were the regional companies large enough to raise capital and to continue their investment?

A second prediction that Morry made that I would agree with is that competition will grow in other countries. Typically, it will grow by this process of privatization which seems to have the common characteristic that it makes a few people very wealthy. With changes

in the organization go major changes in the distribution of income, at least for a small group of people.

Finally was Morry's very intriguing notion about the integration of telecommunications and computers. This, of course, is a very MIT topic. That is the sort of thing we talk about all of the time. I would like to speculate as to whether this is going to happen as a smooth process of expansion or whether this is going to break the telecommunications markets into two. There has always been a division, and the Bell system was always very clear on residence versus business. This has some of the same flavor to it. One part of this market would be POTS - Plain Old Telephone Service. That is still most of telephone traffic today. The other part would be computer-based communications which would handle data, interactive information such as airline reservations, etc.

In fact, the markets would be different in a variety of categories. First, they would hit very different people. Only a small percentage of consumers really want to interact with computers in the intimate way that we all like to do it here. It may be only a small number of people. Second, even people who have the sense of technical electronics often don't have use of the services that computers and telecommunications can give, which is the transmission of vast amounts of data very quickly. If you want to be able to get vast amounts of data, you need to be able to use vast amounts of data. Will people have a need to process this kind of data in any time soon? The third distinction relates to user friendliness. If one thinks now of e-mail and athena, etc., they are pretty straightforward to use, but they do require a certain number of tricks and a certain amount of knowledge. Will everybody know such things over time?

I would like to close with this particular question of segmentation. The prospect for the telecommunications market is that we will be going to telecommunications systems using the same wires and switches. But in terms of what economists think about, who is using the facilities, the cross-elasticity, how much people go back and forth between them, we might, in fact, be coming to a situation where there were two quite separate markets even though they were both using the same technical network. With that, I will throw this open to other questions.

Tanenbaum: Peter, I said in my opening statement that I found your book authoritative and that I agreed with you with regard to the driving forces and alternate scenarios of the telecommunications market. I also said that this was with a few exceptions. One of the principal exceptions is (recall that I grew up as a techy) the role of technology. In the early stages which you discuss, prices and politics mattered. But there is no question in my mind that once you get close to divestiture, we would never have gotten to that point if it hadn't been for technology.

So I would have to say that it was prices, politics, and technology, where the price-technology interaction is a very close one, as you pointed out, because it was technology that was driving down the cost of long distance. It was politics that prevented that from flowing through to the long distance user and instead caused it to benefit local users. The telephone industry fought that at first but then supported it. It was completely supportable in a monopoly environment; but the more it happened, the more unstable it became. The only thing that made the introduction of competition possible was technology. It was microwave

in the decisions you referred to that made it possible for someone to propose building a microwave system without having to bug right of way in order to build a cable system. Technology was at least an enabler but it was so strong an enabler that I would put it up as one of the driving forces behind the changes in telecommunications. Technology did not itself do the driving but if it hadn't been available, the other changes could not have occurred.

Q: Does anybody see AT&T going back to local telephone service?

Tanenbaum: Not this anybody.

Temin: Not in our lifetime. Aside from the economics of it, it would be very difficult legally.

Tanenbaum: As the technology evolves, we may not see much of a distinction between local and long distance service.

Q: Regarding competition, respected papers suggest that in long distance, what we have is an oligopoly. What are your views. For Peter, on coordination, what about the speed with which coordination can occur. Has it been very difficult to coordinate with Europe regarding ISDN?

Tanenbaum: While you were speaking, Peter, I noted that you mentioned that standards of coordination has not been a problem. I was going to say what was just said. Not only has the dimension of time changed, however, but also the U.S. position in terms of influencing standards has changed. The standards in the telephone industry have been set de facto by the U.S. for the most part. This was due to the much larger markets we serve and to the fact that most international telecommunications either originated or are terminated in the U.S. That is changing with time but that has certainly been the case. Also, we were the technology leaders. So we always had a view of what standards were needed before other people had started thinking too much about them. It is a easy to influence standards in that kind of environment. The U.S. influence is now much less because Bell has been sub-divided. Also, the rest of the world is now a lot more powerful in technology as well as in financial aspects of telecommunications. Some of this may have happened anyway; but divestiture did have an effect.

Temin: I would question this. We are comparing this not with some ideal situation; but with the old Bell system, which was as slow as molasses in terms of getting new things out. When we compare, we need to think about realistic alternatives. To get back to the ISDN, people who are in the business are always unhappy about the speed with which things occur, so this gives us no information at all. It is their business to write articles saying that it is moving too slowly. Third, about ISDN, comes back to my point about the markets, there was not a lot of pressure to get ISDN rights because there were not a lot of people out there who could figure out what they wanted to do with ISDN.

For your other question regarding oligopoly, if anybody thought that telecommunications was going to be like the corner drug store, they were just nuts. This is not that kind of a market. If you notice, even the corner drug store has been taken over by chains. What we are getting is what we in the modern world call competition. It tends to be workable competition, or sometimes oligopolistic. With economies of scale, you don't need to maintain many different companies. Rather, you need to maintain conditions of entry so that if costs change or if the few companies get together and raise prices, that others can enter the market and exploit the opportunities.

Q: Peter, you said that you envision a time when the industry will be segmented. I'm interested in your view of the nature of the segments in communications and the things that will enforce it.

Temin: I was thinking, not that there would be legal separation or even technical separation; but rather as separation in the way that economists think of it. We think of different markets and the cross-elasticity of demand, sometimes of supply. The sense is that various uses would be quite different even though from a technical perspective they would use the same dialing plan, the same wires, same computers, etc. In fact, there is likely to be one set of uses in which people will use augmented POTS, such as POTS with fax machines. Then there will be others with needs for ISDN and more sophisticated users along such lines. But the assumption is that shifting from phone systems to things like e-mail will not be responsive to even large changes in prices. So, in thinking about pricing, entry, competition, one could separate these out, even though they are using, in a sense, the same electronic highways.

Tanenbaum: In the past, we have talked about two markets - business and residence. Business volumes are comparable to, if not someone larger than, residential volumes. Business is a large user of data. The last figure I remember was that data use was approaching 20 percent of the circuit minutes and growing at a substantially faster rate than voice. Fax is, of course, a substantial contributor. But, in reality, there are many different kinds of markets. For example, on a regular business day "800" calls are now 40 percent of the total long-distance volume. There will be so many new markets that it doesn't help me to think of only two markets - POTS and non-POTS. Further, the advent of personal communication services (PCS) may substantially change the way we use communications. I think the market will be diversified rather than segmented. That will make it very important for businesses and large organizations to be very highly conversant in telecommunications applications.

Q: You don't envision segmentation based on band-width?

Temin: It probably would go to that. The POTS users would not need large band widths and the computer users probably would; but I don't think it is on any regulated band width.

Q: What about possible changes in newspapers?

Temin: One thing we can agree on is that the newspapers are very worried about this. If this goes through the POTS market, the demand for newspapers would stay quite high because those people would not be looking for an electronic means of getting their information. If that is the case, the competition for newspapers will still come from television more than from telecommunications.

Tanenbaum: The argument has been that telephone companies are in the information business but the basis of that argument is very similar to the basis of the argument that broke up the Bell system. It revolves around the question of the monopoly that local telephone companies have with regard to access to the home and, to a significant degree, to businesses as well. The question of whether the people who control the monopoly should have any say over how that monopoly is used becomes contentious. The question is not whether or not the local telephone companies should be in the information business but rather whether they should be providing the message as well as the medium. One of the reasons it was argued that it was necessary to break up AT&T was that you would never be able to separate costs and prevent subsidies to various parts of the business. As long as there is a monopoly in local distribution, the people who control that monopoly should make that distribution available to everybody and should not be in the business of competing with people who must have that local distribution access in order to be in business.

Q: Please share your thoughts on possible combinations between the telcos and newspapers.

Tanenbaum: That gets back to the prior issue of whether you allow one organization to control the only means of access and also compete with people who rely on those means to be in business. The same arguments would be raised in cases of mergers between telcos and newspapers. Some think that there is at least a possibility of competition between local telcos and news providers and the Justice Department, among others, would be unlikely to want to remove that prospect of competition by allowing mergers.

Temin: The legal and political issues Morry raises are interesting. The economics are also important. We have seen a few combinations of cable companies and telcos. But what are the economic advantages of crossing these lines? The thought is that if you own many different cable outlets then maybe there are economies of scale in providing certain kinds of switches but one tends to think of the different parts of the industry as having very different organizational needs, different marketing needs, different equipment needs. We need to think about and try to predict what are the economies gained from these; or are the gains just political?

Q: This is just a comment, another question to think about. Is there a market for the new services? Look at the failure of interactive services to really take off.

Temin: It is very hard to predict demand but that doesn't mean it won't be there. Before there were fax machines, people didn't miss them. Once they had them, they realized the potential. Service-end innovations may be needed more than organizational innovations.

It's not a question of whether there will be more demand for what we do now but rather will the increased capability allow us to do things we're not thinking about now.

Q: What are your views on electronic democracy?

Temin: It is hard to know what the future of this will be. Perot is certainly singing its praises but I think when we look back at history, we tend to focus on the things that were successful. We have to remember that the process by which innovations emerge is always very messy so there are many failed attempts before there is a success.

Q: What have been the effects of divestiture on standards, on the processes by which these are established, and on the players involved in setting standards?

Tanenbaum: I think I said earlier that that was one of the costs of divestiture. It is not all that clear to me where, relative to the rest of the world, we stand now; but it does seem that our influence is smaller than it used to be. My own feeling is that establishing standards is also a lot harder now than it used to be.

Q: When will there be competition in the local markets?

Tanenbaum: I think this will be metered by the technology. When the cost of the current technology versus the cost of the new technology are far apart, little happens. As those curves approach convergence, however, things happen very quickly. I don't know when that will be. It will also depend on how efficient the local telephone companies are.

Temin: For business/data users, competition is already coming very rapidly. For the POTS market, competition is at least ten years away.

Q: For Dr. Tanenbaum, how would you know what the costs of your operations are, segment by segment, in order to be able to compete? That is, how can you know which segments are actually being subsidized, which profitable, etc?

Tanenbaum: That was a large issue for AT&T and I suppose it still is for the local companies. We always knew what are total costs were and that's all you needed in a monopoly; but the accounting systems for understanding costs of each segment did not exist and are now emerging but it is very complicated. We can rate some services with much more clarity about costs but when I retired a year and a half ago, we were just putting together a new accounting system. That will be another step forward in relating pricing to actual costs, a "must" in a competitive market. To the degree that you're regulated, you don't have much control over allocating resources to determine prices. The regulators control the algorithms. The situation is better now but it has been a problem and we have spent a lot of money trying to fix it.

Q: Is there a need to coordinate all of the digital processing, with almost all entertainment

moving this direction? Are we better or worse off than our worldwide competitors in this and, if worse off, what can we do about it?

Tanenbaum: The AT&T network is totally digital. The local networks are not. Sprint is 100 percent digital on transmissions and MCI is either a 100 percent or close to that. All of the switching is digital. All of the major trunks in the AT&T network are fiber optic. Just about everything new that the Europeans and the Japanese are putting in is digital but it is my impression that they still have a lot that has not yet been converted to digital. It is quite costly. We wrote off about seven billion dollars worth of old equipment in our accelerated conversion. Europe and Japan seem to be doing this more slowly. There are many people thinking about what the network should look like twenty years from now. All of the U.S. competitors are working hard on these questions. We know that we will be competing with each other so there is a lot of motivation.

Ruina: I'd like to thank you all for coming and thank our speakers as well.