5-1997

A Primer on Changing Information Technology and the Fisc

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Published In
National Tax Journal, , 50, 3, 607-621.

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National Tax Association Spring Symposium, Arlington, Virginia, May 19-20, 1997.
Also to appear in *National Tax Journal*.

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Contents

1 Introduction

From the electric light to the automobile, history is filled with examples of new technologies that quickly change the way people live, conduct commerce, and run their governments. The modern computer will soon see its sixtieth birthday, and the telephone is even older. Why should such information technology still be driving fundamental change in our social institutions, including our methods of funding government? Certainly, automobile technology reached a mature steady state long before then, as did its ability to transform society.

Our goal in this paper is to answer this question in two ways:

- to describe in non-technical terms the components of changing information technology; and,
- to discuss their potential implications for how we fund government.

We hope this information technology primer and discussion of implications will bring greater realism to those seeking to adapt traditional fiscal institutions to such new activities as electronic commerce.

The paper is organized as follows. Section 2 defines information technology, reports how its components have continued to become more productive, and discusses recent innovations in communications technologies as well as increased demand for information services. Section 3 introduces several evolving uses of new information technology that lead to non-traditional financial transactions: barter and electronic money. Section 4 undertakes an analysis of the implications for tax officials of reduced knowledge about where, when, and with whom economic activities take place in order to tax resultant economic flows or stocks.

2 A Primer on the Changing Nature of Information Technology

2.1 Components of Information Technology: the Revolutionary Evolution

Information technology has one or more of the following essential functions:

- storing information
- processing information
- moving information.

When there is a significant change in the functionality of any technology of great importance, social repercussions usually follow. Imagine what would happen if new technology suddenly allowed automobile traffic to travel ten times faster with comparable safety and expense. Cars would become even more prevalent, competing technologies like airplanes and videoconference systems would suffer, and ultimately, the very idea of cities and communities would change.

When determining how fast information technology changes, we must look at the above three aspects of the system to understand how it will impact them. Consider the role of information in modern retailing. Every store in a modern retail chain moves weekly inventory reports to the national headquarters, where the reports are stored until all data has been collected. The information is then processed along with historical data on the market and the latest scouting reports, and results are sent back to each store who may adjust prices, and to wholesale buyers who will make their purchases accordingly. A significant change in a system's ability to store, process, or move information, e.g. the ability to cost-effectively transmit detailed instructions back to stores as opposed to brief price statements, could lead to dramatic changes in the functionality of information technology systems and the extent to which we rely on them.

Computing technology, which stores and processes information, has been growing at a phenomenal rate since the birth of the modern computer during World War II. Table 1 shows these growth rates. We also show the amount of time required for capabilities to improve by a factor of 10, which would typically be considered a revolutionary change to most technologies. Storage capabilities are represented by state-of-the-art DRAM chips and disk drives, both of which are important storage devices in any modern computer. Processing capability is represented by the rate that computer instructions can be executed measured in millions of instructions per second (MIPS). Costs are shown for both large (mainframe) and small (microcomputer) computers.

What is astonishing is not that this technology has made significant advances in productivity, but that the *rate* of technological advance has not decelerated. In contrast, consider a $1,000 automobile of the 1950's that could travel 50 miles per hour carrying two people, and imagine that automobile speed, capacity, and cost changed at the same rates as computer processing rates, DRAM capacity, and microcomputer cost, respectively. After forty years, this car would travel at speeds of 8.2 million miles per hour, carry 785 million passengers, and 16 of these wonder cars could be bought for a penny!

Table 1: Recent Computing trends

Measure	Annual change	Improves by factor of 10 every:
Processor MIPS	+35%	7.6 years
DRAM bits/chip	+64%	4.6 years
DRAM cost/bit	-25%	8.0 years
Bits/disk	+14%	17.6 years
Disk cost/bit	-21%	9.6 years
Mainframe cost	-15%	14.2 years
Microcomputer cost	-30%	6.3 years

Source: Siewiorek(1996).

The ability to move information has also been changing rapidly, as shown by trends in local-area computer networks. Roughly twenty years ago, the ethernet burst into the computer market. It allowed computers to communicate up to 2 kilometers at burst rates of 10 million bits per second or Mb/s, and sustained rates of roughly one third to one half of this. FDDI (fiberoptic data distributed interface) networks emerged in the late 1980's, allowing sustained rates of almost 100 Mb/s or a ten-fold improvement in the amount of information that can be transmitted per unit of time. Today, gigabit per second or Gb/s (1000 Mb/s) local-area networks are under development which will again lead to a ten-fold improvement in the amount of information that can be transmitted per unit of time. With storage and computing costs dropping dramatically as well, the creation, manipulation, and delivery of information in multiple forms (data, images, audio, combined) are creating new products and services that were not thought possible a decade ago.

Not only have the capabilities of information technology systems been in a constant state of revolution, but it is periodically necessary to reinvent the relationship among these three basic components of information technology or what is called "architecture". System designers must constantly make trade-offs between information processing, storage, and transfer, and optimal trade-offs change over time as their productivities and prices make new combinations more attractive. Is it better to store the encyclopedia locally, or to retrieve specific entries from the publisher when needed? Is it better for a communications carrier to offer sophisticated information services, or to focus on simply transmitting information at maximal speed and leave the processing to the customers' equipment? While the answers to such questions change with technology, often in very large ways, successful architectures remain transparent to the final user.

2.2 Communication Technologies

2.2.1 Packet-Switched Networks

The simplest telephone system had a wire called a circuit that ran between two phones, and was used exclusively to allow communications between those two phones. Unfortunately, this approach does not scale effectively. That is, with n subscribers, one would need n*(n-1)/2 separate lines to insure that each subscriber would be able to communicate with all others. The original solution was *circuit switching*, in which a telephone system includes many phones, and many dynamically reconfigurable switches that connect some incoming links to other outgoing links. When a call is made, switches are configured to create a connection from the source to the destination, and this circuit may pass through an arbitrary number of switches. Capacity along this path is reserved specifically for the call. Once the circuit has been established, it is as if there is a permanent connection between the two phones. When the call terminates, the resources are released, making them available for other calls. With circuit switching, the number of lines connecting to telephones remains at n, and the number of switches needed to deal with call volume grows over time with demand but is far less than n.

A newer alternative, called packet switching, is now changing the nature of communications. The idea is that all information should be digitized, and then broken up into discrete blocks of information. Control information is then appended to these blocks, the way a postal customer may include information about sender, receiver, priority, and urgency on the envelope of a letter. The 'customer's' portion of a packet may contain part of an electronic mail message, 10 milliseconds of recorded voice from a telephone conversation, or the corner of a digitized X-ray image. Once a packet enters the network, it is forwarded from one "router" or switch to the next, until it ultimately reaches its destination.

In some systems, a sender has no way of knowing the path by which a packet will travel, or even the location of the destination. This would be similar to mailing a letter with only the recipient's name, and letting the postal system figure out the recipient's address. (This is in stark contrast to telephone networks, where the telephone number is partially an address, i.e. it includes an indication of the part of the country where the recipient resides.) This approach is a significant advantage from a technical perspective, as it frees individuals from the onerous task of keeping track of everyone's location, and it may allow the network to transparently adjust to component failure or congestion.[1]

The Internet and local computer networks like the ethernet were based on packet switching, largely because it allows resources to be shared efficiently. Consider the following application. A business needs a 1 Mb/s connection between its Pennsylvania office and its Maryland office. Before packet-switching, that connection would have sat idle at times when the business had nothing useful to send. With packet-switching, when this business is not generating packets, the capacity may be used for someone else's packets. Thus, packet-switching undermines the concept of reserving resources. With packet switching, it is not essential to reserve resources in the traditional way unless a priori performance guarantees are required. Indeed, most computer traffic is transmitted "best effort," whereby the network does its best to get a packet to the destination through whatever resources are available at the time, but the packet may not make it, forcing a retransmission some time later. Networks *may* keep track of when resources are specifically reserved, but typically no record is kept of specific packets sent or dropped, so the network has no audit trail indicating what information was sent, when, and to whom. Keeping track of such information would significantly increase the cost of the system.

Today, telephone networks, cellular networks, and possibly even cable television networks are all moving towards packet switching. Packet switching facilitates the development of *integrated-services* networks, which are networks that carry diverse kinds of traffic such as voice, video, and computer file transfer in an integrated and consistent manner. This allows telephone, cable TV, and Internet providers to invade each others markets. Competition is enhanced, and the survivors of this competition can build larger networks, which is important because current communications technologies have significant economies of scale. This also facilitates development of complex *multimedia* applications, which are applications that simultaneously generate multiple types of traffic. For example, a sophisticated collaborative work system may support telephony, video-conferencing, the exchange of spreadsheets and graphs, and an on-screen blackboard that users thousands of miles apart can all see and write on.

2.2.2 Layering

The first thing any engineer is taught about the design of packet switched networks is the essential concept of *layering*. This concept simplifies network design, but may complicate tax policies. All network functions are assigned to some layer i, and layer i can interact only with layer $i-1$ and layer $i+1$. Thus, each layer wraps the lower layers; layer $i+1$ need know nothing about layers 1 through $i-1$. For example, in the seven-layer system defined by the International Standards Organization (ISO), layer 1 allows a switch to send one bit of information (accurately or not) to another switch over a single communications link. Layer 2 uses this service, and adds the ability to retransmit anything received in error,

[1] As will be discussed further in later sections, it may be a nightmare from a tax perspective.

among other things, to send blocks of information reliably across a single link. Layer 3 adds routing functionality, among other things, to carry blocks of information across an entire network, passing through many switches if necessary. If a network switched from copper links to fiber optics, it would need a new layer 1, but layer 3 would remain unchanged. Conversely, if a designer wanted to add functionality to layer 3, like the ability to send a message to multiple destinations instead of just one, then this would have no impact on layer 1. Note that each layer consumes a service from the layer below and offers its own.

2.2.3 Emerging Wireless Communication Technologies

While the data rates of wired networks are rapidly increasing, it is also becoming cost-effective to provide much of the functionality of today's wired systems through wireless systems. An important set of new wireless applications are called *personal communications services* (PCS). Indeed, the U.S. government recently released a large block of the radio spectrum which is intended for PCS. There is no single PCS application or technology, making it difficult to characterize. It will undoubtedly include wireless telephone services, computer communications, personal digital assistants, and more. One underlying premise that many PCS developers have stressed (and the reason for the "personal" label) is that PCS allows you to communicate with people, not just with places where a telephone or computer happens to be located. This concept is not new. Cellular telephones already allow it. To some extent, so do the new *advanced intelligent network* features of today's telephone systems, which support call forwarding and 800 numbers that send calls to the operator with the lightest load. However, wireless PCS systems will accelerate the trend, making it increasingly common that people (and electronic vendors) will have no way of knowing the location of those with whom they are communicating.

The most dramatic wireless systems under development are those based on *low-earth-orbit satellites* (LEOs). Unlike their geosynchronous counterparts, LEOs remain close to the earth, and they move relative to an individual on the ground. Proximity makes communicating with them better and cheaper, but since they move, it is impossible to communicate with a specific satellite for long. Several companies plan to develop constellations of LEOs that literally span the globe, so that from any point on the ground, there will always be a satellite overhead. People will be able to travel worldwide without changing phone numbers, with all the information traveling through space. Although these systems are still under development, the first LEOs have already been launched.

2.3 Demand Explosion

There has been a strong trend to make communications a more integral part of information technology systems. This makes the applications more scattered geographically. It also increases the demand externality, as the value of a system increases when customers, service providers, and common carriers adopt a compatible system. Products with strong positive externalities are often difficult to launch, and are initially prone to slow growth. However, once a critical mass has been reached, demand often explodes, making it difficult for both customers and vendors to keep up. It is even harder for regulators. The fact that cost and performance tend to improve rapidly reinforces this effect. A good example of such explosive growth is the Internet. As shown in Figure 1, the amount of traffic carried on the Internet has been growing rapidly and exponentially. Demand increased by a factor of 10 in just three years.

More than one in three American homes now have a computer, and with annual consumer spending on computer-related equipment (*excluding* businesses) now exceeding consumer spending on televisions, penetration should continue to rise. Moreover, cities like Pittsburgh have launched innovative and aggressive programs to make computers accessible to all residents from public places, so all segments of society will have increased access to this technology. Electronic commerce has not yet taken off the way popular services like the World Wide Web have, but the way has been paved.

3 New Arrangements in Information Technology

3.1 Increasing Use of Barter

Barter for goods and services in the information technology area, in lieu of exchange of information services for currency, can be beneficial for market participants if monitoring costs, necessary to measure the extent of other's uses of, for instance, capital facilities, are large or the value of such services is difficult to agree upon.

Barter is fundamental to the Internet, which is really a network of networks, each of which provides services for the others. For example, Sprint operates one such network, and it sends monthly bills to organizations that are physically connected to its network. Sprint implicitly agrees that it will carry any Internet traffic it receives, including traffic that does not originate or terminate with one of Sprint's customers. It does not charge other carriers for this service. In return, customers of Sprint gain the ability to communicate with customers of other carriers.

There are two reasons why this is attractive. First, communications systems often show tremendous economies of scale. It is an expensive and labor-intensive process to dig up streets and run copper or fiberoptic cables to each home. It costs little more to run several cables. Moreover, as described in Section 2.2.1, individual customers will not transmit packets all the time, so when a given link carries traffic from many sources, the law of averages allows a designer to assume that at any given time, a small fraction are active. Thus, a 10% increase in traffic load will increase capacity costs by considerably less than 10%. (Cooperation occasionally breaks down when this is not the case, e.g. when it took significant capital expenditures to add transatlantic cables.) Second, pricing mechanisms based on actual usage are costly and add overhead, so there has been reluctance to introduce them. For the moment, even if there is an imbalance in the extent of the benefit, all participants profit significantly from offering each other free communications services.

This kind of economy of scale is not unusual or unique to information carriers. Information providers are also likely candidates for barter agreements, provided that they serve different customer bases. Creating more copies of information has negligible cost when it is in electronic form. For example, if the *Chicago Tribune* and the *London Independent* newspapers begin offering on-line services to their respective subscribers, it would cost the Tribune little to furnish information on American news to interested British subscribers.

Figure 1: Internet Traffic Growth Over Time.

Barter may be an inexpensive approach to make both services more valuable to subscribers. The exact value of this transaction is impossible to determine. Indeed, the newspapers would both argue that no transaction occurred at all. Taxation would be difficult.

The economies of scale described above engender another interesting phenomenon: an increasing number of firms that survive on "gifts" rather than direct revenues. This is not new. Public television and radio chose this path for many of the same reasons: it costs the same or even less to transmit information to every one rather than just to those who subscribe. All recipients are asked for donations, which in the case of public television are untaxed, and as long as a few respond, the station survives. This also occurred with *freeware*, which is free software that has typically been distributed on inexpensive disks. Those who like the software are asked to send a gift to its creator (possibly to a post office box in the Cayman Islands). Today's Internet eliminates even the cost of the disk, making this an attractive means of distributed information and software.

3.2 Public Key Encryption

The innovation that can best turn a global system overflowing with information into an important place of business is *public key encryption*, which was invented in the 1970's. This approach to encryption is based on the idea that there may be functions that transform information in a way that is very hard to reverse. For example, imagine that every one in the world knew how to multiply by 7, but Ann is the only one who knows the inverse: how to divide by 7. Dividing by 7 would be Ann's private key, while multiplying by 7 would be her public key. Ann could protect her stored information by multiplying all numbers by 7. People could similarly send Ann numbers without risk of eavesdropping by first multiplying those numbers by 7. Ann could also use her knowledge for *authentication*, i.e. to prove its really her, because if you pick a number and multiply it by 7, then Ann is the only one who can tell you what the original number was. Finally, Ann can use this approach to guarantee the *integrity* of her messages, i.e. to insure they have not been tampered with. If she sends a number and that number divided by 7 and someone tries to alter the original number, the recipient will be able to tell this by multiplying by 7.

Privacy protection, integrity detection, and authentication are the essential ingredients to any commerce system. Although it is not possible to create a function that is impossible to invert, it is possible to create one that would take a billion years to invert with the fastest computer available today. Such approaches are known; they are relatively inexpensive, extremely difficult to regulate, and increasingly common. As they become common, so will safe and untraceable electronic commerce transactions. (Of course, given the speed at which computers improve, today's unbreakable code is tomorrow's vulnerability.)

3.3 Electronic Money

Many of today's fund transfers may someday occur in electronic form, and then these transactions could also become as difficult to monitor and tax as the barter of electronic services described in Section 3. Public key encryption as described in Section 3.2 enables the creation of electronic money. "Banks" (or any individual or firm that wants to play this role) will accept payment from customers, and then allow customers to buy goods or services with a simple exchange of information, making sure that vendors get paid in the process. Customers with the proper information can demand that the bank return their money at any time. 'Banks' (depository and non-depository institutions) will try to put as much electronic money as possible into circulation, because every dollar in circulation will be deposited and invested at differential interest rates. Electronic money is also attractive to buyers and sellers. It can be exchanged over a network, takes negligible time, and it works equally well for transactions of a few cents and a few billion dollars. Banks may even pay customers a small interest rate on the money they are holding. The bank is also free to determine what its own electronic money can be redeemed for: dollars, yen, gold, Boeing stock, the Mona Lisa, or a specific patent of unknown value.

There are many possible systems of electronic money, and no consensus as to which is best. Some will automatically create an audit trail, while others are untraceable. Some involve money that can only be used once with a specific vendor, while others involve money that can be exchanged an unlimited number of times. Three plausible example are presented here.

In the one preferred by tax collectors, the bank would have complete knowledge of all transactions in order to oversee them, much the way a credit card company knows who is involved in each transaction, when it occurs, and the amount of money exchanged. Each purchase would involve communications among buyer, seller, and bank. However, the potential for abuse of privacy in such a system is great. Many customers will not like the fact that someone knows the details of every purchase they make, especially if that information can be revealed to a telemarketer or a competing business.

The alternative is to conceal the identity of all participants. One way to do this is through a *smart card*, a small electronic device that records the amount of electronic money that is currently held. Precursors already exist in the form of cards with magnetic strips. Such cards are typically used to purchase goods from the organization that issues the cards. Examples are cards for telephone calls and subway fares. Smart cards will add electronics capable of running complex communications protocols and encryption algorithms, making it safe to exchange electronic money more than once before demanding compensation from the issuer. Giving someone \$10 may be as simple as connecting two smart cards, and adding \$10 to one while subtracting from the other. If these devices can be made such that they are immune from tampering or counterfeiting, then electronic commerce can take place without any involvement from the bank. In effect, the bank can now create currency, which all of its customers can exchange at will. Transactions are as untraceable as cash transactions, except that electronic money can be exchanged over any telephone or Internet connection. Moreover, millions of dollars in electronic money can be carried across borders in a small wallet rather than a large suitcase. Many are now trying to perfect such a smart card.

A final example allows the bank to remain involved, and to take an active role in stopping counterfeiting, but still protects the anonymity of customers. The bank might create a \$20 token, which is associated with both a public key and a private key. Whoever knows the private key can claim \$20. Everyone can verify that it is really a \$20 token using the public key. Trading protocols are established that destroy the old private key and create a new one for the new holder of this \$20 token. The bank is involved in the trade, and can make sure that this \$20 token really is in circulation, but need not know who is losing and who is gaining the token. As with the smart card, the bank can then create currency, which all of its customers can exchange at will. The bank has no idea who is exchanging currency. Although the bank knows how much currency is exchanged, it doesn't know the amount of the transactions either. For example, if it sees a $20 exchange and a $5 exchange, were these two separate transactions, or was this a single $15 transaction, and the $5 was simply change?

The first step in avoiding the creation of the latter form of electronic money is to reduce incentive to create it. One important reason for law-abiding individuals to prefer the anonymous form of money is fear that information on their transactions will become public. Strong laws for privacy protection are needed to reduce such fears. However, this is no guarantee that untraceable electronic money isn't coming soon.

4 Some Implications and Issues: Where, When and Who is Doing What?

A desirable tax system is typically described as one that: (1) raises requisite funds to support the costs of needed public services without constant rate adjustments; (2) alters economic choices as little as possible except to correct identified problems; (3) is certain and inexpensive for taxpayers to comply with; (4) is inexpensive for tax administrators to run; and, (5) achieves agreed upon distributional goals. Moreover, at the national level many expect a tax system to be consistent with and enable the achievement of macro-economic stabilization goals.

The federal and state governments can affect the use and design of information technology in a variety of ways. Through the regulatory process they historically have defined market access, overseen the investment decision and through the setting of prices affected profitability. With deregulation, these have become less important. Federal spending on research and development on a variety of basic and applied research strategies have helped maintain the rate of technological change. Finally, federal tax policy, especially the determination of the tax lives and allowable rate of depreciation of the components of information technology, can affect architectural designs by affecting relative, after-tax prices. Because the technologies underlying information technology often change in dramatic ways, identification of one component as a tax base, e.g. the bit tax, may provide an unexpected volatility in fiscal results.

With information technologies characterized, normative considerations of a good tax system identified, and general effects of how the national public sector can affect information technology, we turn to some of the implications of information technology for state level taxation.[2]

Much of the recent focus by *state* tax experts on the implications of information technology has concentrated on positing a nexus standard for particular tax bases when transactions are characterized by electronic commerce, and then trying to devise workable approaches to situations in which paper trails are sparse or non-existent between sellers and buyers. Below, we discuss in more detail the implications of changing information technol-

[2] Many of the issues raised viz a viz inter-state taxation apply equally to international tax issues.

ogy for those interested in determining where, when, and who is creating economic activity which can be measured and taxed.

4.1 'Where?' Implications and Problems

Modern technology will make it increasingly common for sales to occur where buyer and seller are in different states; this raises the question of whose sales tax should apply, e.g. place of origin or destination? Taxes can not be based on the location of the seller because the communications technology described in Section 2.2 makes it possible for the seller to move without the slightest inconvenience to its customers. However, with today's technology, taxes can not be based on the location of the buyer because the seller can not determine where the buyer is located. With some (but not all) technical approaches, a bank acting as an intermediary may be able to determine a billing address of some kind, but this too is easy to manipulate for tax avoidance, as the billing address need not have any relationship with the physical location of the buyer.

Even if location can be determined, the very concept of a nexus is based on the underlying assumption that there is a "place of business:" a location where employees gather with the appropriate tools to create a new product, or where buyer and seller come together to transact business. Emerging information technology threatens this fundamental assumption. For example, a technician points an ultrasound device at a patient in rural Alaska. The results are processed by a supercomputer in Seattle, while a doctor in California watches the results and talks with the patient. The doctor doesn't know where the patient is, nor can the patient tell that the doctor is on vacation in California and not in her Colorado office. So where did this examination take place? In medicine, education, engineering design, and countless other activities, geographically distributed efforts will become increasingly common, making the definition of where these activities occur, and which of the players are within the same company as opposed to independent contractors, entirely arbitrary.

4.2 'When?' Implications and Problems

Far less has been written about the equally important issues of When an economic or financial event occurs and its implications for tax and financial reporting. By "When" we mean the important question of measuring, recording, and being able to verify the time at which "information events" occur.

Several issues arise. First, current and planned network architectures do not record the time and date of information movement across one or several networks. Thus, sender and receiver (seller and buyer) may then be obligated to keep track of each event or summarize and record such events for financial and tax reporting purposes.

Second, to the extent there are no widely used or accepted equivalents to paper journal entries with associated time stamps as well as the signature of the author(s) making the journal entries, subsequent third party verification of the timing of activities may simply not be possible. Third parties include not only tax administrators, but internal and external auditors who measure such activities for internal management purposes and external financial reporting and public disclosure purposes. It should also be noted that such information ultimately informs us about the state of the economy because such records are the source of virtually all economic and financial statistics collected by the federal government.

That means the timing of activities and associated payment flows in the electronic market place can not be independently measured. To some extent these are not new phenomena as computerized record-keeping has been important for most businesses for a considerable period of time. However, the absence of carrier verification of the timing (and often the nature of) transactions in a world of electronic commerce increases the incentive between buyer and seller to create events for particular purposes. Where there never is a paper trail that initiates the economic activity, there is perhaps a new kind of "white-out" that enables those so-inclined to create virtual economic and financial realities which can not be audited.

4.3 'Who?' Implications and Problems: Common Carrier or Local Representative?

A company that does business in a given state is taxable in that state if it meets the nexus standard for the tax in question. A company that does business in that state through a local representative can also be taxable. Under *Quill*, a business that operates in a given state only through a common carrier like the U.S. postal system is not responsible for remitting use tax into that state. Unfortunately, today's information technology can blur the distinction between common carrier and local representative beyond recognition, threatening the principles in *Quill*.

When does a carrier become a local representative? Clearly, when AT&T leases a specific communications line into a state that connects an information provider with its customer, AT&T is acting as a local representative. It is as if the company owns that communications line. However, as described in Section 2.2.1, packet switching facilitates efficient sharing of resources. A company may pay a monthly fee for a guarantee that communications resources are available upon demand, although it may not be the same exact cables and switches every time. From the company's perspective, this is no different from leasing, but from the carrier's perspective, those resources can be used for other things when idle, making this a superior arrangement. Or perhaps the company knows that there is a one in a billion chance that resources will not be available at the instant desired. Thus, the carrier can "oversell" the resources, but the chances of all subscribers wanting to use the resources simultaneously are negligible. Perhaps the chances of finding the resources busy are only one in a million, or one in a thousand. At some point, the arrangement begins to look like typical phone service, where there is always some chance of getting a busy signal because all circuits are in use. The distinction between local representative and common carrier is therefore an arbitrary one.

4.4 'What?' Implications and Problems

4.4.1 Barter and Tax Avoidance

As noted earlier, barter often takes place when value is uncertain but exchange beneficial. Several points are germane here that have implications for the fisc. First, intermediation is usually argued to be promoted through the use of currency or currency equivalents, and historically has been viewed as a way to allow markets to specialize further since exchange of purchasing power is enhanced. The above technological innovations could readily allow the creation of their own "store of value" which could be denominated in something other than a national currency or internationally agreed upon value such as the value of a troy ounce of gold. Were an information unit to be a new standard of barter and value, and no link to currency denominated in values fixed or functionally defined, it is easy to imagine that revenues of any seller would be systematically understated with the result that income and income tax due would also be systematically understated.

Second, tax and financial accounting rules have historically required economic actors to value "considerations" in the measurement of cost and revenue so that trading of in-kind goods and services are properly reflected in income measurement . Whether or not electronic barter has created tax avoidance opportunities depends on a number of factors: the value of the services to barter participants compared to their known capital and operating costs, the relationship of monitoring costs to these known operating costs, and whether or not various asymmetries in timing and barter value allow meaningful tax avoidance strategies.

4.4.2 Layering and Double Taxation

The analysis of transaction taxes typically results in the dictum against taxing sales to businesses which use the purchased goods and services in their own businesses. Otherwise, such taxes will cascade and create incentives for vertical integration and other tax avoidance schemes which result in the loss of economic efficiency. Sales tax statutes typically exclude from transactions taxes such goods and services which are for resale (thus excluding wholesalers from double-taxation), and prohibit the taxation of goods and services which are altered or used in the manufacture of other products.[3]

The discussion in Section 2.2.2 of layering indicates just how difficult it is to make such traditional distinctions and utilize traditional mechanisms in the area of information technology. Every layer i offers a service, and (if $i > 1$) it uses the service offered by layer $i-1$. So which services are taxable? For example, company A offers 1.5 Mb/s analog telecommunications services that many companies use for video conferencing. In addition to these subscribers, company B subscribes to this service, adds digitization and packet-switching capabilities as described in Section 2.2.1, and offers its service to companies that want to their interconnect their computer networks. Company C subscribes to Company B's service, and adds its own software to offer an electronic mail service to interested consumers. Company D uses this service to offer electronic mail in which the sender may write email in English, while the receiver sees a message in Spanish, or vise versa. In effect, each of these companies is offering a service that is both wholesale and retail. Thus, the prevailing

[3] See Due and Mikesell(1994).

method of designing communications networks makes it inherently difficult to tax customers once, and only once.

This problem applies to content providers as well as communications providers. For example, company A sells digitized versions of the paintings from many painters. Company B selects a few of these paintings, orders them, and adds text to create educational material on the evolution of impressionism. Again, it is difficult to differentiate wholesale and retail services. This distinction depends in part on the intellectual property rights that accompany a given sale of information, and many arrangements are possible.

4.5 Some Longer Term Implications

If the reader concludes by now that the brave new world of information technology portends greater angst for international and inter-state tax administration, we can only observe we share these concerns. We have made the observation that the opportunities for what is traditionally defined as fraud seem qualitatively greater in the world of cyberspace because many of the traditional mechanisms for third party verification are absent. Also, the opportunities for aggressive tax planning seem qualitatively larger.[4]

If monitoring costs are relatively high, and the sheer volume of activity large, it seems likely that buyer, seller, and carrier will be unwilling to construct records that can be traditionally examined for verification. Perhaps the development of agreed-upon statistical sampling techniques will constitute a workable alternative to maintaining exponentially growing disk files of transactions. We surmise that discussions of such issues will follow the initial definition and classification work which characterize much of the working group activities, once fiscal officials begin to appreciate the potential volume of activity which would be saved for audit purposes.

At a more fundamental level, it seems likely that the growth of information technology and the increasing difficulty of answering the "where" question for tax purposes insures that the states will become less and less able to identify and attribute economic activity to fixed geographic areas, without imposing undue burdens and costs on market participants.

One strategic response to this problem is to view the federal government as the societal tax collector, and to increasingly fund needed state and local services through intergovernmental grants. While a greater geographic spread will potentially reach more and more cyberspace economy participants, the federal government is also likely to be unable to geographically attribute activity to particular states.

Revenue sharing via approximate formulas maybe a workable solution. This seems most meritorious in the case of state business taxes, and will increasingly make sense viz. a viz. consumption taxes. However, given the historical unwillingness of the Congress to accept Supreme Court invitations to legislate in such limited areas as *Bella Hess* and *Quill*, it may be that this suggestion may not see implementation for a considerable period of time.

[4] For example, attributing destination of electronic commerce on the basis of the purchaser's billing address may seem workable, but can be readily planned around through the maintenance of an electronic billing address at a (non-depository) electronic bank from which payment is debited and whose physical server is located in a non-sales tax state (or country). It seems reasonable to expect that such tax avoidance opportunities will become available given the low cost associated with the establishment of such sites.

The second long-run issue involves the distinction between business and household consumption. If we are correct that it will be increasingly difficult to answer the "Who?" question with the right economic answer, then another long-run implication of information technology viz. a viz. the fisc may be to focus on the proper measure of household income as the final place for taxation to rest, rather than consumption and business gross receipts. This suggests in turn the desirability of addressing how existing federal and state corporate income tax policies impose multiple taxes on corporate source income, and the sort of remedies which have been proposed over the years to limit or eliminate such multiple taxation.

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