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# Public Networks and Economic Growth

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Abstract: This paper discusses the role of public networks in economic growth and development.

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Perhaps the most fundamental question of economics is: “What leads to economic growth?” Sustained growth can make a huge difference in things that matter – infant mortality, education, quality of life – within a single generation. Moreover, it is clear that policies matter: at the end of World War II, North Korea was the richer, relatively well-developed portion of the Korean peninsula, whereas today South Korea is over fifteen times richer per person.

Governments have played a substantial role in growth, with contributions that are both positive and negative. While some economists argue that government only harms growth, the empirical evidence doesn’t corroborate this position. Moreover, there are sound theoretical reasons for government involvement in coordination and public goods. Most empirical literature is consistent with a finding that government involvement in transportation and communication enhances economic growth. This note government explores involvement in, either through regulating, subsidizing or operating, public networks. Economics has recently developed new tools for operating public networks and exchanges, which can be brought to bear on this critically important problem.

## **Public Networks**

There are many distinct networks that are either operated by the government, subsidized by the government or heavily regulated by the government. Early networks included roads and mail, both of which had private provision. The development of a rail network was heavily subsidized by the US and European governments. In most cities, the subway and trolley networks developed either as a public operation or with substantial public assistance. While phone networks were primarily developed privately, they came under substantial regulation as a public entity. Similarly, electrification involved a mix of public and private development. The airwaves for commercial television were granted without charge and most nations offered public television as well. In all of these examples, the government facilitated network deployment with investment, creation of rights-of-way, or both. In contrast to these examples, financial markets developed without substantial public input.

The networks with substantial public involvement typically involve transportation – of goods (highways, rail, water), of people (highways, rail and trolleys), of power (electric grid, oil, gas and gasoline pipelines), and of information (post, telephone, television, satellite). These networks have the benefit of connecting us to each other and reducing the costs of operating many, even most, businesses.

While there are substantial private consumption aspects to these networks, there are also significant external effects as well. Communication involves several people; much of the value of telephone networks is lost when few participate. The mail service is often credited as unifying the nation. The construction of canals in the United States opened up development of much of the eastern portion of the country, and the rail network make development of the west possible. Without the lowered transport costs, it was prohibitively costly for farmers and ranchers to get goods to market. The Panama Canal continues to have a substantial impact on east/west trade. The interstate highway system in the United States had dramatic effects on trucking costs, which cascaded through other businesses. For example, the consolidation of the beer industry is often attributed to the interstate highway system.

Transport – of goods and information – is a critical input to economic development. Governments have been heavily involved in the creation of transport networks, and there is a solid economic reason for this. First, transport often is a local natural monopoly. Once a pair of cities is connected by a rail line, the construction of a second rail line, with resulting excess capacity, subjects the operators to ruinous competition. Consequently, only the largest cities were connected by multiple rail lines. Lacking competition, it would be surprising for privately-operated transport networks to be priced near average, much less marginal, cost. Second, new forms of transport are subject to a coordination problem. For example, a rail line to an undeveloped area will be successful only if development occurs; thus the rail operator has to forecast the development of the area and the developers forecast the installation of the rail line. As everyone on the web knows, “Build it and they will come” is a wish or a hope, not a guarantee. Sometimes they come, sometimes they don’t.

The combination of substantial scale economies and coordination problems create a major role for government in transportation. Left unregulated, there will tend to be an inefficiently low level of transportation made available at high prices. For this reason, governments have and ought to be involved in transport.

Communication networks present the same characteristics of transportation systems. Most of the costs are fixed costs, independent of the user volume. There are substantial issues of coordination – use of communication systems requires widespread adoption. Like transportation, efficiencies in communications cascade throughout the economy. For example, GPS and two-way radio reduced trucking costs substantially because of the ability to organize backhaul (return journey).

### **Economic Growth is Mostly about Entry and Education**

There are two major forces behind growth: new products, services and means of producing them, and the worker skill levels to build or perform them. Thus, at its root, growth comes from human inventiveness and skills, which are nurtured by education. Growth is expressed by the creation of new companies which enter into markets. I’ll set aside the education portion, which doesn’t diminish its importance, and focus on the new companies.

Long-term sustained innovation mostly arises from entrants into markets. Two main reasons underlie this important and empirically justified conclusion. First, incumbents have little advantage from disruption, that is, from new technologies that radically change the cost of satisfying consumer needs. This effect, the disfavor of disruption by incumbents, is known as “cannibalization” in the product differentiation literature. A new, disruptive development supplied by an incumbent cannibalizes the existing profit stream, and the existing profit stream thereby is a disincentive to innovation and disruption.

Second, many new ideas arise from outsiders possessing familiarity with distinct technologies. For example, brassiere manufacturer Moldex recognized that its brassiere expertise could usefully be applied to the creation of face masks worn by construction workers to prevent breathing dust and contaminants, applying an existing, off-the-shelf technology in an entirely new

setting. There are many examples of outsiders finding new applications for their existing technologies. It is much easier for outsiders – already familiar with the technology – to find applications than for incumbent manufacturers to find relevant technologies.

Moreover, there is substantial empirical evidence that much of growth comes from entrants. The study of the deregulation of the former communist countries supports this view. Moreover, most job creation comes from smaller enterprises, or smaller enterprises growing into large ones.

As a result, in evaluating government promotion and involvement in networks, a critical factor is whether and how entrants are facilitated. In addition, if the government involvement in a network promotes workforce education, that is better still.

### **Facilitating Entry**

There are large firms that enter new industries, and such entry is good for growth. Here, however, I will concentrate on small entrants, or new entrants. The difference is that large firms already have internal infrastructure – accountants, human resources, hardware, distribution, and so on – and thus are less dependent on network infrastructure than new entrants.

Let me lay out a couple of “use cases” concerning entry, to help fix ideas. One example is a good cook, who considers opening a restaurant. This entrepreneur has cooking skills well beyond the norm, but probably lacks any special ability in preparing taxes, hiring reliable workers, advertising, or purchasing plates and silverware. All of these skills need to be acquired to make the restaurant a success, or at least not a sad failure. This is the “better mousetrap” use case, where the product or service offered by the entrepreneur is superior to that available in the market. An important point, however, is that the entrant depends on acquiring additional skills to bring that mousetrap to market.

A second use case is the entrepreneur who sees a need and seeks to fill it. This need could be a delivery service, a packaging service, production of replacement parts for old cars, computer assembly using extra high quality parts, etc. Thousands of companies are created by individuals who see a hole in the system and seek to fill it, thereby enhancing the lives of customers and improving the functioning of the economic system. In this use case, the entrepreneur has no particular skill in the good being delivered, but instead was the first to notice the need; this use case involves an entrepreneur with a better idea.

A third use case is the ‘best execution’ use case, where an entrepreneur thinks they can deliver an existing service more effectively. In such cases an entrepreneur fills a niche by doing better than existing incumbent suppliers. The restaurateur could also be an example of this case, but may be simply differentiated by style rather than superior by execution of the style. The “best execution” case, unlike the previous two, generally involves a better skill set.

In two of the three use cases, entrepreneurs must accomplish many things unrelated to their core skill to make their business successful. The need to accomplish so many distinct things, each with its own requisite expertise and skill, probably accounts for the high failure rate of small business. An important social goal, one not related to my topic of networks, is simplifying the

very difficult life of small business, using the tax code, health care policy, and other government instruments. (Simplifying the tax code itself would be a major improvement in the U.S.)

Networks play an important role in the fostering of entry because networks generally reduce the cost of entry. The classic public utilities – water and electricity – facilitate entry into many businesses by lowering the cost of critical inputs. Similarly, the mail service, when combined with eBay, allows small transaction businesses to operate nationwide. This has made large swaths of the retail economy, which formerly were characterized by local monopolies, into competitive sectors. For example, collectible dolls and fossils used to transact by small retail outlets, but are now sold primarily, and much more efficiently, on the internet. Virtually anything easily transported now can be purchased at a much more competitive price than before the internet. But it is important to realize that the existence of highways, airports and transportation networks play a significant role in facilitating these markets as well as communications.

The importance of information in entry and growth has been highlighted by Chris Woodruff's studies of the Mexican shoe industry and Gordon Hanson's work on Mexican clothing. Substantial aggregations of companies arise, probably due to the importance of communication and information. Thus, information is already a critical input into industrial competitiveness, a trend that will only continue to increase in the next decade.

As more and more operations move online, the importance of communication networks rises. Communication networks – telephone, wireless and internet – are essential to future prosperity. While it would be best if communication networks could be left to the provision by the private sector, communication networks share with water, electricity and highways a very high fixed cost of provision, with more than 50% of the costs being fixed costs. As a result, the threat of natural monopoly is already great. In addition, however, there is a substantial barrier to entry since the provision of telecom services generally involves a great use of the public rights-of-way and telephone lines. It is very difficult to reconstruct such rights-of-way today.

Government should be prepared to step in to correct serious monopolization problems. As Voice-Over-IP (VOIP) has become an effective telephone substitute, public provision of internet services, either by regulation or, preferably, by fostering competition, is today what electrification was fifty years ago: the single best public strategy for creating future prosperity available to the government.

### **Public or Private Provision**

While I think the inefficiency of government is often overstated – large private corporations like General Motors have similar inefficiencies – it is true that the public provision of goods often subjects them to a variety of political pressures, and that much efficiency can be lost in the process. For example, Canada created government-operated PetroCan as a means of insuring competitive behavior by private oil companies, but somehow PetroCan wound up being the most expensive provider, at least when I lived there in the 1980s. For public provision of goods that can be privately provided, publically-financed or subsidized private provision is generally preferable, in terms of innovation, quality and price, over government operation.

The first act of government in the telecom sector should be to remove the entry barriers, e.g. by facilitating the laying of cable. Obtaining the ability to run cable is a formidable challenge often made more difficult by government itself. In the United States, running new cable is generally considered impossible unless it piggy-backs on existing cable. This is why the electric companies, with a grid reaching nearly every home, are considered to be promising potential entrants; not because they know anything about internet, but because they already have rights-of-way.

Government can also sponsor entry by auctioning the right to provide services in areas where services are incomplete, so-called auctioning universal service. Such auctions should favor entrants, with an eye to establishing competition in services, as service areas of companies encroach upon each other.

Such companies – operated in nearby but disjoint geographic regions – are often permitted to merge, on the principle that they are not currently competing with each other. However, such mergers are usually a bad idea; as geographically separated companies represent the best hope for future competition as growth makes their geographic regions collide.

## **Unbundling**

In the United States, most people now buy telephone, internet and television either from a cable company or from a combination of the telephone company (telephone and internet) and a satellite TV company. As a result, even when there is competition, it is limited by the bundling of services. Consumers who would like to switch internet companies are forced to simultaneously adopt a different method of receiving television signals. The bundling of services at the customer end has created substantial switching costs. Not surprisingly, prices for these services in the United States vary greatly by geographic region but are generally higher than in European nations or Japan. On the other hand, the presence of some competition keeps U.S. prices substantially below the rates prevailing in Australia.

Bundling of services offered to the final customer is only one example; bundling of network services generally creates entry barriers into the individual component. Such entry barriers can act as a substantial impediment to competition.

Bundling presents a thorny problem for the government, because a certain amount of bundling is efficient. Whenever costs are lower because of the sale of several services, bundled prices are justified as passing on some or all of the cost savings to the customer. Moreover, in the case of telecom and television services, the presence of high fixed costs suggests that the low bundle charges for individual services cover their low marginal cost; the problem for competition is that an entrant is severely disadvantaged unless the entrant can offer all the services; the lack of competition means that prices overall can be high.

There is no simple solution to the problem of bundling. A certain amount of bundling is efficient, and it is often not straightforward to detect anti-competitive bundling. Nevertheless,

bundling is an important tool for firms attempting to foreclose entry and hence should be scrutinized by the antitrust authority or competition commission.

## **Market Design**

Perhaps the most exciting development in microeconomics in the past twenty-five years is the field of applied game theory or market design. Market design uses a combination of mathematical tools, market experience and laboratory economics to create a practical, effective market structure. Indeed, the economics profession is reaching the point where theoretical tools can be used to improve markets much the way theoretical physics is used in engineering, not as a substitute to experiments but as a complement to experiments, guiding and focusing them.

Market design has been extensively used in the sale of wireless spectrum for mobile telephony all around the world, including in Mexico where the pioneering free market in telecom spectrum was created in microwave spectrum in 1996, informed by market design principles.

Network policy is increasingly studied from a market design perspective. Network operation has the classic problem of high fixed costs. Prices near marginal cost mean the operator does not recoup the costs of investment and has no continuing incentive to invest; higher prices discourage use but encourage investment. Here, I want to highlight two major uses of market design.

First, market design can be used to minimize the cost of service. While this sounds like a worthy goal, it should not be the only consideration. Because such a large portion of network costs tend to be fixed, minimizing the cost of service often involves a single provider. However, using a single provider reinforces the tendency to monopoly created by large fixed costs. It is preferable to use government policy to encourage entry, at least where encouraging entry is not too costly. The promotion of entry can be engineered into the market design by favoring small firms, by favoring unbundled pricing, and by encouraging open network access. Market design often tends to take a static view of the market, out of expediency rather than necessity. However, as I emphasized above, markets are dynamic and a static view, while never fully appropriate, is especially inappropriate in network industries.

Second, market design can be applied to the design of government regulatory institutions themselves. Do the institutions have the incentive to represent the future needs of society, or are they likely to be captured by special interests? Special interests in this context are primarily incumbent firms looking to preserve market power. Do the institutions contain appropriate checks and balances, so that secret deals and favoritism see the light of day? Do agencies with decision authority have access to the information needed to make appropriate decisions? Is there a mechanism for follow-through?

Follow-through has been a continuing problem in the United States in antitrust. Government agencies – the Federal Trade Commission (FTC) – may make deals with companies, essentially finding a cure for antitrust problems. The parties agree to these “fixes,” but the FTC lacks a powerful mechanism to enforce the agreement. It isn’t that they can’t enforce the agreement, but rather that the incentive to enforce a past agreement is limited. In comparison, an agreement

filed with a court and overseen by a judge has an enforcement agent, and hence is much more likely to be enforced on an ongoing basis.

## Principles of Two-Sided Market Design

Public networks are intermediaries, and as such, application of market design principles to public networks should reflect the fact that the markets have two sides. Many, but not all, applications of market design principles involve one-sided markets. However, the matching examples, including school choice and the National Resident Matching Program, involve connecting individuals with institutions or individuals with individuals. While still in its infancy, principles of exchange design are starting to emerge and are worth understanding.

Here, I will summarize ten principles of exchange design.

Exchanges connect individuals and thus there must be a language for exchange. An important aspect of language is that it is *expressively easy*, which means it is easy to use because it permits the economical description of operations with a few mnemonic terms. Similarly, exchanges should be *strategically simple*, meaning that a simple, straightforward behavior performs well. Thus, if the buyers are bidding, bidding a fraction of buyer value should do reasonably well for the buyer no matter what the sellers do. An important method of creating strategic simplicity is *iteration*, that is, permitting the participants to revise their reports, bids or actions in light of the tentative outcome. Iterative mechanisms are familiar from auctions, where prices rise as bidders revise their bids (upward only). But the principle extends to two-sided exchanges.

Lack of information is a barrier to exchange; the appropriate *revelation of information* is a key facilitator of exchange. We have observed that aggregate statistics are an important element of exchange design. Aggregate statistics increase the comfort level of traders without threatening the value of their own private information.

Many analysts have suggested *transparency* is an important element of exchange design, but in fact transparency is part of a continuum and represents a tradeoff. In some markets, complex algorithms may be an asset to the exchange, suggesting trades and prices in a fair way. Thus, transparency is one side of a tradeoff, where the other side is efficiency. A useful value of transparency is that participants make better decisions.

Complex algorithms give rise to the potential for concealing bias of exchanges. An important principle for the long run health of any exchange is *neutrality*, that the exchange is not unduly biased toward a party. In its opening year, the US CO<sub>2</sub> pollution permit auctions were biased toward sellers, to such an extreme that sellers who should not have participated did, buyers who should have participated did not and prices did not reflect values. This problem was subsequently fixed.

A particular party that exchanges should not be biased in favor of is the exchange itself; *exchange earnings* should not be excessive. Excessive exchange earnings lead to the creation of competing exchanges.

Related to the use of complex algorithms is “*mushing*.” Mushing entails treating unlike things as alike as a way of achieving market thickness. It is clear that market thickness is a good thing, since it leads to competitive prices. The use of mushing, to treat similar items as identical, has the advantage of creating thicker markets, but the disadvantage that the differences may matter.

Related to mushing is the size of price steps. A great deal of attention is paid to the size of price steps, also known as increments or deltas. Relatively large price steps have a modest effect on efficiency and make the exchange both more expressively easy and strategically simple and reduce the amount of iteration needed to achieve convergence. Consequently, it is desirable to limit the number of prices by increasing the step size. This can be done by only permitting even amounts (e.g. pesos or thousands of pesos, depending on the item being traded), or in percent.

Last, but not least, participants in exchanges use tools to facilitate participation. These tools are often moderately expensive to produce. Providing tools centrally can dramatically facilitate efficiency by insuring all parties have access to information. Tools should facilitate tracking of aggregate statistics and comparing participant behavior to the statistics.

## **Conclusion**

Sutherland et al. (2009) present a deep analysis of role of public utilities in encouraging economic development. Not surprisingly, it is challenging to measure the effects. Nevertheless, it is clear that public networks have been a critical facilitator of economic prosperity.

A similar problem arose in measuring the effects of computers in corporate productivity. Although firms spent an enormous amount of money on computers, the data didn't indicate there was much payback from the expenditures. The measurement problem, of course, is that the world isn't standing still. The presence of computers gave rivals a competitive edge, lowering profits; firms responded by buying computers. Profits fell or were flat and computers expenses were high. However, had the firms not purchased computers, profits would have fallen even further. The expenditures on computers mitigated the fall in profits. The same forces inducing the fall in profits also induced the purchase of computers.

Part of the missing profitability of computers was an unmeasured increase in productivity. Printed matters became beautiful; we have become used to home printing that exceeds the quality of the professional printing of our parents. This improvement in technology is most extremely felt in facts. Where looking up the diameter of the earth, the star in the Mask of Zorro, or the population of Mexico City used to require a trip to the library and a somewhat arduous search through reference volumes, we now have nearly instant access to much of the knowledge of the world. The internet represents the greatest provision of public goods provision in the history of the world.

Economics has developed new tools for improving markets. These are powerful tools, which can be used at both the network operator level and at the regulatory level. In applying these tools it is worth bearing in mind the “Hippocratic Oath of Antitrust:” Do not deter entry.

The internet is probably as revolutionary a platform for human development as the printing press. The printing press, for the first time, made “knowledge for the masses” possible, and is probably ultimately responsible for the industrial revolution and much of modern development. The internet offers three striking advantages over printed matter for economic development. First, the internet is much quicker and more efficient; finding information on the internet is dramatically easier than browsing a library. Second, and more important, the internet can match the user’s skills. Thus, the internet can detect a user’s knowledge level and provide appropriate knowledge and tools to match the user’s existing abilities. Books typically require human teachers to facilitate knowledge and teachers are inherently limited, especially as relatively small class sizes seem necessary to produce efficient knowledge development. The lack of adequate teachers is one of the main challenges of development. In contrast to human teachers, the internet is scalable, and educational programs can be broadcast to an arbitrary number of individuals at linear cost. Taken together, the internet represents a giant leap ahead, on the order of the printing press, offering an opportunity to let every individual reach their full educational potential.

What running water did for public health, the internet does for the mind. It would be a shame if this revolution in public goods, and the huge increase in worker skills and economic efficiency these public goods promise, was lost for the sake of one corporation’s profits.

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