Public goods, firm size and [horizontal structure] growth

(or) **Public goods, horizontal structure and growth**

Yoram Barzel

August 28, 2007

Introduction

The paper commences with a static economy where competitive firms produce generic goods. Exogenous population growth is then introduced, which in turn induces individuals to produce public goods. I study the effects that maximizing individuals who develop and exploit public goods have on the structure and competitiveness of industry and on economic growth.

Public goods may reduce the cost of production as well as altering products; I first discuss the former. To gain from his public goods, a developer may follow one of two basic strategies. The developer of the public good may produce the product using it, taking advantage of the zero marginal cost to the use of the public goods. Or he may sell its services to all comers, charging a fixed royalty rate per unit of output of the private goods using the public goods.

Developers' gain from their public goods is an increasing function of the number of units of the commodity using their services *with their*

permission. That number depends on whether whole industries use these services, or whether only one firm does. When the public good is offered to all comers, any commodity producer who finds its use profitable will license it and use it to the point where its marginal cost is equal to the royalty rate. If the public good offered to all is economically attractive, all firms will use it. It is highly likely that the number of units using the public good services via the royalty arrangement exceeds that when used exclusively by one firm.

The choice a developer has between exclusively using the public good and, given that it is legally protected, licensing it to all comers depends primarily on the relationship between the cost function of individual firms and that of the whole industry. The first arrangement dominates for the output range where the marginal cost of the firm (with zero marginal cost of using the public good) lies below the minimum average cost of firms in the industry inclusive of the royalties they pay. That range depends on how fast the marginal cost rises and on the size of the industry. We expect that the more firms there are in an industry and the less elastic is the cost curve, the greater the advantage of exploiting public goods via royalties.

The exploitation of public goods within firms, especially if they modify their products (and not just reduce cost), is responsible for creating diverse firms within industries; firms that differ in size and in the product they produce. The two main factors that induce that variety are the diversity of consumers' tastes for the commodities' varieties, and the costliness of exploiting the public goods via royalties.

Three basic firm types will be in operation in the wake of the public goods introduction. 1. Firms that integrate the production of public goods with the production of private goods that use the public goods' services. 2. Firms that specialize in the production of public goods, selling their services to those producing private goods. 3. Firms that produce no public goods and buy the services of such goods that are produced elsewhere. As shown below, certain factors blur the boundaries between the three firm types.

The first type firms tend to be large taking advantage of their zero marginal cost of the use of the public goods they produce. They engage in research in-house; they innovate primarily for internal, but also occasionally for external use; the commodities they produce are differentiated and they have monopoly power over them. The second type firms obviously have monopoly power over their public goods. Their

viability crucially depend on legal protection by the state. More such firms will emerge as intellectual rights are enhanced and tightened.[1] Because of high transaction costs, these firms tend to charge fixed royalty rates even though the marginal cost of using the services of their goods is zero. The existence of such firms is a necessary condition for competition among firms of the third type.

Individual develop public goods when the flow of benefits they generate equals their cost; i.e., when they just become profitable. Given that the economy is growing, they enhance per capita income. For industries with numerous firms, when specialized developers who charge royalties introduce the public goods, the income enhancement tends to exceed that by an *order of magnitude* when similar such goods are introduced by firms that use them in house; the number of units using the public good is much larger in the former than in the latter case.

There is a large and diverse literature that discusses three issues relevant to this study; relating market size to industrial structure, considering price formation and competition, and discussing the effect of public goods on economic growth. Three path-breaking papers deal with these issues. Stigler (1951) shows that as the extent of the market

[1] The more firms there are in an industry, the more valuable are legal rights over public goods.

increases, in order to exploit their scale economies, firms will alter the set of processes they deploy. The scale economies he considers seem to stem form plants that are large relative to the industries using them. Proceeding along the same line, I bring up the effect of public goods, and I add the effect of the difference in cost and returns from the decision to "make or buy". Arrow (1959) shows that perfect competition is incompatible with price formation, and argues that firms need some monopoly power in order to change prices. I elaborate on his analysis by bringing out the public good nature of forming prices. Regarding economic growth, Romer (1986) incorporates information, which is a public good, in a competitive growth model. He claims that his model is derived under individual maximization, but he does not explicitly study individuals' behavior. I show that once individual behavior is considered, and consistent with Arrow, the economy *cannot be competitive*.

Public goods come in many shapes. This paper is concerned only with those useful for some or all firms in industries such as product modifying innovations, but not with others such as the organizing legal institutions or preparing book manuscripts.

The assumptions

I start with a simple static model of the economy. Replacing then the static with dynamic conditions, a rich structure of industries emerges. I make two sets of assumptions. The first, maintained throughout, is: The existence of exogenously determined rule of law; it has patent and other intellectual right laws that extend indefinitely; the costs of transacting are positive, and rights are not perfectly delineated. The second set of assumptions, one of which is to be amended presently is: The economy is static; it contains competitive, constant returns to scale industries; all commodities are generic.

Given the current static conditions, it must be true that the production of all profitable public goods has already been undertaken, and no one can profitably produce new ones. The static state is then amended: For exogenous reasons, the population starts to grow and the rate of discount becomes positive.[2] I assume as well that prior to the induced changes that the new conditions produce, the economy grows proportionately to the growth in population.[3]

Economic and legal rights to public goods

[2] Population growth primarily acts as a catalyst here. Once its effects start to be realized, the emerging forces become self-perpetuating.

[3] Unlike Barzel 1968, I now assume that the cost of transacting is positive. In addition, I abstain form normative considerations.

Before proceeding I clarify the notion of "rights". Maximizing individuals will not produce goods, whether private or public, unless they can establish rights over them. What is the nature of the rights the producers of public goods can acquire? I distinguish between economic rights and legal rights. As used here, the benefits that owners get from the goods and assets they "own" are their economic rights, and this is what they maximize.[4] Legal rights are those the state recognizes and helps enforce. Economic rights may exist in the absence of legal protection. When legal protection is absent, owners of public goods maintain rights over them first, if others are ignorant of them, as with trade secrets, and second, as long as others do not succeed in copying them. Such time span for coppying is often short, but when it is significant, the production of public goods may become profitable even without secrecy.[5] That is not to say that legal protection is not valuable; it is, especially for public goods. Legal protection is at the heart of patents and copyrights that back the corresponding economic rights. Legal protection also enhances the value of trade secrets by enabling the use of restrictive contracts with employees. I

[4] Thieves benefit form the goods they steal, and thus have economic rights over them. This is why "owning" is placed inside quotation marks.

[5] It is said in banking circles that although new banking products can be easily imitated, banks enjoy exclusive rights over them for six months.

argue below that legal rights are *vital* for the exchange of the services of public goods.

The emergence of patented innovations

In this section I focus on innovations, but the discussion fully applies to other public goods. To trace the effects of population growth, consider one of the competitive industries. Suppose a producer has an idea for a useful, cost-saving patentable innovation. In what comes, I use several numerical parameters, but the qualitative results are entirely general. I assume that the industry consists of eighty similar one-person firms; the cost of developing the idea and patenting it equals one-year worth of the innovator's revenues, the discount rate is 10%, and the innovator's profit maximizing fixed royalty rate is one tenth of one percent of the value of clients' output. Given the assumed parameters, , the net present value of the innovator's royalty revenues before the economy starts to expand would equal 80% of his cost (equal to one-year revenues).[6] So its net value is negative, and he would not undertake it. As the economy starts to expand, a time will arrive when the innovation becomes profitable. The net present value of the innovation is maximized if the innovator

[6] Given the fixed royalty rate, optimal firm size will not change. Since the maximizing royalty rate is less than the cost saving, the number of firms in the industry will increase. For simplicity I disregard the effect of the industry output expansion.

undertakes the investment just as the number of firms in the industry reaches one hundred.

The introduction of even a single innovation has a number of basic effects: 1. The economy ceases to be fully competitive since the innovator has monopoly power over the use of the innovation. 2. There is a once and for all shift in economic activity. Even on a per capita basis, the economy is not static any more. 3. A Pareto condition is violated since the marginal cost of using the innovation is zero but the royalty rate is positive. The industry using the innovation, however, remains fully competitive.

Perfect price discrimination would have allowed exploiting the innovation to the point where its marginal cost is zero. Given the costs of transacting, however, effecting such discrimination is prohibitively costly. But if the innovator continues to produce the commodity, he will increase his output to exploit his zero marginal cost of using the innovation in his production decision. How far he would expand depends on the scale diseconomies in the production of the commodity. If these are modest, he might become the sole, monopolistic producer of the commodity because of his advantage over his competitors. Although the sole producer, his pricing discretion is constrained by the cost saving the innovation brings

about. If the diseconomies are steep, he will produce the commodity side by side with other firms, though his output will be larger than the others'.

As the economy continues to expand, innovators would develop additional patentable cost saving innovations. These will produce changes in other industries similar to those just discussed. With the emerging stream of such innovations the economy ceases to be static, and the level of per capita income will increase steadily.[7] The process snow-balls as the higher income will increase the profitability of additional innovations and each new innovation makes some still newer ones profitable.

Product altering innovations have more complicated effects. If all buyers of a product switch to its new, modified variety there is nothing to add to the above discussion. Indeed, all firms will produce the new variety to uniform specifications, and it will also be generic. If some consumers do not switch, different varieties of the commodity would sell side by side and the number of firms producing each would be smaller than the previous combined number. As the number of varieties multiplies, although the number of firms in some or all segments of the industry may become small, the potential for entry, if not actual entry, will keep these firms competitive.

[7] Population might increase in proportion to the increase in income, but this possibility would not alter the general results about industry structure.

The public goods I focused on are innovations. Many other public goods such as accounting methods or product design will also be introduced. Their introduction will produce results similar to those innovations produce so long as their producers can obtain legal rights over them and license their use to all comers.

Why not all public goods legally protected?

Public goods producers do not always protect them by legal means. Besides goods that do not meet legal criteria, producers expect some of the goods to be more profitable when protected by keeping them secrets. I first ask when does legal protection fail to protect and then when is the sale of information, whether or not legally protected, not feasible.

Public goods producers may choose to shun legal protection and the accompanying courts enforcement for three reasons. 1. The revelation associated with filing for the rights may lead to (legal) emulation. 2. The use of a public good may reveal to the licensees a method that could be copied illegally and then effectively to evade paying royalties. 3. Preventing the resale of protected or unprotected information may be prohibitively costly. I now elaborate.

1. Public goods such as innovations solve problems, and the documentation that accompany filing for them reveals what the problems

are. By studying the patent applications, other developers become aware of the problems the patents solve. This may inspire them to develop competing solutions to the same problems, thus reducing the value of the legal protection. Developers who believe that their innovations are vulnerable to such emulation may choose not to rely on the legal protection.

2. Some public goods reduce the cost of producing commodities without altering them. Licensees who learn how the cost is reduced may continue to use the new method while falsely claiming not to. Just observing the output does not reveal whether or not the protected method was used. The cost of acquiring the information to prove that the licensees are still using the protected methods may be prohibitive. In such cases, developers will not rely on legal protection

3. Given the fixed cost of collecting the information, and the constant low marginal cost of reproducing it, the license or royalty rate the seller charges for its use must exceed the marginal cost. The sale of information, however, is vulnerable to its unauthorized resale as buyers do not thereby lose the information. Buyers encounter costs in reproducing the information they buy, in having to pay a penalty when caught in violation of the law or of a contractual commitment and in selling. They will resell

the information if, for some quantity, their average reselling cost is less than what they are charged.

When buyers' costs of reproducing and reselling a piece of information is low relative to the price the information collector must charge, the information producer is unlikely to be able to profitably sell it. This is likely to be the case when legal protection is unavailable or ineffective. When the expected penalty from legal violation is relatively low, the original collector of the information will find its sale unprofitable.[8] They may then gain only by using the information themselves.[9] The producers of commodities will then produce their information in house, and in this respect become vertically integrated.[10]

Developing non-patented innovations

Consider now a producer who has a idea for a cost saving innovation that its cost and return are similar to those used in the section before last. but that patent protection for it is not cannot effective. Without such

[8] An additional factor reducing the effectiveness of legal protection is that once the information is sold to a large number of buyers, tracking the source of illegal resale becomes very expensive. Given that the information will become cheap in the illegal market, no one would pay much for it to begin with.

[9] Even then, however, collecting the information will not necessarily pay. If it is to be profitable, its use should not reveal its contents, or at least the ability to copy should occur with a significant time lag.

[10] However, they could outsource the production via exclusive contracts.

protection, the producer must expand his output if he is to profit from the innovation. But expansion has its own costs. His firm size has been optimal prior to the introduction of the innovation. At the optimal size, on the margin, the gain from specializing equals the costs of supervision and of shirking. Given the numerical parameters, to gain form the innovation the innovator would be able to recover the costs by expanding his firm's output by a factor in the order of 100; i.e., to the level of output produced by 100 firms under patenting. It is implausible, however, that he would be able to recover his cost when the innovation saves 0.1% of the cost.

Consider further the 100-fold expansion factor. Because the firm expands beyond its minimum average cost size, the 100 times expansion factor is insufficient to cover its cost; it has to expand further. Two factors mitigate this effect. One is that the (internal) cost savings the innovation generates exceeds the maximizing (implicit) royalty rate. The other is that once the innovation is developed, the innovator's marginal cost of using it is zero. Whatever the precise ultimate expansion factor, for an industry initially consisting of many small firms, the necessary increase in size of the firm developing the innovation must be radical. Where patent protection is unavailable, or is ineffective, it seems that innovations would

be developed only if the cost saving (or product modifying) are much higher than those needed to be profitable when patenting is effective.[11]

The decision to integrate the production of non-patented innovations with the production of commodities could take place after the innovations are developed, or prior to it. In terms of organization, "outsiders" may gain from their ideas for improving an existing product in a number of ways: 1. By selling the ideas to one of the product producing firms. 2. By developing the ideas and then selling them in their more advance form to one of the product producing firms. 3. By producing the commodities after developing the ideas. Insiders, i.e., employees of firms in an industry may also come up with innovating ideas regarding the products their industries produce. Unless they develop them within the firms employing them may develop the innovations, or they may leave their employers to develop the innovations, and then proceed along the second and especially the third line.

Innovators may be short of the amount of capital (and perhaps expertise) required to develop their innovations. The needed amount is largest for innovators who attempt to produce the product, and least for ones who sell their not-yet-developed ideas. The more difficult is the

[11] This difference may explain why the rate of introducing innovations accelerated after patent rights and their enforcement was enhanced.

delineation of an idea and of the innovation after it is developed, the greater the difficulty of selling or of financing it, and the greater the chance it will be stolen by firms to which the innovation is offered or by those financing it.

Where these difficulties are perceived to be dominating, existing firms may choose to initiate the innovation research. Firms already producing the commodity may encourage their employees, who are experienced with its products, to innovate. They may also recruit specialized would-be innovators to their research departments. Either way, they will supply their employees with the necessary capital and other resources.

Given the uncertain outcome of the innovation process, we expect firms' research departments to generate not only innovations that directly apply to their products, but also other innovations that have applications outside their main line of production. We expect innovations that do not apply to firms' main products to nevertheless be developed by them if they are difficult to exploit by patent. In case the newly developed product does not significantly interact with the firm's existing operations, we expect it to eventually divest the operation specializing in the new product. As firms' R&D departments are likely to come up with additional product

improvements as time passes, the number of firms in each industry will shrink, leaving a small number of relatively large firms in each industry.

For two reasons the products these firms produce are not likely to remain uniform. First, different firms are unlikely to come up with identical product-modifying innovations, and thus their products will diverge. Second, had all firms produced identical commodities, they could relatively easily copy such features as the others' prices, advertising and product design. Once the differentiation process starts, firms may deliberately attempt to further it to make copying more difficult. They will differentiate also to make the demand facing them less elastic.

Less obvious public goods

When one firm purchases the services of a public good, it may appear that all other firms in the same industry would do likewise. But as just argued, commodity-producing firms that also produce public goods for their own use become differentiated from other firms in the same industry> Therefore, a public good that is designed for a particular firm is not necessarily suitable to other firms in the same industries. Independent producers of public goods, then, may simultaneously develop similar such goods, and offer them to firms in (more or less) the same industries producing similar products. In addition, firms in the same industries may

also develop internally similar public goods. Observing that multiple similar public goods are produced for the same industries, one might mistakenly think that these goods are private.

Consider firms' finances. Firms' whose cash flows are subject to random fluctuations wish to optimize the value of their financial activities. The financial services packages that banks prepare are public goods; banks' costs of preparing them are fixed, and the packages can be applied repeatedly at a low marginal cost. Individual banks' mix of clients, however, differs from others'. Different banks prepare distinct financial service packages to suit their particular clients. Although not custom made, and thus not meeting the precise needs of every client, they may be attractive to small firms for whom producing the services in house is not economical.

Rather than use the standardized packages banks prepare, large firms may produce such services that meet their specific needs in-house. The marginal cost of the in-house services is zero, and because they are large, they are able to recover their preparation cost. These custom made services are not well suited for others, so their producers will be their only users.[12]

[12] Specialized firms could, and sometimes do produce custom-made packages of such services for individual customers. For two reasons they do

The obvious implication here is that small firms will rely on bank finances more than large firms do.[13]

Many other goods have public good properties. Among them are computer programs, medical insurance packages, personnel policies, lay-out of sale premises, legal services, and communication devices. The above discussion applies to all of them. When services of such goods are newly offered in the market, we expect the number of small firms to increase and the market share of large firms to decline.

The above discussion also applies to commodity standards, which are public goods. When they become available, we expect some firms to adopt them and to contractually guarantee the standardized attributes of their commodities.[14] These firms do not have to invest in forming them. Other firms may be reluctant to spell out the specifications of the relevant attributes of their commodities. In order to persuade buyers to buy their commodities they guarantee these attributes by their reputation or brand name. Such firms have to be large to exploit the scale economies to

---

not always do so. 1. Their exchange would be subject to bilateral monopoly. 2. The package may contain information that customers may not wish to reveal.

[13] Beck et al (2006) provide evidence for such a relationship. I formed my hypothesis after being exposed to their study.

[14] Similarly, it is expected that firms that license patented inventions would tend to contractually guarantee the related attributes. (?)

reputation.[15] Small firms' products, then, will be more standardized than those of the large firms.

Competition and price setting

In this section I reiterate Arrow's (1959) argument that prices cannot be set under perfect competition. I also show that as with other public goods, a dichotomy exists in the organizational mode of setting prices. The gist of Arrow's argument is that under perfect competition, where every buyer and seller is a price taker, no one is in a position to act to restore equilibrium after it is disrupted. When equilibrium is disrupted, the quantity demanded differs from that supplied. When the quantity demanded exceeds that supplied, each seller has monopoly power and will raise price. Similarly, when the quantity supplied exceeds that demanded, every buyer has monopsony power and will offer a lower price. As individuals continue to exercise this market power, competitive equilibrium is restored.

Arrow observes that before equilibrium is restored, resources are not allocated efficiently. Allocation is not efficient then for another reason. As Arrow points out, when demand increases, sellers need information to decide how much to raise prices and when demand falls, buyers collect it

[15] Hemenway (1975) relates standards to firm size.

to decide what price to offer. But he does not consider the need to economize on the cost of collecting the information. Of fundamental importance here is the fact that information is a public good, and that when the market for a commodity is disrupted, all seek the same information to form price. Ideally the needed information would be collected only once.

Duplication occurs if more than one seller or buyer collects it, which happens in the case Arrow discusses. One function that middlemen perform is reducing the extent of the duplication. In Arrow's model, as in most textbooks, consumers trade directly with producers. In reality middlemen exploit the discrepancies between prices sellers seek and those buyers are willing to pay. More to the point here, each middlemen relieves all his clients from the need to collect the same information. Still, the different middlemen duplicate the information collected.

Significantly, the duplication is averted under one form of organization—in organized markets that centralize price setting. A condition for the success of such markets is that the centralized information collector has the power to protect his rights over the information. A firm (the organized exchange) that has property rights over the information can engage in the price setting research and supply its services to all the firms producing the same commodity. It can then

contract to sell its price setting service while stipulating that its buyers do not share the information with others.

Trade is nearly perfectly competitive in organized commodity markets (as well as in markets for shares and financial instruments),. As a rule, the number of buyers and sellers that trade in each of these market is large. The commodities or contracts traded there are homogenous, and the units by which they are priced and transacted are well delineated so that the cost of ascertaining their quality low.[16] The cross elasticity of demand between units sold by different sellers is nearly infinite; buyers will switch all their purchases to sellers who lowers their prices even slightly. Similarly, sellers will switch all their sales to buyers who raise their prices even slightly.

In Arrow's model the deviation from competition is in that firms have transitional monopoly power. In organized markets neither buyers nor sellers set prices; rather, price-setting is undertaken by the exchanges whose livelihood comes from collecting the buy-sell differentials for the service. The exchanges, obviously, have monopoly power over their services and are not part of the competitive system. Thus the

[16] The futures exchanges delineate in great detail the commodities underlying their contracts, thereby assuring the contracts' homogeneity and ease of ascertaining their quality.

competitiveness in the markets organized by exchanges is accommodated by the strictly non-competitive exchanges.[17]

Prices must be set not only for homogenous but also for heterogeneous commodities. In the former case, if price is to be uniform, it has to be centrally set for entire industries. In the latter case, each producer sets his own prices. Numerous commodities (radishes, wines) meet the competitive condition that a large number of sellers and buyers exchange them. These producers may take a ride on the price setting of fellow producers, but because the commodities are not uniform, each producer has to conduct his own price research and finalize setting his prices on his own.

The ability to take a free ride reflects the difficulty each has in maintaining full rights over his own price setting. The different varieties of a heterogeneous commodity have a common component, and ideally this common component would be priced just once. But here producers spends a minimal amount of resources on producing it while taking a ride on others' price setting effort. As will become clearer when discussing other public goods, Too few resources are spent to reach the desired level price accuracy. What enables firms to set their own prices is the slight monopoly power each has due to its uniqueness.

[17] Of course, the exchanges are constrained in the prices they can charge by the threat of entry of competitors that may try to replace them.

Note that sellers in fully monopolized industries obviously have price setting power, and that the ability to set prices is also evident in industries with differentiated products where each producer has significant monopoly power (see Barzel 2007).

The conclusion that price setting is incompatible with competition fully applies to all public goods. As stated earlier, public goods such as innovations or new accounting methods are valued by all firms in an industry. These goods may be developed by independent firms that sell their services to firms in the industry, or alternatively developed in-house by the firms in each industry. In the former case the firms developing the public goods obviously do not constitute competitive industries. The latter situation is more complex. On the one hand, effort is duplicated if several firms develop versions of some public goods internally. On the other, effort is "inadequate" in that no single firm will spend as much resources on the quality of the public good as would one firm serving the whole industry. The industries where each firm produces its public goods may have numerous firms and appear to operate competitively, but they do not allocate resources optimally

Competition and growth

In this section I first argue that Romer's (1986) model is flawed. Romer's asserts that his growth model operates under competition, but I demonstrate that his reasoning is flawed. I then discuss the effect that public goods have on growth via industry structure.

Consider the relationship between the production of public goods and growth. Romer (1986) is concerned with the effect that knowledge, a public good, has on growth. He claims that under individual maximization "in a fully specified competitive equilibrium," growth occurs because "the creation of new knowledge by one firm is assumed to have a positive external effect on the production possibilities of other firms because knowledge cannot be perfectly patented or kept secret." (p. 1003). However, upon inspection it transpires that he does not fully specify competitive equilibrium. I show that under competition no public good will be produced, and neither external effects induced nor growth would occur.

For competitive conditions to prevail, industries must consist of many non-cooperating firms prior to as well as after the production of the new knowledge. I showed earlier that in a many-firm industry, a firm will not develops new public goods for its in-house use unless their effect are very substantial. More importantly, they have to take into account other firms' actions. Now the stock of knowledge in the economy depicted in

Romer's model is available to all firms. Firms in an industry compete with each other and the price they charge must equal their marginal cost. Firms that copy each other's knowledge would charge only the marginal cost of copying, and the firms producing the knowledge would not cover their costs. The outcome is not significantly altered if knowledge does not spread fast. This is because as all firms face the same production problems, when one firm finds a piece of information to be significant, others do too. Thus we expect that if one firm attempts to create a particular piece of new knowledge, many others would create the same, or similar new knowledge. Given competition and the zero marginal cost of the new knowledge, the new knowledge will not result in a gain to its producers but rather in lower real prices; all the cost savings or benefits from product improvements it would generate would pass to consumers. As firms would be unable to recover the cost of new knowledge, they would engage in its creation, and no external effects would emerge.

Firms will engage in creating new knowledge only if they can retain at least partial rights over it. In the case of knowledge resulting in improved products, it is inevitable that different firms will come up with different improvements. As indicated earlier, as their products will diverge, each will gain monopoly power over the idiosyncratic attributes of its

product. The industry, then, would cease being competitive, and of course, its product would cease to be uniform.

It should not be surprising that the attempt to preserve competition while allowing for the creation of new knowledge is logically flawed. How can one deal with inventions or other public goods without bringing property rights or transaction costs to the model? Romer's disregard of property rights leads him to another incorrect conclusion. He states "despite of the presence of increasing returns, the model here does have a social optimum… It can be supported as a competitive equilibrium using a natural set of taxes and subsidies." (p. 1014). But no taxes or subsidies can prevent firms from copying or duplicating each other's information. Such action can only be prevented if individuals are granted rights or patents to each piece of information. The duplication that occurs without such assignment means that resources are not used efficiently, and thus the outcome cannot be a "social optimum".

I too think that new knowledge is a major contributor to growth. But in my view, as with Arrow's price formation, at least some elements of monopoly must exist for public goods to be produced. The growth implications of my model are as follows. Under static conditions income is constant, and no new public goods are profitable to produce. Population

growth initiates a sustained increase in per capita wealth with every new public good.[18] The extent of that growth, however, depends on how extensively the goods are used. When a public good is produced by a specialized producer that sells the services of the good to all firms in an industry, the increase in wealth it induces exceeds that induced by the production of an otherwise comparable public good that is developed within a single commodity producing firm. The reason is that the use of the former type goods benefit the production of entire industries, whereas the latter benefit the production of only one firm. Mitigating the effect is that the firm takes advantage of its zero marginal cost of using the public good while this cost is positive for firms buying the innovation service.

When the state enhances intellectual rights, people have the choice of using public goods as before, or shift the use of such goods from individual firms to whole industries. If they choose the former, nothing changes. If they choose the latter, income increases. Thus, as is almost self-evident, enhancing rights will enhance income (but not necessarily net of the costs associated with right enhancement).

[18] A caveat. The production of public goods such as innovation-copying (itself a public good) and weapons may weaken property rights and lower the level of wealth.

An implication of the argument about firm's horizontal structure is that the percentage of the resources firms devote to internally producing their public goods (partly classified under "research and development") is positively correlated with firm size.

Implications

The model here yield a number of implications, many of them testable. I first offer implications regarding organizational forms, and then ones related to product differentiation (presumably induced by public goods that are not adopted by all firms in an industry).

Three implications regarding the choice of the organizational forms for producing public goods are: 1. The more separable is a public good from the private goods in which it is embedded, the more likely it is that an independent firm will develop it. I expect, for instance, that Apple Corporation will develop hardware modifications for its iMac, but that independent developers will write software that users can install on their machines. 2. The more concentrated is an industry, the more likely its public good production to be integrated within commodity producing firms. 3. The higher the level of a country's rule of law and the stronger its intellectual rights laws, the more likely are public goods to be developed by specialized firms.

By the model here, the introduction of public goods has transformed some of the initially competitive industries into industries producing differentiated commodities and with firms of non-uniform sizes. The following implications seem appropriate even if such industries had a different beginning. Seven of the effects on differentiated industries are: 1. Firms producing differentiated products guarantee them, at least partly, by their reputation rather than contractually; the larger such firms' shares in their industry's output, the heavier their reliance on their reputation. 2. Given the costs customers encounter in learning about differentiated commodities' reputational attributes, the greater the shares of such attributes in a product, the larger is their monopoly power of such monopolistically competitive firms. (Barzel 2007). 3. The less firms spend internally on the production of public goods the more uniform will their sizes be. This is because they have less reason to deviate from their "initial" relatively uniform sizes. 4. As new public goods are offered in the market, firms will gain less from producing such goods in-house, and firm size, especially of large firms, would decline (and income growth accelerate). 5. The enhancement of intellectual rights will lead to smaller firms; the shrinking will be more pronounced in industries that use these public goods heavily, and the dominance of large firms will decline. 6.

Small firms' products will be more standardized than those of the large firms. The latter rely more on their reputation when guaranteeing their products as they enjoy the scale economies to it, whereas the former rely more heavily on general standards.

References

Arrow, Kenneth, "Toward a Theory of Price Adjustment," in Moses Abramovitz, *The Allocation of Resources*, Stanford, 1959.

Barzel, Yoram 2007, "Replacing the Law of One Price with the Law of Price Variability", working paper.

Romer, Paul M. 1986, "Increasing returns and Long-Run Growth", JPE, Oct. 1002-37.

Stigler, George J., 1951, "The Division of Labor Is Limited by the Extent of the Market", JPE, June 185-193.

Notes

Developing public goods within **existing product-producing firms** has several advantages. One is that such firms may already have the complementary production resources. They also tend to have easier access to capital as they can more easily borrow given their better credit rating and greater credibility in evaluation the public goods to be developed.. Several factors may render a contractual arrangement difficult between the public goods producing firms and the product-producing firms. One is that where rights in general and intellectual rights in particular are weak, operating within firms is advantageous. Another is that some public goods are not easily separable from the private ones making contractual delineation difficult. One more factor is that some developers face monopolistic clients and their bilateral monopoly status makes coming to an agreement difficult. Operating within firms avoids these. In addition, the scale of the innovation may be too small to merit a separate firm; here the firm already exists.

Innovators may come from **within** their industries or from the **outside**. Insiders with innovating ideas may choose to quit operating as commodity producers and concentrate their effort on developing

innovations. Conversely, outside innovators, after developing the innovations may decide to also produce the products. No one route seems superior in general; each may prevail under the right conditions.

Both the cost of producing **new public goods** (which depends on how elaborate the goods would be) and the return they would generate are difficult to estimate.

A common practice in the **medical field** is for independent inventors (often aided by venture capitalists) to develop their product and then sell the entire venture to a drug firm with expertise in testing and marketing.

Classifying and enumerating public goods.

Some public goods are applicable to a range of industries, some to single industry, some to single firms and some belong in "other".

I. Goods suitable across industries. 1. Organizing markets. 2. Inventing organizational methods for firms. 3. Inventing accounting methods. 4. Creating financial packages for firms. 5. Writing computer programs. 6. Creating medical insurance packages for employers. 7. Creating personnel policy packages. 8. Creating custom made legal services for firms. 9. Creating communication devices. Note that the wider the

potential range of applications, the less attractive is the within firm development. 10. Weather forecasts.

II. Goods applicable across industries. 1. Setting commodity standards. 2. Market research. 3. Setting prices. 4. Creating new technologies. 5 Store layout.

III. Goods applicable to singe firms. 1. Public good that apply to *idiosyncratic* attributes of commodities.

IV. Other public goods. 1.Books and maps. 2. Sporting leagues' services. (?) 3. Setting standards other than for commodities. 4. National defense. 5. Legal framework. 6. Reputation. 7. Advertising. 8. Litigation applicable to a class of cases.

The public goods I consider are those useful for some or all firms in industries such as product modifying innovations, but not other such as organizing legal institutions or preparing book manuscripts.

Size and scope of firms

1. Firm size in each industry is where economies due to the public goods firms produce are balanced by the other diseconomies.

2. Firms will increase their scope when the public goods they produce apply across commodities or industries. For instance, if an engine

innovation applies to cars, trucks and tractors, a single firm may produce all of these.

The **more differentiated** commodities are, the more attributes their producers will guarantee by reputation. Buyers' reliance on sellers' reputation for the make-up, or quality of the commodities they buy provides the producers of such commodities with "market power."[19]

What is an industry?

1. Does approach here offer an answer? I start with an industry producing a generic commodity. Does it remains an "industry" when differentiation occurs?

2. Price setting is a public good. The scope of a price defines the industry to which it applies. But this does not say much about the scope of industries where commodities are not identical.

The industries in which firms develop innovations internally will become monopolistically competitive. What **characterizes the industries** that will remain competitive.

Generic goods

[19] I discuss the market power that reputational guarantees provide in Barzel 2007.

Consider commodities-producing firms. Their commodities are generic if the firms obtain *all* their public goods from others. When the public goods are product modifying, the goods remain generic when the firms that obtain all their public goods from others continue to produce them. When all producers adopt the same improvements to their commodities, the commodities they produce will have new specifications, but be the same for all firms, and thus remain generic.

Inventions are unlikely to emerge from **small atomistic firms**, and such firms may, but need not operate without using public goods services. For instance, books and magazines devoted to improvements may reach these firms. Such public goods can be easily copied. (?)

Public goods and secrecy

The essence of many public goods in being in the public eye. Examples are advertising and books. Except for their ability to exploit their priority, such goods can be protected only legally. In general, secrecy is useless when the effect of the public good is evident.

Protecting the ownership of public goods via pricing

Consider a public good that is as costly to reproduce as it is to produce originally. Then it is always true that a royalty rate exists such that

it would be unprofitable for a new producer to produce the good.[20] In the absence of competing producers, the royalty rate will usually exceed the one needed to prevent entry. Indeed, it seems that the original producer threatens credibly that once the rival starts investing he will lower his royalty rate to make the rival's net rate of return negative. Moreover, even if the newcomer divides the market with the old one while maintaining the existing royalty rate, entry would be deterred as long as the royalties do not earn twice the investment. However, the original producer's ability to protect himself is greatly weakened if reproducing the public good is cheaper that producing it originally.

Suppose one of the many **producers of a commodity for a futures market** considers the production of a public good for his own use. Being small, unless the impact of the public goods is significant, the rate of return to such endeavors is low. Therefore, he is unlikely to extensively engage in such activities. If indeed the impact of the goods is significant, he might as well switch to develop and market the public good full time.[21]

[20] If demand for the public good is expected to fall, as time passes the royalty rate can be increased without inviting entry.

[21] A public good that modifies the product, would cease to meet the futures specifications.

A **dichotomy emerges**. The producers of public goods may exploit them via royalties, and the firms using them could well then be competitive. Or the public goods producers may exploit them within commodity producing firms. In the latter case, diverse firms emerge. These firms produce differentiated products over which they have monopoly power.

Books

New books are public goods; after the manuscript is written and set, the cost of printing new copies seems constant or falling. Before copyright laws were enacted, the only profit opportunity for the author and original publisher was in being first in the market by at least several months. For widely circulating books, setting the book for printing was a private good as it had to be repeated after each series of printings. As copyright laws emerged, initially in Venice around 1500, they provided protection, but only within the jurisdiction of the copyright. Only recently such protection, via reciprocity, became nearly universal, greatly increasing the profitability of book projects compared with the pre copyright era.

Schumpeter

Although deeply concerned withinnovationsand growth, Scumpetrer seems not to be aware of the public good nature of innovations and of their

declining average cost. Given the discussion here, we can shed light on his conclusion that large firms rather than firms in competitive industries are mostly responsible for growth.

Before states became significantly involved in legally protecting intellectual rights, innovators' main way of profiting from their innovations was by keeping them secret and operating large firms (though as attested by the experience of Gottenberg, keeping secrets was very difficult). The emergence of intellectual rights enabled individuals to gain form their innovations while operating independently, collecting royalties from their inventions.

I have no data to determine how important is the latter type operation. Still, it is clear that not all innovations have to be developed by large firms. This conclusion is at variance with Schumpeter's. [How did Addison operate?]

Schumpeter points to innovation by large agricultural machinery firms. These firms however, freed individual farmers form innovating in house.

Two observations.

More than one firm may develop basically the same public goods. 2. The exact nature of public goods produced for, and sometimes by firms in

each industry depends on their attempted use. Public goods that fit well some firms in differentiated industries may not fit well others.

Standardizing and theft

Serial numbers make standardized commodities less standardize and also make them less attractive theft objects.

Firstly, firms may receive various kinds of public support to R&D and innovation. Secondly, it can lead to the acceleration of return on investments through a rapid diffusion process.Â The horizontal type of cooperation â€“ collaboration with competitors differs from all previous types significantly, because competitors belong to the same industry sector and share similar knowledge about the market, where the firm operates (Miotti, Sachwald, 2003). The main incentive to cooperate with competitors is that their goals in project are similar due to common problems in concrete area (Tether, 2002).Â Other important determinants are size and firmâ€™s age. Small and Young companies rarely engage in innovation cooperation with knowledge production sector and clients.