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BRIEFING NOTE
Defining Natural Monopoly

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Ennis, S (2023) "The Natural Monopoly Paradox: Incumbent Inefficiency and Entry", CCP Working Paper 23-01, 20 February.
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4364914

Executive Summary

This working paper challenges the traditional definition of **natural monopoly**, suggesting that it may fail to account for the **inefficiency of incumbent firms**. The author explores a **paradox** where the entry of a competitor in certain sectors, such as infrastructure and delivery, can paradoxically **reduce total costs**. This finding is crucial because it implies that systematic state protection of existing natural monopolies may not always be justified, especially in the face of potentially more efficient entrants. The paper thus proposes a **new generalized definition** of natural monopoly focused on the incumbent firm and its actual costs, with **important policy implications** regarding regulation and the allocation of public resources. The main implications of this analysis are that, in infrastructure sectors, new investments should not automatically be attributed to incumbent natural monopolies, and that, in postal delivery, incumbents with low mail volumes are those that least warrant state protection.

Key words
Natural monopoly definition
Ineffectiveness of incumbents
Disruptive entry costs
Alternative definition of monopoly
Postal infrastructure implications

What is this about?

The Natural Monopoly Paradox: Inefficient Incumbents and Entry

The classic definition of natural monopoly, formalized by Baumol (1977), is based on the idea of cost sub-additivity: production by several firms increases the total costs of the industry.

Quote: “Natural monopolies are typically defined as activities in which production of an output vector by more than one firm raises total industry costs, an intuition formalized in the classic definition of Baumol (1977).”

This paper identifies a paradox: in some cases, notably infrastructure expansion and delivery, the entry of a competitor can lead to a reduction in total costs, contradicting the traditional definition.

This paradox is particularly relevant when the incumbent is inefficient. Inefficiency may result from a lack of incentives to control costs in the absence of competition.

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Why does this matter?

The classification of an activity as a natural monopoly has considerable policy implications, influencing decisions regarding entry restrictions, subsidy allocation, price regulation, third-party access, structural separation, and even state ownership or control.

Quote: "The definition used has broad policy significance because wide-ranging regulatory determinations, with ensuing effects on citizens and firms, follow from concluding that an activity constitutes a natural monopoly."

Potentially affected industries represent a significant share of economic activity (10% or more) and include key sectors such as electricity, gas, public transport, postal services and telecommunications.

Critique of the Hypothesis of Equality of Cost Functions

Baumol's (1977) standard definition assumes that all firms have access to the same cost function. The author questions this assumption, pointing out that factors such as managerial slack, rent sharing with labor, technological differences, and accumulated inefficiency can lead to different cost structures between incumbent and potential entrants.

Quote: "Crucially, this definition assumes all firms have access to the same cost function. This assumption is open to question due to, for example, managerial slack, rent sharing with labor, differences in technology options, and general inefficiency that can build up in the absence of..."

Proposal of an Alternative Definition of "Natural Monopoly"

The article proposes a definition of "natural monopoly" that focuses on a specific firm (the incumbent) rather than the activity or sector as a whole. This definition takes into account the possibility that the incumbent may not operate at the cost frontier.

The proposed definition examines the circumstances under which a new entrant can lower the total costs of producing a service currently provided by a single firm.

Quote: "This paper proposes a definition of a natural monopolist that analyzes the circumstances under which a second producer in the form of a new entrant can lower the total costs of producing a service that is currently provided solely by one firm."

The condition for the incumbent to be a "natural monopoly" according to this definition is that its cost of producing an output vector ym is less than the sum of the production costs if ym were divided between the incumbent (producing a non-zero subset of the output) and at least one other producer (entrant).

$CI(y_m) < CI(y_1) + C(y_2) + ... + C(y_k)$

Implications for Infrastructure Sectors

In infrastructure sectors with high fixed costs, entry can reduce total costs if a new entrant can make new investments at costs substantially lower than those of the incumbent.

The standard definition of natural monopoly does not take into account the potential for more efficient investment by an entrant.

The paper proposes necessary and sufficient conditions for entry to reduce costs in an infrastructure sector, including when the entrant has lower fixed and variable costs, or when the avoidance of costly future investments by the incumbent by a cheaper entrant offsets the costs of entry.

Quote: "The costs of an incumbent can be “lowered” by avoiding either production that is more cheaply done by an entrant or avoiding future high-cost investments that can be made more cheaply by an entrant."

Concrete examples are mentioned, such as the competitive allocation of the Thames Tideway Tunnel project to the UK rather than to the incumbent Thames Water, and the possibility of substituting activities of new entrants producing energy locally to avoid costly upgrades to the electricity transmission and distribution network.

Implications for Postal Delivery Services

A probabilistic model of postal delivery is developed to analyze the paradox in this sector, building on the generalized definition of natural monopoly. The model shows that when multiple deliveries to the same address are frequent, the natural monopoly characteristics of the postal service are robust to incumbent inefficiency. However, when deliveries are infrequent, substituting a letter from the incumbent to another operator can potentially reduce total system costs.

Quote: "The model shows that when multiple deliveries to an address on a given day are common, the natural monopoly features of postal delivery are robust to incumbent inefficiency, but that when deliveries are infrequent, the substitution of a letter from an incumbent to another firm can potentially reduce delivery system costs overall."

The article suggests that a significant number of developed countries and a potentially higher ratio of developing countries are in the low mail volume category, where entry could reduce costs.

A sufficient condition for entry to have the potential to reduce total cost is derived, involving a comparison of the entrant's new fixed costs and the additional variable costs of overlapping deliveries with the cost reduction resulting from substitution to non-overlapping deliveries.

The analysis shows that if an entrant has lower marginal costs than the incumbent, entry can reduce total costs, particularly in low-volume systems where the probability of overlapping deliveries is low.

Entry by multiple operators does not necessarily reduce costs. If a new entrant takes volume exclusively from other entrants, this increases costs due to overlapping deliveries. However, if a new entrant takes volume exclusively from the (presumably less efficient) incumbent, a reduction in total costs is possible.

Social Welfare and Entry

Entry that reduces total costs in a regulated natural monopoly market (where prices remain constant) improves social welfare by increasing producer surplus (the inefficient incumbent has reduced costs).

Conversely, in the case of a true "y_m-natural monopolist" (an efficient natural monopoly according to the new definition), entry can only raise costs and thus reduce producer surplus, with no gain for consumer surplus.

Policy Implications

In infrastructure sectors, new investment needs (e.g., for CO2 emissions reduction in energy networks) should not be automatically assigned to incumbents, but could be allocated through competitive tendering to favour more efficient operators.
For postal services, the natural monopoly designation has historically supported monopoly protection policies. The amended definition suggests that in countries with low mail volumes, this protection may not be justified, and competition could be beneficial.

Contrary to intuition, low-volume postal services, facing increasing financial difficulties, are those that least meet the criteria of a natural monopoly and where competition could have the most positive effects by reducing total costs through the displacement of inefficient deliveries from the incumbent.

Subsidies, if necessary for universal service, might be more productive if directed to low-cost entrants rather than inefficient incumbents.

Conclusion and Future Extensions

The distance of an incumbent from the cost frontier is a crucial factor in monopolistic industries, including those that meet the technical requirements of a natural monopoly.

A thorough analysis of the incumbent's cost structure, future investment plans and avoidable costs is needed to inform policy decisions regarding the use of public funds and the application of regulatory powers.

Future extensions of this research could include further calibrations for various sectors and examining the impacts of other delivery operators (e.g., parcels, food) on mail delivery, given the changing volumes of mail and parcels with digitalization.

Additional Key Quotes

"This paper supplements the existing literature by integrating the definition of natural monopoly of Baumol (1977), Baumol, Bailey, and Willig (1977)) and Panzar and Willig (1977), with the literature on productive inefficiency. This paper suggests that, absent this integration, the most widely accepted criteria can be incomplete in both infrastructure industries and delivery services."

"In a qualitative sense, most prior categorizations of an activity as a natural monopoly are not questioned by the approach advocated here. This paper focuses only on exceptions to the suitability of the standard definition."

"The precise limits of the definition of natural monopoly have been relatively little examined in recent years. These boundaries merit a renewed examination due to an increased economic focus on possible increased market power, recent inconsistent government approaches..."

"…it is clear that an incumbent can fail to be a “natural monopolist”, in the sense of this paper, while nevertheless operating in a “natural monopoly” in the sense of Baumol (1977)."

"As many as a quarter of developed countries are shown to lie in the low-volume category that is potentially susceptible to cost-lowering entry, and even a higher ratio among developing economies."

"To illustrate the impacts of a modified definition, note that the modification could change activities designated as a natural monopoly. For energy transmission and distribution infrastructure, increases of capacity on the order of 30 percent are often argued as necessary for CO2 gas reduction, with investments worldwide potentially of the order of 600 b USD per year. If the infrastructure is not a natural monopoly, some of this investment support provided might more reasonably be allocated by tender as opposed to direct allocation to potentially high cost incumbent companies."

"For postal services, determinations that natural monopoly characteristics are present affect the appropriate policy towards competition and that of allocation of support for a developing industry."

"A natural intuition suggests that low-volume postal services are especially in need of subsidies. This paper's results counter that intuition. Low volume postal services are, however, less easily to meet the criteria for being a natural monopoly."

"The precise limits of the definition of natural monopoly have been relatively little examined in recent years. These boundaries merit a renewed examination due to an increased economic focus on possible increased market power, recent inconsistent government approaches..."

"This paper proposes a definition of a natural monopolist that analyzes the circumstances under which a second producer in the form of a new entrant can lower the total costs of producing a service that is currently provided solely by one firm."

"The definition in this paper modifies the Baumol (1977) definition to answer the applied question of whether a given firm, such as an incumbent monopolist, is in practice a “natural monopoly,” as opposed to whether a given service could be classified as a natural monopoly when operated de novo on the cost frontier. The difference is important because an activity may be determined to have natural monopoly status, according to the standard definition, when entry would demonstrably lower costs."

"The definition proposed here thus distinguishes between the actual cost function of a given incumbent producer and the minimum cost function more generally available."

"The definition includes the possibility that even if an entrant can have lower variable costs than an incumbent, the incumbent can still be a natural monopolist due to duplicative costs from entry."

"When considering infrastructure industries (water, electricity, gas, etc.) that satisfy the classical natural monopoly condition of Baumol (1977), we show that entry can potentially reduce the total cost of an industry."

"The standard definition applied based on actual costs of an incumbent would generally yield the accurate conclusion that a designated incumbent natural monopoly is the minimum cost producer compared to an industry with new infrastructure-based entry. This arises from..."

"The necessary but not sufficient conditions for entry to have the possibility of reducing costs include $\partial cI/\partial qE < 0$ or $\partial FI/\partial qE < 0$. If at least one of these conditions holds, there is a possibility that an entrant with a transfer of existing or future output from the higher-cost incumbent to a low-cost entrant could lower total costs for the sum of the outputs."

"This proposition emphasizes a general phenomenon: the costs of an incumbent can be “lowered” by avoiding either production that is more cheaply done by an entrant or avoiding future high-cost investments that can be made more cheaply by an entrant."

“Absent at least one of these conditions, the standard natural monopoly definition and the “natural monopolist” definition will yield the same determinations for a given activity.”

"The proposition identifies the conditions under which the incumbent is or is not a natural monopolist in the sense of this paper. From this finding, it is clear that an incumbent can fail to be a “natural monopolist”, in the sense of this paper, while nevertheless operating in a “natural monopoly” in the sense of Baumol (1977)."

"The need for upgrades, and the use of alternative suppliers for monopoly network upgrades is illustrated by the Thames Tideway Tunnel being allocated to a competitively appointed company rather than the incumbent water monopolist for the region, Thames Water."

"Another example could relate to avoiding transmission and distribution network upgrade costs to handle increased electricity demand by substituting activities for new entrants that produce energy locally and reduce the technical demands on the broader transmission and distribution network."

"Another example relates to the investment need predicted for a broad roll-out of electric cars. One debate in this area is over the appropriate role for the often unique distribution company in any geography for building such a network, with the potential competitor..."

"Up to this point, we considered solely cost impacts. While social welfare is often not discussed with respect to natural monopoly, there is value in doing so in this instance. The reason is that the nature of the failure to achieve natural monopoly in practice comes from a situation in which the incumbent is not on the cost frontier. In considering social welfare, but with price regulated as is the case in many regulated services, it is obvious that changes in social welfare from entry are based on the total cost."

"Suppose the impact of the first entrant is cost reducing. The arrival of the first entrant is therefore going to improve social welfare."

"A key intuitive point to draw from this is that each entrant creates additional fixed costs. If the supplementary entrants after the first primarily take value from each other, supplementary entry at the cost..."

"In such a circumstance, a unique incumbent firm both may operate in a natural monopoly sector but not, in fact, be a 'natural monopolist' as defined in this paper. The conditions under which this could occur arise largely from three factors: an absence of high sunk costs in the sector, cost substitutability, and productive inefficiency for an incumbent monopolist."

"This paper's findings suggest a renewed focus on the importance of productive efficiency of incumbents when considering regulatory policy towards natural monopolies. In the context of postal delivery, the findings suggest that those postal incumbents that have the lowest volumes and that are increasingly facing the most serious financial challenges may be exactly the postal services where subsidies are inappropriate and competition would have the most beneficial effects. overlapping deliveries for high-volume postal services is high."

"When an industry meeting the technical requirements of a natural monopoly has an incumbent that is distant from the frontier, the natural monopolist status, as defined in this paper, should not be assumed. A close examination of the incumbent's cost structure, future investment plans, and avoidable costs is imperative. Such an examination can yield essential information to inform policymakers about their use of public funds and their application of regulatory powers."

"Extensions to this paper would prove valuable. Further calibrations would illustrate when the definitions make a difference in applied policy decisions for a variety of sectors….Such extensions would help clarify when policies based on natural monopoly characterizations merit deeper review and, potentially, reversal."

Appendix: Calibration with Postal Volume Data

The article uses mail volume data from various countries to illustrate how the likelihood of overlapping deliveries varies with volume. In low-volume countries (fewer than 100 letters per household), overlap is rare.

Calculations suggest that for entry to reduce costs in moderate- or high-volume countries, the entrant must have a significant productivity advantage. However, in low-volume countries, more modest productivity improvements may be sufficient.

Projections indicate that the number of countries where postal delivery services may not constitute a "y_m-natural monopolist" (according to the new definition) could increase considerably as mail volumes decline due to digitalization.

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