

Chapter XIII

Collusion in Convergent Markets

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I. Introduction

Historically, the telecommunications industry was understood as a sector providing voice communication only, so that it was usually differentiated from other related industries such as data communication or broadcasting. During the last years, however, improvements in Internet-based technologies have increased the substitutability between packet- and circuit-switching data transmission. In particular, packet-based data transmission has proved to be an effective substitute for analog transmission in most of the services provided by telecommunications operators. Technological progress has also affected other closely related industries. For example, technological improvements have broadened the service capabilities in the cable industry, in which the joint supply of television, voice and data services has started to become a common practice. The blurring of the market boundaries between industries that stems from improvements in digital transmission technologies has recently been described as a process of convergence. In its account of this phenomenon, *The Economist* has remarked that:

In applying the 1996 Act, the [US] FCC has sought to make extra distinction between different forms of transmission (copper telephone wire, cable TV, satellite, wireless) and of content (telephone calls, television, data). But the spread of digital technology is making all such distinctions moot. Cable-TV firms carry telephone and internet traffic over their digital networks. Wireless operators pipe e-mail and stream television broadcast. Baby Bell telephone companies such as Verizon, meanwhile, are preparing to enter the television market.¹

Indeed, the process of convergence has been leading firms in different communication markets to enter adjacent industries either as network operators and/or as service providers.² For example, the strong tendency of incumbent fixed-line operators to deliver television services via high-speed Digital Subscriber Lines

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¹ *The Economist*, 'Face Value' (Jan 22, 2005).

² OECD, *Cross-Ownership and Convergence: Policy Issues* (Paris, OECD Press, 1998).

or new purpose-built fibre-optic networks is explained by the emergence of new competitors in their natural markets. Incumbent phone companies are now facing strong competition from cable-TV companies, which are in the position to offer the triple play of TV, broadband Internet and telephony over their networks. In some countries—including France, Italy, Britain and Japan—incumbent operators are also facing competition from over-builders which also offer triple-play bundles over high-speed phone lines. It is then not surprising that incumbents find it imperative to cross their traditional market borders in order to survive within the new competitive environment that convergence has created.³

In Latin America, one of the most important processes of market convergence is also occurring in the telecommunications industry, where the fixed and mobile segments of voice communication are in a process of merging into a single market. The most recent trends in telecommunications markets around the world confirm that the number of mobile communication subscribers has been steadily increasing, while the number of subscribers in the fixed-line segment has been contracting. In OECD countries, for example, fixed lines were the dominant access technology until 2000, when the number of mobile phones overtook the number of fixed lines. The most recent figures for the OECD area show that mobile subscribers outnumber fixed-line subscribers by a ratio of more than three to one. This tendency has been inherently linked to a process of substitution between fixed-line and mobile access. As reported by the same source, ‘The decrease in these countries is mainly attributable to substitution as mobile phone subscribers give up fixed lines that they may now view as redundant.’⁴

The evolution of the voice communication industry in Latin America has also followed this general trend, as illustrated by Table 1 below.

Table 1 reports for this sample of countries that, on average, 62 per cent and 17 per cent of the Latin American population have mobile and fixed access,

Table 1 Fixed and Mobile Penetration Rates in Latin America, 2006

Service	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Venezuela
Mobile	75%	53%	81%	68%	53%	31%	72%
Fixed Line	22%	19%	20%	17%	19%	9%	14%

Source: Latin American Communications and Mobile Data Markets 2007 Report.

³ T Bresnahan and S Greenstein, ‘Technological Competition and the Structure of the Computer Industry’ 47 *Journal of Industrial Economics* 1–40 (1999) have provided a similar account of a process of convergence in the production of computers, and they describe how the presence of strong economies of scope has created incentives for incumbents in one particular segment to enter into new segments of the market. See also Shane Greenstein and Tarun Khanna, ‘What Does it Mean for Industries to Converge’ in David Yoffie (ed), *Competing in an Age of Digital Convergence* (Cambridge, MA, Harvard University Press, 1997).

⁴ OECD, *OECD Communications Outlook* (Paris, OECD Press, 2007), at 95.

respectively. This implies that approximately 45 per cent of the population in the region relies on mobile technology as its only source of voice access. The interesting feature of the table is that this 45 per cent represents the fraction of the population that, in some sense, has substituted away fixed access. This is because had this 45 per cent looked for an alternative means of voice access in the absence of mobile technology, they would have likely chosen fixed access. The data then suggest that the substitution between fixed and mobile services in the Latin American region has not been negligible. Furthermore, it is expected that competition—hence, substitution—between these two technologies will intensify in the years to come, as their degree of service differentiation is reduced. In fact, it is expected that the technologies associated with these two access modes may merge into a single technology:

The line between fixed and mobile calls is blurring ... the emergence of converged devices may necessitate a change in how telephone access paths are counted. For example, several fixed-line operators in the OECD area have introduced devices that place calls over the user's fixed line when the user is at home and over a mobile network when they are away.⁵

The fixed-mobile segment of the voice communication market in Latin America certainly shows features of a convergent market, and it is not the only area where convergence is displaying its technological impact.⁶

The process of market convergence raises important policy issues. For example, the pace and nature of technological change is frequently affected by the regulatory environment in which these changes take place. In particular, one of the critical features of the interaction between technological progress and regulation is that the latter typically displays some degree of sluggishness with respect to the dynamics generated by technological change. This inherent lack of flexibility associated with regulatory surveillance opens the possibility that two initially distinct but converging industries may end up being subject to different regulatory regimes when competing in essentially the same market.⁷

A second topic of policy interest is the extent to which market convergence facilitates collusive behavior. This issue is addressed in this paper through the use of a standard model of product differentiation that characterizes the convergence of two distinct markets over time. In the setting discussed in the following pages, convergence takes the form of an exogenous process of technological change that

⁵ *Ibid.*, at 97. In particular, the OECD mentions that *KT* in Korea, *BT* in the United Kingdom and *Orange* in France have launched phones that use the mobile network when away from home but can connect to the user's broadband connection via Bluetooth or Wi-Fi at home to place calls at fixed rates. *KT*'s 'OnePhone', *BT*'s 'Fusion' and *Orange*'s 'unik' networks allow users to roam seamlessly between a mobile network and the Bluetooth connection without disrupting an ongoing call.

⁶ Other important areas of convergence in the telecommunications industry are the provision of broadband services through cable-modem and DSL platforms, and the provision of TV content via cable-TV and satellite technologies.

⁷ V Pavón-Villamayor, 'La Convergencia y el Principio de la Neutralidad Tecnológica' 74 *El Trimestre Económico* 845–83 (2007).

not only reduces the degree of product differentiation between markets, but also increases the quality of the services associated with them.

On the basis of the analytical treatment of the process of convergence elaborated upon in this paper, this work belongs to the tradition of the economic literature that discusses the effect of product differentiation on collusion. Chamberlin⁸ was the first economist to point out that when sellers are few and products are homogeneous, firms have incentives to engage in tacit collusion. The intuition that reaching a collusive agreement is easier when products are more homogeneous has found extensive support in the academic literature (see Posner,⁹ Stigler,¹⁰ Asch and Seneca,¹¹ Levenstein and Suslow,¹² and Raith¹³). In the same vein, Scherer and Ross have claimed that ‘cooperation to hold prices above the competitive level is less likely to be successful ... the more heterogeneous, complex and changing the products supplied are.’¹⁴

This intuition has also been the basis of the 1992 US Department of Justice and Federal Trade Commission Horizontal Merger Guidelines, which claim that ‘reaching terms of coordination may be facilitated by product or firm homogeneity’.¹⁵

The argument that lower differentiation increases the likelihood of collusive behavior has, however, been disputed. One of the results that has emerged from the repeated game literature has been that the effect of product substitutability on firms’ ability to collude tacitly depends on whether firms compete in prices or quantities. Chang¹⁶ and Ross,¹⁷ for example, discuss a Hotelling model with price-setting firms, and show that increased product substitutability hinders the sustainability of collusion. In a framework more related to the one discussed here—a quantity-setting—Tyagi¹⁸ found that increased product substitutability hinders tacit collusion for the case of linear and concave demand functions, but that product substitutability may either hinder or facilitate collusion for the case of

⁸ E H Chamberlin, ‘Duopoly: Value where Sellers are Few’ 43 *Quarterly Journal of Economics* 63–100 (1929).

⁹ Richard A Posner, *Antitrust Law: An Economic Perspective* (Chicago, University of Chicago Press, 1976), at 59–60.

¹⁰ George J Stigler, *The Theory of Price* (New York, Macmillan Company, 1987), at 226–27.

¹¹ P Asch and J Seneca, ‘Is Collusion Profitable?’ 58 *Review of Economics and Statistics* 1–12 (1976).

¹² Margaret Levenstein and Valarie Suslow, ‘What Determines Cartel Success?’ (2002) *University of Michigan Business School Working Paper*.

¹³ Raith (‘Product Differentiation, Uncertainty and the Stability of Collusion’ (1996) *London School of Economics STICERD Discussion Paper EI/16*) in particular, provides the notion that an increase in the heterogeneity of the products leads to a decrease in the correlation of the demand functions of the goods. This is important because, in an environment where a firm cannot observe its rivals’ actions but has to infer them from signals, collusion is more difficult to sustain, since discriminating between random demand shocks and deviations from the cartel strategy becomes more difficult.

¹⁴ Frederic M Scherer and David Ross, *Industrial Market Structure and Economic Performance* (New York, Houghton Mifflin Company, 1990).

¹⁵ Guidelines available at <www.ftc.gov/bc/docs/horizmer.htm>. See section 2.11 of the guidelines.

¹⁶ M H Chang, ‘The Effects of Product Differentiation on Collusive Pricing’ (1991) 9 *International Journal of Industrial Organisation* 453–69.

¹⁷ T W Ross, ‘Cartel Stability and Product Differentiation’ 10 *International Journal of Industrial Organisation* 1–13 (1992).

¹⁸ R Tyagi, ‘On the Relationship Between Product Substitutability and Tacit Collusion’ 20 *Managerial and Decision Economics* 293–98 (1999).

convex demand functions.¹⁹ The analysis contained in this paper supports Tyagi's conclusion, because for linear demand functions, it is found that collusion is more likely the lower the degree of differentiation across markets.

The paper is organized as follows. Section II provides a detailed description of the analytical framework on which the analysis is based. Section III characterizes the equilibrium outcomes in three distinct competitive scenarios, namely: competition, collusion, and coordination break-up. This section provides some comparative statistics of welfare measures across these scenarios. The core part of the paper is contained in sections IV and V, in which the analytical framework is used to discuss the incentives of firms to engage in collusive practices as convergence evolves. Lastly, section VI provides a brief discussion of the implications that the process of market convergence can have for design and the implementation of competition policies in Latin America.

II. The Model

Consider a differentiated duopoly based on the pioneering work of Bowley.²⁰ The economy contains two sectors. The first sector has two firms providing differentiated services to consumers, while the second is a competitive *numéraire* sector.²¹ There is a continuum of consumers of the same type with a utility function separable and linear in the *numéraire* good. Hence, there are no income effects on the first sector and it is possible to perform partial equilibrium analysis. The standard economic argument to justify this assumption is that consumers spend only a small part of their income on the services associated with this industry. The representative consumer then optimizes the program:

$$\max_{x_1, x_2} U(x_1, x_2) + \left\{ Y - \sum_{k=1}^2 p_k x_k \right\} \quad (1)$$

where $U(x_1, x_2)$ represents the utility that derives from the consumption of services x_1 and x_2 . The term inside brackets describes expenditure in outside

¹⁹ The underlying idea is that higher product substitutability increases both the gains and the costs of engaging in collusion so that the relative magnitudes of these changes—affected by the curvature of the demand functions—determine the net effect of increased product substitutability on collusion. The author found that increased product substitutability increases individual firms' gains from cheating more than their gain from colluding for the case of linear and concave demand functions, which hinders collusion. However, these relative changes can go either way for the case of convex demand functions.

²⁰ Arthur Bowley, *The Mathematical Groundwork of Economics* (Oxford, Oxford University Press, 1924).

²¹ Since the first sector contains exactly two firms and there is no entry or exit, the market structure is exogenous.

goods when the price of service k is p_k and consumer's income is Y . As in Sutton²² and Symeonidis,²³ it is assumed that utility has the functional form:

$$U(x_1, x_2) = \sum_{k=1}^2 \left(x_k - \frac{x_k^2}{(q_k(\gamma))^2} \right) - 2\gamma \prod_{k=1}^2 \left(\frac{x_k}{q_k(\gamma)} \right)$$

where x_k and $q_k(\gamma)$ stand for quantity and quality of service k , respectively. It is assumed that each firm provides only one variety of the services that are available in the industry. The utility function specified above is just a quality-augmented version of the standard quadratic utility function extensively used in the industrial organization literature, and it has the particular feature that utility is not only increasing in quantities but also increasing in the qualities associated with each of the product varieties (see Dixit²⁴; Singh and Vives²⁵; Shaked and Sutton²⁶). Observe that the parameter $0 \leq \gamma \leq 1$ represents a measure of the degree of horizontal differentiation or substitution observed across markets. It is then possible to characterize—in a sort of inter-temporal framework—the evolution of a process of market convergence by continuously and strictly increasing values of γ . For example, $\gamma = 0$ would characterize a no-convergence regime, since the degree of product differentiation across markets would be so high that consumption of an industry's services would require access to two distinct products or markets. In contrast, $\gamma = 1$ would characterize a total convergence regime, since, when there is perfect substitutability between services at identical qualities, consumption of an industry's services would require access to one product or market only. Therefore, continuously and strictly increasing values in the parameter γ allows for the characterization of a process of market convergence in substitutes.²⁷

The framework discussed in this paper also assumes that all firms' strategic decisions are always evaluated within the planning horizon framed by the process of market convergence itself. For example, a firm evaluating whether or not to engage in collusion at time $\gamma = \tilde{\tau}$ will make its cost-benefit evaluation within the planning horizon that spans from point $\gamma = \tilde{\tau}$ —the time at which the decision is evaluated—to

²² J Sutton, 'One Smart Agent' (1997) 28 *Rand Journal of Economics* 605–28.

²³ G Symeonidis, 'Price and Non-price Competition with Endogenous Market Structure' 9 *Journal of Economics and Management Strategy* 53–83 (2000).

²⁴ A Dixit, 'A Model of Duopoly Suggesting a Theory of Entry Barriers' 10 *Bell Journal of Economics* 20–32 (1979).

²⁵ N Singh and X Vives, 'Price and Quantity Competition in a Differentiated Duopoly' 15 *Rand Journal of Economics* 546–54 (1984).

²⁶ A Shaked and J Sutton, 'Multiproduct Firms and Market Structure' 21 *Rand Journal of Economics* 45–62 (1990).

²⁷ Convergence in substitutes does not exhaust all the possibilities of convergence processes. There is also convergence in complements, which occurs when a new technology opens up the possibility of combining existing technologies to provide a new service. A premier example of convergence in complements is the emergence of the market for handheld computers in the early 1990s. Partly triggered by new advances in handwriting recognition technology, companies from different industries

$\gamma = 1$ —the time at which the process of market convergence ends. The feature that firms make their strategic evaluations within finite planning horizons makes the implications of the analysis more tractable and, more importantly, realistic.

One of the most striking characteristics of market convergence in industries such as telecommunications and information services is the rapid pace of innovation. To model this important feature of market convergence, the following assumption is made explicit:

Innovation. The level of quality provided by each service variety is driven by the parameter of convergence γ according to the following specification:

$$q_k(\gamma) = h_k(1 + \gamma)$$

for $k = 1, 2$, where $h_k > 0$ represents the initial quality associated with each variety before convergence takes off.²⁸

This assumption represents one of the simplest formulations to describe the property that the quality provided by each of the product varieties increases throughout the process of convergence. To see this, observe that when $\gamma = 0$, the level of quality associated with each variety is fixed at the initial level h_k , while as $\gamma \rightarrow 1$, quality tends to be twice as large as its base level: $q_k(\gamma) \rightarrow 2h_k$. In order to keep the analysis as simple as possible, it is assumed that the initial level of quality provided by each firm is the same, so that $h_1 = h_2 = h > 0$. Note that, since the parameter of convergence γ impacts both markets symmetrically, it follows that $q_1(\gamma) = q_2(\gamma) \quad \forall \gamma$. Let us represent this common level of quality as $q(\gamma) = h(1 + \gamma)$.

It is worth noting that in the above framework, parameter γ impacts consumers' utility through two different channels. A first channel is the direct impact that stems from the substitutability between services, which decreases utility as γ increases. This substitution effect derives from the fact that consumers derive lower utility from the consumption of the two products due to the increasing substitutability between their functions. The second channel is the indirect impact of γ on consumers' utility through its effect on quality, which increases utility as γ increases. This quality-driven demand effect is the result of the consistent quality improvement that is observed across products throughout the process of convergence.

Finally, the solution to the utility maximization problem described by condition (1) gives the following linear system of inverse demand functions:

$$p_1 = 1 - \left\{ \frac{2x_1}{(q_1(\gamma))^2} \right\} - \left\{ \frac{2\gamma x_2}{q_1(\gamma)q_2(\gamma)} \right\}$$

like telecommunications, computers and consumer electronics combined their technologies to offer the first handheld computers in the market.

²⁸ In section V, a more general representation of the process of innovation in the industry is explored.

$$p_2 = 1 - \left\{ \frac{2x_2}{(q_2(\gamma))^2} \right\} - \left\{ \frac{2\gamma x_1}{q_1(\gamma)q_2(\gamma)} \right\}$$

These demand functions will be used extensively in section III. The analysis also assumes that firms compete in quantities and that the production technology is characterized by constant marginal costs which, without loss of generality, are normalized to zero. Formally, the game played at each level of γ is described by two players: the firms operating in the two markets that converge. The set of strategies associated with each firm is to choose a strictly positive level of output while each firm's payoff is explicitly given by:

$$\Pi_j = p(x_j, x_i)x_j$$

for all $i, j = 1, 2$ but $i \neq j$. One of the advantages of the analytical framework explored in this paper is that welfare measures are extremely tractable, since total and consumer surplus are simply described by $U(x_1, x_2)$ and $U(x_1, x_2) - (\Pi_1 + \Pi_2)$, respectively.

III. Characterization of Equilibrium Outcomes

In this section, the one-shot equilibrium outcomes of three distinct competitive scenarios between firms are explicitly characterized. The first scenario corresponds to a process of standard competition between duopolists; the second scenario—which corresponds to a coordinated outcome or collusion—is modelled as a multi-product monopolist problem; while the third scenario characterizes the equilibrium outcome that derives from the break-up of coordination. Some comparative statistics of welfare measures across these distinct scenarios are also explored.

A. Duopolistic Competition

The one-shot equilibrium outcome associated with competition between duopolists in a converging market derives from the solution to firm's j optimization program, namely:

$$\max_{x_j} \Pi_j = \left(1 - \left\{ \frac{2x_j - 2\gamma x_i}{(q(\gamma))^2} \right\} \right) x_j \quad \forall i, j = 1, 2 \ i \neq j$$

By deriving the first order conditions and by solving simultaneously these best-response correspondences, the following (symmetric) equilibrium quantities and prices are obtained:

$$x_1^* = x_2^* = \left\{ \frac{h^2(1+\gamma)^2}{2(2+\gamma)} \right\} \quad p_1^* = p_2^* = \left(\frac{1}{2+\gamma} \right)$$

It is straightforward to see that $\partial x_1^* / \partial \gamma = \partial x_2^* / \partial \gamma > 0$, so that the competitive output increases and the competitive price decreases, $\partial p_1^* / \partial \gamma = \partial p_2^* / \partial \gamma < 0$, as the process of convergence evolves. In the following, $\hat{\Pi}_1(\sigma_1 = \sigma_2 = 0)$ and $\hat{\Pi}_2(\sigma_1 = \sigma_2 = 0)$ will denote the equilibrium level of duopolistic profit per period associated with each of the concurring firms. Explicitly, this level of profit is given by:

$$\hat{\Pi}_1(\sigma_1 = \sigma_2 = 0) = \hat{\Pi}_2(\sigma_1 = \sigma_2 = 0) = \frac{1}{2} \left\{ \frac{h(1+\gamma)}{2+\gamma} \right\}^2$$

It is worth noting that $\partial \hat{\Pi}_1(\sigma_1 = \sigma_2 = 0) / \partial \gamma = \partial \hat{\Pi}_2(\sigma_1 = \sigma_2 = 0) / \partial \gamma > 0$, so that competitive profits increase through the process of convergence, regardless of the higher substitutability that is observed across market products.

This result contrasts with a standard Cournot framework with no innovation, $q_k(\gamma) = h_k$, where higher substitutability between products would imply both lower outputs and prices as convergence evolves and, hence, lower profits. It is therefore clear that the driving force behind the result of increasing competitive profits in our framework is the process of innovation underlying the relevant product markets.

B. Collusion

Consider now a scenario in which the concurring firms are able to coordinate the amount of output that is sold in the industry. In particular, assume that this output coordination takes the form of a multi-product monopolist that allocates output quotas across distinct production plants.²⁹ In this standard multi-product monopolist problem of dependent demands with separable costs, outputs per period are determined through the following program:

$$\max_{x_1, x_2} \Pi = \left(1 - \left\{ \frac{2x_1 - 2\gamma x_2}{(q(\gamma))^2} \right\} \right) x_1 + \left(1 - \left\{ \frac{2x_2 - 2\gamma x_1}{(q(\gamma))^2} \right\} \right) x_2$$

²⁹ Jean Tirole, *The Theory of Industrial Organisation* (Cambridge, MA, MIT Press, 1998).

The solution to this problem gives the following equilibrium levels of outputs and prices:

$$x_1^{**} = x_2^{**} = \left\{ \frac{h^2(1+\gamma)}{4} \right\} \quad p_1^{**} = p_2^{**} = \frac{1}{2}$$

Note that since $\partial x_1^{**} / \partial \gamma = \partial x_2^{**} / \partial \gamma > 0$, the collusive output also increases as the process of convergence evolves. Also observe that collusive prices always remain above competitive prices. This is not surprising, because when products are substitutes, a multi-product monopolist would find it optimal to increase the prices of substitute products in relation to the prices charged by a duopoly due to the negative externality posed by their substitutability itself.³⁰ The equilibrium level of profit per period associated with each of the collusive firms is then given by:

$$\hat{\Pi}_1(\sigma_1 = \sigma_2 = 1) = \hat{\Pi}_2(\sigma_1 = \sigma_2 = 1) = \left\{ \frac{h^2(1+\gamma)}{8} \right\}$$

which is also strictly increasing in γ . Figure 1 below shows the comparative statistics of the levels of welfare associated with the competitive and the collusive outcomes as a function of the parameter of market convergence γ . The competitive and collusive total surplus in the industry are represented by $U(x_1^*, x_2^*)$ and $U(x_1^{**}, x_2^{**})$, respectively, while the competitive and collusive industry profits are represented by $\Pi_1^* + \Pi_2^*$ and $\Pi_1^{**} + \Pi_2^{**}$, respectively. Figure 1 then illustrates two standard points. First, the implementation of a collusive agreement always reduces total surplus. This is illustrated as a downward movement of the $U(x_1^*, x_2^*)$ schedule to level $U(x_1^{**}, x_2^{**})$.

Secondly, profits in the industry increase as a result of collusion, as illustrated by the upward movement of the $\Pi_1^* + \Pi_2^*$ schedule to level $\Pi_1^{**} + \Pi_2^{**}$. Therefore, Figure 1 implies that the consumer surplus derived from a collusive outcome is always lower than the one associated with competition. To see this, let us assume that the process of market convergence has reached level $\gamma = \tilde{\gamma}$ in Figure 1 above. In competition, consumer surplus is given by the distance AB while, under collusion, it is given by the distance CD, which is smaller.³¹

³⁰ Massimo Motta, *Competition Policy* (New York, Cambridge University Press, 2004).

³¹ Incidentally, note that under a total welfare standard the consumer surplus loss associated with the distance DB would be of no concern for the competition authorities. This is because DB just represents a monetary transfer from consumers to producers with neutral effects on aggregate welfare. In contrast, under a price welfare standard, DB would be computed as part of the welfare loss that stems from collusive behavior.

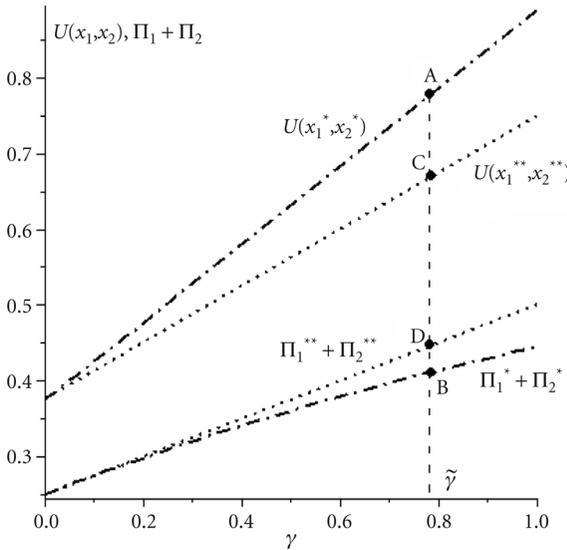


Figure 1 Competitive and collusive welfare as a function of γ

C. Coordination Break-up

To compute the one-shot outcome associated with the breakup of coordination between the colluding firms, assume that firm 1 deviates from its collusive behavior at time $0 < \tilde{\tau} \leq 1$ of the convergence process. Therefore, at time $\tilde{\tau}$, firm 1 chooses its output according to the program

$$\max_{x_1} \Pi_1 = \left(1 - \left\{ \frac{2x_1 - 2\tilde{\tau}x_2^{**}}{(q(\tilde{\tau}))^2} \right\} \right) x_1$$

where x_2^{**} denotes the cooperative output chosen by firm 2 at time $\tilde{\tau}$. The solution to this problem gives firm 1's optimal level of output and associated profit:

$$\tilde{x}_1 = \left\{ \frac{h^2(2 + \tilde{\tau})(1 + \tilde{\tau})}{8} \right\} \quad \hat{\Pi}_1(\sigma_1 = 0, \sigma_2 = 1) = \left\{ \frac{h^2(2 + \tilde{\tau})^2}{32} \right\}$$

Since $\partial \tilde{x}_1 / \partial \tilde{\tau} > 0$, it follows that the optimal size of the deviating output is larger the lower the degree of substitutability observed across market products. Similarly, the size of the deviating profits is increasing in convergence: $\partial \hat{\Pi}_1(\sigma_1 = 0, \sigma_2 = 1) / \partial \tilde{\tau} > 0$. The following section explores in detail the extent to which collusive behavior is sustainable in markets characterized by convergence processes.

IV. Collusion and Market Convergence

In order to address the question of whether market convergence facilitates collusion, consider the grim strategy of Friedman,³² given as follows. Choose initially the collusive output. At time $0 < \tau \leq 1$, choose the collusive output only if both firms have chosen the collusive output during the entire time interval prior to τ ; otherwise, choose the competitive output thereafter.

Without loss of generality, the following analysis is based on the assumption that firm 1 deviates from its collusive behavior at time $0 < \tilde{\tau} \leq 1$, triggering the subsequent non-cooperative behavior of firm 2. The following lemma provides the core result of the paper.

LEMMA 1: Collusion & Convergence. *Collusion is sustainable provided $0 < \tilde{\tau} \leq 0.312$ and unsustainable when $\tilde{\tau} \geq 0.384$ holds. When $0.312 < \tilde{\tau} < 0.384$ condition,*

$$\begin{aligned} & \hat{\Pi}_1(\sigma_1 = 0, \sigma_2 = 1) \Big|_{\gamma=\tilde{\tau}} - \hat{\Pi}_1(\sigma_1 = \sigma_2 = 0) \Big|_{\gamma=\tilde{\tau}} \\ & + \int_{\gamma=\tilde{\tau}}^1 \hat{\Pi}_1(\sigma_1 = \sigma_2 = 0) \exp(-\delta(\gamma - \tilde{\tau})) d\gamma \\ & > \int_{\gamma=\tilde{\tau}}^1 \hat{\Pi}_1(\sigma_1 = \sigma_2 = 1) \exp(-\delta(\gamma - \tilde{\tau})) d\gamma \end{aligned}$$

holds provided $\delta \geq \bar{\delta}$, so that collusion is only sustainable for $\delta < \bar{\delta}$, where $\bar{\delta} \in (0, 1)$ represents the discount rate at which the discounted value of profit streams when deviating and colluding are equal.

The left-hand-side of Lemmas 1's inequality expresses the discounted value of the streams of profits accrued to firm 1 when it deviates from its collusive behavior at time $\tilde{\tau}$. In turn, the right-hand-side of the inequality establishes the discounted value of the streams of profits accrued to the same firm when it honors the collusive agreement from time $\tilde{\tau}$ on. In particular, observe that the term $\hat{\Pi}_1(\sigma_1 = 0, \sigma_2 = 1)$ appearing on the left-hand-side of the inequality represents the one-off payoff obtained by firm 1 at the time of its deviation $\tilde{\tau}$. Also observe that the third term on the left-hand-side of the inequality computes the present value of the stream of profits, discounted at rate δ , that derives from

³² J Friedman, 'A Non-Cooperative Equilibrium for Supergames' 38 *Review of Economic Studies* 1-12 (1971).

duopolistic competition from time $\tilde{\tau}$ onwards—the punishment period. A careful examination of this third term leads to the observation that it also includes the no-cooperative profit that firm 1 would have obtained at time $\tilde{\tau}$. This profit should not be included there since it is known that at $\tilde{\tau}$, firm 1 gets the deviating profit instead of the no-cooperative profit. In other words, the correct specification of the discounted value of the streams of profits deriving from deviating at time $\tilde{\tau}$ requires the subtraction of the no-cooperative profit obtained by platform 1 at time $\tilde{\tau}$. This is the reason why the term $\hat{\Pi}_1(\sigma_1 = \sigma_2 = 0)$ is subtracted from the left-hand-side of Lemma 1's inequality.

The core claim associated with Lemma 1, which predicts that cartel stability increases with the degree of product differentiation, can be divided into two parts. First, the lemma claims that the question of whether collusion arises in converging markets can be answered unambiguously—eg, irrespectively of the discount rate—depending on the extent to which product markets are differentiated. In particular, the lemma provides the intuition that collusion is unambiguously feasible (in the sense that the discounted value of the stream of collusive profits is always higher than the one-off deviation profit plus the discounted value of the stream of competitive profits for any δ) during the initial stages of market convergence, and unambiguously unfeasible when convergence has surpassed a minimum threshold.

Figure 2 below illustrates the first of these two scenarios. It shows the discounted value of profit streams—as a function of the discount rate δ —associated with a process of convergence still in its initial phases, $0 < \gamma \leq 0.312$, when the behavioral deviation occurs at time $\tilde{\tau} = 0.30$.

The figure illustrates that in these circumstances deviation from collusive behavior is not optimal, since the discounted value of profit streams associated with collusion are, for any discount rate δ , higher than the discounted value of profit streams that derive from deviating at time $\tilde{\tau} \in 0 < \gamma \leq 0.312$.

The rationale behind this result is simple. When convergence is still in its initial phases, deviation does not increase profits significantly since market products are still highly differentiated. This improves the conditions for having a collusive agreement. At the same time, the size of the punishment associated with a deviation occurring during the initial stages of convergence is not negligible. It is true that in the short run, the size of the punishment cannot be particularly large since differentiation between products is still high. However, in the long run, the process of convergence itself increases the size of the punishment. This is because as products become closer substitutes, the competition intensifies, and this increases the relative size of the sacrificed profits that would have been obtained had the collusive agreement been kept in place. Overall, the size of the punishment outweighs the benefits of cheating, and therefore the conditions for a coordinated outcome are strengthened.

Observe that this is just another instance of the so-called pro-collusive intrinsic effect of demand growth (innovation, in the setting of this paper) on collusion, which establishes that the higher the rate of demand growth, the higher is the

$$\tilde{\tau} = 0.30$$

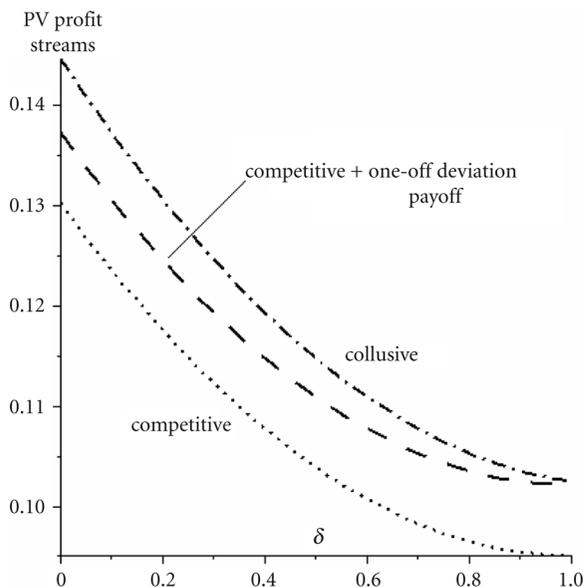


Figure 2 Present value of profit streams as a function of δ

importance of future profits from collusion relative to the current gains from deviating.³³ The pro-collusive intrinsic effect of demand growth on collusion characterizes perfectly the situation described in this paper during the initial phases of convergence, because the expected rise in demand increases the future cost of deviation, which in turn implies that an increase in the market growth (innovation) rate induces an increase in the maximal level of sustainable collusion.

Notwithstanding the similarity between these two conceptual frameworks, the bottom line is that when the process of convergence is going through its initial phases, collusion is sustainable because the short-term gains from deviation are not large enough to compensate for the future loss of profitability derived from a coordinated outcome.

Figure 3 below illustrates the second of the two scenarios described above. It shows the discounted value of profit streams—as a function of the discount rate δ —that derive from a process of convergence that goes through its terminal phases, $\gamma \geq 0.384$, when the deviation in conduct occurs at time $\tilde{\tau} = 0.40$.

In this scenario, collusion is unfeasible because the discounted value of profit streams associated with cooperation are, for any discount rate δ , lower than the discounted value of profit streams deriving from deviation. The rationale behind this result is, as before, the balance between short- and long-run cost and benefits.

³³ H Vasconcelos, 'Sustaining Collusion in Growing Markets' (2008) *CEPR Discussion Paper No 6865*.

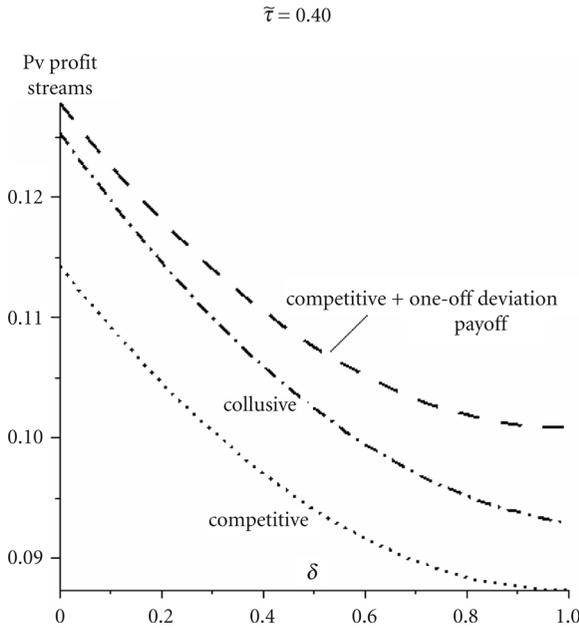


Figure 3 Present value of profit streams as a function of δ

A first observation is that in this case any deviation has the potential to increase profits significantly because the level of market product differentiation is relatively low. This improves the economic incentives for a successful deviation. At the same time, the size of the punishment associated with deviation lowers. It is true that, in the short run, the size of the punishment is large since product differentiation is now relatively low. However, since the process of convergence is evolving through its terminal stages, this large punishment is relatively short-lived. Overall, the incentives for deviation dominate the incentives for maintaining coordination, and this makes collusion unstable. Formally, the pro-collusive intrinsic effect of demand growth (innovation) on collusion is dominated by the incentives to deviate since the expected rise in demand is not particularly high.

The second part of Lemma 1's claim is that, when market convergence evolves through an intermediate range, collusion can be feasible depending on the rate at which future profits are discounted. In particular, the lemma establishes that when convergence evolves through this intermediate period, $0.312 < \gamma < 0.384$, collusion is feasible provided the discount rate is not too high: $\delta < \bar{\delta}$. As before, Figure 4 below illustrates the discounted value of profit streams that derive from a process of convergence that goes through this intermediate period when deviation occurs exactly at time $\bar{\tau} = 0.35$.

The figure illustrates that the discounted value of profit streams associated with collusion are strictly higher than the discounted value of profit streams

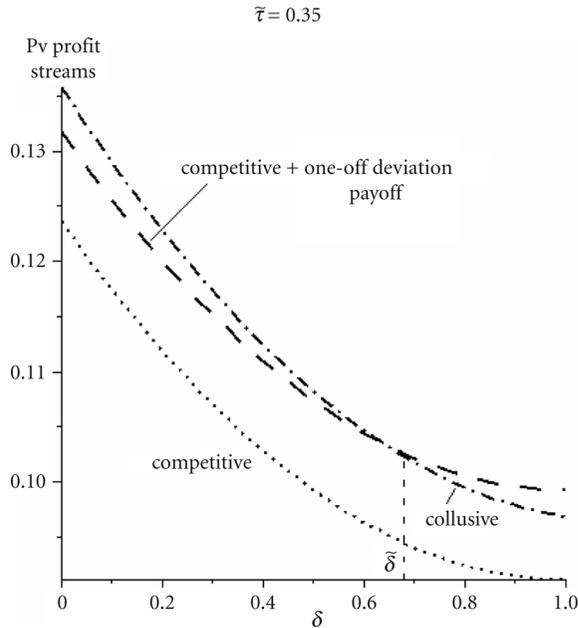


Figure 4 present value of profit streams as a function of δ

that derive from deviation only when $\delta < \bar{\delta}$. The intuition behind this result is as follows. The discount rate represents the weight that firms place on the value of future profits. When $\delta \rightarrow 0$, short run profits are equally valuable as future profits, while when $\delta \rightarrow 1$, profits of the same size are seen as more valuable in the present than in the future. Therefore, collusion is more feasible when δ is low, because only a firm that cares about future profits has incentives to enforce a collusive agreement. In contrast, when δ is high, collusion is less feasible since the attractiveness of earning higher profits now versus tomorrow increases, which makes cooperation more difficult to sustain.

V. Collusion, Convergence and Innovation

One of the most striking characteristics of market convergence in some industries is its pace of innovation. Gambardella and Torrisi,³⁴ for example, have found that during the period of 1984–92, for the 32 largest US and European electronics

³⁴ A Gambardella and S Torrisi, 'Does Technological Convergence Imply Convergence in Markets? Evidence from the Electronics Industry' 27 *Research Policy* 445–63 (1998).

firms, higher economic performance was associated with companies that focused on their core business but widened their technological capabilities. This result is somewhat intriguing, as one would expect technological diversification to be encouraged by the prospect of moving into different product markets where these technologies can be applied. The authors argue, however, that the expansion of technological capabilities may also be used to extract greater rents in core product markets by creating more complex products that incorporate distinct technologies. In other words, technological expansion is used not only to enter into different markets, but also to innovate in the functionalities associated with existing products.

The pace at which converging industries innovate has important implications not only for the measurement of welfare, but also for firms' incentives to collude. This is because innovation, by affecting current and future profits, also alters the intertemporal profile of optimal choices underlying the decision whether or not to engage in collusive behavior. In order to explore the impact that innovation has on collusive behavior, assume now that the evolution of the quality level provided by each firm is given by:

$$q_k(\gamma) = h_k(1 + \alpha\gamma)$$

where $0 \leq \alpha \leq 1$ represents an index of the observed degree of innovation in the industry. When $\alpha = 1$, as in the analysis carried out so far, innovation is meant to be maximal, since quality in the industry evolves basically according to the dynamics of the parameter of convergence γ . In contrast, when $\alpha = 0$, the industry is characterized by no innovation, since the quality in the industry remains anchored at its base level h_k . The following lemma illustrates this.

LEMMA 2: Collusion & innovation. *Let τ_{\max} denote the latest deviation time such that, for any $\tilde{\tau} \leq \tau_{\max}$, condition:*

$$\int_{\gamma=\tilde{\tau}}^1 \hat{\Pi}_1(\sigma_1 = \sigma_2 = 1) \exp(-\delta(\gamma - \tilde{\tau})) d\gamma > \hat{\Pi}_1(\sigma_1 = 0, \sigma_2 = 1) \Big|_{\gamma=\tilde{\tau}} - \hat{\Pi}_1(\sigma_1 = \sigma_2 = 0) \Big|_{\gamma=\tilde{\tau}} + \int_{\gamma=\tilde{\tau}}^1 \hat{\Pi}_1(\sigma_1 = \sigma_2 = 0) \exp(-\delta(\gamma - \tilde{\tau})) d\gamma$$

holds for any δ . The lower the pace of innovation in the convergent market, the lower the sustainability of collusion since τ_{\max} is strictly increasing in α .

The content of Lemma 2 is illustrated by Figure 5 below. Lemma 2 claims that the time span—represented in the graph by τ in the vertical axis—over which

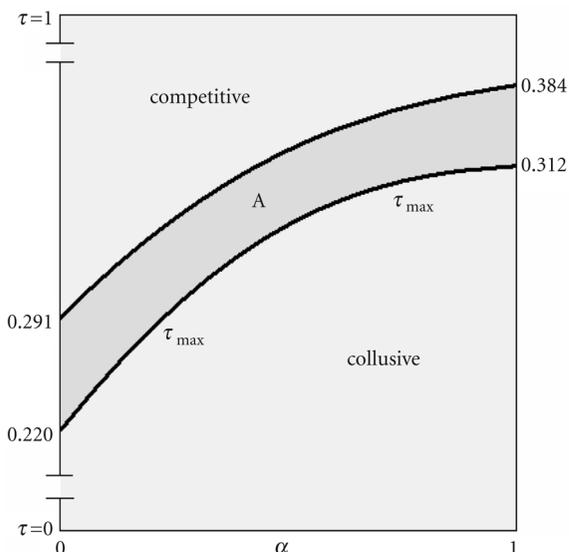


Figure 5 Innovation and the incentives for collusion

collusion is feasible shrinks as the index of the industry's innovation becomes smaller.³⁵ In other words, collusion is easier to sustain in markets with a high rate of innovation. In principle, this claim would seem to contradict the standard wisdom that in industries characterized by high rates of innovation, collusion is more difficult to sustain.³⁶

This standard wisdom is based, however, on the implicit assumption of *asymmetric* innovation. In particular, Ivaldi *et al* have argued that

innovations, particularly drastic ones, may allow a firm to gain a significant advantage over its rivals. This prospect reduces both the value of future collusion and the amount of harm that rivals will be able to inflict if the need arises.³⁷

The intuition seems reasonable. However, when innovation is symmetric and sizeable, the size of the punishment associated with an early deviation increases, since the amount of future profits that have to be sacrificed also increases. Thus symmetric innovation, by increasing the size of the intertemporal punishment, improves the conditions for the stability of collusive behaviour.

³⁵ The area demarcated by Λ represents the combination of innovation and convergence rates over which the feasibility of collusion depends on the size of the discount rate.

³⁶ M Ivaldi, B Jullien, P Rey, P Seabright and J Tirole, 'The Economics of Tacit Collusion', *Final Report for the European Commission* (Toulouse, IDEI, 2003).

³⁷ *Ibid*, at 32.

VI. Implications for Competition Policy in Latin America

The implications of market convergence for competition policy in Latin America are vast. It has been commonly argued, for example, that the blurring of the boundaries between distinct product markets brought about by convergence has eroded the market power of incumbents in many markets. This notion of convergence as a force that encourages market entry has important implications for the case of regulated industries in the region, since it would provide a rationale for the deregulation of markets. Nevertheless, it would be adventurous for the regional competition authorities to initiate a process of deregulation on behalf of this view, since the extent to which convergence encourages market entry is, in its essence, an empirical question.

The main focus of this paper, however, has been on a different area of public policy interest: market convergence as a mechanism that encourages joint dominance. In particular, the paper has presented a framework in which the risk of collusion between symmetric rivals in a converging market is higher, the lower the level of substitutability observed between market products. To illustrate the relevance of this result for competition policies in Latin America, consider the evolution of the process of convergence between the provision of fixed and mobile voice services in the region. As mentioned in the introductory section, fixed-mobile convergence is taking the form of converged devices that allow seamless switching between mobile and local networks for mobile users. It is also likely that the initial provision of these converged services will be dominated by the current major operators of voice communications services—both fixed and mobile—in the region. This would imply that the risk of collusive behavior between the providers of these newly converged services is the highest in cases where the pre-convergence market structure associated with the converging markets is not very competitive.

This argument is particularly relevant for the case of Latin American jurisdictions, because the market structure in the fixed segment of the market in the region has historically been highly concentrated and the mobile segment has been experiencing a strong process of regional consolidation during the last years. Indeed, the regional mobile market is currently dominated by only two firms, *Telefónica* and *Telmex/América Móvil*, which have operations in 26 countries of the region and together have 64 per cent of the regional mobile market.³⁸ It is precisely in this context of high pre-convergence concentration in the fixed and mobile segments of the market that the analytical framework discussed in this paper takes regional relevance, since the results suggest that there will be a risk of

³⁸ It is also worth noting that, since entry into the mobile market is restricted by the availability of spectrum, the industry is inherently oligopolistic.

collusion between these dominant operators before these converged services are finally commoditized in the marketplace. The enforcers of anti-collusive policies in the region should then pay special attention to the evolution of recently created markets in industries characterized by high pre-convergence concentration, since there is a risk that anti-competitive agreements will be taking place in those markets.

An additional implication of the model discussed in this paper is that, because collusive behavior is more likely to occur during the initial stages of convergence, widespread uncertainty on whether markets are converging can play in favor of the enforcement of anti-collusive policies. To see this, assume that a firm operating in the initial stages of a convergent market is unsure whether technological change will threaten its market position in future periods. Provided that the likelihood of cartel detection is relatively high, this firm will underestimate the benefits of colluding now since the amount of forgone profits in future periods gets (arbitrarily) smaller. Therefore, uncertainty would lead to a scenario in which, regardless of the fact that structural conditions are given for cartel stability, firms may not collude.

A final implication of the analysis for competition policy in the region is related to innovation. When innovation is markedly asymmetric across firms in a way that a pattern of market dominance can be identified (eg, a firm is in the position to dictate the evolution of the market), competition authorities should be less concerned with the presence of coordinated effects, since the risks of having collusive agreements between the concurring firms is relatively low. This argument has a strong Schumpeterian flavor because, when innovation is markedly asymmetric, strong patterns of market dominance can be identified and this diminishes the chances of successful collusive behavior. Hence, when innovation is asymmetric, a higher rate of innovation is associated with lower chances of successful collusion. In contrast, when innovation is more symmetric in nature, as discussed in this chapter, a higher rate of innovation is associated with higher chances of successful collusion. It is therefore of paramount importance for competition authorities in the region to incorporate into their collusion-related assessments factors that describe the degree of innovation asymmetries observed across firms, since this can provide invaluable information during the process of determining whether collusion is taking place in markets that converge.