Yardstick competition, privatization and company restructuring

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RESUMO

Um dos mecanismos mais importantes para amenizar o problema de assimetria de informação do regulador é o uso de "yardstick competition" Seu uso tem implicações para a divisão ótima de companhias estatais antes da privatização. Estendemos para n empresas o esquema introduzido por Armstrong, Cowan e Vickers (1994) para duas empresas. Os autores mostram que, em comparação com uma situação de monopólio, o bem-estar aumenta quando se separa a companhia em duas áreas, com dois diferentes proprietários. Estendemos esse resultado e mostramos que a combinação de ganhos de informação do regulador com a diminuição na incerteza, quando a covariância constante de custos entre áreas é positiva, resulta em ganhos em se separar horizontalmente as companhias antes da privatização. A introdução de economias de escala torna os resultados ambíguos.

Palavras-chave: yardstick competition, privatização de empresas, divisão de empresas.

ABSTRACT

One of the important devices to smooth the information asymmetry problem of the regulator is using "yardstick competition" The use of this mechanism has implications on the optimal division of a state-owned company before its privatization. We extend the framework introduced by Armstrong, Cowan and Vickers (1994) from 2 companies to n. The authors show that welfare increases when separating the company in two areas with two different owners compared to a monopoly. We extend this result and show that the combination of the regulators information gains and a decrease on uncertainty when a constant covariance of costs across areas is positive, results in gains from separating horizontally the companies before privatization. The introduction of scale economies turn the results ambiguous.

Key words: yardstick competition, state company privatization, firm division.

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I Introduction

One relevant issue in the privatization of sectors such as telecommunications, electric power and railroads is what should have been the best approach concerning the horizontal separation or division of the state-owned company in regional grounds[1] for the sake of fostering competition after sale.

The problem is that if the old monopolist state-owned firm is not divisible in smaller units that compete in the same geographical area, no horizontal division would reduce the pre-existing local market power of the companies after privatization. This is the case of telecommunications as stressed by Vickers and Yarrow (1991, p. 237) for the UK experience in the privatization of British Telecom (BT):

> "*if a dominant firm is divided into component parts, there may be scope for competition between those parts. In BT's case, however, the scope for competition between the parts is limited. For example, local network A would not compete with local network B head-on in the product market because each would enjoy a natural monopoly in its locality at the present state of the technology.*"[2]

However, it is still possible to foster an indirect way of competition when restructuring state-owned companies, mainly in infrastructure sectors with characteristics of natural regional monopolies in some segments: yardstick competition. In this regard, Armstrong, Cowan and Vickers (1993, p. 75) stress that

> "*yardstick competition is a way of regulating several regional monopolies so as to induce a form of competition via the regulatory mechanism that weakens individual firms monopolies of information, and hence improves the terms of tradeoff between allocative, productive, and distributional efficiency. This is done by making the reward to one firm depend on its performance relative to that of other firms.*"

1 While by "vertical separation" we mean separation between, for instance, local service and access from long distance service in telecommunications, "horizontal separation" implies spliting the local services of a company in their respective areas.

2 This natural limitation on local network competition was also stressed by Armstrong (1998,p. 135): "*...no matter how many competing networks there are....the local network operation sector has the peculiar feature that increasing the number of competing firms does not overcome all monopoly problems.*"

These authors stress that this dimension of the problem was completely neglected in the privatization of BT in the UK. On the other hand, this was not neglected in the process of restructuring before privatization in other reforming countries.

In Brazil, the Government split TELEBRAS[3] in three regional companies before privatization. As stated in the Brazilian Guidelines for the Telecom Reform of 1997, this strategy was also based on the fact that *"the very existence of several companies would make the job of the regulatory body easier since several companies mean lower monopoly power and higher likelihood of comparative competition among the operators."* Also in Argentina, as Abdala and Hill (1996) observe, the division of Entel, the Argentina telecommunications state-owned company, before its privatization was also due to the explicit concern of the Argentina government to foster yardstick competition. Even in the antitrust suit against AT&T in the US decided in 1982, where the main concern was the vertical break-up of the company, there was a preference of the Court for AT&T to split the Baby-Bells in at least more than one company to smooth the problem of information asymmetry from the regulator. Finally, more recently, competition policy in the UK considered the usefulness of yardstick competition. As noted by Newbery (2000, p. 163), the Merger and Monopolies Commission in the UK

> *"has so far rejected several mergers because the value of the information that would be lost with the merger was thought to be higher than the efficiency gains from merging, indicating the value of such benchmark models."*

The purpose of this article is to address what would be the relevance of separating horizontally a state-owned company in **more** than **two** regional companies as was the case of Brazil, Argentina and US instead of two, for the sake of implementing the most efficient yardstick competition. From a theoretical point of view it is important, since most of the models using yardstick competition compare simply a monopoly with a duopoly. We basically extend a model proposed by Armstrong, Cowan and Vickers (1994) from *2* to n regional monopolies after the process of company restructuring before privatization. We will see that the standard conclusions of the yardstick competition (or, more generally, relative performance) analysis still holds in the particular setting of ACV, when we increase the number of regulated firms to be compared under suitable hypothesis. But we will see that there is not only the greater ability of the regulator to compare companies that matter for the extended result. There is a further point represented by the increase in

3 The Brazilian state-owned holding responsible for over 90% of telecommunications services in Brazil before privatization in 1998.

the uncertainty of the fully integrated company that grows with the number of areas due to the positive correlation among areas. The combination of regulators information gains and the decrease on the "uncertainty effect" always results in welfare gains from separating horizontally the companies before privatization.

In the next section, we proceed to a brief review of the economic literature on yardstick competition. Section III presents the basic extension of the ACV model, with some variants. Section IV show how to change the model to incorporate scale economies and its relevance for the BMTR. Section V realises some empirical exercises with Brazilian telecommunications real data, illustrating how the model works. Section VI concludes.

II Yardstick competition: a theoretical review

Yardstick competition appears in the economic literature with the general problem of a principal aiming to provide the adequate incentives to solve a multi-agent moral hazard problem. The principal would base the rewards to the agent on relative performance and not only on individual performance. The principal monitors one agent using the performance of other agents as signals of the value of the agent's private information. In a regulation context, the regulator is the principal and the regulated firm(s) is the agent(s). The main appeal of the use of other agents' signals to build a relative performance incentive mechanism is to smooth the problem of high rents and/or sub-optimal effort level that can result in a second best equilibrium with a single agent with unobservable effort and/or unobservable type.[4] Baiman and Demski (1980) wrote the first paper on how relative performance mechanisms could help on the solution of multi-agent/principal problems in the economic theory.

Holmstrom (1982) went further and showed, in a very general context of multiple agents, that the optimal reward rule for one agent may only depend on his individual performance if and only if outputs are independent. It means that the optimal mechanism design may always involve some kind of comparative performance if there is at least some correlation between outputs. At the same time, the author reaches an important result for our purposes (p. 337-338): The principal can get arbitrarily closer to the first-best perfect information solution when the number of agents increases.

4 See the basic model of principal-agent in Mas-Collel,Whinston and Green (1995, chapter 14.B). The authors show that the simple presence of moral hazard (on effort) does not imply the need for positive rents or sub-optimal effort if the agent is risk neutral. But if the agent is risk-averse, the existence of more than one effort level implies positive rents (above the participation constraint) to the agent.

Nalebuff and Stiglitz (1983) shows, in the restricted context of relative performance based on a contest mechanism with risk neutral agents, that more than a simple smoothing of the informational problem, the principal can even achieve a first-best optimum through an appropriate designed contest.[5] An important finding of the authors (p. 32), also related with Holmstrom's paper, is that increasing the number of players to be compared expand the amount of information to the regulator and improve the scope for designing relative performance schemes.

Demski and Sappington (1984) show a more general mechanism design involving rewards based on relative performance where the principal is able, through the adequate incentive reward design, to achieve the full information efficient solution. The main hypothesis behind this result is risk neutrality and the existence of at least a small amount of cost correlation. The authors did not check the impacts of increasing the number of agents, since there was no need for further agents beyond two.

Other multi-agent models like Auriol and Laffont (1992) and Dana (1993), for instance, also built relative performance models where the benefits of yardstick competition to the principal trades-off other variables, making the final result ambiguous. Particularly interesting is the model of Auriol and Laffont.[6] The trade-off is between the sampling effect (a higher probability of drawing a high marginal cost for the industry) and yardstick competition on one side calling for duopoly, and the need to avoid wasteful duplication, calling for a monopoly. When the fixed cost required is high enough, the scale effect offsets the yardstick and sampling effects and a monopoly is a better structure than a duopoly, even considering the possibility of smoothing information for the regulator through the duopoly.

The first paper that introduced more directly the use of relative performance or "yardstick competition" in the regulation theory was by Shleifer (1985). The author builds a very simple reward mechanism where, under certain conditions, the unique Nash equilibrium of the two regulated firms game is the command optimum of the regulator.

The main purpose of Shleifer was to criticise the generalised use of cost of service regulation at that time as a low-powered incentive scheme. However, the usefulness of yardstick competition goes beyond the simple replacement of a low-powered incentive

5 Note that in a contest, the reward is purely based on the ordinal positions or the rank of the players and not in the magnitude of the relative performance.

6 We focus on the cases described by the authors where the regulator decides the market structure before the agents know their types. This case is closer to the BMTR since the regulator decided the market structure before the new owners have full knowledge about the privatised firms productivity.

scheme. As stated by Laffont and Tirole (1993, p. 71), a high-powered incentive scheme is not always desirable, since the regulator has two targets: Improve efficiency and extract rents. High-powered incentive mechanisms do not always care about the second. Yardstick competition is a mechanism that cares about both targets as shown by the authors (p. 84-86). Moreover, if the costs are perfectly correlated in their model, the maximum high-powered scheme of a fixed-price contract, based on relative cost performance of two firms, achieves the first best perfect information result. Furthermore, when the costs are not perfectly correlated, the regulator can implement an optimal contract that would attain the same result as if the regulator could observe the correlated information.

More recently, Sobel (1999) and Dalen (1998) raised the impact of yardstick competition on investment incentives. The first author stress the basic trade-off: more information to the regulator improves the efficiency of ex-post regulation while ex-ante this also makes the firm less willing to invest, supposing that it is costly to make transfer from consumers to firms.[7] This emerges in a context where the regulator has limited commitment ability to safeguard the returns on further investment and this reduces the value of additional information brought by yardstick competition to the regulator. On the other hand, Dalen (1998) shows why this proposition from Sobel is not so general. Everything depends on which type of investment is being considered. If the investment is "industry-specific", the investment undertaken by a firm affects the technology available to all other companies in the industry. This means that, under yardstick competition regulation, most of the gains from investing will not be appropriated by investors, since relative positions do not change, which undermines the incentive to invest. But if the investments are "firm specific" with no spill-overs throughout the rest of the industry, the incentive to invest is even enhanced with yardstick competition regulation than without. This occurs because as "*yardstick competition enables the regulator to filter uncertainty caused by common technology shocks*", this "*makes the incentive scheme more high-powered, and this, in turn, increases the firm's value of having private information about the remaining firm-specific part of the technology.*"

Armstrong, Cowan and Vickers (ACV, 1994, p. 74-77) propose a model of price regulation based on yardstick competition. ACV (p. 64-66) introduce a model of price regulation of one firm with two products with a positive cost correlation. Given that the firm faces a greater degree of aggregate uncertainty with cost correlation, it must receive a greater degree of insurance as an incentive device from the regulator to operate in the

7 Otherwise, the regulator would always wish to build the most high-powered incentive scheme (see chap. 8) favouring cost decreases and thus no trade-off remains.

market (fulfil the "participation constraint") implying higher prices. Optimum prices are higher the greater is the cost correlation parameter.

Separating the firm in two and designing a suitable price mechanism based on yardstick competition inverts this relationship: Prices decrease when the cost correlation increases. Furthermore, making a plausible assumption (see the model below) about the behaviour of the individual participation constraint when separation occurs, we can conclude either that prices decrease when both separation and yardstick competition are introduced for **any** positive value of the correlation between costs.[8]

A necessary condition for yardstick competition to work well is that the regulator be able to compare firms for which private information is highly correlated. Based on their model, ACV (1993, p. 77) state that:

> "*when there are several regional monopolies with private information that is correlated, the effectiveness of regulation is improved by the use of yardstick competition rather than by regulating each firm independently... The reason for this is that being able to observe a second firm's cost realisation improves the precision with which the regulator can infer the effort level of a given firm from its own cost realisation.*"

Proceeding to a welfare analysis, the authors raise the question of regional separation with some important conclusions:

> "*A natural question in this context is whether a given integrated firm should be broken up regionally in order to reduce the firm's monopoly of information and to take advantage of yardstick competition ...* "

And they found that:

> "*...welfare under integration is decreasing in the correlation "r" and...welfare with regional separation is increasing with "r" Therefore a greater degree of correlation in the firms environments will, all else being equal, make regional separation relatively more desirable.*"

In the case of Brazil, for instance, horizontal separation involved three very large and different regions in terms of geographical characteristics, distances (supply conditions), population density, income (demand conditions) and so on. If supply and demand condi-

8 Notice that the authors did not make this last conclusion.

tions in these regions are very different, the problem related to the information asymmetry between the regulator and the firms may not be much reduced.[9] Laffont and Tirole (2000, p. 52) point out that this differentiation of conditions of operation among companies is the most relevant problem that ensues on the reduced use of yardstick competition in real world. However, they state that the role of informal benchmarking should not be underestimated:

> "... *explicit contractual benchmarking is rare in regulation because of alleged heterogeneities* ... "
>
> "*Benchmarking often plays a more informal role through improvement of regulators and the public's information derived from observing similar situations elsewhere. Benchmarking leads to higher-powered incentive scheme by decreasing the need to rely on regulator's beliefs about the firm's efficiency.*"

In this regard, note that regulation based on yardstick competition can be based on second-order variables, concentrating on the common trends of cost and demand conditions and not on the current "levels" (a first-order variable). In this case, the regulation through yardstick competition would not require similar supply and demand conditions among the regions, but only common trends in the shocks affecting them.[10]

At a first glance, it is intuitive that the possibility of regulating through yardstick competition is enhanced, the higher the number of firms. This was an important conclusion derived in the papers from Holmstrom (1982) and Nalebuff and Stiglitz (1983).

As we will see, the combination of risk aversion and yardstick competition as proceeded by ACV, make separation of the companies beyond 2 always welfare enhancing, under suitable hypothesis.

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9 Laffont and Tirole (2000, p. 52) point out that this differentiation of conditions of operation among companies is the most relevant problem that results in the reduced use of yardstick competition in real world. On the other hand, the authors state that the role of informal benchmarking should not be underestimated. Laffont and Tirole (1993, p. 86) are quite optimistic about the increasing use of yardstick competition, despite the few examples. Yardstick competition was a relevant consideration in the assessment of the merger between the two baby bells, Bell-Atlantic and Nynex, in the US as shown by Brenner (1999, p. 139-140), but the Federal Communications Commission FCC - concluded that reducing the number of Bell companies from six to five would not bring a substantial effect.

10 Laffont and Tirole (1993, p. 86) are quite optimistic about the increasing use of yardstick competition in the regulatory provisions in the real world, mainly in the water and electricity distribution sectors, despite the few examples found in that time by the authors.

III The ACV model extended

Suppose that demand in all areas is completely inelastic and always equal to one as supposed by ACV. Assume that the regulatory authority regulates the total revenue P of all areas based on a fixed amount A and on the marginal costs of the company in each of the "n" areas (or the 27 states of Brazil in the case of TELEBRAS). Total revenue in all areas is:

$$P(A,\rho,c_1,c_2...c_n) = A + (1-\rho)\sum_{i=1}^{n} c_i \tag{1}$$

where ρ is a parameter that determines the sensitivity of price to costs in the regulator's rule. Notice that (1) is a generalization of equation (3.12) from ACV (1993, p. 65). We start with the full integration result (no horizontal separation). Each one of the n areas can present a different value of the respective total cost c_i.[11] All these n values are ex-post observable by the regulator, which knows that they have the following general formula:

$$c_i = \theta_i - e_i \tag{2}$$

being all the values of θ_i in each area, private information to the firm, and e_i, the effort level of the firm in the area i, both not observable by the regulator.[12] In other words, this is a moral hazard model (non-observation of e_i) as in the standard models of regulatory information asymmetry of Laffont and Tirole (1993). The firm effort decision, e_i is taken before the realisation of θ_i and brings a disutility to the firm described by the function $\Psi(e_i) = e_i^2/2$.

However, we assume strong symmetry across areas in the sense that the mean and the variance of the parameter related to private information about the total cost are the same in all areas i. The regulator knows the main characteristics of the distribution function of θ_i: its mean, $E(\theta_i) = \mu$ and variance $Var(\theta_i) = \sigma^2$ Furthermore, we assume that the covariance among all θ_i is lower, but proportional to the variance value, being for all $i \neq j$, $Cov(\theta_i, \theta_j) = r\sigma^2$ with $0 \leq r \leq 1$.

The firm is risk averse with the utility function depending on the expectation (positively) and variance (negatively) of the profits Π as depicted in the following formula:

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11 This is the main difference with ACV who suppose that c_i is the marginal instead of total cost. We think that this formulation is more appropriate.

12 The regulator observes the sum of both variables, c_i, but is unable to disentangle them.

$$U = E(\Pi) - \frac{\gamma}{2} * Var(\Pi) \tag{3}$$

Now, we disentangle these terms, based on the variables already presented.[13]

$$U = A - \rho\sum_{i=1}^{n}(\mu - e_i) - \sum\frac{e^2{}_i}{2} - \frac{\rho^2\sigma^2\gamma}{2}[n + n(n-1)r] \tag{4}$$

Taking the derivative of U in respect to each e_i and equating to zero, we find the general formula for the optimum level of effort chosen by the firms e_i*, given the rule (1) imposed by the regulator:

$$\frac{\partial U}{\partial e_i} = \rho - \frac{2e_i}{2} = 0 \qquad e_i^* = \rho \tag{5}$$

Assuming that the regulator wishes the regulated firm not to shut down, he/she will choose A such that U is higher than or equal to the reservation profit level π_0 of the regulated company. Given that rents are costly[14], the regulator chooses the optimum level of the fixed payment A*, setting $U{=}\pi_0$.[15] In other words, the participation constraint must be binding. Using (4) and (5), we write the participation constraint.

$$A^* - \rho\sum_{i=1}^{n}(\mu - \rho\ ) - \sum_{i=1}^{n}\frac{\rho^2}{2} - \frac{\rho^2\sigma^2\gamma}{2}[n + n(n-1)r] = \pi_0$$
$$A^* = \pi_0 + n\rho(\mu - \rho) + \frac{n\rho^2}{2} + \frac{\rho^2\sigma^2\gamma}{2}[n + n(n-1)r] \tag{6}$$

The regulator must settle the optimal value of ρ as well. As he wishes to minimise the payment, the regulator uses (5) and (6) in (1), minimising in respect to ρ:

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13 See Appendix 1.

14 Someone can easily wonder why firms rents are costly for regulators. Laffont and Tirole (2000, p. 51) presents three foundations for this assumption: i) the firms have lower weight than the other agents in the social utility function; ii) the weigh of the regulated firm is the same from the other agents, but transfers to the firm must be financed through distortionary taxation; iii) when the firm is subject to budget balance, the firm's rent is financed through mark-ups on the firm's services that distort consumer's consumption.

15 Remind that U is defined in expected values.

$$E[P(A^*,c_1,c_2...c_n)] = A^* + (1-\rho)\sum_{i=1}^{n}(\theta_i - \rho) =$$
$$E(P) = \pi_0 + n(\mu-\rho) + \frac{n\rho^2}{2} + \frac{\rho^2\sigma^2\gamma}{2}[n+n(n-1)r] \tag{7}$$

$$\frac{\partial EP}{\partial \rho} = n\rho + \gamma\rho\sigma^2[n+n(n-1)r] - n = 0$$
$$\rho^* = \frac{n}{n+\sigma^2\gamma(n+n(n-1)r)} = \frac{1}{1+\sigma^2\gamma(1+r(n-1)} \tag{8}$$

Replacing the optimum value of ρ^* of (8) in (7), and after some manipulations, we reach the expected total revenue in the situation with full integration across *n* areas, L_{int}:

$$L_{\text{int}} = \pi_0 + n\mu - \frac{n}{2[1+\sigma^2\gamma(1+(n-1)r)]} \tag{9}$$

The reader can check that (9) is a generalisation of (3.14) from ACV (1993, p. 65) built for the particular case of *n=2*. We will compare this result with the situation without integration. To do so, we also generalise the revenue regulation equation (3.21) from ACV (1994, p. 75):

$$P_i(A,c_1,c_2,...c_n) = A + (1-\rho)c_i + k\rho(\sum_{j\neq i} c_j) \tag{1'}$$

Now, since each area is owned by a different agent, instead of total revenue in all areas, the regulator has to regulate revenue per area P_i. Note that the parameter ρ measures the power of the incentive scheme regarding yardstick competition. Indeed, ρ multiplies negatively the term c_i and positively the other *n-1* terms c_j. The higher ρ, the larger the positive impact of the other companies costs in the price of the firm in area *i* and the larger the negative impact of company's *i* cost in its own price.

Since (2) and (3) are also valid for this case, we derive the values of $E(\Pi)$ and $Var(\Pi)$, using the same reasoning from the derivations of the Appendix 1 in Appendix 2, we get

$$Ui = A + (1-\rho)(\mu-e_i) + k\rho(\sum_{j\neq i}^{n}(\mu-e_j)) - (\mu-e_i) - \frac{e_i^2}{2} - \frac{\gamma\rho^2\sigma^2}{2}[1+kr(n-1)+k^2(n-1)(1+r(n-2))]$$

$$\frac{\partial Ui}{\partial e_i} = -(1-\rho) + 1 - e_i = 0$$

$$e_i^* = \rho \tag{5'}$$

Note that (5') is exactly equal to (5). The optimal level of effort in any area equals the value of the parameter ρ chosen by the regulator. The analogous of the binding participation constraint of equation (6) is derived in the same way here, in Appendix 2, replacing π_o by π_1.

$$A^* = \pi_1 + \rho(\mu-\rho) - \rho k(n-1)(\mu-\rho) + \frac{\rho^2}{2} + \frac{\rho^2\sigma^2\gamma}{2}[1-2kr(n-1)+k^2(n-1)(1+r(n-2))] \tag{6'}$$

The regulator minimises the expected revenue per area, choosing the optimal values of ρ^* and k^*, taking the proper derivatives.

$$E(P_i) = \pi_1 + \frac{\rho^2}{2} + \frac{\gamma\rho^2\sigma^2}{2}[1-2kr(n-1)+k^2(n-1)(1+r(n-2))] + \mu - \rho$$

$$\frac{\partial E(P_i)}{\partial \rho} = \rho + \sigma^2\rho\gamma[1-2kr(n-1)+k^2(n-1)(1+r(n-2))] - 1 = 0 \tag{8'}$$

$$\rho^{**} = \frac{1}{1+\sigma^2\gamma[1-2kr(n-1)+k^2(n-1)(1+r(n-2))]}$$

$$\frac{\partial E(P_i)}{\partial k} = \frac{\rho^2\sigma^2\gamma}{2}[-2(n-1)r + 2k(n-1)(1+r(n-2))] = 0$$

$$2r(n-1) = 2k(n-1)(1+r(n-2)) \tag{10}$$

$$k^* = \frac{r}{1+r(n-2)}$$

Substituting (6'), (8') and (10) in (1') and taking the expectancy, we reach the expected revenue per firm:

$$L_{i\,non-\text{int}(n)} = \pi_1 + \mu - \frac{1}{2\{1+\sigma^2\gamma[1-\frac{r^2(n-1)}{1+r(n-2)}]\}}$$

We can assume that the regulated firm minimum level of profit satisfying its participation constraint is proportional to the size of the operating area. If the area encompasses the whole country, the minimum profit is π_o and if the area encompasses only $1/n$ of the country area, the minimum required profit is $\pi_1 = \pi o/n$. Therefore, the sum of expected revenues in all areas is simply the expression above multiplied by n, giving:

$$L_{non-\text{int}(n)} = \pi_0 + \mu n - \frac{n}{2\{1+\sigma^2\gamma[1-\frac{r^2(n-1)}{1+r(n-2)}]\}} \qquad (11)$$

The difference of welfare between horizontal separation and integration is measured by the difference of total expected revenues (or the inverse of total rent extraction) that are required to the regulated companies in the cases of full-integration (9) and non-integration (11). Thus, we get our first theorem:

Theorem 1: Assuming "n" areas of operation of a completely inelastic service with total cost given by (2), the distribution function of the θ_{is} with constant mean, variance and a positive constant covariance among them, the disutility of the effort to the firm given by the formula $\Psi(e_i) = e_i^2/2$, the utility function of the firm given by (3), the total revenue of an horizontal integrated operator in those "n" areas given by (1), the sum of revenues of "n" non-integrated operators given by (1´), and the choice variable of the firm being "e_i" and the choice variables of the regulator being the parameters "A", "ρ" and "k" in (1) and (1´), we have that, in equilibrium, welfare is always greater under non-integration than under full integration.

Proof: Note that both expressions (9 and 11) only differ in the last term of the denominator. Thus, we have $L_{int} \geq L_{non\text{-}int}$ if:

$$r(n-1) \geq \frac{-r^2(n-1)}{1+r(n-2)}$$

$$\rightarrow$$

$$1 \geq -r(2n-3) \qquad (12)$$

Note that a sufficient condition for the inequality to hold true, when there is a a positive constant covariance $0 \leq r \leq 1$, is that $n \geq 1$, which always holds true in this problem.

Thus, social welfare separating *n* areas is always higher than with full integration for any *n*, which is a generalisation of the basic model of ACV with two goods (areas).

It is important to remark that the results of the basic ACV model and the extension depend not only on the gain of information of the regulator when he is more able to regulate based on yardstick competition. The result also depends on the risk aversion of the firm. The effect of introducing risk aversion is that the agents will require relatively more compensation if he/she owns more areas. This happens because the increase in the uncertainty increases more than proportionate to the number of areas due to the positive correlation among areas, summarised by $r\sigma^2$ The combination of the gains in information by the regulator (the "yardstick competition effect") and the decrease on uncertainty (the "uncertainty effect")[16] obtained with horizontal separation results in gains on separating horizontally the companies.

An interesting theoretical departure from the basic ACV model is to suppose $-1 \leq r < 0$. In this case, the covariance between the θ_{is} remains constant, but negative. Note that the regulator, as before, continues extracting more information from companies when horizontal separation occurs. However, the uncertainty effect, contrarily to the conventional hypothesis of positive correlation, typical of an analysis on yardstick competition, goes the other way. When correlation is negative, horizontal integration across geographical areas diversify instead of amplify the company risk. This reduces the required compensation when horizontal integration occurs and can compensate the loss of information of the regulator in this process.

Looking at (12), we see that the "uncertainty effect" starts to more than compensate the "yardstick competition effect" from some n high enough, such that the inequality does not hold anymore. Indeed, when $r =$ 1, (12) holds with equality for $n=2$ and does not hold anymore from $n=3$ on. When $-1<r<0$, there will always be some $n \geq 3$, such that (12) does not hold anymore, which means that more horizontal integration before privatization is desirable. Therefore, we can present the following theorem:

Theorem 2: Assuming the same hypothesis of theorem 1, except for that the covariance among the θ_{is} is negative, we always find a value of "n" high enough from which, in equilibrium, welfare is always greater under full integration than under non-integration.

Proof: It is straightforward from the proof of theorem 1 in equation (12), just making $1<r<0$.

While negative correlation does not seem a suitable hypothesis for telecommunications, this could hold for sectors such as hydropower generation, which cost, in the short run, can depend on the rain season in each area of the country. For a sufficient large

16 This effect was not observed by ACV which implies that the authors overestimate the "yardstick competition effect"

country like Brazil, there may be enough variation of weather along the year across regions to turn this hypothesis a relevant one.

Notice that we are comparing the results of integration versus non-integration for a given number of areas, n. Now, we address the impact of increasing horizontal separation from n to $n+1$ companies, which configures a more general result. For this purpose we have to make some adjustments. First, the mean of the total cost parameter θ_i reduces, since an increase in the number of areas in the same territory reduces the mean total cost per area in the exact amount to keep the mean total cost constant. In other words, there would be no sense to increase the sum of total cost parameters θ_i in a given territory just because it was split in $n+1$ rather than n areas. As the mean of total cost in n areas is given by $n\mu$, the mean of total cost in all areas has to remain at $n\mu$. So, when changing from n to $n+1$ areas, we have to replace the mean of total cost per area μ by x $\left\{(n+1)x = n\mu \Rightarrow x = \frac{n\mu}{n+1}\right\}$

At the same token, the variance and covariance of θ_i for the case of n+1 areas will be given by:

$$Var(\theta_i)_{n+1} = \frac{n^2}{(n+1)^2}\sigma^2$$

$$Cov(\theta_{i,}\theta_j)_{n+1} = r\frac{n^2}{(n+1)^2}\sigma^2$$

Proceeding to the same steps we made before, the reader can easily check that:

$$\rho^{***} = \frac{1}{1+\sigma^2\gamma\frac{n^2}{(n+1)^2}[1-2kr(n-1)+k^2(n-1)(1+r(n-2))]} \qquad (8'')$$

$$k^{**} = k^* = \frac{r}{1+r(n-2)} \qquad (10')$$

The value of the total revenue in a given area will be given by

$$L_{i(non-\text{int})(n+1)} = \pi_2 + \frac{\mu n}{n+1} - \frac{1}{2[1+\sigma^2\gamma(\frac{n^2}{(n+1)^2})(1-\frac{r^2(n-1)}{1+r(n-2)})]}$$

Using tne same rationale from before, we suppose that the new participation constraint (π_2) shrinks n the same proportion of the area and then $\pi_2 = \frac{\pi_o}{n+1}$. At the same time, to get the total expected revenue across all *(n+1)* areas, we multiply the previous equation by *(n+1)*:

$$L_{(non-\text{int})(n+1)} = \pi_0 + n\mu - \frac{(n+1)}{2[1+\sigma^2\gamma(\frac{n^2}{(n+1)^2})(1-\frac{r^2(n-1)}{1+r(n-2)})]} \qquad (11')$$

Theorem 3: Assuming the same hypothesis made in theorem 1 and that the utility level that defines the participation constraint shrinks in the same proportion of the operated area in the sense that $\pi_2=\pi_0/(n+1)$, we have that, in equilibrium, welfare always increase with a deeper fragmentation of the industry.

Proof: The difference between (11') and (11) is given by:

$$\frac{1+[n(1-\frac{n^2}{(n+1)^2})+1]*[\sigma^2\gamma(1-\frac{r^2(n-1)}{1+r(n-2)})]}{2[1+\sigma^2\gamma(\frac{n^2}{(n+1)^2})(1-\frac{r^2(n-1)}{1+r(n-2)})]*[1+\sigma^2\gamma((1-\frac{r^2(n-1)}{1+r(n-2)})]} \qquad (13)$$

The expression (13) is always greater than zero since $0<\frac{n^2}{(n+1)^2}<1$ *and* $0\leq\frac{r^2(n-1)}{1+r(n-2)}\leq 1$

This means that the expected revenue by separating *n* companies is greater than by separating *n+1* companies. The deeper the horizontal segmentation, the larger the welfare in this model. Thus, the sum of the gains from improving the capacity of the regulator to regulate through yardstick competition plus the decrease on uncertainty from owning smaller areas in this model implies an always increasing level of welfare due to horizontal separation.

IV Introducing scale economies in the model

We can easily introduce scale conomies in this model and obtain trade-offs from these variables with yardstick competition, deriving the optimal number of companies to be split. We can suppose that as the number of operating firms n (and also the number of areas to be compared from n to $n+1$) increase, the total cost does not decrease in the exact proportion to $n/(n+1)$. Now, to account for scale economies, we establish that the mean value of the total cost is not anymore $(n\mu/(n+1))$, but $(n\mu\delta(n)/(n+1))$ such that:

$$\delta(n) - \delta(n+1) \geq 0 \quad \text{for all } n \tag{14}$$

The expression of the difference between n and $n+1$ from (13) must be added with:

$$n\mu(\delta(n+1) - \delta(n)) \tag{15}$$

Given the hypothesis in (14), the expression (15) is always negative. This means that the difference on the total payment between n and $n+1$ firms with yardstick competition will be given by

$$n\mu(\delta(n+1)-\delta(n)) + \frac{1+[n(1-\frac{n^2}{(n+1)^2})+1]*[\sigma^2\gamma(1-\frac{r^2(n-1)}{1+r(n-2)})]}{2[1+\sigma^2\gamma(\frac{n^2}{(n+1)^2})(1-\frac{r^2(n-1)}{1+r(n-2)})]*[1+\sigma^2\gamma((1-\frac{r^2(n-1)}{1+r(n-2)})]} \tag{16}$$

We cannot guarantee that (16) is positive for all n. If the scale effect represented by the magnitude of total cost times the differential of δ is high enough compared to the gain of information to regulator from yardstick competition and the decrease on the risk factor stressed above, then (16).

Given (14), we know that the first term from (16) always increase in absolute terms with n. The evolution of the last term when n increases is ambiguous and depends on the other variables. So, we cannot state *a priori* which effect ("scale economies", "yardstick competition" or "uncertainty" effects) dominates when fragmentation increases.

It is not possible to assure, through the model extension in (16), whether the second term increases or not with "n" and whether this offsets the first term. In other words, it is not possible to check whether the combined "uncertainty" and "yardstick competition effects" in (13) and in the second term of (16) present increasing or decreasing returns in the present setting.

It is intuitive that for large countries, the larger may be the gains from horizontal separation, at least for large areas, relatively to smaller countries like the UK.[17] In other words, scale economies may present decreasing returns and it is worthwhile to add a few comments about that.

In the past, scale and scope economies based the "natural monopoly" argument that justified a single firm supplying all telecommunications services in a given area or country. The basic reason for the existence of scale economies in telecommunications is the high proportion of fixed to variable costs. Scale economies are particularly strong at the local fixed network operation.[18]

17 The inclusion of heterogeneity in the problem can be an insightful extension in this model. Indeed, the three regions of the BMTR present very different characteristics among themselves. The problem is that, accounting for heterogeneity, the value of r is not the same between all pairs of regions. In this case, the simplification assuming a single r, does not hold anymore. The way in which companies are separated may matter for welfare since when splitting states with similar conditions in Brazil, the gain of information of the regulator is higher compared to the case of separation of states with different (and non-comparable) conditions. Related to this issue, there is the optimal response of the regulator. She can design a smarter yardstick competition scheme allowing for different values of k in equation (1'), according to the (different) correlation among operators. The regulator can make k_{ij} as close as possible to zero when $cov(\theta_i, \theta_j)$ is closer to zero and the larger as possible when $cov(\theta_i, \theta_j)$ is closer to 1. In other words, the regulator will use yardstick competition in the price formula of each company weighting more the areas with higher reciprocal degree of covariance. This happens because comparing separate companies with low degree of covariance only increases the uncertainty without greater gains in terms of information to the regulator. Anyway, it is important to have in mind that, as Newbery (2000, p. 163) stress, while in water companies (and electricity in a lower degree) different local conditions ("hillier country, direr climate, porous soil, more agricultural residues, more urban streets," etc..) are crucial and bring enormous troubles for designing any yardstick competition scheme, telephone systems are much less sensitive to local conditions. Therefore, this problem of differentiated covariance among areas tends to be much less important in this sector, suggesting that the gains from yardstick competition can be greater than in others.

18 Armstrong (1998, p. 134-135) calls scale economies in telecom as "economies of density" and states that *"....the sector which has the most widespread natural monopoly cost conditions is local fixed network. This is largely because of economies of density, whereby it is cheaper per person to build a local network connecting, say, 5000 people in a given area than it is to connect 500. (The reason is partly because the cost of a local exchange can be spread over more local users, and partly because the greater use of remote concentrators and the like means that a lower proportion of the local network is made up of costly dedicated cabling and ducting).*"

The long distance service was the first one in telecommunications where the increasing returns hypothesis was broken up due to the technological change that reduced the requirements of fixed costs.[19] In the last twenty years, the natural monopoly argument in the local service has started to be challenged as well.

On the other hand, the fact is that scale and scope economies continue to be important issues in telecommunications, mainly regarding the kind of restructuring that transformed TELEBRAS before privatization. Indeed, in the current state of art of the telecommunications technologies, fixed costs are not as important as in the past and average costs may not be decreasing across all the TELEBRAS system. Therefore, this argument would not call always for a bigger size of the unit to be privatized,[20] but only over a more limited range of the system. Viscusi, Vernon and Harrington (VVH-1995, p. 487-488) show how the evolution of the long distance service telecommunications technology in the US implied a continuous fall of the fixed costs compared to variable costs, reducing the natural monopoly characteristics of the sector.

Turning back to the BMTR, we have that by the moment of the privatization, each of the 27 concessions owned by TELEBRAS in Brazil had their own long distance network inside each state with very few direct connections among each other. These inter-state connections were provided by EMBRATEL also owned by TELEBRAS. As EMBRATEL was privatized separately, the scale/scope economy gains from keeping together several concessions of different states would be positive only within the boundaries of each state where there was, in fact, several operating connections among different locations off the EMBRATEL national network. As there were no relevant direct links among the states, there were no relevant scale economies to be explored beyond their boundaries, without the EMBRATEL network links by the time of privatization. In other words,

19 Armstrong (1998, p. 135-136) states that the lack of natural monopoly conditions is currently prevalent in the long distance service: " *there are probably no other significant areas of natural monopoly in the industry. For instance, traffic on many trunk routes is heavy, and once economies of scale in providing capacity are exhausted, the extent of natural monopoly is likely to be limited in the trunk network. This is specially so if competing networks can easily obtain rights of way and can, for instance, lay fibre-optic cable along railway lines or electricity transmission lines. Thus, except for remote areas, there is no reason to expect major natural monopoly cost conditions in long distance operation network. ... Similarly, there is little evidence of natural monopoly in international network operation.*"

20 The implicit intuitive hypothesis that seems pervasive for most of the policy makers around the world is that "competitiveness" always justify leaving domestic competition aside. The national companies would always benefit from being "big" and eventual harm to local consumers would be curbed through the "globalisation process" Dutz and Khemani (1995, p. 28-29) present several arguments that shows why globalisation is not a perfect substitute for domestic competition. Furthermore, the authors (p. 20) challenge the myth of "competitiveness" as an argument against domestic competition, quoting an important part of the classical book of Porter (1990): "*Rivalry at home is not only uniquely important to fostering innovation but benefits national industry....In fact, creating a dominant domestic competitor rarely results in international competitive advantage. Firms that do not have to compete at home rarely succeed abroad. Economies of scale are best gained through selling globally, not through dominating the home market.*"

scale and scope economies could be obtained in the TELEBRAS system, apart of EMBRATEL connections, coming from the local network at the city/municipality level to the whole state. However, beyond the limits of a state, scale economies went virtually to zero. As stated by Dores (1999),

> *"Each holding of the wire telephone system ... before the privatisation operated on an independent way and had their own plants with different technologies, given that in the past the Brazilian government was not concerned with technology standardisation. Therefore, currently, in each holding, there are several technologies for the same kind of equipment, which means difficulties in respect of the operation and maintenance as well as in the scale for acquisition and interconnection of the state networks .The networks of each local concession were isolated from each other, since they were not allowed to supply long distance services, an exclusive attribute of Embratel."*

This is an aspect that reduces the force of the scale argument to justify an aggregation of TELEBRAS beyond the state level.

At this point, it is important to address the validity of the scale and scope arguments in telecommunications around the world. An early evidence is the survey of Fuss (1983) and its updating in Waverman (1989, p. 83-95), who concluded that

> *"the weight of the evidence of all these studies is simply not strong enough, since changing the level of aggregation, the functional form, the constraints imposed, or the objective function dramatically alters the results. The message is simply that the data available are insufficient to enable researchers to discriminate between alternative hypotheses ... My view is that the subadditivity test for aggregate AT&T data is so sensitive to data and to econometric technique that it cannot be relied on for making policy."*

Anyway, Waverman (p. 94) guess that given the huge size of AT&T, scale and scope economies between 1947-77 was unlikely. Fuss and Waverman (2002, p. 164-174)), once more, updated the balance of studies on the econometric evidence on scale economies in telecommunications and this kind of conclusion about them remains basically untouched.

The main message is that while there is a more robust evidence for relevant scale economies at the local level, this does not hold true for the long distance.[21] As we are stressing along this article, in the concrete case of the BMTR, not horizontal segmentation within the Brazilian States, but across them, we can be reasonably safe that the first term in (16) may not be relevant at all. This means that, even being a conventional argument to define the optimal company size in this sector, scale economies in the BMTR may only influence the result in (16) for areas lower than the state level. Therefore, for $n \leq 27$. Theorem 3, which disregards the impact of scale economies seems to be the most relevant result.

V Application of the model to the Brazilian telephone sector

It is interesting to illustrate the model dynamics through the concrete numbers of the Brazilian case. As every empirical exercise, we have to make some simplification to be able to infer about the impacts of the horizontal segmentation strategy in the BMTR.

First, we estimate the variance of total costs in the Brazilian telephone sector. To get an harmonized accounting measure of the companies total costs, we pick the data on sales and net profit of the three regional telephone companies in Brazil in 2002, from Revista Exame, July, 2003. The difference between these variables bring an estimate of the total costs f each company. We take the mean deviations and thus calculate the variance of total costs that reach **R$ 864.651,6 millions** as depicted in Appendix 3.

Another crucial parameter is the coefficient of risk aversion, γ. We use the estimation provided by Barreto (1997), quoted and used by Ellery and Bugarin (2003), on the substitution intertemporal elasticity of 0,7, which is inversely related to a coefficient of risk aversion of (1/0,7=)1,4.

Our interest is to address the difference of welfare between the situation with full-integration and horizontal separation for different values of "n" and the correlation coefficient "r" We make it for n=3, the actual segmentation proceeded in the BMTR, n=27. assuming that each state-based subsidiary of TELEBRAS would be privatized indepen-

21 Interestingly, the same debate about the existence of scale and scope economies in the wire sector is being done in the mobile sector. While Mckenzie and Small (1997) found that scale economies exist in the US mobile segment only until a small range of subscribers. Foreman and Beauvais (1999), criticising the small sample exercise performed by the former, found for the GTE mobile company, significant scale economies.

dently with full cross-ownership constraints among areas,[22] and n=10, an intermediate value between the previous two. We also assume six values for the correlation coefficient, 1; 0,5; 0; -0,5 and -1. The difference of results of welfare with horizontal separation (equation 11) and full integration (equation 9), crossing the different values assumed for "n" and "r" are presented in the three first columns (after the "r" column) of Table I.

Table I
Welfare Forgone with Full Integration: Comparison with Different Horizontal Separation Strategies

	n=3	n=10	n=27	Dif. N=10 and n=3	Dif. n=27 and n=3
r=-1	1,50000124	0,0000023234	0,0000057992	-1,4999989157	-1,4999954400
r=-0,5	0,0000000000	0,0000035404	0,0000080544	0,0000035404	0,0000080544
r=0	0,0000000000	0,0000000000	0,0000000000	0,0000000000	0,0000000000
r=0,5	0,0000012391	0,0000067590	0,0000207114	0,0000055198	0,0000194722
r=1	1,4999995870	4,9999995870	13,4999995870	3,5000000000	12,0000000000

Note that there are strong increasing returns of horizontal fragmentation when "r" increases from 0 to 1. When "r" is 0, there is no gain in horizontal separation and the difference of welfare is zero. When both, "r" and "n" increase, welfare increases with horizontal separation. Comparing to full integration, the Brazilian telephone sector would be losing a total of US$ 1,5 million a year, if the regulator had not proceeded to the actual horizontal separation with n=3.

On the other hand, the potential forgone benefit could be even greater, reaching US$ 13,5 millions, assuming that the company could be split in 27, one for each state a year. This also gives us the forgone benefit from not being more aggressive in fragmenting horizontally TELEBRAS by the time of its privatization, which can be seen in the last two columns of table I. The forgone benefit is very high for r=1, reaching **US$ 12 millions (US$ 3,5 millions)** a year if the regulator had split TELEBRAS in 27 (10) instead of 3 regional companies. As the local cost conditions in telecommunications does not vary too much, we can say that there could be some welfare gains from extra fragmentation in TELEBRAS due to the "yardstick competition effect gain" and the "uncertainty effect gain"

22 We recognize, this is a bit harsh hypothesis, since it would not be easy to find too many bidders in the international market to participate in 27 auctions in the fixed telephone privatization of Brazil.

In the theoretical exercise with a negative "r", the Brazilian parameters applied show that horizontal separation with r=-1 and n=3 still compensates relatively to the full integration case. However, in this case, increasing "n" from 3 to 10 and 27 is not worthwhile. To be more precise, the value of "n" sufficiently large to make the best horizontal segmentation approach, when r=-1, is 3. Note, however, that for lower absolute values of r, such as *-0,5*, splitting in 27 companies is better than 3 and even 10 companies.

VI Conclusions

Yardstick competition is a promising way to regulate companies, decreasing the distortions caused by lack of information from the regulator.

Beyond the policy through entry post-privatization, perhaps the most important moment to foster yardstick competition is when restructuring state-owned companies before privatization. While the theoretical models usually compare monopolies with duopolies where yardstick competition is used, we generalize a model by Armstrong, Cowan and Vickers (1994) to conclude that this motivation remains when considering n instead of *2* companies. A crucial aspect behind these results stems from the hypothesis of risk aversion of the regulated firms.

There are useful insights from this generalization. First, when there are no scale economies among companies in different geographical areas, more fragmentation **always** increases welfare, when there is a positive cost correlation across areas. Second, as expected, this can be reversed when there are scale economies of the company across different geographical, but this result depends on the behaviour of the function of scale economies $\delta(n)$ at each value of n and on the path of the uncertainty and yardstick competition effects. It is plausible to assume that scale economies in telecommunications in Brazil, previously to privatization, even if positive, presented decreasing returns. However, it is not clear whether this may be compensated by the uncertainty and yardstick effects, since they can go either way.

Third, an interesting departure of the basic ACV model occurs when there is a negative correlation of costs among areas. In this case, the "yardstick effect" and the "uncertainty effects" go in different directions and this also brings ambiguous effects of more integration in the model. As the "uncertainty effect" presents increasing returns as horizontal consolidation increases, we find an upper bound in the benefits that more fragmentation can bring. This upper bound will be lower, the higher the absolute value of the correlation coefficient, r

These findings can be helpful in addressing the impacts of the state-owned company restructuring before privatization in respect of the ex-post ability of the regulator to reduce his problem of information. Thought, this was a recurrent argument introduced by regulators for the shape of horizontal division of the companies, we guess that there was still some room to increase horizontal separation in the Brazilian experience, mainly in view of its large territory. This reasoning can be useful for the pre-privatization restructuring of state-owned companies in countries that are still reforming their economies.

The empirical exercises presented in section V, with two parameters extracted from Brazilian data in 2002, show that a more aggressive horizontal separation approach would be welfare-enhancing. The increase on welfare would be greater, the closer the correlation coefficient to 1.

Appendix 1

$$E(\Pi) = E\left\{\left[A + (1-\rho)\sum_{i=1}^{n} c_i\right] - \sum_{i=1}^{n} c_i - \sum_{i=1}^{n}\frac{e^2{}_i}{2}\right\}$$

$$E(\Pi) = E\left[A - \rho\sum_{i=1}^{n}(\theta_i - e_i) - \sum_{i=1}^{n}\frac{e^2{}_i}{2}\right]$$

$$E(\Pi) = A - \rho\sum_{i=1}^{n}(\mu - e_i) - \sum_{i=1}^{n}\frac{e^2{}_i}{2}$$

$$Var(\Pi) = \rho^2 n\sigma^2 + \rho^2\sum_{i=1}^{n}\sum_{\substack{j=1\\ j\neq i}}^{n}\operatorname{cov}(\theta_i,\theta_j)$$

$$Var(\Pi) = \rho^2\sigma^2(n + n(n-1)r)$$

Appendix 2

$$E(\Pi i) = A + (1-\rho)(\mu - e_i) + k\rho(\sum_{j\neq i}^{..}(\mu - e_j) - \mu + e_i - \frac{e_i}{2}$$

$$Var(\Pi i) = Var(k\rho\sum_{\substack{j=1\\ j\neq i}}^{n}\theta_j - \rho\theta_i)$$

$$Var(\Pi i) = \rho^2\sigma^2 + \rho^2 k^2 Var(\sum_{\substack{j=1\\ j\neq i}}^{n}\theta_j) - 2k\rho^2\sum_{\substack{j=1\\ j\neq i}}^{n}\mathrm{cov}(\theta_i,\theta_j)$$

$$Var(\Pi i) = \rho^2\sigma^2[1-2kr(n-1)] + \rho^2 k^2[(n-1)\sigma^2 + \sum_{\substack{j=1\\ j\neq i,m}}^{n}\sum_{\substack{m=1\\ m\neq i,j}}^{n}\mathrm{cov}(\theta_j,\theta_m)]$$

$$Var(\Pi_i) = \rho^2\sigma^2[1-2kr(n-1)] + \rho^2 k^2[(n-1)\sigma^2 + (n-1)(n-2)r\sigma^2]$$

$$Var(\Pi_i) = \rho^2\sigma^2[1-2kr(n-1) + k^2(n-1)(1+r(n-2))]$$

Appendix 3

Estimate of the Operational Expenses of the Brazilian Regional Companies -2002

(in US$ millions)

	Sales	Net Profit	Estimate of Total Expenses	Mean Deviation	Square Deviation
Telemar	6303,7	452,2	5851,5	1038,2	1077928,5
Telefônica	5480,5	487,4	4993,1	179,8	32340,0
Brasil Telecom	3975,9	380,7	3595,2	-1218,1	1483686,4
Total	15760,1	1320,3	14439,8		
Mean	5253,4	440,1	4813,3		
Variance					864651,6

Source: Revista *Exame* - Melhores e Maiores -Julho 2003.

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