Risk and systemic risk perception in the telecommunications sector in Brazil: an investor perspective assessment.

Charlita de Freitas, Luciano and Euler de Morais, Leonardo and Manuel Baigorri, Carlos

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RISK AND SYSTEMIC RISK PERCEPTION IN THE TELECOMMUNICATIONS SECTOR IN BRAZIL: AN INVESTOR PERSPECTIVE ASSESSMENT.

Luciano Charlita de Freitas* (corresponding author: lucianofreitas@live.com)
PhD, Graduate School for International Development and Cooperation, Hiroshima University
Regulatory Specialist at ANATEL
*Corresponding Author

Leonardo Euler de Morais
MSc, University of Brasília
Regulatory Specialist at ANATEL

Carlos Manuel Baigorri
PhD, Catholic University of Brasilia
Regulatory Specialist at ANATEL

ABSTRACT

This article approaches the risk perception towards the Brazilian telecommunications sector and how it might affect the flow of data driven investment in the country. Empirical evaluations are carried out with risk assessment metrics, Value at Risk (VaR) and Conditional Value at Risk (CoVaR), for a sample of telecommunications companies. Such approach is complemented by a descriptive review of the sector´s potential sources of risk and contagion channels. Results present own risk for each company in the sample and their individual contribution to the systemic risk in the sector. Besides, findings suggest that systemic risk perception might play an important role on investors´ decision to invest in the telecommunications sector in Brazil. Final remarks include notes on the potential benefits of adopting risk metrics as a tool to improve governance in the sector.

Keywords—*Risk, Systemic Risk, Infrastructure, Investment.*

1. INTRODUCTION

Risk and systemic risk assessment of non-financial sectors is an incipient practice in Brazil. Nevertheless, recent initiatives carried out by regulatory agencies, market analysts and investors have sponsored the expansion of these mechanisms in search of improving the sector's governance and towards better regulation design.

Such an approach is coherent with the ongoing debate about risk exposure of non-financial regulated sectors. The telecommunications sector in Brazil is particularly suitable to this debate since it is susceptible to market, operational and compliance risks, as well as the idiosyncrasies of a coexisting public and private regimes. Besides, the sector is highly dependent on third party capital for infrastructure modernization.

This study intends to provide an assessment of own individual risk of companies and their contribution to the systemic risk of the entire telecommunications sector. Complementarily, it suggests inputs for the design of prudential mechanisms toward risk mitigation in the sector.

For the purpose of conceptualizing, systemic risk is defined as the susceptibility of a macro shock that produces nearly simultaneous, large, adverse effects in a sector or all of the domestic economy or even international system [1,2]. It can also refer to the risk of a chain reaction within interconnected agents or a type of spillover that involves weaker and more indirect connections [2]. According to OECD [1], highly complex and interdependent large-scale technical systems are particularly susceptible to change that poses risks to themselves while also causing disruptions thorough cascading effects.

For the purpose of empirical analysis authors estimate risk assessment indicators such as Value at Risk (VaR) and Conditional Risk Value (CoVaR) with quantile regression method. These indicators allow estimating the probability of loss of individual return of companies, given a certain confidence interval, and the effect of the performance of a given institution on the aggregate risk of the sector, respectively.

References for the analysis are set on observations for a sample of telecommunications companies that have their shares traded in the stock market and that operate simultaneously in retail and wholesale infrastructures markets. These institutions are distinguished by high degree of vertical integration and irrefutable interconnection within the sector and with other sectors of the economy [3].

An axiom that guides the development of this study is the nexus between the investor's perception of risk and their propensity to invest. Such cause and effect relation along with the oddities of the Brazilian telecommunications sector will be better detailed throughout the study.

The paper is structured as follows: Section 2 outlines the context in which the telecommunications sector operates and highlights the degree of sectoral interconnection. Section 3 describes the methodological aspects and the data base statistics. Section 4 presents the results and distinguishes the institutions with higher own risk and their

contribution to the sector's systemic risk perception. Concluding remarks contains proposals for prudential measures.

2. "TOO INTERCONECTED TO FAIL": NOTES ON RISK SOURCES AND CONTAGION CHANNELS IN THE TELECOMMUNICATIONS SECTOR

An appraisal of intensity and scope of systemic risk in the telecommunications sector requires a preliminary understanding about the sector´s main risk sources and the channels of contagion spread.

Regarding the sources of risk, authors have highlighted the market, the compliance obligations and the specificities of the telecommunications industry as the leading factors [4,5]. Market risk embodies the inherent dynamics of services supply and demand in a competitive environment. This relation is particularly affected by boundless applications developed within the ongoing technology revolution which latest phenomenon is the dissemination of internet based solutions that has among other features contributed to substitute those provided by conventional telecommunications companies.

By its turn, the so-called compliance costs refer to the regulatory and legal obligations to comply with certain standards of conduct. The guarantees of service provision continuity and the obligation for high standard universalization of legacy services are remarkable examples of hyper regulation in the sector. Particularly, the obligation of continuity has become a major source of risk perception in the sector due to its linkage with moral hazard behaviors by companies that would ultimately increase its exposure to risk facing the expectation of government support in eventual continuity failure.

Still in the compliance spectrum it is noteworthy that services offered through the Internet presupposes greater freedom of offer and fewer incidence of fiscal and regulatory costs, typical of the conventional operators.

Finally, there are technical matters affected to the operation of the sector. One issue within this spectrum is the considerable claim for infrastructure modernization in order to cope with the intensive data use demand. Such a demand imposes higher reliance on third-party investors due to capital intensive investments.

2.1. *Opus Reticulatum:* the level of interconnection of the telecommunications industry in Brazil

As for the means of risk propagation, it might be recognized the high degree of network interconnection between telecommunications companies and between them and other economic agents. Communications infrastructures are the backbone for the entire economy functioning and its availability is essential for the economy to prosper. Following figure 1 partially illustrates the extent of the interdependencies between the communications and other utilities and relevant services sectors.

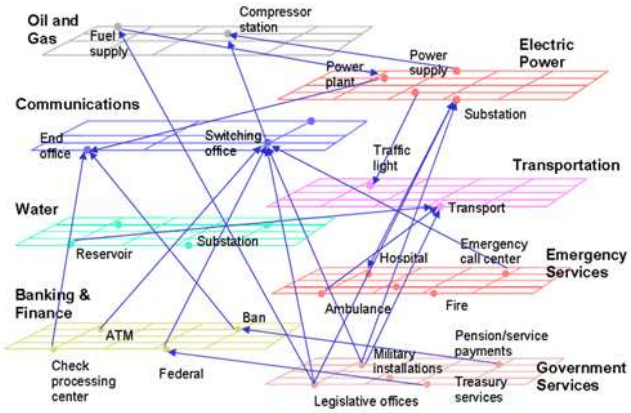

Figure 1 - Interdependencies of the communications architecture. Source: [6]

Consistent networks serve as a communication and transaction platform for the entire economy and are correlated to higher standards of productivity across all sectors as well as source of innovative ecosystems and to support economic growth [7].

3. METHODOLOGY

For the purpose of empirical evaluation this study is set on the combination of two complementary metrics commonly used as risk indicators from the investor's perspective. The first is the Value at Risk (VaR) which purpose is to asses the individual risk of companies in a given sample. The second is a derivate of the first and is referred to as Value at Conditional Risk (CoVaR) and aims at measuring the systemic risk of the sector.

VaR is a univariate risk metric that allows the identification of the probability of performance losses during a given period, given a confidence interval. By its turn, the CoVaR represents the Value at Risk of a broader group of institutions, conditioned to the performance of an given institution under stress.

Taking as basis the CoVaR authors have conceived the ΔCoVaR which purpose is to assess the systemic risk, calculated by the difference between the CoVaR conditioned to a certain stress institution and the CoVaR of the institution in its median state [8]. This approach is used experimentally in this study, since there is no settled consensus about preferential methodology for assessing the systemic risk of non-financial sector.

3.1. Application of VaR and CoVar in the context of telecommunications industry

To the purpose of quantification of VaR and CoVaR authors have systematically relied upon quantile regression [8,9,10]. This array allows for estimating individual risk for each of the companies in a selected sample and the systemic risk for the overall sector.

In algebraic terms the VaR of an institution i at a given percentile q is defined by:

[equation 1]

$$Pr\left(X^i \leq VaR_q^i\right) = q$$

With X^i indicating the performance of institution i, represented in this study by the daily variation of the market value for which the VaR_q^i is defined. Given the characteristics of VaR_q^i, and the quantile, its value is typically negative. In other words, the returns correspond to the left hand side of the results distribution.

By its turn, the CoVaR relates two parts - on the one hand the performance of the sector and, on the other, the individual results of a given institution. Thus, $CoVaR_q^{j|i}$ might represent the VaR of the system that makes up the telecommunications sector j, conditional on an event $\mathbb{C}(X^i)$ of a single institution i. Thus, $CoVaR_q^{j|i}$ is implicitly defined by the quantile q of the conditional probability distribution:

[equation 2]

$$Pr\left(X^j \leq CoVaR_q^{j|\mathbb{C}(X^i)} \middle| \mathbb{C}(X^i)\right) = q$$

To capture the temporal variations in the joint distribution of X^i and X^{system}, authors have relied on state variables. A state variable is a vector used to describe the natural dynamism of the financial market, independent of the effect forces of a particular institution [9]. For the purpose of this study the return of the BOVESPA Index (IBOV), represented in the model with the lagged expression M_{t-1}, was chosen as state variable.

The quantile regression, with daily observations and quantile q = 5%, is estimated with the following equations:

[equation 3]

$$X_t^i = \alpha^i + \gamma^i M_{t-1} + \varepsilon_t^i$$

$$X_t^{system} = \alpha^{system|i} + \beta^{system|i} X_t^i + \gamma^{system|i} M_{t-1} + \varepsilon_t^{system|i}$$

The returning coefficients are input for setting the $VaR_t^i(q)$ and $CoVaR_t^i(q)$ indicators in the following terms:

[equation 4]

$$VaR_t^i(q) = \hat{\alpha}_q^i + \hat{\gamma}_q^i M_{t-1}$$

[equation 5]

$$CoVaR_t^i(q) = \hat{\alpha}^{system|i} + \hat{\beta}^{system|i} VaR_t^i(q) + \hat{\gamma}^{system|i} M_{t-1}$$

A property of CoVaR is the endogeneity of systemic risk. Thus, the CoVaR of each institution is, by its nature, endogenous and depends on the risk assumed by other institutions in the sample. Therefore, the CoVaR is placed as a measure of equilibrium, as it is likely to adapt to environmental changes and provide incentives to institutions to regulate their own exposure to risk [8,9].

Finally, the systemic risk, defined by $\Delta CoVaR_t^i$, for each institution comes out the application of the following equation:

[equation 6]

$$\Delta CoVar_t^{system|i} = CoVaR_t^i(q) - CoVaR_t^i(50\%)$$

$$= \hat{\beta}^{system|i}\left(VaR_t^i(q) - Var_t^i(50\%)\right)$$

The significance of the econometric models was evaluated using the Wald and likelihood ratio tests. These tests allow verifying the significance of the models.

3.2. Limits of VaR and CoVaR metrics to non-financial sectors.

Despite the relative maturity of VaR and CoVaR applications for risk assessment in the financial sector, this approach is not conclusive for others sectors of the economy. Challenges to a broaden use of this method are generally concerned with the complexity of adapting the usual metrics to the peculiarities of other sectors, comprehending the characteristics of liquidity, tolerance to risk, the channels and speed of contagion, the sample limitation, and so on.

A feature that worthies' specific attention in this context is the diversity of capitalization channels available for some sectors. For instance, whenever taking the Brazilian telecommunication into account it might be aware that major companies are domestic branches of multinational organizations which decision to flow in investment is not exclusively bound on financial measures.

Moreover, leveraging the long-term finance available from its state-owned development bank (BNDES), has figured as the single main provider of infrastructure financing, with tax exempt infrastructure bonds. In other words there are alternative sources of financing that complement the typical flows of investment and eventually might reduce the importance of risk indicators formulated from variables derived from the financial market.

Regardless of the specificities, it is categorical that the conceptual and technical bases that justify the initiatives for risk assessment of financial institutions are similar to those of several other sectors. Within the telecommunications sector it is possible to distinguish typical characteristics of scarcity, service essentiality and high degree of interconnection that usually justifies systemic risk analyzes in banks, credit providers and financial systems.

In view of these specificities, it is essential that the approach on the subject of risk assessment for non-financial sectors develop into specific research. With special relevance, efforts must address the reworking of risk metrics to the conditions of others sectors and their institutions.

4. DATA BASE

For the purpose of this study, the dataset are all taken from public available sources. References for company performance and sample selection are provided by the BM&F BOVESPA historical series basis and from the companies' annual balance sheets [11]. The sample is a well-defined subset of the entire sector, comprehending companies with common shares traded on stock exchanges and simultaneous operations in the retail and wholesale markets of infrastructures. Due to this delimitation, the groups Claro S/A and Algar Telecomunicações, among other smaller providers, were excluded from the sample. The following table summarizes the characteristics of these institutions.

Table 1: Sample Summary (Year: 2015, in R$ millions)

Company	Total Asset Value (R$)	% Assets Sector Share	Net Equity	CAPEX	Net Total Debt
Telefónica (VIVT3)	R$101,6	32,94%	R$68,6	R$ 15,3	R$ 4,8
Oi (OIBR3)	R$97,0	31,42%	R$13,2	R$ 13,5	R$ 43,2
Tim (TIMP3)	R$35,4	11,47%	R$16,9	R$ 2,3	R$ 1,2

Source: BM&F BOVESPA, 2016 e company´s balance sheet.

This data covers daily observations from January 2005 to June 2016. The period comprises significate events with effects over the entire sector such as the merger between Brasil Telecom S/A and Telemar Norte Leste S/A in 2008, the acquisition of Vivo by the Telefónica in 2011, the acquisition of GVT by Telefónica in 2015, as well as the events that preceded the request for judicial recovery of Oi in 2016, among others.

It also includes several periods of economic growth and crises. Highlights to the recession triggered by the collapse of the US subprime mortgage market in 2008 and the recent events of the Brazilian political-economic crisis. Following figure 2 resumes the performance of companies' stocks during the sample period.

The data were structured in a panel of daily references for returns of the market value of OI (OIBR3), VIVO (VIVO3VIVT3) and TIM (TIMP3) shares. Estimates of VaR_q^i and $\Delta CoVaR_t^i$ are designated by X^i, to the 5% quantile.

Losses references in the returns of the telecommunications sector, X_t^{system}, were also from the BM&F BOVESPA historical series basis. This reference was used as a proxy of telecommunications sector performance and comprehends the average of the returns of the market value of the sector, weighted by the lagged market value. This option follows the mainstream literature recommendations [8].

Criticisms about this proxy are related to the effects of mechanical correlation between institutions performance and that for the sector. In order to minimize the possible effects of correlation, authors chose to easy the preconditions of sample selection and by this mean to include in the sample size, for the purpose of sectoral performance evaluation, all telecommunications companies listed the stock market, regardless of the portfolio of services rendered.

In addition a consistency test was performed to assess whether the correlation produces effects on the estimates. The test follows the mainstream literature and consists of re-estimating the ΔCoVaR of a given institution using the system return variables composed by the weighted returns of all institutions of the sample, except that for the company for which the ΔCoVaR was estimated [9].

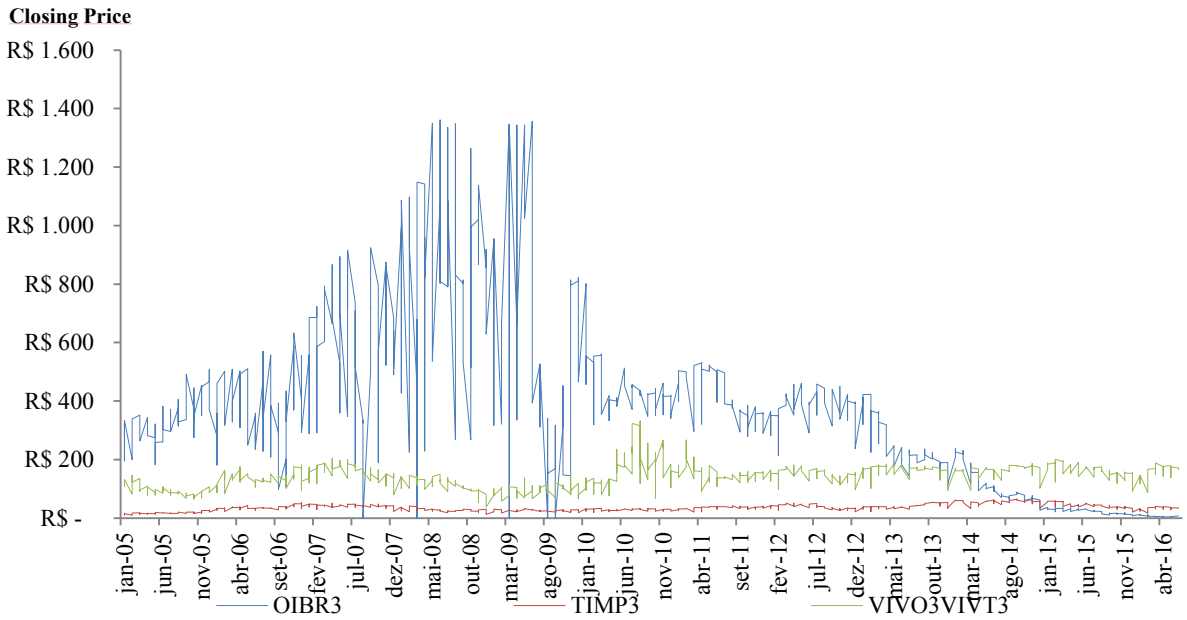

Figure 2: Daily stock closing value

Source: BM&F BOVESPA [11]
Note: The amounts of the common shares of Vivo and Telefónica were chained in such a way as to ensure the consistency of the historical series after the period of consolidation of these companies.

5. RESULTS AND DISCUSSION

5.1. Results of risk evaluation model

Table 2 resumes the coefficients of regression models. The regression models were set for daily data base available for OI, VIVO and TIM and spans over 2585 days. The 5% quantile corresponds, on average, to observations on the 129 worst closing results of the organizations in the sample.

Results for individual (VaR) and systemic risk (ΔCoVaR) as well as the ranking of risk indicators are presented in Figure 3. Regarding VaR, results suggest that Oi S.A. (OIBR3) displays the highest individual risk among the companies that make up the sample. Oi's results imply that at the 5% quantile there is a probability equal to or greater than -9.61% of return losses.

Table 2: Results of the estimates

Company	Equation 3a: $X_t^i = \alpha^i + \gamma^i M_{t-1} + \varepsilon_t^i$		Equation3b: $X_t^{system} = \alpha^{system\|i} + \beta^{system\|i} X_t^i + \gamma^{system\|i} M_{t-1} + \varepsilon_t^{system\|i}$		
	$\hat{\alpha}^i$	$\hat{\gamma}^i$	$\hat{\alpha}^{system}$	$\hat{\beta}^{system}$	$\hat{\gamma}^{system}$
Telefônica (VIVT3)	-2,313*	0,4925*	-5,437**	2,159*	0,1983*
Oi (OIBR3)	-54,8	-1,717*	-10,78*	-0,05*	1,3997*
Tim (TIMP3)	-4,79**	0,5819*	-1,568*	2,2796*	0,1059*

Notes: Wald significance tests and likelihood ratio suggest that the terms of equations 3a and 3b are significant for estimates of the VaR and CoVaR models. *, ** denotes significance at 15% and 5%, respectively.

Table 3: Results of VaR and Systemic Risk (ΔCoVaR) for the Brazilian telecommunications market

Company	$VaR_{q=5\%}$	Individual Risk Ranking	$\Delta CoVaR_{q=50\%}$	Systemic Risk Ranking
Oi	-9,61	1◦	-12,53	1◦

(OIBR3)				
Tim (TIMP3)	-4,20	2◦	-4,56	2◦
Telefónica (VIVT3)	-1,82	3◦	-3,07	3◦

Results for ΔCoVaR also point out Oi S.A. (OIBR3) as the main source of systemic risk in the telecommunications sector. Hence, among the companies in the sample, Oi S.A. imposes the largest individual and marginal contribution to the sector's systemic risk.

The findings are consistent with the factual evidence observed in the company's performance. Emphasis stands on the degree of leverage, the volatility in the value of shares and the systematic loss of market value [12, 13]. It is important to notice that the span of observations precedes the request of judicial recovery posed in June 2016.

Results for other companies in the sample reveal a relative lower risk and systemic risk pattern. Since the sample of telecommunications companies with participation in the stock market is modest, inferences in this study are only relativized between companies in the sample.

5.2. Risk perception in a context of critical demand for data driven investment in infrastructure

Availability of modern data oriented networks is a crucial component of high-speed Internet access provision. Hence, efforts towards the deployment of this infrastructure have gained a particular importance within the policy agenda in Brazil given the exceptional benefits attached to the digitalization of the economy.

However, there is a downward trend in telecommunications investment that is not compatible with the expectations of Brazilian policy makers. Such a trend might be related to the investor's perception of risk.

These circumstances require the development of strategies to mitigate risks and to enhance returns for infrastructure investment, along with regulatory reforms to easy the flow of investments in the sector.

Initiatives such as the development of risk metrics and the comprehension about risk sources and systemic risk contagion channels might affect positively the credibility of the regulatory action and the establishment of policy commitments addressing issues as regulatory stability and effective mechanisms for risk mitigation.

In addition, initiatives towards regulatory reforms with inceptives to reduce risk exposure and to facilitate investment flows in the sector might create a better environment to infrastructure investment, including those related to redundancy routes and the construction of alternative networks.

5.3. Prudential supervision: initiatives to mitigate systemic risk in the telecommunications sector in Brazil

This study provides references for the potentials usages of risk indicators such as VaR and CoVaR for the purpose of improving governance in the telecommunications sector. Particularly, regulatory body might enhance its supervision capacity by defining prudential regulation initiatives turned to mitigate excessive risk exposure.

For instance, by including risk metrics in its monitoring apparatus regulators would improve its responsiveness to eventual crises of credibility caused by one or more institutions under stress.

To be successful, such initiatives require coordination with other regulators, in particular the securities and exchange authorities, in order to facilitate the sharing of information and adequacy of systemic risk methodologies to the telecommunications sector.

Besides, actions towards the promotion of competition in infrastructure markets would have particular benefit to mitigate sectoral risk. That is why strengthening competition in infrastructure provision implies lower dependence on dominant infrastructure providers.

It must also be recognizable that certain political and regulatory risks are relevant sources of subjective risks. For instance, the risk of maintain the focus on regulation of fixed line concessions with rules of assets reversibility or actions towards the increasing of taxes on telecommunication services might endorse the risk perception among investors. Therefore governments may also take steps to mitigate compliance risks by electing measure of regulatory stability and a positive long term approach to easy invest flow in the sector.

7. CONCLUSIONS

This article addresses the own individual risk of companies and their contribution to the systemic risk of the Brazilian telecommunications sector as well as their effects on the investors' perception of risk.

Results suggest that Oi S.A. displays, simultaneously, the highest individual risk and it is the prime diffuser of systemic risk in the sector. Since higher risk perception imposes greater costs of financing and lower availability of funds, by increasing the its risk perception it might be expected additional challenge to finance its operation and therefore to modernize its infrastructure. Besides, since the company holds a significant share in the infrastructures supply in the country, it might be expected that eventual delay in its infrastructure modernization would impose a cascade effect over other sectors.

These evidences justify the adoption of prudential supervision measures in order to create a better governance environment towards the sector and by this mean to mitigate its exposure to risk perception related costs. To be effective it is fundamental to reduce the sources of sectoral

risks such as the compliance costs and the current limiting rules for investment flow.

Notwithstanding the benefits of risk assessment in the sector it is noticeable that decreasing volume of securities issued by telecommunications providers in Brazil in recent years, justified by alternative sources of financing, might affect estimates like VaR and CoVaR due to the decreasing amount of data availability. It implies that future researches on the theme must search for alternative metrics in order to get a proper estimate of risk.

While the present study is by no means an exhaustive approach of the risk assessment to the communications sector, it is set on a structured the methodological discussion so that it has applicability to broader range of industries.

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