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The transmission of credit risk in the Brazilian shoe supply chain

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ABSTRACT

The world financial system is now undergoing a global economic crisis of staggering proportions. This evolving global and financial crisis and credit crunch afflicted developed and developing economies. In the vast majority of countries, credit concession has been deeply affected, and new and innovative ways to grant credit needed to be developed in order to reduce risk. The use of accurate information in the credit concession analysis process, where credit scores play a crucial role, became imperative. In this context, the present study brings new insights to this discussion because it aims at verifying potential transmission of credit risks among companies in the context of the Brazilian shoe supply chain. For that, the author brought supply chain concepts largely discussed in the operations arena to the credit risk analysis. The results show that when the retail link experiences a variation in the credit risk level (hereby

represented by credit score), the credit risk in the industry is directly affected, but after a specific number of periods.

INTRODUCTION

The interest in company credit risk is a more recent phenomenon in relation to the research in operations management. The first known study on the theme is from Fitzpatrick in 1932 in which he compared very successful nineteen companies to companies that failed between 1920 and 1929 in the USA. Compared to the current models, the method used was very simple. The researcher analyzed the finance indexes of the companies, classified them above and below a pre-established pattern, and then analyzed the behavior of these indexes over time. Fitzpatrick concluded that the companies' financial indexes could provide important insights to the determination of the delinquency risk of the company.

Through careful analysis of the studies and development in the area of company credit risk, what is observed is that the focus is mainly in the company itself and its financial indexes in an isolated approach. Similarly to the techniques and studies of operations, that during many decades treated the companies as independent systems, with little or no connection with other agents linked in the supply chain, the studies of credit risk are still in the early stages in incorporating the business dynamics of the companies in the context of supply chains. Since the issues related to credit risk took on new contours when subjected to the theories of SCM (BENDOLY, 2003; SPEKMAN, 1998), this paper aims at identifying and explaining potential credit risk transmission between companies when moving up and downstream in the chain. With this mind, the researcher relied upon econometric models and time series analyses applied to a pre-selected delinquency index. Observing the behavior of credit risk transmission among

companies in the Brazilian shoe supply chain, we propose the inclusion of the interaction among these companies in the construction of models for credit risk analysis. As a result, we expect to bring new insights on improving the accuracy and predictive capacity of such models, and eventually the quality of credit policies.

LITERATURE REVIEW

Fooladi and Fatemi (2006) claim that in order to maximize shareholder value the company should implement risk management practices only if the total value is increased, and therefore, the shareholder value. This may be a result of minimizing the costs of financial risk, tax minimization, and/or minimizing the possibility of the firm to discontinue profitable projects due to lack of generating funds to accomplish them.

In contrast to the maximization of shareholder value, the assumption of managerial risk aversion (which is based on the agent theory) states that managers will seek to maximize their own welfare. This means that managers can, temporarily, engage in practices of risk management at the shareholders' expense. Specifically, when the interests of shareholders are not perfectly aligned with the managers' ones, managers can pursue strategies of risk management designed to isolate their own benefits from the effects of changes in interest rates, commodity prices or currency values. Regardless the driving force is the maximization of shareholder value or managerial risk aversion, we will always see companies engaging in management practices of credit risk.

Credit risk arises from uncertainty in the ability of counterparty to meet their obligations; in other words, it is the volatility of future earnings with consequences on the process of establishing the value of the creditor.

Credit risk exists because the promised cash flow may or may not be paid in full by the various borrowers. There are several levels of credit risk due to the lack of full or

partial payment. As the credit risks are, in theory, not eliminated, the task of institutions is to estimate the risk of loss and incorporate it in the risk premiums.

The increasing variety of types of counterparties (from individuals to governments) along with the continued expansion of different forms of obligations (from car loans to complex transactions in derivatives), made the credit risk management one of the most important activities of risk management in the financial services industry.

The decision-making process for granting credit incorporates the collection and processing of a large number of information about borrowers. This information can be obtained from official documents - financial statements, statutes, registers, contractual changes, business planning, etc..; from companies - administrative, operational, technological, marketing and strategy; and from third parties - suppliers, customers, intelligence agencies, and banks. One of the most relevant information is the credit score that represents the applicant's default probability or delinquency index.

In the "credit analysis" phase, the institution establishes the credit risk level it will be taken with the applicant. This step aims at determining the credit risk of the customer based on the traditional "Cs of Credit" - character, capacity, capital, conditions, collateral - presented by Silva (1995, 2001).

The next step is known as "credit decision." Given the possibility of structuring a loan with the applicant - the amount, duration, rate guarantees and product - becomes a business decision that is systematically used as a factor of feedback to the policy of the credit institution.

Credit Score

As mentioned earlier, credit score is one of the most relevant information when establishing the credit risk level of a transaction.

The systems of credit score objectively measure credit risk, indicating the probability of default at a given time horizon, usually 6 or 12 months. Statistical models for small and medium enterprises and also judgmental models for corporations are often used for this purpose.

The evolution of systems of credit score in recent decades has been driven by the emergence of new information technologies that allow manipulation and processing of an increasing volume of data and information. As the habits of individuals and companies to obtain credit and payment have been captured in a systematic way and consisted in unified data bases, there was a substantial increase in the accuracy of expected default probability.

Historically, the first scoring systems were restricted to the subjective analysis of the creditors. Financial indexes and market information were incorporated into the analysis, initially through univariate approach (indexes analyzed separately) and then through multivariate approach and its traditional quantitative methods (linear discriminant analysis, logistic regression) and alternative methods (neural networks and generic algorithms).

The parameters normally used in credit risk statistical models are based on 5 dimensions (the known Cs of credit):

- Character: indicates the intention of the obligor to meet their obligations.
- Conditions: macroeconomic factors.
- Capacity: ability to meet the commitments made to the creditor; basically is the ability to generate sufficient cash to pay loans.
- Capital: goods and resources to pay off the debts.
- Collateral: guarantees to facilitate the credit operation (eg mortgage, pledge, guarantee, bond).

The information for the analysis of the Cs are obtained from different sources, for example, registration forms, proof of payment of income tax, cash books and other. The information most commonly used in the analysis of credit risk are:

- Registration: identification, age of the company, location, activity, administration, board, insurance, real estate, customers, suppliers, bank references. Source: Boards of Trade, banks and companies.
- Relationship with suppliers; historical payments, payment profile, business references. Sources: mailing and reciprocity data.
- Negatives: bounced checks, executive actions, bankruptcy and shares in bankrupt companies. Sources: registries, courts, banks and companies.
- Financial reports, financial statements, cash flow, financial ratios, standard rates. Sources: banks and companies, newspapers, accounting firms.
- Sector: predicting performance of the company's activity.

Probability of Default

The objective definition of the probability of default becomes imperative to conduct the analysis since different conceptualizations lead to different results. In this study the author adopted the guidelines established by the *Basel Committee on Banking Supervision*. In 1975 the central banks of the Group of Ten countries (Belgium, Canada, France, Germany, Italy, Japan, Luxembourg, Netherlands, Spain, Sweden, Switzerland, United Kingdom and United States of America) created the Committee on Banking Supervision which aims to strengthening the resilience of banking sector. In 1988 the Committee published the Basel Capital Accord (Basel I) aiming at the internationalization of banking and establishing guidelines for the areas of risk management, banking supervision and financial market. In June of the following year, the Committee submitted a proposal to replace the Agreement in place that included

more sophisticated concepts of risk sensitivity, and in January 2001 published the New Basel Capital Accord (Basel II) in order to give greater stability to the world's financial system. The New Accord, with a strong focus on the risk assumed by banks, established that the capital required would vary according to greater or lesser propensity to risk. Two methods for credit risk assessment have been proposed: (1) Standard Criterion - establishes a risk weight for each type of credit distributed in 4 categories (20%, 50%, 100% and 150%). By this criterion, the bank can make the classification with the support of a public agency or private risk rating *(rating* agency), and (2) International Classification - the banks are allowed to use their own classification methodology credit risk.

The adoption of the guidelines of Basel II by developed and developing countries leveraged the discussion about probability of default of borrowers and the development of advanced methods for its measurement. Under this agreement, a default is considered to have occurred with regard to a particular obligor when either or both of the two following events have taken place:

(1) the bank considers that the obligor is unlikely to pay its credit obligations to the banking group in full, without recourse by the bank to actions such as realizing security (if held).

(2) the obligor is past due more than 90 days on any material credit obligation to the banking group. Overdrafts will be considered as being past due once the customer has breached an advised limit or been advised of a limit smaller than current outstandings.

In this research, the unity of analysis adopted was the probability of default of companies of the Brazilian shoe supply chain.

METHOD AND DATA ANALYSIS

Unit of analysis

This research aims at identifying potential transmission of credit risk among companies in the Brazilian shoe supply chain. As discussed earlier, the systems of credit score objectively measure credit risk, indicating the probability of default at a given time horizon, usually 6 or 12 months.

The unit of analysis adopted in the present study was the credit score developed by Experian and denominated CreditRiskScoring™. It is a consolidated model recognized both nationally and internationally and adopted by companies of different sizes and industries.

Data collection

The research was carried out with data gathered from Brazilian companies of the shoe supply chain. The selection criteria were company size (small, medium and large), number of segments (large and small retail, shoe industry), and easiness for the researcher to gather information from the main agents of the chain. Initially, the mapping of the companies and their correlation was made. This mapping was refined by the exclusion of companies with inconsistent registration information. Information such as location, lines of products, size and partners were obtained from The Brazilian Union of Footwear, ABICALÇADOS, Fiesp and The Ministry of the Development of Industry and Trade.

Measures

Although the Brazilian shoe supply chain was formed by a large number of industries and companies, for the research, only industry (production) and retail companies were selected due to their relevance for the analysis. The credit risk, CreditRiskScoring™ , of each company was obtained from Experian databases. The score ranged from 0

(default) to 1,000 points (at risk). A total of 2.136 companies formed the sample. The monthly scores were gathered from January 2000 to June 2007, comprehending 90 samples of each company. Every link of the supply chain was formed by a group of companies with similar business nature. The average score of each link were then calculated. The following table summarizes the way the average probability of default (credit risk) for 90 periods were calculate:

Period	**Company 1**	**Company 2**	**Company 3**	**. . . .**	**Company n**	$\overline{CR}$
1	CR_{11}	CR_{12}	. . . .	. . . .	CR_{1n}	$\overline{CR_1}$
2	CR_{21}	CR_{22}	. . . .	. . . .	CR_{2n}	$\overline{CR_2}$
3	CR_{31}	. . . .	CR_{33}	. . . .	CR_{3n}	$\overline{CR_3}$
...	**...**	**...**	**...**	**...**	**...**	⋮
m	CR_{m1}	CR_{m2}	CR_{m3}		CR_{min}	$\overline{CR_m}$

Stationarity

The unit root was used to verify the (non) stationarity of the model. The starting point was the stochastic process:

$$Y_t = \rho Y_{t-1} + \varepsilon \; ; \text{ where } -1 <= \rho <= 1 \qquad [1]$$

When $\rho = 1$, there is at least one unit root, and it is a non-stationary process. Applying suitable transformations:

$$Y_t - Y_{t-1} = \delta Y_{t-1} + \varepsilon \; ; \text{ where } \delta = (\rho - 1) \qquad [2]$$

The null hypothesis is tested: $\delta = 0$. Because H_o was not rejected, one can conclude it is not a stationary process. Applying augmented Dickey-Fuller which states that under the null hypothesis, the estimated value t of the coefficient of Y_{t-1} follows the

statistics (Tau), one would conclude that either Retail and Industry links are non-stationary (integrated).

Table 1: Analysis of Stationarity

Chain (Retail and Industry)	T-statistics	p-value	Conclusion
Shoes	-0.5466	0.8797	Integrated
	0.8974	0.9955	Integrated
* Critical Values: -2575 (1%) -2,881 (5%) -3,485 (10%) - Constant + Trend			
** Values Critics: -2,376 (1%) -1,665 (5%) -1,293 (10%) - Constant			

Cointegration

The regression of a non-stationary time series against another non-stationary time series can produce a spurious regression. If when subject to an analysis of unit root μ_t is stationary, it means that although y_{1t} and y_{2t} are individually integrated of order I(1), their linear combination is I(0). If the result of regression y_{1t} and y_{2t} is valid, both variables are co-integrated. From the economic point of view, two variables are co-integrated if they have a long term relationship or long term equilibrium.

In this case, we can estimate the regression model without problems, since none of the trends of the stochastic variables will distort the process. However, a test of hypothesis should be carried out in order to detect the presence of co-integration or not. For the sake of this research, a Test of Johansen was applied. The procedure generates two statistical tests to detect the existence of co-integration. The first, called trace test, tests the null hypothesis that there are at least *r* co-integrating vectors. The second, called the Eigenvalue test, tests the hypothesis $r + 1 = 1$ co-integrating vectors.

Table 2: Johansen tests for co-integration

Chain	Hypothesis	Trace Test	Eigenvalue Test	Lag
Shoes	r, l <= 0	9.9194	6.5936	4
	r, l <= 1	3.3257 *		
Significance levels: * 10% ** 5% *** 1%				

From the results above, one concludes that the supply chain has at least one co-integrating vector. Thus, one ensures that there is a balance between long-term retail and industry, as well as a greater capacity of predictability between both time series.

The next step is to estimate the error correction models. These models are applied in non-stationary co-integrated time series. The co-integrating vector is defined as a correction term that shows how long-term deviations are gradually adjusted from changes in the short term, or the effects of individual shocks on the system dynamics.

Table 3: Cointegration

Cointegration Rank Test Using Trace Under Restriction						
H0:	H1:		Trace	5%	Critical Drift in ECM	Drift in Process
Rank = r	Rank> r	Eigenvalue		Value		
0	0	0.2165	24.3070	25.47	Linear	Linear
1	1	0.1026	7.4726	12:39		

Note that the statistical trace (TRACE) is smaller than the critical value, indicating that the series are co-integrated with level 1. The long-term parameters (*beta*) are shown in the table below. Because the normalization procedure applied (in this case using the variable C_CAL), the entries in the first row of the table are equal to 1.

Table 4: Long term estimates

Long-Run Beta Coefficient Based on the Restricted Trend		
Variable	1	2
C_CAL	1.00000	1.00000
I_CAL	-1.76448	-1.15671
t	0.31086	0.03617

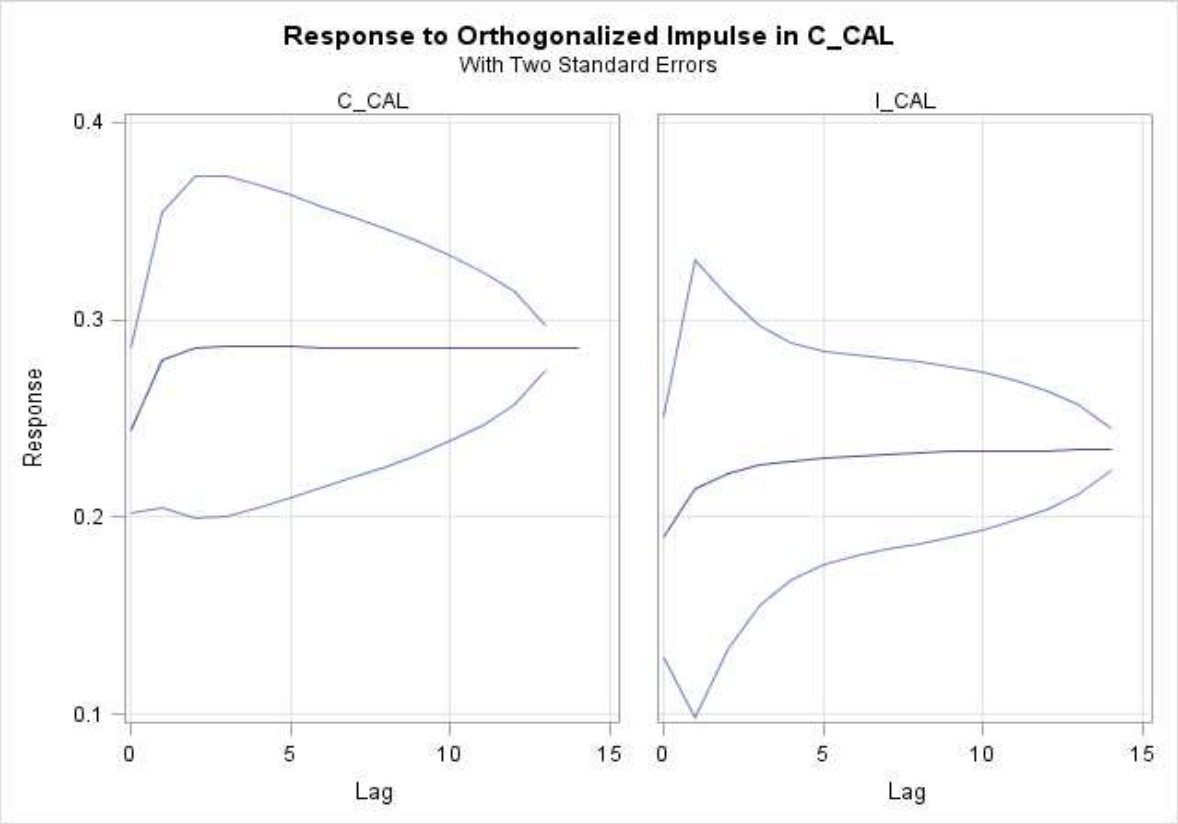
Eventually, the model parameter estimates can be seen below and refer to a VECM (2), with rank 1 and linear trend.

Table 4: Model Parameter Estimates

Model Parameter Estimates						
Equation	Parameter	Estimate	Standard Error	t Value	Pr> | t |	Variable
D_C_CAL	Const1	-0.23647	0.09686	-2.44	0.0175	1
	LTREND1	0.00818	0.00266	3:07	0.0032	t
	AR1_1_1	0.01698	0.0395			C_CAL (t-1)
	AR1_1_2	-0.02069	0.04812			I_CAL (t-1)
	AR2_1_1	0.2563	0.13196	1.94	0.0566	D_C_CAL (t-1)
	AR2_1_2	-0.14112	0.06166	-2.29	0.0255	D_I_CAL (t-1)
D_I_CAL	Cost2	-0.55901	0.20805	-2.69	0.0092	1
	LTREND2	0.0188	0.00572	3:28	0.0017	t
	AR1_2_1	0.24025	0.08483			C_CAL (t-1)
	AR1_2_2	-0.29273	0.10337			I_CAL (t-1)
	AR2_2_1	0.19789	0.28344	0.7	0.4877	D_C_CAL (t-1)
	AR2_2_2	-0.14275	0.13245	-1.08	0.2853	D_I_CAL (t-1)

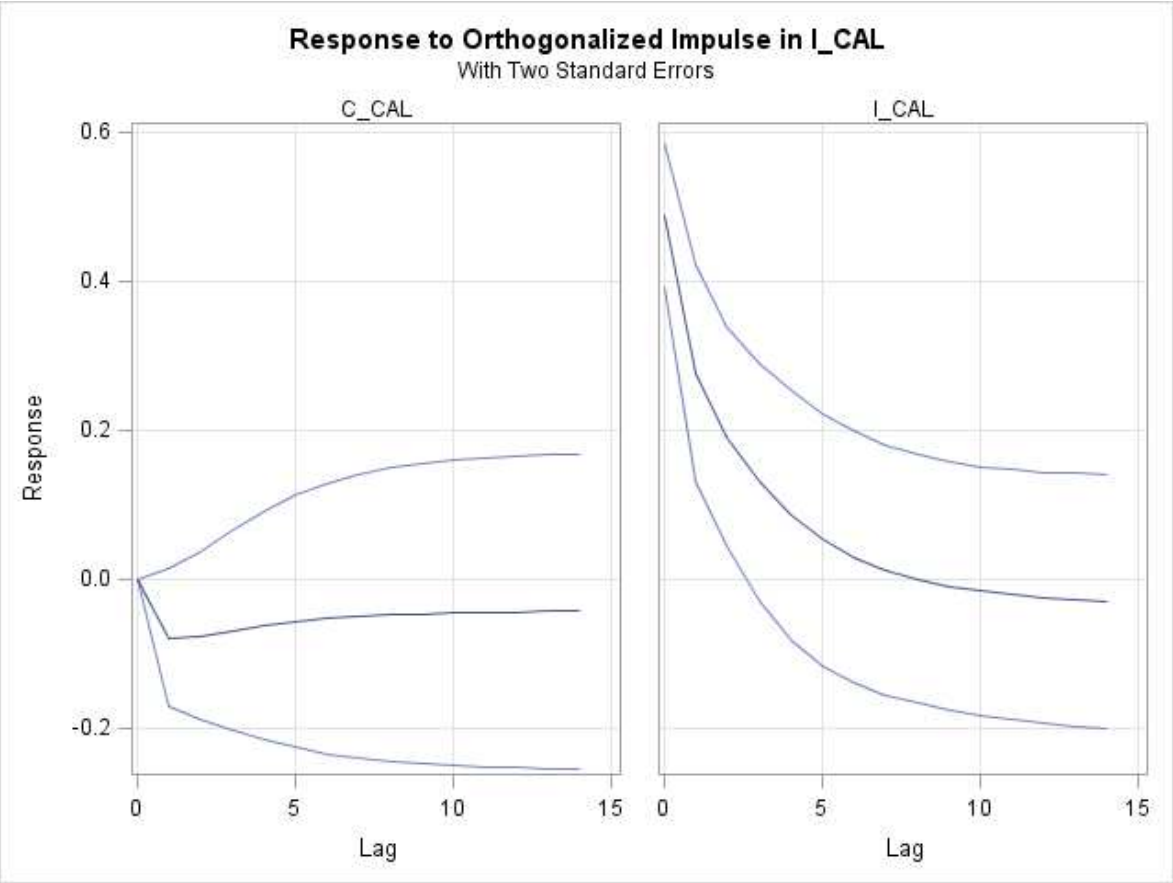
The model adjusted for the shoes supply chain proved to be very robust. The terms AR(2) and the linear trend are quite significant in the first equation. The graphs below show the impulse responses for each variable in the model.

Chart 1: Impulse in Retail



Analyzing the cross effects, one can conclude that the initial shock in the retail link leads to a surge in the industry. However, after 5 months the effect levels off positively. When we observe the shock impact of the industry on retail, the result is opposite. Initially one can observe a negative sharp decrease that stabilizes about 3 months later and remains. However, the shock seems to be quite small.

Chart 2: Impulse in Industry



Granger causality

According to Stock (2003), the Granger causality states that if X Granger causes Y, then X is a useful predictor of Y, given the other variables in the regression. This does not mean that a change in X will cause a subsequent variation in Y, but that past values of X seem to contain useful information to predict variations in Y, besides those contained in past values of Y. The mere existence of a relationship between variables does not mean that there is causality between them or prove the direction of influence. Koop (2000) highlights that in the case of time series: "time does not run backwards. That is, if A occurs before B, then it is possible that A causes B, but it is possible that B causes A. In

other words, the events of the past can cause the events of today, while future events can not". Diebold (2001) complemented with "the statement that A causes B is just a shorthand for the most accurate statement that A contains useful information in predicting B (in the sense of least squares linear) besides the past values of other variables system. The mere association between two economic variables is insufficient to determine its cause. The correlation, for example, shows the relationship between the variables, but is symmetric (A correlates with B and B correlates with A), while the link is non-symmetric (unidirectional). Granger causality (1969) is a specific concept of causality in time series. The idea is simple: the variable X causes Y if Y can be better estimated using past values of X_t and Y_t than using only historical values of Y_t. For such (a) Yt must occur before X_t +1, and (b) Yt should contain information relevant to predict X_t +1 that are not found in a group with other variables. The fact that Y Granger-causes X does not mean that there is an economic engine that future values of X are caused by Y, but that Y is relevant to estimate X. Gujarati (2006) also pointed out that, since the future can not predict the past, if X Granger-causes Y, then changes in X should precede changes in Y. Therefore, in a regression of Y against other variables (including its past values), if we include lagged or past values of X and they significantly improve the prediction of Y, then we can say that X Granger-causes Y.

So far, it has been shown that both co-integration analysis and presence of unit roots have a direct relationship with the predictability capacity of a time series. It has also shown that the existence of co-integration relationship indicates the existence of a long-run equilibrium among variables. But, what can we say about the short term? The answer can be verified through testing Granger causality. The Granger test is quite simple and useful when one wants to know more about the short-term dynamics and

predictability of a time series. The results of Granger causality test for the first 12 lags of Brazilian shoe supply chain are shown below:

Direction	Lag	Shoe
Industry>Retail Retail>Industry	1	4.96093** 0.1358
	2	3.74428** 0.5015
	3	1.9109 0.4147
	4	3.67206*** 0.4187
	5	1.7644 1.1734
	6	2.72987** 0.9815
	7	2.06904* 1.0970
	8	1.4447 1.1858
	9	1.4358 1.0579
	10	1.1209 0.8455
	11	1.1206 0.7699
	12	1.5392 0.6752

From the results above, industry Granger-causes retail in lags 1,2,4,6 e 7.

Discussion

Porter (1996) states that supply chains join together several value chains, and usually are comprehended by several links such as obtaining raw materials, production

processes, storage of finished products, distribution network and the end user. Poirier and Reiter (1996) defined supply chain as a system by which companies deliver their products and services to their customers in a network of interconnected organizations. Although there are variations in the supply chain conceptualization, researchers agree that the components of supply chains are all linked either through organizational structures, processes, product development, operational resources, financial resources or other dimensions (CHRISTOPHER, 1997; LIFT, 2004; HARLAND, 1996; BEAMON, 1999; WOOD and ZUFFA, 1998).

From the perspective that there always be interconnections between companies in a supply chain, it is expected that there is a potential transmission of risk, specifically credit risk.

Analyzing the cross effects, one can conclude that the initial shock in the retail link leads to a surge in the industry. However, after 5 months the effect levels off positively. In other words, if for example due to an economic crises there is a short in the shoe sales and the retail stores experience a higher business risk, this variation will be transmitted to the industry link, but after 5 months the effect will be totally absorbed (stabilization or plateau). Also, there is a balance between long-term retail and industry, as well as a greater capacity of predictability between both time series.

When we observe the shock impact of the industry on retail, the result is opposite. Initially one can observe a negative sharp decrease that stabilizes about 3 months later and remains. However, the shock seems to be quite small.

In terms of the direction of the risk transmission, we can conclude that industry Granger-causes retail in lags 1,2,4,6 e 7.

Conclusions, limitations and future research opportunities

This research is limited to the Brazilian shoe supply chain. Other supply chains can have different dynamics leading to different results. Another limitation is the use of the average of the credit scores (aggregated approach). In order to improve accuracy, research can be developed using scores individually (company approach).

There is a wide range of research alternatives to better understand how credit risk is transmitted among companies in the context of supply chain. The main impact of such knowledge will be the development of credit concession policies that reduces the risk for the creditors and the costs for the borrowers.

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