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The failure of risk management for nonfinancial companies in the context of the financial crisis: lessons from Aracruz Celulose and hedging with derivatives

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The main contribution of this article is to present hard evidence on hedging strategies and relate it to behavioural and agency problems resulting from speculation with derivatives. We focus on the case of Aracruz Celulose. We show how the real hedge position of Aracruz – that lost US$2.1 billion in currency derivatives – deviated from its optimal hedge as the result of speculation with Over-the-Counter (OTC) derivatives.

Keywords: hedging; FX exposure; derivatives; foreign-currency; risk exposure; agency theory; behavioural finance

JEL Classification: M21; G15

I. Introduction

The financial crisis brought billions of losses due to derivatives trading as part of hedging strategies for nonfinancial companies in many countries (Dodd (2009) suggests that losses totalled around US$500 billion for nonfinancial companies during the period 2008–2009). This article aims to shed light on this topic by focusing on the hedging policy of a Brazilian company that lost over US$2 billion due to exchange rate movements resulting from the financial crisis of 2008. In particular, we show how the company deviated from the optimal hedge early in 2008 by the use of 'innovative' derivatives. We contribute to the literature in two ways: first by describing in detail, with an unusually rich dataset, the hedging policies of Aracruz; and then by presenting an empirical analysis of the case, relating the downfall of the company with the indirect effects of the financial crisis. We build on previous case studies, such as Brown (2001), to show how companies can indeed speculate on derivatives, even if inadvertently, and we try to provide an explanation for a class of nonfinancial companies that suffered heavy financial losses following direct and indirect events from the financial crisis.

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Most studies on this topic can be divided into two types: what managers did right that should be emulated and what they did wrong that should not be repeated. One relevant case in the hedging literature is the collapse of Metallgesellschaft (MG). This seminal case falls in the 'should not be repeated' kind and provides many insights into the risk analysis involving hedging strategies that use derivatives. Although many papers have analysed this case (see, e.g. Culp and Miller, 1995; Edwards and Canter, 1995; Krapels, 2001), doubts still remain on the validity of the company's strategy, with some authors claiming the company's strategy was sound, while others defend the view that it inappropriately increased the overall risk of the company. In any case, the literature on the MG case alone provides enough lessons to prevent managers from undertaking strategies that would increase the overall risk of companies through hedging with derivatives. In the present case, Aracruz Celulose posted losses of US$2.13 billion in derivatives in the last quarter of 2008. These losses were 3.7 times greater than the Earnings Before Interest and Taxes (EBIT) in 2007 and represented 30% of Aracruz's market capitalization if we consider the value of the company at the end of the second quarter of 2008. The company's collapse was marked by a stock plunge of more than 90% in 3 months, and only ended when Aracruz was acquired by another pulp producer in 2009.

We try to verify if the strategy developed by Aracruz was sound, and derive the effects of the financial crisis on the company's position. We try to explain Aracruz's financial strategy to understand if hidden risks were the real culprits in the collapse of the company or if managers led the company to a situation of such increased leverage that its downfall was inevitable. We appeal to the Bodnar and Marston (2001) model of foreign exchange risk exposure. The main idea is to derive the optimal hedge of the company during the period 1999–2008 and compare the optimal hedge with the effective one that was used to hedge the company's exchange rate risk, using behavioural finance and agency theory to provide a rationale for the departure of the optimal to the realized hedge. We also endeavour to explain why the company suffered heavy losses due to rapid exchange rate movements following the turmoil in financial markets in August and September of 2008.

The second section presents a brief literature review to contextualize the Aracruz case in the empirical foreign-exchange hedging literature. The third section introduces the stylized facts surrounding the case, placing the company's downfall in the context of the ambient financial crisis as well as similar cases from around the world. The fourth section deals with the formal models and presents results for the optimal and effective hedging of the Aracruz for the period 1999–2008. Finally, the fifth section summarizes the case and offers comments on implications for future research.

II. Hedging Exchange-Rate Risk with Derivatives

The theoretical literature on hedging exchange-rate risk for firms that face currency exposure is well established, with the main result being that using the optimal hedging ratio for financial hedging strategies increases firm value. Even when simple hedging of expected output may not be the optimal risk management strategy (Brown and Toft, 2002), some level of hedging does enhance the value through exchange-rate risk minimization.

In the case of empirical research, we find a wide range of results. Geczy *et al*. (1997) present a seminal discussion on the main reasons for the use of derivatives for hedging currency risk by firms with exchange-rate exposure. They divide the incentives for hedging into three categories: capital market imperfections, the exposure to foreign exchange-rate risk and the costs of implementing a derivatives strategy. The idea is that for a single firm, the proxies representing these variables would be: cash flow volatility, growth opportunities and leverage. And for the executives, incentives would be related to stock-based remuneration and annual bonuses. We return to the incentives presented by Geczy *et al*. (1997) when discussing the case of Aracruz.

Allayannis and Ofek (2001) measure the incentive to hedge in firms with currency exposure in the US. They conclude (p. 273) that the use of foreign currency derivatives is positively associated with companies' market value and that, on average, firms that face currency risk and use currency derivatives have a 4.87% higher value than firms that do not use currency derivatives. Fok *et al*. (1997) find that hedging reduces financial distress for US companies. However, Judge (2006) shows that in the UK hedging actually increases the potential financial distress of companies that employ such strategies. Another alternative result is that of Guay and Kothari (2003), which find that financial derivatives are not an economically important component of corporate risk management because nonfinancial companies hold modest relative derivatives positions relative to firm size, operating cash flows, investing cash flows and other firm benchmarks, while Aabo (2006) demonstrates that foreign debt is a sensible

alternative to currency derivatives in managing exchange rate exposure to risk.

Bartram (2008) suggests 'that managers of non-financial firms with operations exposed to foreign exchange rate risk take savvy actions to reduce exposure to a level too low to allow its detection empirically' (p. 1508); and Adam and Fernando (2006) argue that cash flow gains from derivatives trading increases shareholder value. We try to show what happens when managers are not as savvy as in Bartram (2008), and that cash flow gains from derivative trading may give incentives for excessive financial exposure to derivatives.

III. The Case of Aracruz Celulose

Many companies in emerging and developed markets lost billions of dollars in derivatives in the wake of the financial crisis. Although precise numbers are difficult to come about due to disclosure issues, Dodd (2009) estimates that – for 12 countries that include Poland and economies of Asia and Latin America, the financial crisis affected possibly 50 000 firms, with derivative losses totalling roughly $530 billion. Kamil *et al*. (2009) present a small subsample of companies in Mexico (six companies) with a total loss of US$4.7 billion (with an average loss of 23% of total assets) and three companies in Brazil with a total loss of US$5.5 billion – and an average loss of 46% of total assets. Some other cases around the world include Citic Pacific in Hong Kong (losses of US$2 billion, Daewoo in Korea (US$ 1.77 billion) and China Eastern Airlines (US$0.85 billion).

The case of Aracruz is similar to other companies – it was first announced in September 2008 that the company had heavy losses due to currency derivatives and on 3 October it announced a total loss of US$1.95 billion (later amended to US$2.1 billion). In the meantime, the stock plunged from an average of R$12 throughout 2008 to less than R$1.5 later in October. In November 2008, Brazilian stockholders sued Aracruz's former CFO, while some American stockholders (the company is traded in the US market through American Depositary Receipts – ADRs) joined in a class action against the Board.

In 2008, Aracruz Celulose was the biggest world producer of bleached eucalyptus pulp, with 26% of the world market, market capitalization of US$7.1 billion (8 July 2008) and a net revenue of US$1.42 billion. Aracruz was a single product manufacturer with steady growth in terms of revenue, output capacity and profits throughout the period 1999–2007. It also had a 'BBB' flat rating by Moody's, S&P and Fitch, possessing investment grade since November 2005. It was self-sufficient in wood with a total of 593 000 hectares, self-sufficient in electricity and had a private port terminal that shipped 85% of its total output. It also had three production sites with an annual capacity of 3.3 million tons (ARACRUZ, 2008). It was also the only company in the celluloses sector to be a part of the Dow Jones Sustainability Index. More than 95% of the company's revenue came from exports.

Moreover, delivering a historical average of 50% EBITDA margin, stylized facts on Aracruz were: first Brazilian company listed on NYSE (1992) under level III in the ADR Program; first Brazilian company to publish its audited financial statements in English each quarter; its financial policy was approved by the Board and accessible on the company's website; it also won the Instituto Brasileiro de Governanca Corporativa (Brazilian Institute of Corporate Governance) award in the innovation category (ARACRUZ, 2008). By all measures, Aracruz was regarded as a solid company with good growth prospects and sizable market power.

IV. Optimal and Effective Hedge for Aracruz

The model

Here we use Bodnar and Marston's (2001) model to derive Aracruz's optimal hedge ratio during the period 1999–2008. The model has the main advantages of being simple and easy to apply to financial data.

The main hypotheses of the model are:

- The value of a firm can be expressed in terms of a stream of present and future cash flows.
- Net investment of the firm is equal to zero.
- Cash flows are expected to be constant from year to year.

From these simple assumptions, Bodnar and Marston (2001) derive the foreign exchange exposure as proportional to the derivative of current profits with respect to the exchange rate. The general result is (for its derivation, see the original paper)

$$\delta = h_1 + (h_1 - h_2)\left(\frac{1}{r} - 1\right) \tag{1}$$

in which the general exposure of the firm (δ) is a function of: h_1 = foreign currency-denominated revenue as a percent of total revenue; h_2 = foreign

Table 1. Optimal hedge for Aracruz during the period 1999–2008

Year	R (%)	h_1 (%)	h_2 (%)	Optimal hedge (δ)	EBIT (US$ '000)	Optimal hedge (US$ '000)
1999	37.73	94.64	25.00	2.10	225 462	472 539
2000	45.66	94.84	25.00	1.78	340 517	605 933
2001	28.88	96.12	25.00	2.71	177 413	481 165
2002	27.88	97.61	25.00	2.85	172 289	491 733
2003	36.37	96.14	25.00	2.21	422 542	932 130
2004	31.33	95.00	25.00	2.48	456 401	1 133 804
2005	27.33	95.95	25.00	2.85	441 924	1 257 604
2006	24.50	95.97	25.00	3.15	502 452	1 581 256
2007	23.24	93.61	25.00	3.20	570 978	1 828 438
2008	13.87	92.92	25.00	5.15	245 415	1 263 054

Notes: The table reports data on the optimal hedge for Aracruz in the period 1999–2008 from Bodnar and Marston (2001): optimal hedge is $\delta = h_1 + (h_1 - h_2)(1/r - 1)$, in which r is the *EBIT*/*Revenue*, h_1 is the foreign currency revenue in relation to total revenue and h_2 is the foreign currency costs in relation to total costs. Both h_1 and r come from financial reports. Information on h_2 comes from *investor relations* at the company. The optimal hedge in dollar terms is the simple multiplication of columns 5 and 6. The results are based on a model with some serious limitations, since there is no competition or uncertainty, but we can surpass these drawbacks by using this model not as a predictor, but as an *ex-post* check. Results show a constant growth on the optimal hedging needs for the company.

currency-denominated costs as a percent of total costs; r = profits as a percent of total revenues.

The model is flexible enough to allow for three cases: a pure exporter, a pure importer and a multinational firm which sells both domestically and abroad.

Translating (1) to real data is easy: the idea is to relate the ideal hedge to variations in the *EBIT*, the optimal hedge (h) that completely eliminates the exchange rate risk

$$h = EBIT * (-\delta) \tag{2}$$

This in variation terms is equal to

$$\Delta h = EBIT * (-\delta) * \Delta e \tag{3}$$

In which Δe is the variation in the exchange rate, measured in percentage points. The model does not cover quantity risk, in which the quantity of foreign currency exposure is uncertain due to the fact that the firm sells its product abroad, but it does not know how much it will sell or at what price. So the model has some serious limitations; there is no competition or uncertainty, which leads to very stylized assessments of risk exposure. As a result, it does not have a great prediction capability, losing its value as a reference to companies planning their hedging strategies. However, we can surpass these drawbacks by using this model not as a predictor, but an *ex-post* check whether the effective hedge was successful or not. Following this rationale, we use an *ex-post EBIT* as the main measure for the determination of the hedge ratio. We are concerned not with the company's best strategy, but with a rational hedging choice by the company's managers. If we can show whether the type of hedge was appropriate, and that the strategy used by the company was not adequate, it is not necessary to extend the model to a more comprehensive one. The possible differences found between the effective and the optimal hedge could be a result of revenue uncertainty.

Optimal hedge

The necessary data for measuring the optimal hedge h in Equation 2 are: foreign currency revenue in relation to total revenue – h_1; foreign currency costs in relation to total costs – h_2; profits in relation to total revenues (here *EBIT*/*Total Revenues*) – r. Both h_1 and r come from financial reports, but there is no reported data on h_2. Information on h_2 comes from *investor relations* at the company, and is corroborated by interviews with hedge fund managers at a major Brazilian investment bank who regularly track the company. The common view is that h_2 is close to 25% in the period analysed. We use this number and a sensitivity analysis shows that for even large changes in h_2 the results remain unchanged. For the period 1999–2008, data are presented in Table 1 (in absolute values), and the optimal hedge is the product of δ and the *EBIT*.

Table 1 shows an increasing pattern in the optimal hedge position of Aracruz, with a particular jump to a δ of 5.15 in 2008. All changes in δ are primarily due to the changes in r, because h_1 is stable throughout the period (h_2 is fixed by assumption). Since the EBIT margin (r) decreases significantly in the period 1999–2008, the optimal hedge position in US$ terms

significantly increases, from less than US$0.5 billion in 1999 to US$1.8 billion in 2008. This alone should have provided managers with strong incentives to procure more hedging for Aracruz. Further, we show how the company reacted to the increasing need for hedging.

Effective hedge

The real hedging position of Aracruz is composed of three components: liabilities in foreign currency; net assets in foreign currency; and the position in derivatives (the amount being effectively hedged instead of a simple marking to market). Here we assume, following Aabo (2006), that foreign debt is an alternative to the use of currency derivatives. Aracruz assumes a short position in derivatives to hedge against a fall in the local currency, the real short position of the company is then the sum of short-term liabilities in foreign currency plus the derivatives net position (notional values) minus net assets in foreign currency. The real hedging position for the company (h^*) is therefore

$$h^* = Liabilities + Derivatives - Assets \qquad (4)$$

For the purpose of determining h^* data came from the financial reports of the company during the period 1999–2008, with the value of the foreign currency used being the value of the Dollar against the Brazilian currency, Real, on the last day of each period.

The company used six different types of derivatives during the period 1999–2008 to hedge its position, two were standardized contracts and the others were Over-the-Counter (OTC) derivatives. The two standardized derivatives were standard futures contracts at the Brazilian Mercantile Exchange (Bolsa de Mercadorias e Futuros – BM&F) – in use during 2002 and during 2005–2007 and currency coupons, in use during 2002 and 2003.

The four OTC derivatives were: Non-Deliverable Forwards (NDF), during 1999–2002, conventional swaps, in 1999, 2007 and 2008, an exotic swap with monthly settlements and a structured derivative called sell target forward, which we credit with the company's downfall. Both were used in 2008, and the sell target forward does not show in the end of the year data because it did not exist before 2008 and all the positions regarding this derivative were settled before the end of the year.

The sell target forward was the main contributor for the excessive risk taken by Aracruz. It is a structured derivative composed of the combination of a short position in an NDF coupled with a short position in exchange-rate options. The premium received from these options enables the company to obtain better FX rates than the market. The contract is valid for a year with monthly settlements that bring the value of the whole contract to the present. This is important because it is the source of the major financial hurdle implicit in the contract. Dealing with this derivative, for Aracruz, is equivalent of selling 12 calls with successive monthly strike dates, and also 12 NDFs. As the contract constitutes a combination of calls and NDFs, there is no limit to how much the company can lose, but there is a limit for the loss of the counterparty.

An illustration should enlighten the potential loss of this derivative for the company. Suppose that the actual exchange rate is R$1.60 per dollar, the strike price is R$1.65 per US$1, the notional value is US$15 million and that at the end of the first month the exchange rate jumps to R$2 per dollar (granted, a big jump in the exchange-rate, but this is smaller than the one that happened in the financial crisis). The total losses for the company are determined by

$$l = n2t(X - S) \qquad (5)$$

And the percentage loss in US$ (Δp) in n due to changes in S is

$$\Delta p = \frac{2t(X - S) * 100}{S} \qquad (6)$$

where l is the amount of losses, n is the notional value of the contract, X is the strike exchange-rate, S the actual exchange-rate, t the number of months left in the contract and '2' is due to the double effect from this derivative as it is composed by an NDF and an exchange-rate option. For the illustrative example, $l = 15 * [2 * 12 * (1.65–2)] = -R126 million or – US$63 million at the new exchange-rate. There is no maximum loss for the contract, but a local currency devaluation of 50% exposes the company to a potential loss of eight times the notional value of the contract.[1] The risk trade-off was clearly deleterious for the company as the financial risk of this product was much bigger than the risk from operations that the company was trying to hedge.

Table 2 shows the short positions in derivatives and the pattern of hedging for the company during the period 1999–2007 using the notional values of the derivatives.

Table 2 shows that before 2008 the company incurred, in hedged positions, at most US$1.4 billion, in line with the values of the optimal hedge (h). However, in 2008 the total spikes to US$6.3

[1]The result of the following equation: $\Delta p = \frac{2*12*(X-1.5X)*100}{1.5X}$.

Table 2. Effective hedge done by Aracruz Celulose – 1999–2008 – US$ 000

Year	Futures	NDF	Currency coupons	Swaps	Exotic derivatives	Liabilities–assets	h^*
1999	0	24 148	0	41 439	0	536 501	602 088
2000	0	2864	0	0	0	298 185	301 049
2001	0	13 058	0	0	0	481 267	494 325
2002	128 500	30 000	15 849	0	0	436 243	610 592
2003	0	0	67 666	0	0	937 097	1 004 763
2004	3000	0	0	0	0	992 006	995 006
2005	500 000	0	0	0	0	850 754	1 350 754
2006	289 000	0	0	0	0	637 458	926 458
2007	150 000	0	0	334 115	0	558 970	1 043 085
2008	0	0	0	215 000	3 600 000	2 513 626	6 328 626

Notes: This table shows the real hedging position of Aracruz divided by the type of derivative used. Results show the amount effectively being hedged instead of a simple marking to market. Data come from the notes of the financial statements and are end of the period. Real hedge (h^*) is the sum of the position in derivatives plus liabilities in foreign currency minus assets in foreign currency: $h^* = Liabilities + Derivatives - Assets$. Results show that the company really started using derivatives in 2002, but did not take significant or leveraged positions until 2008. The results for 2008 show that the company still had a significant leveraged position in derivatives by the end of the year coupled with a surge in liabilities for the positions it was able to close.

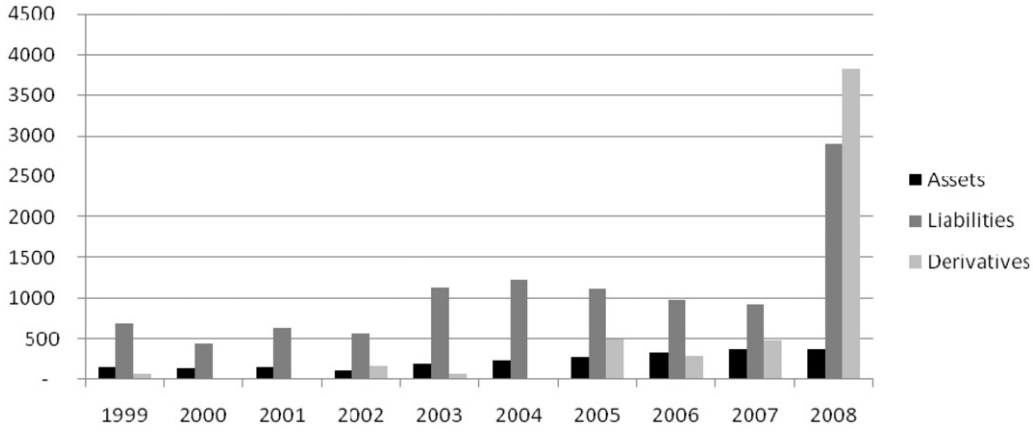

Fig. 1. Aracruz's foreign currency liabilities and assets, and derivatives short position (US$ million) – 1999–2008
Notes: The figure shows the increase in foreign currency liabilities, assets and derivatives short position of Aracruz during the period 1999–2008. Data come from the financial statements, with derivatives' total calculated with data from the notes of the financial statements. Results clearly show the impact of the company's poor management of hedging strategies by its impact on both liabilities and the derivatives position by the end of 2008. This impact came from the rapid depreciation of the Brazilian currency in September 2008.

billion and that is for the end-of-year data, after the company realized losses in derivatives trading that impacted the liabilities, as can be seen in Fig. 1.

Figure 1 shows that the company started to pursue hedging strategies more vigorously in 2003 by incurring growing liabilities in foreign currency. After 2005, there is a growing trend in the use of derivatives. We can see that for 2008 the financial burden of sell target forwards is distributed through a large increase in liabilities, as well as short positions in derivatives.

Comparing the annual optimal hedge (h) with the annual realized hedge (h^*), Fig. 2 shows how the company followed a hedging strategy that is broadly consistent with an *ex-post* optimal hedge until 2005. In 2006 and 2007, the company actually hedges less than the optimal hedge, either by underestimating the *EBIT* or its revenues. In 2008, however, the real hedge position increases to US$6.3 billion, out of line with h. This increase, however, does not reflect the highest exposition of the company in 2008.

As a result of the crisis, the company disclosed the information regarding quarterly exposition

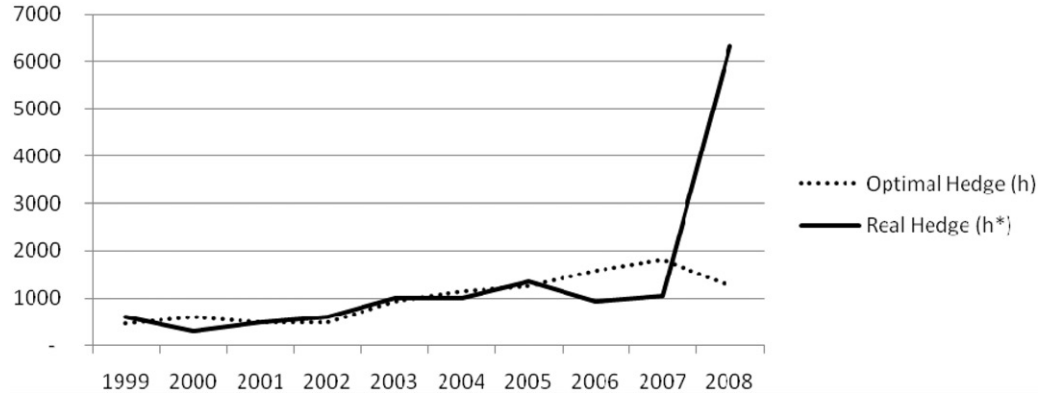

Fig. 2. Aracruz optimal and real hedge (US$ million) – 1999–2008
Notes: The figure reports data on the relationship between the optimal and real hedge positions for Aracruz during the period 1999–2008. Optimal hedge is $\delta = h_1 + (h_1 - h_2)(1/r - 1)$, in which r is the $EBIT/Revenue$, h_1 is the foreign currency revenue in relation to total revenue and h_2 is the foreign currency costs in relation to total costs, and real hedge (h^*) is the sum of the position in derivatives plus liabilities in foreign currency minus assets in foreign currency: $h^* = Liabilities + Derivatives - Assets$. The results show how in 2008 the company deviated from a long-run strategy, in which the real hedge position closely followed the optimal hedge position.

Table 3. Effective hedge done by Aracruz Celulose – 4Q07–4Q08 – US$ 000

Quarter	Liabilities	Assets	Exc-traded derivatives	Sell target forward	Exotic swap	Other OTC derivatives	Effective hedge (h^*)
4/2007	929 131	370 160	150 000	0	0	334 115	1 043 085
1/2008	929 201	402 502	270 000	0	0	345 837	1 142 537
2/2008	1 109 795	451 442	0	5 280 000	600 000	559 480	7 097 833
3/2008	1 578 190	417 930	−538 000	8 640 000	2 400 000	305 059	11 967 320
4/2008	2 888 466	374 840	0	0	3 600 000	215 000	6 328 626

Notes: The table provides quarterly exposures for Aracruz during the last quarter of 2007 and 2008. Data come from the notes on the financial statements' notional values for derivatives, in which positive values means short position. First two columns show the growth in foreign-currency liabilities and assets, with the other columns giving the notional value for each type of derivative used by Aracruz. The last column yields the effective hedge of the company, which is the sum of derivatives plus assets in foreign-currency minus liabilities. For the sell target forward, we calculate the exposure of Aracruz as $E = n2t$, in which E is the exposure, n is the notional value of the contract and t the number of months left in the contract. As we can see, the effective hedge of the company increases from US$1.1 billion to US$7 billion in the second quarter of 2008, mainly because of sell target forwards. It reaches almost US$12 billion in the third quarter of 2008 with exotic swaps also playing a role. It is in this quarter that the crisis hit the Brazilian economy. The company is then able to close some contracts, but there is a strong impact on its balance sheet – represented by the growth in liabilities in the last quarter of 2008, from US$1.5 billion to US$2.9 billion, and cash flow. Stock prices decline from R$12 to R$1.43 and the company is eventually acquired by the VCP Celulose, forming the Fibria in 2009.

to derivatives. Table 3 provides quarterly exposures for the company, by applying Equation 4 to quarterly data and using notional values for derivatives, in which positive values means short position.

Table 3 shows the poor timing of the company in using OTC derivatives to hedge its position, with h^* jumping from approximately US$1 billion to US$7 billion in the second quarter of 2008. Aracruz's exposure grew considerably in the months preceding the crisis and spiked just before the crisis hit, as a result of sell target forward. The consequence, predictably, was a massive restructuring of the company's hedging position, the sell-off of its sell target forward position, and the doubling of its liabilities in foreign-currency. In the beginning of 2009, the company was still exposed to the exchange-rate risk due to the trading of sell target forwards for more maturing swaps. The financial burden, however, resulted in the company being acquired by its smaller competitor, Votorantim Papel e Celulose (VCP), by approximately US$3 billion in early 2009. The resulting company changed its name to Fibria and is traded in the New York Exchange.

The impact of the financial crisis

One pressing question is how to relate the events that led to Aracruz's downfall with the financial crisis that began in 2007 but picked up steam in 2008. A major lesson from the crisis is that systemic risk was seriously underestimated throughout the entire financial system. However, the link between the crisis and the nonfinancial companies is less explored. We argue that even if works like Bartram (2008) are generally right – that managers do make savvy decisions regarding hedging strategies – there is still an underestimation of the number of companies pursuing badly designed hedging strategies. The main reason for such strategies not causing more financial havoc for nonfinancial companies is that, for the effect to be large enough there are two necessary conditions: the underlying risk has to be sufficiently large and/or misunderstood; and the market should move swiftly enough so that managers cannot react in time. Most of badly designed risk strategies can be mitigated, but the original feature of the financial crisis was to constrain reaction by managers on their hedging positions.

In the present case, the catalyst for losses, as previously observed, was the rapid depreciation of the Real, jump-started by the contagion of the crisis to the Brazilian financial markets. The trend before the crisis was of a continuous currency appreciation and this rapid reversion resulted in the huge losses experienced by Aracruz. No other macroeconomic shock could have conceivably made the Brazilian currency depreciate by 23% in a month, especially in a scenario in which the country was the recipient of copious amounts of foreign capital. Since early 2010, the appreciation process has returned with the Real returning to its pre-crisis level in mid-2011. The financial crisis uncovered many badly designed strategies in financial and nonfinancial companies, either directly or indirectly. If the company had a fall on revenue only, this would not be sufficient to cause the losses incurred in 2008. It was the rapid depreciation of Brazilian Real, resulting from the financial crisis that triggered huge losses with derivatives.

Agency theory and Aracruz

There is no simple explanation for why the company hedged its position as it did in the months preceding the financial crisis. Explanations in the Brazilian media at the time included incompetence, bad faith, greed and bad luck. Of course, 'bad faith' and 'bad luck' are hardly explanations at all; but if we only use Geczy *et al*. (1997) as the basis of analysis, we cannot conclude that rational incentives were responsible for such a high exposure to derivatives as experienced by Aracruz. As for the executives' incentives, the remuneration scheme was based on the performance of share prices during 3 years and there was no turnover in the position in the preceding 4 years. In general, correct incentives were given to the CFO, with a focus that was not only based on short-term gains.

We do not try to provide an explanation for overexposure of the company, but point out some possible different drivers that could have influenced Aracruz's strategy. Behavioural issues, such as hubris (see, e.g. Wiseman and Gómez-Mejia, 1998; Li and Tang, 2010; and Wiseman *et al*., 2011 for a general framework on the issue), could have contributed; errors in calculating the risks of sell target forward may have influenced the risk-taking behaviour of managers; and a lax governance structure could have permitted the strategy to go unchecked (in the last case, as we can see in the financial statements at the end of 2007, the treasury department was responsible for proposing and executing risk management strategies).

Allayannis and Ofek (2001) show that companies generally do not speculate with currency derivatives, but another issue that may have influenced the decision to enter in sell target forward contracts relates to exchange rate expectations and the financial gains with hedging before 2008. It was a common knowledge to market players that in the period preceding the financial crisis of 2008, the Brazilian currency was in a process of appreciation due to significant influxes of external capital through financial and commercial channels. Specifically, carry-trade caused an influx of external capital of over US$70 billion in 2007 and was on pace to increase by 50% in 2008, totalling over US$100 billion in new short-term capital before the crisis hit. Agents expected that the Brazilian currency would continue to rise against the dollar, continuing the process that begun in 2003. Figure 3 shows the US$S/R$ exchange rate during the period 2003–2007, showing patterns in the expectation of exchange-rate movements for 1-, 6- and 12-month horizons, plus the effective exchange rate.

The main pattern in the figure is that both expected and effective exchange rate present an appreciation of R$ against the US$ during a long period preceding 2008, followed by sharp depreciation when the crisis hit.

Whatever the true explanation, the error in the risk management strategy cost the company dearly, showcasing yet again that, as in the case of MG, proper risk management is essential for any kind of hedging. There are many implications from this case to future risk management issues in nonfinancial

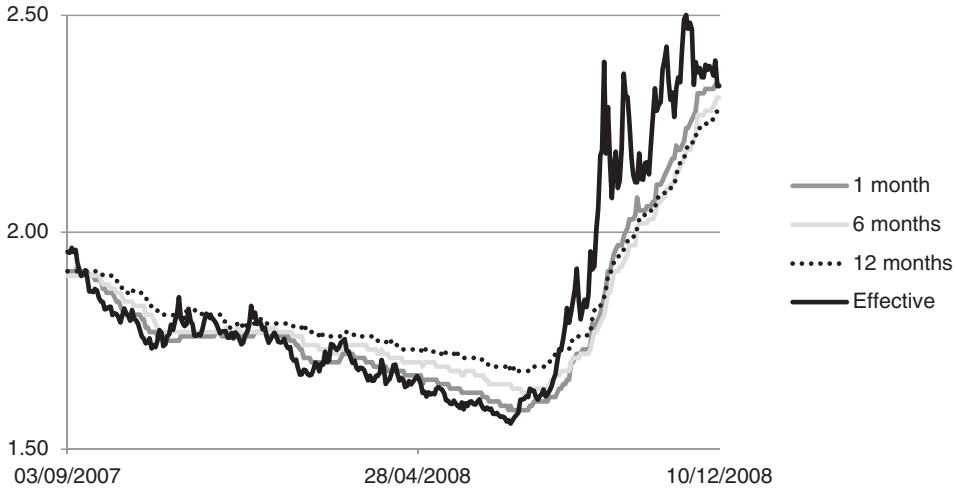

Fig. 3. Expected (1, 6, 12 months) and effective exchange rate – US$/R$ – 2007–2008
Notes: The figure shows the expected and effective exchange rate between the Brazilian currency and the US dollars. Source is the Brazilian Central Bank. There was a clear trend of currency appreciation before September 2008 and a pervasive notion that it was a continuous process that would continue for some time. The rapid depreciation took economic agents by surprise.

firms. That companies are still dabbling in excessive risk through derivatives is no surprise in itself, but the broadness of losses is staggering and future managers need to put in place the governance structures that do not allow for excessive risk-taking.

V. Final Comments

The idea that companies are efficient in using currency derivatives finds ample evidence in the literature. The main goal of this article was to provide hard evidence on the mismanagement of risk strategies that were only revealed by turmoil in financial markets due to the financial crisis. We go beyond showing just how Aracruz speculated with derivatives in 2008, contrasting with a good track performance in achieving the optimal hedge since 1999. We use the model developed by Bodnar and Marston (2001) to show that the company's real hedge position deviated from its optimal hedge.

We show how usual incentives to hedge, such as cash flow volatility, growth opportunities and leverage, are not enough to explain the risk exposure of Aracruz. We draw from behavioural finance and agency theory (such as Wiseman *et al*., 2011) and posit that the speculation with derivatives by Aracruz's executives happened because of weak governance structures related to risk management that failed in preventing *hubris* and mistakes in computing the financial risk of OTC derivatives.

This case is important because it is difficult to find an explicit evidence of agency problems resulting in speculation with derivatives, and in the present case this is coupled with significant financial losses from unexpected exchange rate movements following the financial crisis of 2008.

Future lines of research should explore this and other cases of mismanagement of hedging with derivatives to provide more information on how firms really operate their hedging positions. An important question concerns the sources of derivative losses for companies around the world. Was over-hedging also a problem for other companies? Also, cross-section analyses of companies that posted losses in derivatives could identify which governance mechanisms were ineffective in preventing excessive risk exposures.

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