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Crises: Evidence from Brazil

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Balance Sheet Effects in Currency Crises: Evidence from Brazil

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Abstract

In third generation currency crises models, balance sheet losses from currency depreciations propagate the crises into the real sector of the economy. To test these models, we built a firm-level database that allowed us to measure currency mismatches around the 2002 Brazilian currency crisis. We found that between 2001 and 2003, firms with large currency mismatches just before the crisis reduced their investment rates 8.1 percentage points more than other publicly held firms. We also showed that the currency depreciation increased exporters revenue, but those with currency mismatches reduced investments 12.5 percentage points more than other exporters. These estimated reductions in investment are economically very significant, underscoring the importance of negative balance sheet effects in currency crises.

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1. Introduction

The international financial crises in the 1990s that struck many emerging countries inspired a group of models designed to explain currency crises based on firms' decisions. Called third generation currency crisis models, they focus on the post-devaluation losses suffered by firms with unhedged foreign debt. In imperfect capital markets, these negative balance sheet effects tighten credit restrictions, leading to a reduction in investments that, according to third generation models, propels the currency crisis into the economy's real sector (Krugman, 1999; Aghion et al., 2001).[1]

To evaluate third generation models, recent literature has used firm-level information, estimating the impact on investment of balance sheet changes due to exchange rate movements. However, while in some studies firms that hold more dollar debt invest less in the wake of currency devaluation, others studies identify non-significant – or even positive – effects of the balance sheet losses on investment.[2]

As a rule, the results' ambiguity is partly due to limited data: in general, the use of foreign currency hedge instruments is only reported in the explanatory notes of financial statements. This limitation means that empirical works often disregard hedge instruments and use dollar debt as a proxy for currency mismatches. Consequently they overestimate currency mismatches and underestimate the impact of currency losses on the firms' investments, a bias that should vary in different countries depending on firms' hedging vehicles.

In this article, we test the transmission mechanism for balance sheet losses using a database that allows us to measure the currency mismatches – defined as foreign currency debt net of foreign currency assets and derivatives – of publicly held Brazilian firms between 2000 and 2004. This period includes the Brazilian currency crisis of 2002, which resulted in a 53% depreciation of the *real* vis-à-vis the dollar. Having a currency mismatch measure, we may adopt an empirical strategy that focuses on the central implication of third generation models: the drop in investment by firms with unhedged foreign currency debt resulting from currency depreciation.

If the balance sheet loss resulting from currency devaluation were the only significant event of 2002, the difference in investment (before and after the crisis of 2002) by firms with unhedged foreign debt just before the crisis would give us an estimate of the balance sheet

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[1] Hubbard (1998) reviews the literature on investment and credit market imperfections.
[2] For a review of literature that tests the balance sheet effects of currency depreciation, see Galindo et al. (2003a).

effect. It is quite unlikely, however, that the balance sheet effect was the only important channel of the crisis of 2002. Currency crises almost always affect the economy's relative prices, for example, impacting firms' investment propensity. Thus, the difference in investment by firms with currency mismatches reflects not only balance sheet effects, but also other consequences of the crisis, that may not be observable, but that impact all firms, as well as other events that happened during that period.

There is, however, a simple way to separate balance sheet effects from other effects. The difference in investment by firms without pre-crisis currency mismatches would seem to capture the full range of effects from the crisis, except for balance sheet effects. Therefore, the difference in investment changes by firms with and without currency mismatches provides estimation – called differences-in-differences – of the balance sheet effects.

Applying this difference-in-differences method to our data supports the conclusions of third generation models. Adopting 2001 as the base year (the year prior to the crisis of 2002), the effect of the 2002 depreciation on publicly held firms that reported balance sheet losses was that they reduced their investment rates more than firms that did not report losses: 8.1 percentage points in 2003 and 5.5 percentage points in 2004. Given that the average investment rate of all the firms was 8.1% in 2001, the significant economic impact of balance sheet effects is more than evident.[3]

As we elaborate in the text, the estimates for investment cuts incorporate firm characteristics to control any bias in selecting the firms with unhedged foreign debt (treatment group) and the firms without currency mismatches (control group). These two groups were formed in such a way that balance sheet effects would apply only to the treatment group. This differences-in-differences approach, however, is contingent on the reliability of the currency mismatch measure used to establish the treatment and control groups.

We may strengthen the reliability of the treatment and control groups by considering a subset of these two groups: export firms. Currency depreciation should not only indicate financial losses for firms with unhedged foreign debt, it should also mean competitive gains for export firms. In this case, the logic of third generation models predicts increases in investments by export firms, which should be less dramatic for exporters with unhedged foreign debt.

The results do in fact show very significant competitiveness and balance sheet effects following the Brazilian crisis of 2002. Between 2001 and 2003, export firms increased net

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[3] Our differences-in-differences approach follows Abadie (2005).

revenue 16.8% more than firms that did not export, and their investment rates rose 7.2 percentage points more than their non-exporting counterparts. In the same period, and consistent with third generation models, the investment rates of exporters with currency mismatches just prior to the crisis fell 12.5 percentage points more than the rates of export firms without currency mismatches.

Data from the Brazilian currency crisis of 2002 support that there is a sharp drop in aggregate investment during currency crises in economies where a large number of firms have unhedged foreign debt.

The remainder of the article is organized as follows: the next section briefly describes some empirical evidence on balance sheet effects; Section 3 describes the database; Section 4 estimates the balance sheet effect of the currency depreciation of 2002 on investment rates and analyzes the robustness of the results; Section 5 estimates the balance sheet effect together with the competitiveness effect of the crisis of 2002; lastly, Section 6 concludes.

2. Existing Evidence

The emerging market currency crises of the 1990s were characterized by dramatic drops in economic activity and collapsing financial systems. These crises fueled debate on the impact that currency depreciation had on economies' performances. Extensive theoretical writing ensued, showing that when currency mismatches are present, currency devaluations can be contractionary, reversing the expansionary effects of the conventional open economy models. However, these models do not provide conclusive results. For example, Céspedes et al. (2002) show that depreciations are contractionary only when there are simultaneously high levels of foreign debt and large imperfections in the international capital markets.

In fact, Céspedes (2004) and Galindo et al. (2003b), using macroeconomic data from a set of countries, found evidence that foreign debt reduces the expansionary effect of currency depreciations, and may even turn them contractionary in cases of high foreign debt. These results were not fully confirmed, however, by studies using firm-level data. Using a sample of firms from seven Latin American countries in the 1991-1999 period, Bleakley and Cowan (2002) found that firms with greater foreign currency debt invest more following periods of currency depreciation. On the other hand, Aguiar (2005) showed that after the Mexican crisis of 1994, the exporters' investment was constrained by weak balance sheets.

An initial attempt to reconcile these ambiguous results was made by articles that analyzed the importance of the balance sheet effects for six Latin American countries separately

(Argentina, Brazil, Chile, Colombia, Mexico and Peru).[4] These articles followed the standard approach of Bleakley and Cowan (2002), but presented some innovations as the use of dynamic panel techniques (GMM) to incorporate the covariance structure in time and address possible endogeneity problems of the independent variables. The evidence from these studies is also inconclusive. While for Mexico, Argentina, Peru and Brazil the balance sheet effects were negative and significant, for Colombia and Chile the balance sheet losses provoked by currency depreciation did not significantly impact their firms' investments.[5]

The ambiguity continued. The most recent attempt to test balance sheet effects sought more precise measures for currency mismatches that would incorporate firms' currency hedge positions. Cowan et al. (2005) studied the case of Chile and showed that, consistent with previous studies on Chile, firms with higher foreign currency debt did not invest less after periods of currency depreciation. However, when foreign debt was measured net of currency assets and derivatives, the balance sheet effects of currency depreciation became negative and significant.

This article follows the line of Cowan et al. (2005) by incorporating currency hedge positions into our measure of currency mismatches. However, our work differs from his and the other aforementioned articles in that it limits the sample period to the time around a specific currency crisis. We emphasized building a control group of firms that were not subject to the balance sheet losses proposed by third generation models. As explained in the introduction, the control group allowed us to isolate the impact of balance sheet effects using only investment data around the time of the crisis. Restricting the sample period to the years just before and after the crisis, we lowered the risk of capturing structural breaks that would distort the results.[6] Additionally, the appropriate selection of control groups made it possible to test more directly the impact of balance sheet effects, for example, by comparing investment by exporters with and without currency mismatches.

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[4] The articles were published in a special edition of the Emerging Markets Review 2003; 4.

[5] In the case of Brazil, we adopted the results described in Bonomo et al. (2003), which is a revised version of the article these authors published in the Emerging Markets Review 2003.

[6] Bonomo et al. (2003), for example, argue that the negative balance sheet effects in Brazil were limited to the floating exchange rate period (1999-2002). When they restricted the sample to the period 1991-1999 that Bleakley and Cowan (2002) used, which included only one year of floating exchange rate, the balance sheet effects were positive.

3. Data Description

3.1 Sample Period

This study is built around the Brazilian currency crisis of 2002. In that year, the Brazilian exchange rate fell approximately 53% in relation to the dollar. The devaluation of the Brazilian currency began in April and reached its maximum in September of 2002, on the eve of presidential elections in which a leftist party was highly favored to win (which proved accurate). What, luckly, did not prove accurate were market expectations regarding the aconomic policy put in place by the new government. The new President Lula´s economic policy kept the three basic pillars of his predecessor´s: inflation targeting regime, floating exchange rate and high primary government surpluses. Firms that had heavy unhedged foreign debt suffered enormous financial losses in the crisis. Moreover, the cost of foreign loans rose considerably and the rollover rate for foreign currency debt fell, indicating tighter credit restrictions.[7] These conditions offer a natural experiment for testing the balance sheet effects predicted by third generation models. In order to analyze this experiment we identify a treatment group formed of firms that reported large financial losses with the currency depreciation of 2002 and a control group formed of firms that did not report balance sheet changes.

After identifying the control and treatment groups, we tested the balance sheet effects using the "difference-in-differences" method, which compares the average difference in investment rates of firms in the control and treatment groups before and after the currency depreciation. Implementing our econometric strategy required, however, pre-crisis data, for which we used only the years 2000 and 2001 to avoid contamination from the currency crisis of January 1999, which culminated in flexibilization of Brazil's exchange rate regime. As post-crisis periods, we evaluated only the two years following the crisis (2003-2004). The year 2002 was not included in the sample: the currency depreciation began in April of 2002, which could affect the results if firms invested in the first quarter of the year. Figure 1 traces

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7. The Central Bank of Brazil's 2002 Annual Report shows that the rollover rate for notes and commercial papers fell from 83% in the second half of 2001 to 16% in the second half of 2002, while that of direct loans fell from 111% to 68% for the same comparison period. Although we do not have data on firms' borrowing costs, the country risk, measured by the Emerging Markets Bond Index Plus (EMBI+), an index calculated by JP Morgan, shows that the premium on Brazil's portfolio of securities over US Treasury securities with the same terms reached a record high of 2.436 base points on September 27, 2002. As the cost of overseas borrowing for firms is positively correlated with the cost of the country's borrowing, the EMBI+ suggests there was a rise in loan costs for firms in 2002.

Brazil's nominal exchange rate between 1997 and 2004, particularly the substantial depreciations in January 1999 and during the second semester of 2002.

Figure 1: Nominal Exchange Rate (Real/US$)
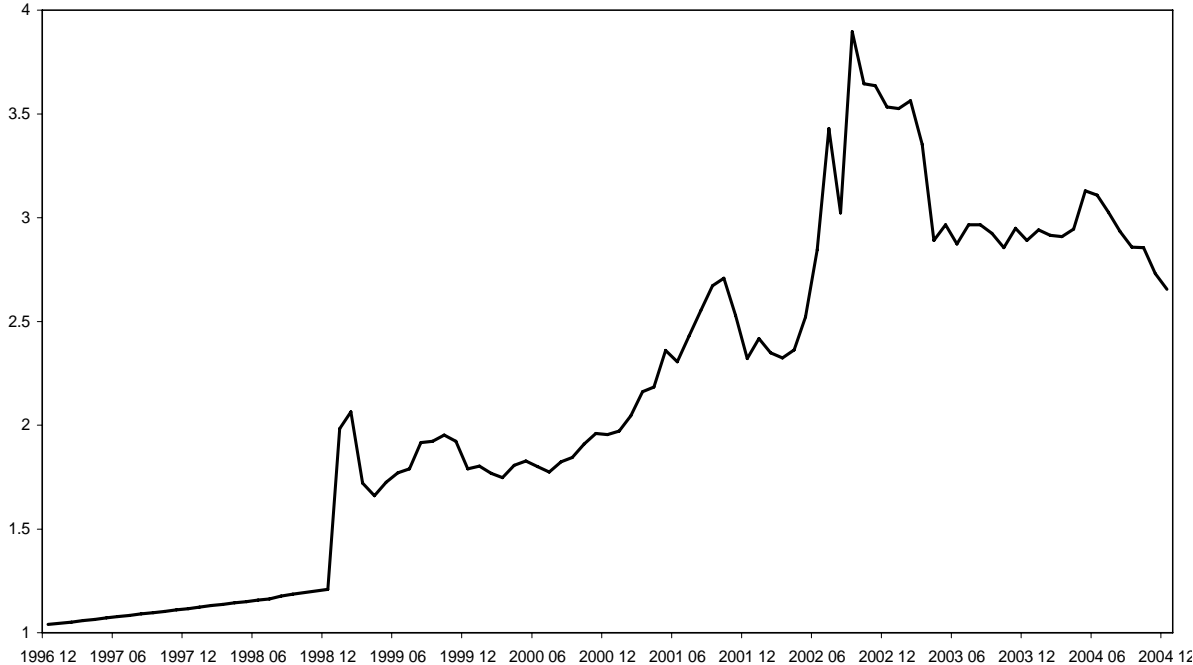
Source: Central Bank of Brazil

3.2 Sample Selection and Database

Once the sample period was determined, we described the sample firms. The Economática database served as the foundation for the sample selection.[8] From an initial sample of 477 Brazilian publicly held firms, we established an unbalanced panel of 274 firms. We excluded firms in the financial and insurance sectors (43 firms); those that were not trading publicly in December of 2002 (125); diversified holding firms with stakes in financial firms or without operating revenues (26); those whose balance sheet dates were not December (2); and those that did not have financial statements available for our sample period (4). Three firms were also excluded because their balance sheets were practically identical to those of other sample firms in the same economic group.[9]

With the sample defined, we then obtained information on the financial variables to be used in our analysis: investment rate, total assets, total revenue, operating profit and bank

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[8] Information about Economática may be obtained at www.economatica.com.
[9] From each pair of firms with very similar balance sheets, we included the one with higher total assets.

debt, the latter being the total debt in foreign currency plus debt in domestic currency, including debentures. While the investment rate, total assets, total revenue, operating profit and debentures were obtained from the Economática database, the currency composition of bank debts and assets was collected from the explanatory notes of consolidated balance sheets.

We used the firms' consolidated financial statements instead of the controlling firms' statements because many publicly held Brazilian firms are holding firms with no operating income or debt in foreign currency during the period analyzed.[10] Additionally, many of the firms analyzed, even those that are not holding firms, borrowed overseas or had foreign currency assets through controlled firms. Thus, by consolidating the data we were also analyzing the firms that are not publicly held, but were directly or indirectly controlled by the firms in our sample.

To test the balance sheet effects, we measured firm performance by its gross investment rate, which is the sum of fixed asset variation plus depreciation divided by once lagged fixed assets.[11] So that this investment measure would most accurately reflect the balance sheet effect of currency depreciation, we made some adjustments to our sample. First, we excluded 30 firms that reported negative net worth before the crisis of 2002. These firms were probably in financial distress prior to the currency shock, which could distort their investment policies. We then researched news reports on each firm to identify changes in capital during the sample period that were not directly related to currency depreciation, such as mergers and acquisitions, the sale of stock holdings in subsidiaries and reassessments of fixed assets; these normally imply changes in assets not related to balance sheet effects.[12]

Unfortunately, we did not find standardized information on the values of capital changes attributed to these events. Where we found the total amount of the operations, we excluded the observations (firms-year) from the sample when the value exceeded 10% of a firm's assets, assessed at the beginning of the year in which the operation took place.[13] This criterion prevented small transactions from eliminating material information about the firms' investments. However this criterion may not be used in cases where the value of the stock transactions or asset reassessment was not reported in the news. In these cases, we avoided

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[10] For example, on the balance sheets of the 274 controlling firms in the sample in 2001, 53 firms did not report operating revenue and 101 firms did not have foreign currency debt. Consolidating controlling firm data with that of their controlled firms, the number of sample firms without foreign currency debt fell from 101 to 57.

[11] We did not use capital expenditures to measure investment, as this would significantly reduce our sample size due to the small number of firms for which Economática has this information.

[12] This research was conducted in the news contained in the Economática database.

[13] The results of the regressions described in the following section did not change qualitatively with the use of lower cutoff values, such as 5% and 1% of assets.

distortions of investment rates by excluding the observations in which the absolute value of the firms' gross investment rates exceeded 40%.[14] In total, analysis of firm news reports resulted in the exclusion of 54 observations.

In addition to the financial variables, we collected import and export data on the firms in our sample from the Foreign Trade Secretariat (SECEX). These data are important to our study for two reasons. First, import and export data allow us to analyze the competitiveness effect of currency depreciation, and second, they can influence currency mismatches and investment decisions and are thus important variables in our econometric analysis. Both the export and import values were converted into domestic currency using the year's average exchange rate, and like the other variables described in this section, subsequently deflated by the Consumer Price Index (IPCA).[15]

Lastly, we calculated the currency mismatch for each firm in our sample to identify which of them suffered significant balance sheet losses from the currency depreciation of 2002. We defined currency mismatch as debt linked to foreign currency net of foreign currency assets and derivatives. Data on foreign currency debt and assets were colected from the explanatory notes of the firms' consolidated annual balance sheets, which were obtained from the Securities and Exchange Commission of Brazil (CVM). Foreign currency debt was calculated by the sum of loans in foreign currency, commercial debts, supplier financing and foreign securities. Foreign currency assets were calculated as the sum of financial market investments in foreign currency (cash, government issues indexed to the dollar and overseas client credits).

Positions in foreign currency derivatives reported in balance sheet notes include currency swaps contracted domestically or overseas as well as other currency derivatives like dollar options, futures and forwards.[16] However, many of the firms that report positions in foreign currency derivatives do not specify the amounts, but rather report only their spending and revenues on these contracts. Other firms report positions in foreign currency derivatives together with positions in interest rate derivatives; in these cases we did not use this balance

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[14] The results of the regressions described in the following section did not change qualitatively with the use of minimum cutoff values for investment rates equal to 30% and 50% in absolute value.

[15] To reconcile SECEX data and financial data, we identified the firms by their Corporate Taxpayer Identification Numbers (CNPJ). This allowed us to consider firms with different CNPJs separately, even if they are in the same group. Since we used consolidated data, we also obtained import and export figures for 334 firms that are subsidiaries or associate firms of controlling firms in our sample. Our export measure was either the consolidated export figures reported in balance sheet explanatory notes or the sum of the exports of the controlling and controlled firms obtained from the SECEX (sum weighted by the respective stock holdings), whichever was greater. For imports we used only the SECEX database, since most financial statements do not report import spending.

[16] To accurately assess positions in currency options, we must know each option's strike price. As this detailed information was unavailable for most of the firms, we considered the consolidated financial positions in options reported in balance sheet notes.

sheet information. To minimize such gaps, we complemented the data with information on foreign currency swaps between financial institutions and non-financial firms between 1999 and 2002 registered with the Clearing House for the Custody and Financial Settlement of Securities (CETIP). Oliveira (2004) was the first to compile these data, based on confidential information from the Central Bank of Brazil.

3.3 Sample Statistics

Table 1 shows the number of sample firms each year and classifies them in one of the following seventeen sectors: Food and Beverages, Commerce, Civil Construction, Energy, Electro-electronics, Industrial Machinery, Mining, Non-metallic Minerals, Paper and Pulp, Oil and Gas, Chemical, Steel and Metallurgy, Telecommunications, Textiles, Transportation Services, Veichles and parts, and others.[17] The final sample contains an average of 218 publicly held firms in the sample period, with a maximum of 232 in 2001 and a minimum of 197 in 2004. The main reason for this reduction between 2001 and 2004 was not the currency crisis of 2002, but changes in the firms' ownership structure: all sample firms that closed their capital after 2002 reported positive net worth.[18]

One essential condition for our strategy to test balance sheet effects was a representative sample of firms with foreign debt prior to the crisis. Table 2 shows that 77.6% of our sample firms had debt in foreign currency in December of 2001, a percentage that changed little during the sample period. A more detailed analysis (not presented in the table) indicates that only 7.6% of the firms did not have foreign debt throughout the entire sample period. However, firms with foreign debt may manage exchange risks using hedge instruments designed to avoid losses with devaluation of the *real*. Table 2 shows that in December of 2001, 53.9% of the sample firms had foreign currency assets or derivatives: 38.8% had derivatives while 33.2% had foreign exchange assets. In addition to the hedge instruments, foreign currency debts may be covered by future export revenue net of imports, which could circumvent the credit restrictions that could imply a reduction in investment.

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[17] The industry divisions are those used by Economática to classify publicly held Brazilian firms. As there was only one firm in the Agri and Fisheries sector, we included it in the Food and Beverage sector.
[18] The telecommunications sector accounted for much of the reduction in the number of sample firms. When the privatization of Telebrás ended in 1997, many of the privatized firms underwent corporate restructuring and were incorporated by the controlling firms.

Table 1: Number of Firms in the Sample per Sector

Sector / Year	2000	2001	2002	2003	2004	Mean
Total	204	208	204	194	177	196
Food and Beverages	14	14	14	15	12	14
Commerce	9	10	10	9	8	9
Civil Construction	13	13	11	12	10	12
Electro-Electronics	9	10	9	9	8	9
Energy	27	26	26	28	26	27
Industrial Machinery	9	8	9	7	6	8
Mining	3	3	3	3	3	3
Non-Metalic Minerals	6	6	6	5	4	5
Paper and Pulp	8	9	9	9	8	9
Oil and gas	8	8	8	7	6	7
Chemical	18	18	17	16	17	17
Steel and Metallurgy	26	27	25	25	25	26
Telecommunications	19	21	23	15	13	17
Textiles	21	20	20	20	18	20
Transportation Services	2	3	2	3	1	2
Veichles and Parts	12	12	12	11	12	12
Others	20	24	24	23	20	22

Note: The firms were classified per sector based on the Economática database. From an initial sample of 477 publicly held Brazilian firms, we selected 274 non-financial firms for the sample to be used in this article. We excluded firms in the financial and insurance sectors (43 firms); those that were not trading publicly in December of 2002 (125); diversified holding firms with stakes in financial firms or that did not have operating revenue (26); those that did not close their fiscal year in the month of December (2); those that did not have the necessary testing data (4); and three firms with balance sheets practically identical to other firms in the same economic group. We also excluded 54 observations of firms that underwent significant capital changes, such as mergers and acquisitions, sale of holdings in controlled firms, or reassessment of fixed assets.

In fact, Table 2 does show a significant number of exporters and importers: in December of 2001, 58.2% of the firms exported and 67.7% of the firms imported. As the exporters usually have some importing activity (but not necessarily vice-versa), it is not surprising that there are more importers than exporters in our sample. However, the import and export figures of many of these firms account for a very small percentage of their total revenue, while aggregate figures show considerable imports and exports for our sample firms, accounting for 39.4% of Brazil's exports and 26.5% of its imports in 2004 (figures not presented in the table).

Table 2: Characteristics of Sample Firms

Characteristic of firms / Year	2000	2001	2002	2003	2004	Mean
With foreign currency debt	77.7%	77.6%	78.1%	79.3%	77.7%	78.1%
With foreign currency assets and/or derivatives	47.3%	53.9%	61.8%	58.1%	59.4%	56.0%
With foreign currency assets	30.4%	33.2%	37.7%	41.0%	41.1%	36.5%
With foreign currency derivatives	28.1%	38.8%	46.9%	35.5%	35.0%	37.0%
With export revenues	59.8%	58.2%	58.3%	60.4%	57.9%	58.9%
With import expenditures	71.9%	67.7%	67.5%	64.5%	65.5%	67.5%

Note: This table presents the percentage of the number of firms in the sample with debt, assets and derivatives in foreign currency, export revenue and import expenditures each year.

Table 3 presents descriptive statistics. Just before the crisis of 2002 (December of 2001), firms had foreign debt equal to 14.8% of their assets. This amount implies large balance sheet losses after 53% currency depreciation like the one in in 2002. However, for these losses to negatively affect investments, these firms must not have matched their foreign currency debt with income linked to the exchange rate. The second and third lines of Table 3 show that the losses resulting from foreign currency debt in 2002 were partially offset by gains from hedging. Foreign currency debt in 2001 was partially covered by foreign currency assets (3.1% of total assets) and derivatives (3.7% of total assets), reflecting an average currency mismatch equal to 8% of total assets.

In 2002, average foreign currency debt and derivatives as a percentage of total assets grew substantially. However, at least some of this growth was due to currency depreciation, which impacted the value in domestic currency of these variables. After the crisis, the currency mismatch fell to 6.5% of total assets in 2003 and 5.6% in 2004. For the entire sample period, the median currency mismatch, equal to 2.6% of total assets, was far less than the 7.2% average, which indicates that some firms had considerable unhedged foreign debt. In fact, a median equal to zero foreign currency assets and derivatives shows that over half the firms did not hedge their exposure in the sample period.

Table 3 also shows that exports also rose in the period, on average accounting for 10.8% of total revenue while imports accounted for 3.4%. Thus, the average percentage of total export revenue net of imports was 7.3%. Average operating profit before tax and interest was 8.5% of assets. The gross investment rate went from 10.7% in 2000 to 8.3% in 2001, reaching its 3.3% low in 2002. After the crisis, investment gradually recovered: 5.5% in 2003 and 9.4% in 2004.

Table 3: Descriptive Statistics

Variable / Year	2000	2001	2002	2003	2004	Mean	Median
Foreign currency debt / Total asset	14.1%	14.8%	17.2%	14.7%	11.9%	14.6%	10.8%
Foreign currency asset / Total asset	2.3%	3.1%	3.8%	3.7%	3.3%	3.2%	0.0%
Foreign currency derivatives / Total asset	2.1%	3.7%	7.6%	4.5%	3.0%	4.2%	0.0%
Currency mismatch / Total asset	9.8%	8.0%	5.8%	6.6%	5.6%	7.2%	2.6%
Exports / Total revenue	10.3%	10.4%	10.2%	11.3%	11.7%	10.8%	1.0%
Imports / Total revenue	3.7%	3.2%	3.2%	3.2%	3.5%	3.4%	0.4%
Net exports / Total revenue	6.5%	7.2%	6.9%	8.0%	8.2%	7.3%	0.0%
Operational profit / Total asset	7.1%	8.1%	8.6%	8.1%	10.7%	8.5%	8.5%
Investment rate	10.7%	8.3%	3.3%	5.5%	9.4%	7.4%	3.7%
Total revenue (US$ million)	1086	1.038	775	1.052	1.278	1.046	294
Total asset (US$ million)	1.774	1.598	1.161	1.430	1.418	1.476	131
Total debt / Total asset	25.5%	26.8%	29.5%	27.8%	24.9%	26.9%	26.3%

Note: This table presents the descriptive statistics on the firms during the sample period. Foreign currency debt was calculated as the sum of all debts indexed to or denominated in foreign currency, whether borrowed domestically or overseas. Foreign currency assets were calculated as the sum of financial market investments in foreign currency, mainly cash, government issues indexed to the dollar and overseas client credits. Foreign currency derivatives include positions in swaps contracted domestically or overseas and positions in other foreign exchange derivatives such as dollar options, futures and forwards. Currency mismatches were measured by the total foreign currency debt net of foreign currency assets and derivatives. Exports were measured by either the consolidated export figures reported in balance sheet explanatory notes or the sum of the exports of the controlling and controlled firms obtained from the SECEX (sum weighted by the respective stock holdings), whichever was greater. Imports were calculated by the value of import spending by controlling and controlled firms (weighted according to their respective holdings), obtained from SECEX. Both exports and imports were converted into domestic currency using the average exchange rate of each year. Net exports are exports net of imports. The investment rate is defined as $(K(t) - K(t-1) + depreciation) / K(t-1)$, where the capital stock (K) is defined as fixed assets net of depreciation. Total debt was calculated by the sum of the value of loans and financing in foreign currency and in domestic currency, including debentures. Operating profit was taken before tax and interest. Total revenue and total assets were converted into dollars using the exchange rates at the end of each year.

In terms of firm size (total assets and total operating revenue), the sample is highly varied because there were few large firms. While the median firm had total assets of 131 million dollars and revenue of 294 million, average total assets and average total revenue were equal to US$ 1.5 billion and US$ 1.0 billion, respectively. In terms of financial leverage measured by the percentage of total debt over total assets, the sample was not so disparate, with an average and median of 26.9 and 26.3%, respectively.

4. Balance Sheet Effects

In the previous section, we provided evidence of the aggregate level of large currency mismatches just before the currency crisis of 2002. These currency mismatches lead to severe balance sheet losses in the event of currency devaluation. According to third generation models, these losses induce credit restrictions that in turn force firms to abandon investment projects.

In this section, we identify which firms presented foreign currency mismatches prior to the crisis of 2002 and test whether these firms (our treatment group) reduced their investments more than firms that did not report post-crisis balance sheet changes because they did not have currency mismatches (our control group).

4.1 Treatment and Control Groups

Table 4 shows that, in fact, a large percentage of firms had large currency mismatches in December of 2001. For example, 25% of the firms had currency mismatches exceeding 12% of assets, and 10% of the firms had currency mismatches exceeding 25% of their assets. On the other hand, some firms had null or negative currency mismatches. Statistics not given in the tables identify 33 firms (14.2% of the total) with positions in currency assets or derivatives exceeding their foreign currency debt, and another 53 firms (22.8%) without currency mismatches in 2001, because they were either perfectly matched or reported no foreign currency positions on their balance sheets. Thus our sample contains a considerable number of firms that reported heavy losses from the crisis of 2002 and a large number that did not report losses.

To estimate the balance sheet effects of currency depreciation on firms' investment, we would ideally compare investment rates by firms that reported losses with their investment figures when there was no crisis (counterfactual). Unfortunately, there is no information on how much these firms would have invested if the crisis had not occurred. To address this problem, we compared the investment rate changes (before and after the crisis) of firms that reported losses from the crisis due to currency mismatches (treatment group) and firms that reported no crisis-related balance sheet changes (control group). The control group's average investment change thus gives us a way to replicate the counterfactual. To ensure that this counterfactual is accurate, we must then monitor possible selection differences between firms with and without currency mismatches.

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Table 4: Distribution of the firms' currency mismatches

Percentile	Currency Mismatch / Total Asset
1%	-8.6%
5%	-3.8%
10%	-0.8%
25%	0.0%
50%	3.2%
75%	12.2%
90%	25.0%
95%	34.7%
99%	48.3%

Note: This table presents the distribution of currency mismatching on total assets of the sample firms in the year 2001, just before the currency crisis of 2002. The currency mismatch is measured by foreign currency debts net of foreign currency assets and derivatives.

Table 5 presents the results of tests of differences in averages of characteristics of the firms with and without mismatches just before the currency crisis of 2002. The group with mismatches has 102 firms while the control group has 130. The group of firms with mismatches includes all the firms that in 2001 had currency mismatches exceeding 5.3% of their assets. This cutoff value was chosen in such a way that the control group firms had an average currency mismatch over assets equal to zero.

The first line of Table 5 shows there was no statistically significant difference in the two groups' investment rates: the firms with mismatches invested an average of 7.6%, compared to the 8.9% of firms without mismatches. The average currency mismatch of firms with mismatches was 18.4% of assets in 2001, a level that results in average losses of nearly 10% of assets after a 53% currency shock like the one in 2002.

Firms with mismatches had a larger percentage of revenue from exports, 12.6% as compared to the 8.7% of firms without mismatches, but the difference in averages is not statistically significant. The average difference in import figures between the groups was only 0.3% of revenue, firms with mismatches being slightly ahead. On average, the firms with mismatches reported export revenue net of imports equal to 9.2% of total revenue, as compared to 5.5% of the matched firms. This difference in averages, however, is not significant to 10% (p-value of 0.111). The groups presented no significant differences in operating profit. In terms of size, the firms in the treatment group (with mismatches) were considerably larger than the firms in the control group. On average, the logarithms of the net revenue and assets of mismatched firms were equal to 13.6 and 14.1 as compared to the

matched firms' 12.7 and 13.2. The mismatched firms were also significantly more leveraged, with debt of 36.3% of assets as compared to 19.4% of the group with matches. Foreign currency debt largely accounted for this leverage difference, as both groups reported average domestic indebtedness of around 12% of assets.

In summary, the results in Table 5 show that the groups of firms with mismatches differed significantly from firms without mismatches, not only in terms of currency mismatches, but also in terms of size and leverage.

Table 5: Summary of financial characteristics of firms with and without currency mismatches in 2001

Groups of Firms	Mismatched (N=102)		Matched (N=130)		Mean Difference (*p*-value)
Variables	**Mean**	**Median**	**Mean**	**Median**	
Investment rate	7.6%	2.9%	8.9%	6.0%	-1.3% (0.589)
Currency mismatch / Total asset	18.4%	15.0%	0.0%	0.0%	18.4%*** (0.000)
Exports / Total revenue	12.6%	3.9%	8.7%	0.0%	3.8% (0.111)
Imports / Total revenue	3.4%	1.0%	3.1%	0.1%	0.3% (0.742)
Net exports / Total revenue	9.2%	0.5%	5.5%	0.0%	3.7% (0.111)
Operational profit / Total asset	8.4%	8.4%	7.9%	8.2%	0.4% (0.712)
Log total revenue	13.6	13.9	12.7	12.7	0.9*** (0.000)
Log total assets	14.1	14.2	13.2	13.0	0.9*** (0.000)
Total debt / Total asset	36.3%	35.6%	19.4%	16.3%	17.0%*** (0.000)
Domestic debt / Total asset	12.3%	11.3%	11.8%	6.9%	0.5% (0.753)

Note: Selected summary statistics for firms with and without mismatches in 2001, just before the crisis of 2002. The investment rate is defined as (K (t) – K (t-1) + depreciation) / K (t-1), where the capital stock (K) is defined as fixed assets net of depreciation. The currency mismatch is defined as foreign currency debt net of foreign currency assets and derivatives. The firms classified as having mismatches are those with currency mismatches exceeding 5.3% of their assets in 2001. We chose this cutoff value for the mismatched group so that the control group would have an average currency mismatch over assets equal to zero. Exports and imports were converted into domestic currency using the average exchange rate for each year. Net exports are exports net of imports. Operating profits were calculated before tax and interest. Total debt was calculated by the sum of the value of financing and loans in foreign currency and in domestic currency, including debentures. The far right column shows the differences in means and the *p*-values for tests of equality of means with different variances between the firms with and without mismatches. The coefficients significant to 10, 5 and 1% are indicated by *, ** and ***, respectively.

4.2 Methodology and Results

In order to test whether the currency crisis caused firms with currency mismatches to reduce their investments more than firms without currency mismatches, we conducted two sets of tests. The first was based on the differences-in-differences method and the second on propensity score matching. These methods of estimation are used in studies designed to evaluate the effectiveness of a specific exogenous intervention policy, estimating the policy's average effect (treatment) on the individuals affected (treated) by the policy.[19] In our study, the treated firms are those that had large currency mismatches in the period immediately prior to the currency depreciation of 2002, that is to say those that were (negatively) impacted by the currency depreciation. The treatment effect is the impact on investment of losses resulting from the currency depreciation.

4.2.1 Differences-in-differences

The differences-in-differences approach estimates the balance sheet effect of the currency crisis on investment by the difference in average investment rate changes (before and after the crisis of 2002) of two groups of firms. One group had crisis-related balance sheet losses because they had unhedged foreign currency debts (treatment group), and the other group reported no losses (control group). The differences-in-differences estimator is as follows:

$$\left(\frac{\sum\limits_{i \in treatment} Y(i,t)}{M} - \frac{\sum\limits_{i \in treatment} Y(i,t-1)}{M} \right) - \left(\frac{\sum\limits_{i \in control} Y(i,t)}{N} - \frac{\sum\limits_{i \in control} Y(i,t-1)}{N} \right)., \tag{1}$$

where $Y(i,t)$ is the investment rate of firm i in year t, M is the number of firms in the treatment group (firms that reported crisis-related losses) and N is the number of firms in the control group (firms that did not report losses).

The idea of the differences-in-differences estimator is quite simple. If the balance sheet losses resulting from currency depreciation were the only significant event of the year 2002 that impacted investment, we could estimate this impact simply by the changes in investment rates (before and after the crisis) of firms with currency mismatches (treatment group). However, since it is highly unlikely that the balance sheet effect was the only significant

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[19] Some examples of intervention policies tested in empirical studies are aid programs, training, tax credits and unemployment insurance policies.

event in 2002, we deduced the control group's investment difference from the treatment group's investment difference. Since the control group's balance sheets were not affected by the currency depreciation, this difference in differences must exclude other events that could have influenced investment in the period.

The differences-in-differences estimator therefore should isolate the impact of balance sheet effects on investment, unless there was selection bias in forming the two groups. Selection bias may suggest, for example, distinct trends in the two groups' investment trajectories, independent of balance sheet effects. In the absence of due control, these pre-existing trends would lead to a distorted estimate of the balance sheet effect.

However, not all selection bias creates problems in the differences-in-differences method. Biases arising from variables that are constant over time (observed or not) are absorbed in the fixed effects of the differences-in-differences model. Examples of these variables are the industries, geographical locations and nationality of the firms. Relevant bias then is associated with selection variables that vary over time. The traditional way of handling pre-existing trends is to obtain the differences-in-differences estimator based on a regression model, in which specific variables are introduced linearly to monitor the trends of the treatment and control groups. Following Abadie (2005), we adopted this econometric specification:

$$Y(i,t) = \mu + X(i) \cdot \pi(t) + \tau \cdot D(i,1) + \delta \cdot t + \alpha \cdot D(i,t) + \varepsilon(i,t), \tag{2}$$

where $Y(i,t)$ is the investment rate of firm i in period t.

In equation (2), the firms are observed in a pre-treatment period (t=0) and in a post-treatment period (t=1). $D(i,t) = 1$ is an indicator variable that takes value one if firm i is part of the treatment group (firms with currency mismatches just before the crisis) and the period is post-treatment (t=1). Since the firms are only exposed to losses in the period t=1, $D(i,0) = 0$ for all of i, $D(i,1) = 1$ for the treated firms and $D(i,1)=0$ for those not treated. While the variable $D(i,1)$ takes into consideration differences in the treatment and control groups that are constant over time when measuring the average investment rates, variable $D(i,t)$ captures the impact of balance sheet effects on this difference. The coefficient α is therefore the differences-in-differences estimator described in equation (1).[20]

In addition to the variables that recover the differences-in-differences estimator, equation (2) contains a trend component common to all firms, t, a random residual, $\varepsilon(i,t)$, and a vector $X(i)$ of the firms' characteristics. Inclusion of this vector controls possible differences in

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[20] For a more detailed discussion of the differences-in-differences models and possible extensions, see Meyer (1995).

investment trajectories of the treatment and control groups. For this, the firms' characteristics should be correlated with investment and capture differences in the two groups.

As selection variables, we included exports and imports, both normalized by total revenue, operating profit over total assets, the logarithm of total assets, the percentage of total debt over total assets and the investment rate. All these variables are measured in the pre-crisis period and potentially determine hedge and investment decisions.

Export firms specifically should be less inclined to hedge, as their revenue's response to a currency depreciation at least partially offsets any balance sheet losses; in contrast, importers are more inclined to hedge. While larger and more profitable firms tend to have more investment opportunities, accounting for their greater interest in hedging, they may be less subject to credit restrictions and thus less inclined to hedge. Likewise, the relationship between financial leverage, measured by the percentage of total debt over total assets, and hedge decisions can be ambiguous. Firms with greater financial risk may want to hedge in order to minimize cash flow volatility and avoid paying predicted bankruptcy costs (Smith and Stulz, 1985). However, if shareholders see their shares as options in firm value, may be optimal to leveraged firms to speculate (Ljungqvist, 1994). Lastly, including the investment rate of the base period affords a dynamic to the investment, which can be seen when there are adjustment costs (Laeven, 2001).

In our sample, the firms are identified in each period t. We can therefore differentiate equation (2) with respect to t, obtaining:

$$Y(i,1) - Y(i,0) = \delta + X(i)' \cdot \pi + \alpha \cdot D(i,1) + \eta(i,t), \tag{3}$$

where $\pi = \pi(1) - \pi(0)$ and $\eta(i,t) = \varepsilon(i,1) - \varepsilon(i,0)$.

One advantage of specification (3) is that it clarifies elimination of non-observable variables that are constant over time. Based on equation (3), we adopted the following econometric specification to estimate the impact of the 2002 currency depreciation on investment by firms with large currency mismatches prior to the depreciation:

$$
\begin{aligned}
InvestimentRate_{i,2003} - InvestimentRate_{i,2001} &= \delta + \alpha I(Mismatched)_{i,2001} \\
&+ \Pi_1(Export/\mathrm{Re}venue)_{i,2001} + \Pi_2(\mathrm{Im}port/\mathrm{Re}venue)_{i,2001} + \\
&\Pi_3(Operacional\ \mathrm{Pr}ofit/Assets)_{i,2001} + \Pi_4(LogAssets)_{i,2001} + \\
&\Pi_5(Debt/Assets)_{i,2001} + \Pi_6 InvestimentRate_{i,2001} + \eta_{it}
\end{aligned}
\tag{4}
$$

In equation (4), the dependent variable captures the adjustment of the gross investment rate before and after the 2002 currency crisis. The year 2001 is the base period (pre-crisis). As

we explained in the preceding section, the year 2002 was excluded from the sample because, among other reasons, the currency depreciation began in April of 2002, which could affect our results if the firms had made investments in the first quarter of the year. We therefore analyzed the average balance sheet effects on the firms' investment rates in the year 2003. Variable I(Mismatched) is the equivalent in equation (3) of the term D(i,1), meaning an indicator variable that assumes the value one for firms in the group with large currency mismatches in 2001 and zero in the opposite case.

If balance sheet losses resulting from currency depreciations raised loan costs, we should observe a relative reduction in investments by firms with currency mismatches just before the crisis, as compared with firms protected from currency risk. In this case, the estimated coefficient α should be negative. In the opposite case, α should be statistically equal to zero. In these tests, we used clusters at firm level to estimate robust standard errors to serial correlation and heteroscedasticity.[21]

Column (A) of Table 6 presents the results of the estimation of a simplified version of our differences-in-differences model, without the variables that controls selection biases. In this specification, between 2001 and 2003 the firms with currency mismatches invested 7.6 percentage points less than firms that did not report foreign currency losses related to the crisis of 2002 (*p*-value of 0.077). The economic significance of these balance sheet effects is considerable given that the average investment rate of all firms was 8.1% in 2001. Introducing the variables that control selection biases, Column (B), the drop in investment by the firms with mismatches is even sharper and more significant. The firms with currency mismatches reduced their investment rates 8.1 percentage points more with a *p*-value of 0.004. Thus there is favorable evidence for the third generation models of currency crises: the balance sheet effects of currency depreciations led to substantially reduced investment.

Among the vector of characteristics of the firms, only two variables significantly impacted the change in investment rates in the 2001-2003 period: exports over total revenues and the investment rate in the base period. The percentage of exports in total revenues positively affected the firms' investment rates following the currency crisis, indicating competitiveness gains. The negative coefficient of the investment rate in the base period may signal an adjustment in investment rates in the crisis scenario.

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[21] Bertrand et al. (2004) show that allowing an arbitrary covariance structure between the periods of time reduces problems of serial correlation in studies that apply the differences-in-differences method with over 50 observations in the cross section.

To capture the endurance of the impact of balance sheet losses on investment rates, we re-estimated our model replacing the year 2003 with 2004 as the post-crisis period. Column (C) shows that the negative balance sheets effects did not dissipate in the second year after the currency shock. Relative to the matched firms, the firms with currency mismatches reduced their investments between 2001 and 2004 by 5.5 percentage points more (p-value 0.077). Once again, the results indicate the relevance of balance sheet effects.

Table 6: Balance Sheet Effects on Investment: Differences-in-differences

	Δ(Investment rate)		
	(A)	(B)	(C)
I(Mismatched)	-0.076*	-0.081***	-0.055*
	(0.077)	(0.004)	(0.077)
Investment rate		-0.867***	-0.855***
		(0.000)	(0.000)
Exports / Total revenue		0.180**	0.001
		(0.023)	(0.990)
Imports / Total revenue		-0.023	-0.043
		(0.853)	(0.700)
Operational profit / Total asset		0.101	-0.008
		(0.605)	(0.980)
Log total assets		-0.003	-0.013*
		(0.713)	(0.072)
Total debt / Total asset		-0.023	0.032
		(0.742)	(0.651)
Constant	-0.011	0.097	0.277***
	(0.749)	(0.339)	(0.009)
Obs.	217	217	197
R^2	0.01	0.71	0.68

Note: This table contains the results of the least squares estimation of variants of equation (4) in the text. The dependent variable is the change in gross investment rate, measured as (K (t) – K (t–1) + depreciation) / K (t–1), in which the capital stock (K) is defined as fixed assets net of depreciation. The year 2001 is used as a base (pre-crisis). The year 2003 is used for the post-crisis data in Columns (A) and (B) and the year 2004 in Column (C). I(Mismatched) is an indicator variable that takes the value one for firms with currency mismatches exceeding 5.3% of their assets in 2001 and zero in the opposite case. Currency mismatch is defined as foreign currency debt net of foreign exchange assets and derivatives. The other control variables are fixed in the base year. Exports and imports were converted into domestic currency using the average exchange rate for each year. Total debt was calculated by the sum of the value of loans and financing in foreign currency and domestic currency, including debentures. Operating profit was calculated before tax and interest. Log of total assets is the logarithm of total assets. We used clusters at the firm level to estimate standard deviations and to correct possible errors of serial correlation and heteroscedasticity. We reported the p-values robust to errors of serial correlation and heteroscedasticity in parentheses. The coefficients significant to 10, 5 and 1% are indicated by *, ** and ***, respectively.

4.2.2 Propensity score matching

As previously noted, one fundamental condition for testing the impact of balance sheet effects from currency depreciations is to control possible differences between treatment and control group firms to ensure that investment changes are due only to the balance sheet effects. Ideally the control group is random and identical to the treatment group except for the currency mismatch factor. However, building such a control group may not be possible for at least two reasons: first, finding firms with these characteristics is not likely; second, if they do exist, they would not be found through a random experiment given that the level of currency mismatches over assets is decided by firms.

In the differences-in-differences method, possible biases in selecting the treatment and control groups are controlled by introducing a vector of characteristics of the firms (*X*). One cause for concern in this approach, however, is the linear specification assumption for vector *X*. In contrast, propensity score matching is a nonparametric method that also addresses the difficulties of building a random control group. The results are based on the conditional independence assumption. Applied to our study, this assumption says that depending on the set of selection variables included in the model (which we will continue to call *X*), the expected investment rate of control group firms should equal the expected investment rate of treatment group firms if the crisis had not occurred. The challenge in matching is to find a set of *X* variables that will satisfy the conditional independence assumption. In practical terms, however, the larger the number of variables included in the model, the more difficult it is to find control group firms similar to the treatment group firms, and moreover, the greater the problem, which could limit the use of the matching method. One alternative for managing these problems is to use a function of the set of selection variables. Rosembaum and Rubin (1983, 1984) proved that, without loss of generality, we might substitute the *X* vector with the probability that, given *X*, the firm will be in the group with mismatches. This result motivates the propensity score matching: to find for each firm with currency mismatch a firm without currency mismatch with the closest probability of being in the group of mismatched firms, given vector *X*.

The first step is to run a PROBIT model to find the probability the firms will be in the group with mismatches. For this method of building the sample of counterfactual firms to be valid, a second assumption is needed: every firm with currency mismatch (treatment group) has a counterpart in the group of firms without currency mismatching (control group), and any

firm is a possible participant.[22] In order to increase the chances of this assumption being satisfied, we restricted our sample to firms with and without mismatch whose propensity scores (i.e. their probability of being in the mismatched group, obtained in the PROBIT model) were in the common support of the joint distribution.

So T is the set of firms with unhedged foreign currency debts with a propensity score in the common support. The estimator of the average effect of the treatment on treated firms (i.e., the balance sheet effect of currency depreciation) is calculated by the following equation:

$$\sum\nolimits_{i \in T} \left[InvestmentRate_{it} - InvestmentRate_{jt} \right] \frac{1}{N_T} \tag{5}$$

where, among the matched firms, j is the firm whose propensity score is closest to the mismatched firm i in the period t.[23]

With the exception of the investment rate, which is our variable of interest, we chose as selection variables the same ones used in the differences-in-differences model. Additionally, we included indicator variables for each of the seventeen sectors identified in Table 1.[24] The sectors may be important in determining the firms' currency mismatches. For example, firms that did not export but whose business involves tradeable goods could also benefit from the change in relative prices following the currency crisis. As such they could choose to assume greater currency risk than other firms.

Table 7 presents the results for each year of our sample. Panel A shows the results of the PROBIT. Size and financial leverage are important selection factors. The coefficients of these variables were positive and significant in all the years analyzed. These results suggest that large and more leveraged firms have a greater probability of having large currency mismatches. The coefficients of the other variables had the expected signs, but did not significantly affect the probability of the firms being in the group with mismatches.

Panel B of Table 7 shows that matching the treatment group with the control group brings a significantly lower average investment rate in the two years following the crisis of 2002 among the firms with currency mismatches, as compared to the firms without currency mismatches. More precisely, while the difference in the investment rate of both groups was

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[22] In formal terms, this assumption corresponds to $0 < \text{Prob} \{I(\text{Mismatched})=1|X_{it})\} < 1$, with X_{it} being the selection variables included in the model.

[23] This estimator is known in the literature as an average treatment on the treated (ATT). For a more detailed description of the matching method and use of a propensity score, see Blundell and Dias (2002).

[24] In the differences-in-differences model, these variables were incorporated into the fixed effects.

not significant in 2001 (only 0.5 percentage points), the investment rate of the group with currency mismatches was 10.1 percentage points in 2003 and 6 percentage points in 2004 less than the group without mismatches.

Table 7: Balance Sheet Effects on Investment: Propensity Score Matching

Panel A: PROBIT				
Variables / Year	**2000**	**2001**	**2003**	**2004**
Exports / Total revenue	0.44	0.25	0.20	0.91
	(0.527)	(0.714)	(0.761)	(0.208)
Imports / Total revenue	-0.33	-0.91	-1.48	-1.43
	(0.821)	(0.524)	(0.287)	(0.300)
Operational profit / Total asset	-1.83	-0.53	-0.45	0.04
	(0.259)	(0.663)	(0.686)	(0.973)
Log total assets	0.22***	0.12*	0.13*	0.19***
	(0.006)	(0.084)	(0.070)	(0.015)
Total debt / Total asset	4.55***	3.15***	2.77***	2.50***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-4.36***	-2.96***	-2.84***	2.95***
	(0.000)	(0.002)	(0.003)	(0.000)
Sector Dummies	Yes	Yes	Yes	Yes
Obs.	218	232	217	196
Pseudo-R^2	0.34	0.24	0.20	0.19
Chi^2 (*p*-value)	0.000	0.000	0.000	0.000
Panel B: *Propensity Score Matching*				
	2000	2001	2003	2004
Investment rate (Mismatched)	0.102	0.072	0.0146	0.058
Investment rate (Matched)	0.108	0.077	0.116	0.119
Investment Difference	-0.006	-0.005	-0.101***	-0.060**
Confidential Interval (1%)	(-0.164;0.127)	(-0.162;0.072)	(-0.256;-0.022)	(-0.264;0.005)
Confidential Interval (5%)	(-0.123;0.092)	(-0.137;0.051)	(-0.230;-0.050)	(-0.354;-0.013)
Confidential Interval (10%)	(-0.090;0.073)	(-0.094;0.040)	(-0.245;-0.064)	(-0.246;-0.022)

Note: Panel A presents the results of a PROBIT regression to calculate the probability that each firm in our sample would be in the group of firms with mismatches. Currency mismatch is defined as foreign currency debt net of foreign exchange assets and derivatives. The firms with mismatches are those with currency mismatches exceeding 5.3% of their assets in 2001. We chose this cutoff value for firms to be included in the group with mismatches so that the group without mismatches would have an average level of currency mismatches over assets equal to zero. In Panel B, Matchings is the size of a sample matched between firms with and without currency mismatches. The matched firms selected are those with the closest propensity score after the sample was restricted to firms in the common support. Investment/K_{-1} (Mismatched) and Investment/K_{-1} (Not Mismatched) are, respectively, the average investment rates of the groups with and without currency mismatches in the matched sample. Investment Difference/K_{-1} is the average effect of the treatment on the treated firms, determined by the difference in the investment rates of the mismatched and matched firms. The confidence intervals (1, 5 and 10%) were calculated by bootstrapping through 1000 replications. The coefficients significant to 10, 5 and 1% are indicated by *, ** and *** respectively.

In summary, the results found in this subsection corroborate the results obtained by using the differences-in-differences estimators: the balance sheet losses associated with the currency depreciation of 2002 negatively affected firms' investment.

4.2.3 Robustness of the results

The results described in the previous subsections suggest that the currency depreciation of 2002 caused firms with large currency mismatches to reduce their post-crisis investment more than firms that did not report losses. We attribute this reduction to balance sheet effects. However, our results could have occurred due to other factors not related to the post-crisis balance sheet effects. In this section we investigate some of these possibilities.

A potential problem with the differences-in-differences approach is the assumption that the crisis affects the treatment and control groups equally. If the groups presented different temporal trends, our results could merely reflect these trend differences. These different trends occur when the treatment and control groups have distinct characteristics (possibly not observable) that provoke different reactions to the shocks.

To address this possibility, we tested for evidence of greater investment reductions by the firms with mismatches in a period without balance sheet losses. For this, we re-estimated equation (3) using the year 2000 as the base year and the year 2001 as a fictitious post-crisis period. If the negative balance sheet effects found in the differences-in-differences estimation resulted from the groups' different trends, we would expect to find greater investment reductions by the mismatched firms than by the matched firms in this "falsification exercise." The results described in Table 8 show that this did not occur. In the 2000-2001 period, the difference in the treatment and control group investment rates was not significant in our differences-in-differences model.[25]

We also analyzed the robustness of the results of the propensity score matching in relation to inclusion of the following selection variables: asset tangibility, defined as the proportion of long-term assets, and two binary variables indicating whether the firms were, respectively, multinationals or with shares listed overseas through American Depositary Receipts. Additionally, we re-estimated the model excluding the sector indicator variables. In all these alternatives, the negative balance sheet effects remained significant at 5% in the year 2003 (results not described in the tables).

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[25] Table 7, described in the previous subsection, also shows that propensity score matching indicated no significant differences in the investment rates of the treatment and control groups in 2000 and 2001.

Table 8: Testing for Trend Differences Between the Treatment and Control Groups

	Δ(Investment rate)	
	(A)	(B)
I(Mismatched)	0.044	0.138
	(0.714)	(0.232)
Exports / Total revenue		0.250
		(0.186)
Imports / Total revenue		0.286
		(0.329)
Operational profit / Total asset		1.700*
		(0.098)
Log total assets		-0.027
		(0.231)
Total debt / Total asset		-0.542**
		(0.022)
Constant	-0.151*	0.154
	(0.059)	(0.547)
Obs.	228	228
R^2	0.00	0.04

Note: This table contains the results of the least squares estimation of variants of equation (4) in the text, except for the period analyzed. In this falsification exercise, we used a period without currency crises. The year 2000 was used as a base period and the year 2001 as the post fictitious crisis period. The dependent variable is the change in gross investment rate, measured as (K (t) – K (t–1) + depreciation) / K (t–1), in which capital stock (K) is defined as fixed assets net of depreciation. I(Mismatched) is an indicator variable that takes the value one for firms with currency mismatches exceeding 5.3% of their assets in 2001 and zero in the opposite case. Currency mismatch is defined as foreign currency debt net of foreign exchange assets and derivatives. The other control variables are fixed in the base year. Exports and imports were converted into domestic currency using the average exchange rate for each year. Total debt was calculated by the sum of the value of loans and financing in foreign currency and domestic currency, including debentures. Operating profit was calculated before tax and interest. We used clusters at the firm level to estimate standard deviations and to correct possible errors of serial correlation and heteroscedasticity. We reported the *p*-values robust to errors of serial correlation and heteroscedasticity in parentheses. The coefficients significant to 10, 5 and 1% are indicated by *, ** and ***, respectively.

5. Competitiveness Effect

In the differences-in-differences approach described in the previous section, the evidence of balance sheet effects comes from a comparison of investments by firms with unhedged foreign debt (treatment group) and firms without currency mismatches (control group). These two groups were formed in such a way that balance sheet losses were significant only for the

treatment group. Note, however, that the reliability of the results depends on the currency mismatch measure, which was the basis for forming the treatment and control groups.

To ensure that the reduction in investment was attributable to the negative balance sheet effects and not due to poorly formed treatment and control groups, in this section we test the balance sheet effects on a more homogenous subset of our sample: export firms. The advantage of this alternative test is that currency depreciation may affect export firms through both the balance sheet channel and the competitiveness channel. Depreciation increases the competitiveness of goods sold internationally, raising exporters' profit in domestic currency.[26] In this case, the logic of third generation models predicts that investments by export firms will rise due to competitiveness gains, and also that this increase will be lower for exporters with unhedged foreign currency debt because of the negative balance sheet effect.

Among the sample firms, 107 reported positive exports net of imports in December of 2001. Of these 107 exporters, 55 had unhedged foreign currency debt.

Initially we test whether, in fact, the depreciation of 2002 increased exporters' competitiveness, raising their net sales revenue more than that of firms that did not export, as predicted in conventional open economy models. For this we again used the differences-in-differences approach. However, here our treatment group consisted of 107 firms with positive exports net of imports in 2001. The control group consisted of 125 firms with positive imports net of exports or no overseas trade in 2001. These two groups help us to estimate the competitiveness effect of the currency depreciation in the usual way: comparing changes in net revenue (before and after the crisis) of exporting and non-exporting firms.

Column (A) of Table 9 shows that the net revenue of the exporting group rose 16.8% more than the net revenue of the other firms in the 2001-2003 period. This result was highly significant (*p*-value of 0.000). Column (B) shows that there were no significant differences in revenue gains between the exporters with currency mismatches and those without. Therefore, we have significant evidence that the revenue of export firms, both with and without currency mismatches, rise more than that of firms that did not export in the aftermath of currency depreciations.

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[26] The extent of the competitiveness effect depends on the pass through from currency depreciation to domestic prices. In general, empirical studies find that this pass through is incomplete, which ensures competitiveness gains. See, for example, Goldberg and Knetter (1997) and Goldfajn and Werlang (2000).

Table 9: Balance Sheet and Competitiveness Effects

	Δ(Log Net Revenue)		Δ(Investment rate)		
	(A)	(B)	(C)	(D)	(E)
I(Exporters)	0.168***	0.146***	0.072*	0.164***	0.110***
	(0.000)	(0.003)	(0.098)	(0.001)	(0.001)
I(Exporters * Mismatched)		0.042		-0.176***	-0.125***
		(0.565)		(0.000)	(0.001)
Investment rate					-0.859***
					(0.000)
Operational profit / Total asset					0.079
					(0.686)
Log total assets					-0.002
					(0.820)
Total debt / Total asset					-0.063
					(0.320)
Constant	-0.037	-0.037	-0.078**	-0.078**	0.057
	(0.173)	(0.174)	(0.024)	(0.024)	(0.592)
Obs.	217	217	217	217	217
R^2	0.06	0.06	0.01	0.04	0.70

Note: This table contains the results of the least squares estimation of variants of equation (5) in the text. In Columns (A) and (B), the dependent variable is the change in the logarithm of revenue net of sales tax, and in Columns (C) through (E) it is the change in gross investment rate, measured as (K (t) – K (t–1) + depreciation) / K (t–1), in which the capital stock (K) is defined as fixed assets net of depreciation. The year 2001 was used as a base (pre-crisis), and the year 2003 was used for post-crisis data. I(Exporters) is an indicator variable that takes the value one for firms with positive net exports in 2001 and zero in the opposite case. I(Exporters*Mismatched) is an indicator variable that takes the value one for firms with positive net exports in 2001 and with currency mismatches exceeding 5.3% of their assets in 2001. Currency mismatch is defined as foreign currency debt net of foreign exchange assets and derivatives. The other control variables are fixed in the base year. Exports and imports were converted into domestic currency using the average exchange rate for each year. Total debt was calculated by the sum of the value of loans and financing in foreign currency and domestic currency, including debentures. Operating profit was calculated before tax and interest. Log of total assets is the logarithm of total assets. We used clusters at the firm level to estimate standard deviations and to correct possible errors of serial correlation and heteroscedasticity. We reported the *p*-values robust to errors of serial correlation and heteroscedasticity in parentheses. The coefficients significant to 10, 5 and 1% are indicated by *, ** and ***, respectively.

According to the logic of third generation models, this competitiveness gain should ease credit restrictions and increase investments by exporters as compared to non-exporters. One could argue, however, that any investment model based on relative prices could predict increased exporter investments, but the predictions of these two types of models could be different if we compare the rise in investments by exporters with and without currency mismatches. The third generation models also predict that the rise in exporter investments would be less significant for those with unhedged foreign currency debt and this is different than predictions of investment models based on relative prices.

In order to test this additional prediction of third generation models, we compared the difference in investment rates (before and after the crisis of 2002) among export firms with and without currency mismatches. In this year, the 55 export firms with currency mismatches before the crisis constituted the treatment group, while the remaining exporters constituted the control group.

The model to be estimated is as follows:

$$(InvestimentRate)_{i,2003} - (InvestimentRate)_{i,2001} = \delta + \beta I(Exporters)_{i,2001} +$$
$$\alpha I(Exporters * Mismatched)_{i,2001} + \Pi_1(Operacional \Pr ofit / Assets)_{i,2001} +$$
$$\Pi_2(LogAssets)_{i,2001} + \Pi_3(Debt / Assets)_{i,2001} + \Pi_4(InvestimentRate)_{i,2001} + \varepsilon_{it}$$

(6)

The dependent variable continues to be the variation in gross investment rate for each firm i in period t. The variables of interest now are the indicator variables I(Exporters) and I(Exporters*Mismatched). The first takes the value one for the firms with net exports in 2001 and zero in the opposite case. The second assumes the value one only for the subset of exporters in the group of firms with mismatches in 2001.

The coefficient β measures the difference in investment rates of the export and non-export firms between 2001 and 2003; this is our measure of the competitiveness effect. If the competitiveness gains caused by the currency depreciations did in fact increase the firms' investments, we should expect a positive β. The coefficient α measures the difference in investment rates between exporters with mismatches and those without: our measure of the balance sheet effect. If the losses provoked by currency depreciation increased the financing costs of exporters with mismatches more than that of exporters without mismatches, we should expect a negative α. If the balance sheet effects did not cause exporters with currency mismatches to have more credit restriction in comparison, then α should be statistically equal to zero.

In Column (C) of Table 9, we show that the competitiveness effect of the currency depreciation of 2002 also positively affected investment. The investment rates of exporters rose 7.2 percentage points more than that of non-exporters (p-value of 0.098). This competitiveness gain would have been even greater if there had not been exporters with large currency mismatches just before the crisis. Column (D) shows that in 2003 exporters with currency mismatches just before the crisis invested 17.6 percentage points less than exporters without mismatches compared with pre-crisis levels. The group of matched exporters invested 16.4 percentage points more than the non-export firms. Both of the results were significant at

1%. Since in this model the change in average investment rate of the sample firms was negative by 7.8 percentage points (captured by the constant δ), we have evidence that the average investment rate of the exporters rose 8.6 percentage points between 2001 and 2003. On the other side, the investment rates of the exporters with mismatches, on average, fell 9 percentage points.[27]

Lastly, we re-estimated the model introducing the variables that control selection biases. The results, described in Column (E), did not change qualitatively. The balance sheet effect impacted investment more than the competitiveness effect for firms influenced by these two effects: the exporters with currency mismatches. The difference in investment rates of export and non-export firms was 11 percentage points. In the exporting group, the investment rates of those with mismatches fell 12.5 percentage points more than the rate of those without mismatches. The only significant selection variable in this model is the investment rate of the base period.

In summary, we may extract two basic conclusions from this section. First, that competitiveness gains are quite substantial after dramatic currency depreciation. Second, the increase in revenues for exporters was not enough to fully counteract the negative effects of balance sheet losses. The natural hedge provided by exports was not sufficient.

6. Conclusion

In third generation models of currency crises, the balance sheet losses of firms with unhedged foreign currency debt exercise a central role in explaining the recessionary effects of the crises. However, empirical evidence that tests the relevance of these models is not conclusive. While in some countries there is evidence that having debt in foreign currency lowers investment by firms following currency depreciation, in others the evidence is not significant or even shows increased investment.

In this article, we test the importance of this balance sheet channel, combining a more precise, firm-level measure of currency mismatches with an analysis focusing on the Brazilian crisis of 2002. To isolate the balance sheet effects from other macroeconomic events that could have influenced investment, we identified two groups of firms: the treatment group, which was formed of firms with currency mismatches just before the crisis of 2002 and thus

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[27] The change in the investment rate of export firms was calculated by the sum of coefficients δ and β in equation (6). In the case of exporters with mismatches, the change is calculated by the sum of coefficients δ, α and β.

reported balance sheet losses; and the control group, which was formed of firms that did not have currency mismatches. While the treatment group's investment changes (before and after the crisis) should reflect both the balance sheet effect and other effects of the 2002 crisis, the control group's changes should reflect only these other effects, which impacted all firms alike. Therefore, the difference in the changes in these two groups gives us an estimate of the balance sheet effect of currency depreciation on the firms' investment rates.

We found that firms with currency mismatches reduced investments more than firms without mismatches an average of 8.1 percentage points the first year after the currency shock and 5.5 percentage points the second year. These negative balance sheet effects were also quite substantial when we used propensity score matching to select a sample of firms without currency mismatches that was most similar to the firms with currency mismatches just before the crisis.

Lastly, we conducted a joint test of the balance sheet and competitiveness effects of the currency depreciation on investment by analyzing the investment changes of exporters before and after the currency crisis of 2002. The results show that the exporters' investment rates rose 11 percentage points more than non-exporters' investments. However, confirming the importance of the negative balance sheet effects, the exporters with currency mismatches invested 12.5 percentage points less than exporters that did not report balance sheet losses related to the currency depreciation.

In summary, the evidence for the Brazilian currency crisis of 2002 shows that the negative balance sheet effects at least partially reversed the competitiveness effect of the currency depreciations, thus capable of making them contractionary, as third generation models of currency crises predict.

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