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Journal of Development Economics 78 (2005) 95–113

JOURNAL OF Development ECONOMICS

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Investment, devaluation, and foreign currency exposure: The case of Mexico

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Received 1 September 2002; accepted 1 June 2004

Abstract

This paper studies firm-level investment in the wake of the Mexican peso crisis of 1994. While exporters outperform nonexporters in terms of profits and sales after the devaluation, their investment is constrained by weak balance sheets. Specifically, we find that firms with heavy exposure to short-term foreign currency debt before the devaluation experienced relatively low levels of post-devaluation investment. The data also imply that increased sales uncertainty after the peg's collapse deterred investment, particularly in the tradable sector. The results confirm the recent theoretical literature's focus on weak balance sheets as driving the recessionary impact of devaluations in emerging markets.

JEL classification: E22; E44; F32; F34; G31; O16
Keywords: Investment; Financial constraints; Balance sheets; Emerging market crises

1. Introduction

The currency composition of debt has occupied center stage in discussions of the emerging market crises of the 1990s. For example, Mishkin (1999) argues that the foreign currency denomination of the typical debt contract in Mexico and East Asia, along with its

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doi:10.1016/j.jdeveco.2004.06.012

short duration, "helped turn the currency crisis into a full-fledged financial crisis." Several studies have also identified the ratio of foreign currency denominated debt to central bank foreign reserves as a leading indicator of currency crises (e.g. Goldstein et al., 2000). Moreover, a theoretical literature is rapidly developing around what Paul Krugman labels "open economy Bernanke–Gertler", referring to the amplification of negative shocks due to the combination of capital market imperfections and weak balance sheets (Bernanke and Gertler, 1989).

Given its prominent role in crisis postmortems, surprisingly little is known about the precise determinants and consequences of the currency composition of debt, particularly at the microeconomic level. This paper utilizes a panel data set of Mexican firms that is unusual for emerging markets in that it identifies whether debt is denominated in domestic or foreign currency. The data on debt composition, along with variables from income and balance sheet statements, are used to explore firm behavior in the wake of the 1994 peso crisis.

The firm-level data reveal that exporting firms outperform nonexporting firms in both sales and profits in the year following the devaluation. This confirms the traditional prediction that the tradable sector (relatively) benefits from a real devaluation, and is in line with the sectoral-level results documented in Krueger and Tornell (1999). Interestingly, however, exporters do not show a greater tendency to invest in new capital relative to nonexporters. The paper documents that this is due, in part, to the large amounts of foreign currency debt held by exporters. Specifically, we find that firms with large exposure to short-term foreign debt before the crisis show a marked drop in investment after the devaluation. Given that exporters borrow disproportionately in foreign currency, this reduces the investment of exporting firms. The estimated coefficients imply that observed foreign currency debt exposure reduced net investment rates for 1995 from positive 1% to negative 3.6%.

Moreover, many firms experienced an increase in the volatility of sales growth after the floating of the peso in 1994, particularly those firms with heavy export shares. This additional uncertainty depressed investment as well.[1] In short, the combination of weak balance sheets and increased uncertainty limited the amount of investment undertaken in the tradable sector, dampening any expansionary effect of the devaluation. In particular, it appears that while tradable firms led the recovery in Mexico, they did so without a relative increase in physical capacity.

Finally, the paper explores the relationship between real exchange rate movements and currency composition of liabilities throughout the rest of the 1990s in Mexico. We replicate the somewhat counterintuitive finding of Bleakley and Cowan (2002) that firms with above average exposure to dollar debt tend to increase relative investment during a contemporaneous real depreciation. However, we show that investment of exposed firms declines the year after a real devaluation. This is consistent with investment exhibiting a reasonably delayed response to asset price movements.

This paper relates to a growing literature on currency crises that stresses shocks to firm balance sheets. Examples of the theoretical literature include Caballero and Krishnamurthy

[1] See Bell and Campa (1997) for the negative effect of exchange rate volatility on investment in an industrialized country context.

(2000), Aghion et al. (2000), and Jeanne (2000). There are a number of empirical studies of crises, although primarily using aggregate data and usually focusing on pre-crisis vulnerability rather than the impact of devaluation. Examples include Frankel and Rose (1996), Sachs et al. (1996), and Corsetti et al. (1998).

The effect of balance sheet health on investment has been studied in the investment/corporate finance literature, examples of which include Fazzari et al. (1988), Hoshi et al. (1991), and Minton and Schrand (1999). This literature is large and additional references may be found in Hubbard (1998) and Caballero (1999). One advantage of the present study is that the source of the relative movement in firm balance sheets is isolated — namely, the currency composition of debt immediately preceding the devaluation. The existing literature often uses changes in cash flow to proxy for balance sheet shocks, which may be correlated with unobserved investment opportunities. The use of pre-existing foreign currency debt helps avoid some of the criticisms leveled at previous studies. Other studies that have carefully identified the source of balance sheet shocks include Gelos and Werner (2002) who focus on shocks to the collateral value of real estate.

2. Data

The data set was provided by the Mexican stock exchange, Bolsa Mexicana de Valores (BMV), and contains quarterly earnings and balance sheet information for over three hundred nonfinancial[2] companies covering the years 1991 through 2000. All variables are reported by the BMV in real pesos, with 2000 serving as the base year and the consumer price index serving as the deflator. Items that are in foreign currency at the end of the quarter are converted to pesos at the contemporaneous exchange rate and then deflated to year 2000 pesos. Appendix A contains definitions of all key variables.

Inclusion in the data set implies that firms listed equity or debt on the BMV, and therefore the data do not capture Mexican firms that are financed solely through private equity or bank loans. The majority of our firms were publicly traded; for example, of the 169 firms for which there are investment data in 1995 and 1994, 119 were publicly traded in 1994, with the remaining issuing debt or listed as shelf registration. Not all companies span the entire time period. Attrition is partly due to the fact that nonpublic firms are in the sample only in years they are issuing debt or maintaining shelf registration. There were only nine publicly traded firms which had shares traded in 1994 but are no longer listed in 1995, all of which were party to a merger or acquisition. Given the limited attrition of public firms from the sample in the year of devaluation, the issue of survivorship bias does not appear to be crucial. The fact that we are dealing with firms that list debt or equity on the BMV implies the sample consists primarily of large firms. The average firm had 5.6 million pesos of sales in 1995 (in 2000 pesos), while the median firm had sales of 1.6 million pesos. The 169 firms used in the main analysis therefore constitute sales of slightly less than one billion pesos. For comparison, GDP in 1995 in year 2000 pesos totaled four trillion pesos. One

[2] Specifically, firms classified by the BMV as mining, industrial, construction, commercial, communication and transportation, service or conglomerate/holding companies. Excluded were commercial banks, brokerage firms, financial groups, insurance companies and mutual funds.

Table 1
Composition of debt

Year (4th quarter)	No. of firms	$D^*_{short}/(D_{short}+D^*_{short})$	$D^*_{long}/(D_{long}+D^*_{long})$	$(D^*_{short}+D^*_{long})/TotalDebt$	$(D^*_{short}+D_{short})/TotalDebt$
1991	234	0.31	0.34	0.31	0.71
1992	236	0.30	0.33	0.30	0.66
1993	233	0.31	0.40	0.33	0.62
1994	211	0.38	0.49	0.42	0.64
1995	197	0.42	0.51	0.44	0.66
1996	199	0.37	0.54	0.43	0.63
1997	183	0.37	0.62	0.45	0.62
1998	179	0.37	0.64	0.45	0.64
1999	171	0.34	0.67	0.42	0.64
2000	147	0.34	0.63	0.34	0.54

Note: Average across companies. See Appendix A for definitions. Values are reported at the end of the fourth quarter for the year specified.

must be careful in speculating how the results for this sample extend to small- and medium-sized companies. On the one hand, such firms may be more likely to suffer from external borrowing constraints. However, the particular channel discussed in this paper concerns dollar denominated debt, which smaller companies are less likely to incur.

The data contain currency and maturity composition of debt, allowing an analysis of the determinants and consequences of foreign currency debt. Table 1 summarizes the currency composition of debt (foreign or domestic) and the breakdown by maturity (less than one year or greater than one year). As is clear from the table, nearly two thirds of the outstanding debt was short-term and over one third of short-term debt was denominated in foreign currency. The percentage of long-term debt denominated in foreign currency is relatively large, reflecting that long-term debt in emerging market currencies is rare (see Eichengreen and Hausmann, 1999).

3. Crisis and recovery

Empirically, the paper represents an event study using the devaluation of the Mexican peso in 1994 as the exogenous shock. As background, Mexico entered the 1990s in the midst of a stabilization of triple-digit annual inflation. The nominal anchor was an exchange rate that was managed within a narrow band (see Fig. 1). The Mexican government also undertook an extensive program of reform that liberalized trade, privatized and deregulated many industries, including the financial sector, and opened the capital account. This program was essentially complete by 1992.[3] After several years of large capital inflows, the peso came under attack in December of 1994, forcing the Mexican government to abandon the existing exchange rate regime. By the end of the first quarter of 1995, the peso had lost 50% of its value relative to the close of the third quarter of 1994.

[3] A notable post-1992 reform is NAFTA, which was ratified in 1993 and took effect at the start of 1994.

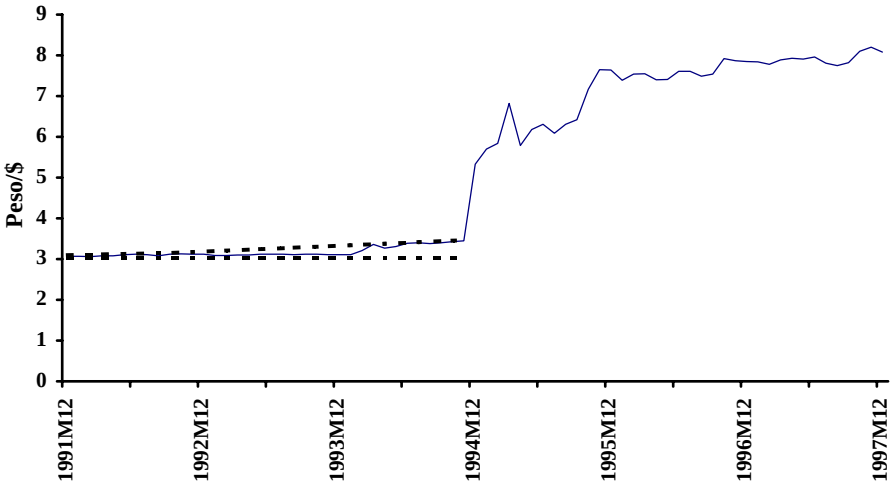

Fig. 1. Peso/$ Exchange rate. The figure plots the end of month exchange rate per dollar for the Mexican peso (source: IFS). Dashed lines represent bands for the fixed exchange rate regime as reported in the IMF's *Exchange Arrangements and Exchange Restrictions*.

The economy's response to the crisis was sharp contraction followed by recovery. Mexican real GDP fell 6% in 1995 and then recorded 5% and 7% growth in 1996 and 1997 respectively. Krueger and Tornell (1999) document that the recovery was driven by expansion in the tradable sector, an outcome consistent with traditional textbook models of real depreciation. Figs. 2 and 3 show that the relatively strong performance in real sales

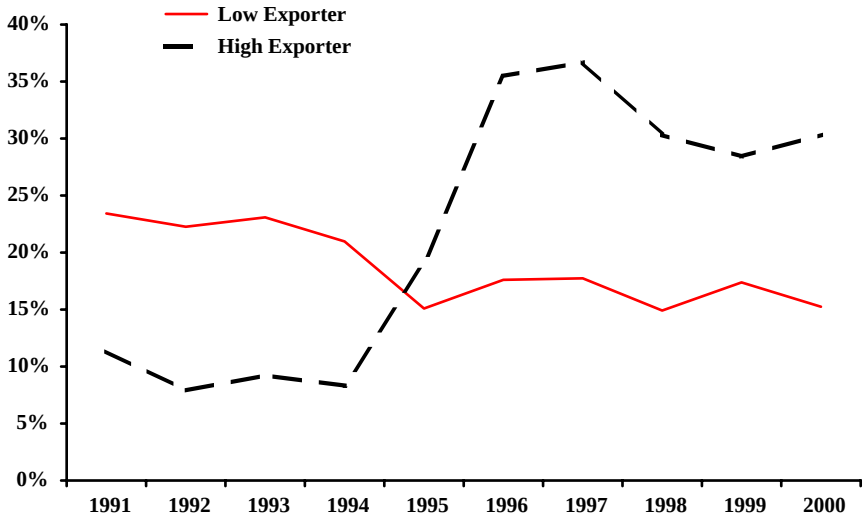

Fig. 2. Profits/*K*. This figure plots the ratio of annual operating profits to end of year capital. High exporter (dashed line) indicates firms that had a ratio of exports to sales in the top quartile for the first three quarters of 1994. Low exporter (solid line) refers to the remaining firms.

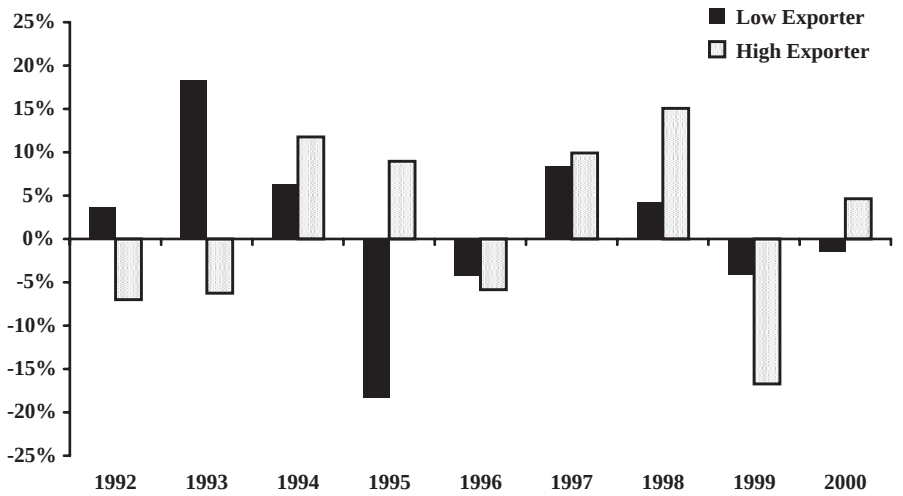

Fig. 3. Sales growth. This figure plots sales growth for low (solid bar) and high exporter (shaded bar) firms (as defined in Fig. 2). Sales growth is defined as the log of annual net sales of the year indicated on the horizontal axis minus the log of net sales for the previous year (in constant pesos).

growth and return to capital for exporting firms can be seen in our firm-level data set. In constructing the figures, we first divide firms into high exporters and low exporters based on the percentage of sales exported over the first three quarters of 1994. High exporters constitute the top quartile of the distribution (specifically, an export to sales ratio of greater than 9% — see Table 2), with low exporters constituting the remaining 75% of firms.[4] Fig. 2 plots the ratio of operating profits to physical capital. All variables are in constant (2000) pesos. The figure clearly demonstrates the improved profitability of exporting firms after 1994. Similarly, Fig. 3 indicates exporters had relatively high real sales growth for 1995. Part of the advantage of being an exporter may be due to NAFTA, which was implemented beginning in January 1994. However, the clear separation between exporters and nonexporters is most distinct in 1995, immediately after the devaluation.

Surprisingly, the strong performance of exporting firms in sales and profits does not extend to net investment. Fig. 4 plots annual investment rates for the two sets of firms. Exporters and nonexporters have similar investment rates immediately before the devaluation in 1994 and in the years following the devaluation. It is not until 1998 that exporters tend to out-invest nonexporters at standard significance levels. In this sense, the relative expansion of the tradable sector in the wake of the peso's devaluation was accomplished without the benefit of increasing (relative) capital stocks.[5]

[4] While arbitrary, the division into two groups at the 75th percentile is not crucial. The regressions reported in Section 4 generate similar patterns.

[5] The fact that exporters do not expand relative capital stocks does not contradict exporters' relatively strong sales growth. More intensive use of existing capital and, perhaps more importantly, relative price movements also contribute to sales growth. In particular, sales are deflated using the aggregate consumer price index, which lagged the peso's initial devaluation (hence the real devaluation). Therefore, a given quantity of exports that maintains a constant dollar price will register as a real increase in sales if the peso experiences a real depreciation.

Table 2
Distribution of key variables

	$(D^*/TotalDebt)_{1994Q3}$	$(D^*_{short}/D_{short}+D^*_{short})_{1994Q3}$	$\Delta Networth_{1994}/K_{1993}$	$\Delta WorkingCap_{1994}/K_{1993}$	$(Exports/Sales)_{1994Q3}$	I_{1995}/K_{1994}
10%	0.00	0.00	−0.25	−0.43	0.00	−0.19
25%	0.05	0.02	−0.03	−0.22	0.00	−0.12
50%	0.31	0.26	0.13	−0.03	0.01	−0.04
75%	0.63	0.54	0.33	0.11	0.09	0.07
90%	0.80	0.73	0.72	0.44	0.35	0.15
Mean	0.35	0.31	0.31	0.11	0.09	−0.02
StdDev	0.30	0.28	1.43	1.31	0.17	0.20
No. of firms	220	220	202	202	220	181

Note: Table reports percentiles of the cross-sectional distribution of the variable listed at the top of the column. See Appendix A for definitions.

The major goal of this paper is to explain why exporters did not invest more aggressively.

4. Devaluation and investment

4.1. Empirical specification

To motivate the empirical strategy used to analyze firm investment, consider the standard quadratic adjustment cost model. Firm j enters period t with capital stock $K_{j,t-1}$

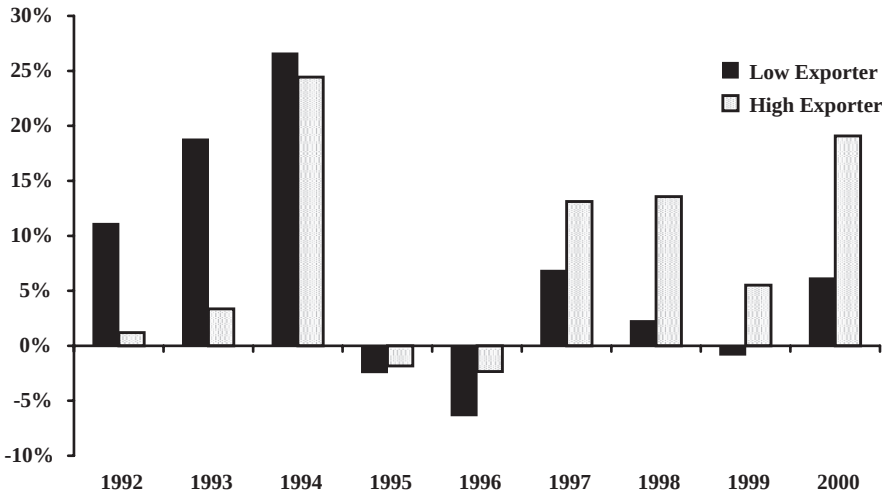

Fig. 4. Investment rates. This figure plots the investment rates for low (solid bar) and high (shaded bar) exporter firms (as defined in Fig. 2). Investment rates are calculated as the capital stock recorded at the end of the year indicated on the horizontal axis minus the previous year's capital stock divided by the previous year's capital stock, all in constant pesos.

and chooses new investment $I_{j,t}$ and variable input $L_{j,t}$ to maximize the net present value of profits, $V_{j,t}$.That is,

$$V_{j,t}\left(K_{j,t-1}\right) = \max_{I_{j,t},L_{j,t}} \left\{\pi_{j,t} + E_t \beta V_{j,t+1}\left(K_{j,t}\right)\right\}$$

$$K_{j,t} = (1-\delta)K_{j,t-1} + I_{j,t} \tag{1}$$

where $\delta \in (0,1)$ is the rate of depreciation, β is the discount rate, and E_t implies expectation with respect to information through time t. We express the firm's profits as:

$$\pi_{j,t} = p_{j,t}F\left(K_{j,t}, L_{j,t}\right) - \chi\left(I_{j,t}, K_{j,t}\right) - w_{j,t}L_{j,t} - r_{j,t}K_{j,t} \tag{2}$$

where p is the price of the firm's output, F is a production function, w is the cost of the variable input and r is the opportunity cost of capital (where we include a subscript j on w and r to reflect possible firm-specific factor costs). The function χ captures the cost of altering the capital stock and takes the standard form (dropping subscript j in what follows)

$$\chi(I_t, K_t) = \left[\frac{b}{2}\left(\left(\frac{I}{K}\right)_t - c\right)^2 K_t\right] \tag{3}$$

where b and c are parameters.

The solution to the investment problem sets the marginal cost of installing a new unit of capital equal to the present discounted value of the marginal return to capital (marginal q). That is,

$$\frac{\partial \chi}{\partial I_t} = E_t\left(\sum_{s=0}^{\infty}(1-\delta)^s \beta^s \frac{\partial \pi_{t+s}}{\partial K_{t+s}}\right). \tag{4}$$

This implies the Euler equation

$$E_{t-1}\left\{\left(\frac{I}{K}\right)_t - \left(\frac{1}{(1-\delta)\beta}\right)\left(\frac{I}{K}\right)_{t-1} + \left(\frac{1}{(1-\delta)\beta} - 1\right)c + \frac{1}{b(1-\delta)\beta}\frac{\partial \pi_{t-1}}{\partial K_{t-1}}\right\} = 0 \tag{5}$$

Letting η_t represent the expectational error, we can rewrite the Euler equation as[6]

$$\left(\frac{I}{K}\right)_t = \left(\frac{1}{(1-\delta)\beta} - 1\right)c + \frac{1}{b(1-\delta)\beta}\left(\frac{I}{K}\right)_{t-1} - \frac{1}{(1-\delta)\beta}\frac{\partial \pi_{t-1}}{\partial K_{t-1}} + \eta_t \tag{6}$$

[6] The timing convention implies period t investment determines the period t capital stock, which in turn governs adjustment costs and output of period t. If instead period $t-1$ capital determined output and adjustment costs in period t, the expected value of period t marginal product of capital would replace that of period $t-1$ in the Euler equation. We include this alternative in the empirical specifications implemented below.

where

$$\eta_t \equiv \frac{1}{b}(E_t - E_{t-1})\left(\sum_{s=0}^{\infty}(1-\delta)^s \beta^s \frac{\partial \pi_{t+s}}{\partial K_{t+s}}\right). \quad (7)$$

The operator $(E_t - E_{t-1})$ represents the change in expectation due to additional information received in period t. We take t to be 1995, the first year after the devaluation. It is controlling for η_t that is of particular interest in guiding our empirical strategy. Mathematical expectation does not imply η_t is orthogonal to all firm characteristics. We are not randomly selecting t, but rather conditioning on t being the period of devaluation. Therefore, any firm characteristic that predicts the covariance between the exchange rate and investment will predict η_t.

Our measures of η_t fall into three categories — (i) changes to the marginal profitability of capital before financing costs, (ii) changes to financing costs, and (iii) changes in the variance of profits. We do not pursue the traditional approach of using average Q (the ratio of market value to replacement value of capital) as a measure for marginal q as many of our firms are not publicly traded and asset markets in Mexico exhibited periods of extreme illiquidity following the devaluation. Moreover, recent work by Gomes (2001) explores why "Q" regressions are ill-suited for exploring the role of balance sheet shocks to investment.[7]

In regard to changes in profitability, the relatively positive impact a real devaluation has on the tradable sector implies that the propensity to export should predict post-devaluation investment. Table 3 column (1) reports a regression of the increase in real profits between 1994 and 1995 on the percentage of sales exported in the first three quarters of 1994 as well as debt composition recorded at the end of 1994Q3. The use of pre-devaluation characteristics ensures that we do not pick up any reverse causality of post-devaluation performance on exports or sales. Confirming the pattern in Fig. 2, export propensity predicts a significant increase in profits after the devaluation. In particular, a 10 point increase in percentage of sales exported implies profits (as a fraction of the capital stock) increase 3%. Our benchmark regression therefore includes the propensity to export before the devaluation as a proxy for innovations to the marginal product of capital. We will discuss issues arising from measurement error in Section 4.3.

As is clear from the firm's first order condition for investment, firms with relatively high borrowing costs will exhibit lower rates of investment. There is a vast literature on capital market imperfections that congregates around the central tenet that a firm's cost of capital is negatively correlated with some measure of net worth or cash flow (see, for example, Bernanke and Gertler, 1989; Hubbard, 1998). A significant challenge to empirically test the importance of balance sheets is separating shocks to cash flow or net worth from changes in investment opportunities. A typical strategy is to use changes in current cash flow as a proxy for shocks to net worth (e.g. Fazzari et al., 1988). However, it may be the case that current cash flow reflects, for example, a positive shock to demand for the firm's product which in turn will lead to higher investment regardless of capital

[7] See Becker et al. (2002) for an analysis of how export propensity and debt composition affected abnormal stock returns during the crisis.

Table 3
Change in profitability and net worth

Dep variable	(1) $\Delta\text{Profits}_{1995}/K_{1994}$	(2) $\Delta\text{Networth}_{1994}/K_{1993}$	(3) $\Delta\text{WorkingCap}_{1994}/K_{1993}$
$(\text{Exports}/\text{Sales})_{1994Q3}$	0.302*** (0.070)	−0.117 (0.312)	0.264 (0.211)
$(D^*_{\text{short}}/D_{\text{short}}+D^*_{\text{short}})_{1994Q3}$	0.011 (0.072)	−0.912** (0.420)	−0.794** (0.372)
Constant	−0.042 (0.036)	0.617*** (0.214)	0.319 (0.196)
R^2	0.04	0.03	0.02
Observations	180	200	200

Note: Each column reports OLS regression of the variable listed at the top of the column against variables listed at the start of each row. See Appendix A for definitions. Robust standard errors are in parenthesis. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

market imperfections. The peso's devaluation provides an alternative and arguably more robust approach. Specifically, using the currency composition of debt immediately before the devaluation identifies the origin of the shock to the balance sheet.

Table 3 documents that foreign debtors experience relatively large declines in net worth and working capital in the quarter of the devaluation.[8] The definition of net worth is assets minus liabilities and working capital is current assets minus current liabilities. (See Appendix A for full definitions and Table 2 for summary statistics.) Therefore, our benchmark proxy for relative balance sheet health is the foreign currency composition of short-term debt.[9] We measure this variable in the quarter before devaluation to avoid simultaneity bias. The regressions indicate that a 10 point increase in the fraction of short-term debt denominated in foreign currency was associated with a 9% decline in net worth (as a fraction of capital) and an 8% decline in working capital. Of course, it may be the case that debt is chosen in anticipation of devaluation, an issue dealt with formally in Section 4.3. If weak balance sheets constrain investment after the devaluation, we should find a negative relationship between exposure to foreign currency debt and post-devaluation investment.

Motivated by a large theoretical literature relating investment to uncertainty, a third set of controls concerns the variance of profits. The predicted sign of the relationship depends on the nature of adjustment costs and returns to scale (See Caballero, 1991). In our data set, exporting firms experienced the greatest increase in sales growth variability (measured in real pesos) after the devaluation. Although the evidence is only circumstantial, this shift may be due to the abandonment of the peg in 1994 and the subsequent increase in exchange rate uncertainty.[10] To capture volatility changes, we measure the standard deviation of the four-quarter change in log sales for each firm both before the devaluation

[8] The reported regressions use the four quarter difference (1994Q4–1993Q4) in net worth and working capital. The one quarter difference yields a similar pattern of results.

[9] Specifically, the percentage of debt due in the next twelve months that is denominated in foreign currency. Similar results are obtained if we use short-term foreign currency debt normalized by capital rather than total short-term debt.

[10] If export prices tend to be set in foreign currency, export sales reported in pesos will reflect exchange rate volatility. Given slow adjustment of domestic prices, nonexporting firms do not share the same sensitivity. Of course, the reverse is true if we use dollars as our unit of account. It is an empirical question whether volatility in pesos or volatility in dollars influences investment.

and after the devaluation.[11] We use sales volatility rather than profit volatility as there is greater coverage of sales in the data set. However, the results are similar if we use the standard deviation of profit growth. In our regressions, we include both pre-crisis volatility and the difference between pre- and post-devaluation volatilities as controls for volatility.

One important feature of the derivation of Eq. (6) concerns firm fixed effects. It may be the case that firms face inherently different investment opportunities (regardless of the peso's devaluation) and such differences may be correlated with debt composition (or other firm characteristics). However, note that the lagged investment term in Eq. (6) captures investment opportunities that are known at time $t-1$. The remaining term η_t captures investment's response to "news" (i.e., the devaluation) received in time t. Firm specific adjustment costs are discussed in Section 4.3.

In summary, our empirical counterpart to Eqs. (6) and (7) takes the following form:

$$\left(\frac{I}{K}\right)_{j,t} = \alpha_{0,t} + \alpha_1 \left(\frac{I}{K}\right)_{j,t-1} + \alpha \mathbf{X}_{j,t} + u_{j,t} \tag{8}$$

where $\mathbf{X}$ is the vector of firm characteristics that proxy for η_t discussed above. The dependent variable is net investment undertaken in 1995.[12] The residual u_t captures changes in investment opportunities that are not controlled for by $\mathbf{X}$ and shocks to the investment cost function. As the variance of u_t may vary across firms, all standard errors are corrected for heteroscedasticity. Eq. (6) calls for the inclusion of lagged profits as well. However, in all the regressions reported, this term never enters significantly and does not significantly influence the other coefficients. We therefore report only the specifications in which lagged profit is omitted.

4.2. Main results

Table 4 reports the results from our benchmark regressions. Recall from Fig. 4 that despite showing strong relative growth in sales and profits, there is little evidence that exporters increased relative physical capital after the devaluation. Table 4 column (1) reports the regression analog of Fig. 4, where the control variable is the ratio of exports to total sales over the first three quarters of 1994. Guided by Eq. (8), we also include lagged investment (specifically, investment undertaken between 1993Q3 and 1994Q3). The results confirm that without additional controls, propensity to export has essentially zero influence on post-devaluation investment, despite increases in profitability and sales.

[11] In measuring post-devaluation sales volatility we are forced to use data reported during and after 1995, raising the issue of simultaneity. While investment influences mean sales, it is not evident that it will influence volatility. Controlling for mean sales growth does not alter the impact of sales volatility. Moreover, the results reported below indicate that the inclusion of the volatility terms does not change the coefficient on debt composition. There is also the issue of whether post-devaluation volatility is larger because it includes the crisis in year 1995. However, post-devaluation volatility measured without data from 1995 yields similar regression results.

[12] Specifically, I_{1995}/K_{1994} is defined as the physical capital stock reported at the end of 1995 minus the capital stock reported for year-end 1994, divided by the 1994 capital stock. While the year-end 1994 capital stock is reported after the devaluation, using stocks reported at the end of 1994Q3 does not significantly change the results. Capital stock is defined as the replacement value of property, machinery, and equipment plus inventories and construction in progress minus accumulated depreciation.

Table 4
Investment rates

Dep var: I_{1995}/K_{1994}	(1)	(2)	(3)	(4)
$(\text{Exports}/\text{Sales})_{1994Q3}$	−0.006 (0.056)	0.119* (0.065)	0.095 (0.070)	0.212** (0.087)
$(D^*_{\text{short}}/D_{\text{short}}+D^*_{\text{short}})_{1994Q3}$		−0.146** (0.064)	−0.107* (0.062)	−0.146** (0.058)
$(D^*_{\text{long}}/D_{\text{long}}+D^*_{\text{long}})_{1994Q3}$			0.018 (0.032)	
ΔStdDev(%ΔSales)				−0.137** (0.062)
$\text{StdDev}(\%\Delta\text{Sales})_{\text{pre}}$				−0.150** (0.062)
I/K_{1994Q3}	0.058 (0.064)	0.075 (0.069)	0.064 (0.069)	0.038 (0.051)
Constant	−0.041** (0.017)	−0.008 (0.022)	−0.034 (0.024)	0.029 (0.029)
R^2	0.01	0.05	0.03	0.11
Observations	169	169	153	164

Note: OLS regressions. Dependent variable in all regressions is I_{1995}/K_{1994} (the capital stock as of 1995Q4 minus that of 1994Q4 divided by the capital stock of 1994Q4, all in constant pesos). Independent variables are defined in the Appendix A. Robust standard errors are in parenthesis. ** and * indicate significance at the 5% and 10% levels, respectively.

An important control that is missing from the regression of Table 4 column (1) is a measure of shocks to the cost of capital. Recall that the hypothesis of imperfect capital markets relates the cost of capital to balance sheet health, which in turn is strongly influenced by pre-devaluation debt composition. Column (2) therefore includes the currency composition of short-term debt as an additional control. The propensity to export now enters positively and significantly, with a ten percentage point increase in the fraction of sales exported implying a 1.2 percentage point increase in investment rates (p-value=0.02). Firms with a large percentage of short-term debt denominated in foreign currency experienced a significantly lower rate of investment, with a ten percentage point increase in debt denominated in foreign currency implying a 1.5 percentage point drop in the investment rate (p-value=0.02). Given that export propensity and foreign debt composition are significantly correlated (correlation coefficient=0.51, p-value<0.01), the balance sheet effect is offsetting much of the benefits of the real devaluation. Column (3) adds the percentage of long-term debt denominated in foreign currency as an additional control. The results indicate that the composition of long-term debt has little impact on post-devaluation investment rates, highlighting the importance of short maturities.

Column (4) includes measures of pre-devaluation sales volatility (StdDev(%ΔSales)) and the difference between pre- and post-devaluation volatilities (ΔStdDev(%ΔSales)). Both enter negatively and significantly, implying high variance lowers investment. Given that exporting firms experienced the greatest increase in sales variability, the inclusion of these controls doubles the coefficient on export propensity.

We can use the estimates of Table 4 to calculate the economic significance of debt composition. Specifically, consider that in our regression sample the mean net investment rate in 1995 is −3.6%. Our estimate of the conditional sensitivity of investment to debt composition is −0.146. If for each firm we multiply the observed debt composition by −0.146 and average over firms, we find that foreign currency debt reduced mean investment by 4.5 percentage points. That is, if all firms had zero foreign currency debt before the devaluation, ceteris paribus, net physical capital would have increased by 1% rather than fallen by nearly 4%.

Similarly, recall that Fig. 4 showed little difference in investment between high exporters and low exporters. In particular, in the regression sample of 169 firms, high exporters and low exporters recorded mean net investment in 1995 of −3.9% and −3.4%, respectively. However, our estimates indicate that debt composition contributed −7.7 percentage points to mean high exporter investment and −3.4 points to low exporters. That is, if all firms held zero foreign currency debt before the devaluation, high exporters would have had mean investment rates of 3.8% while low exporters would have recorded zero net investment.

4.3. Robustness

One concern about the use of pre-devaluation debt composition is the potential that debt is chosen to hedge against capital market imperfections (see Froot et al., 1993). Specifically, firms that desire to expand investment in the wake of a devaluation may reduce their foreign currency exposure to ensure strong balance sheets after the devaluation. To control for this possibility, we need to instrument for debt composition. Our instrument is whether a firm has issued equity in the US through American Depository Receipts (ADRs) as of the first quarter of 1995. Firms that issue equity overseas also tend to issue debt, implying a strong first stage relationship (adjusted $R^2=0.32$).[13] Moreover, ADRs do not serve the same role in hedging exchange rate risks as does debt. One potential concern with using ADRs as an instrument is that firms that issue ADRs may have attributes that are correlated with post-devaluation investment. Any constant difference between firms is controlled for by lagged investment (recall the discussion of Eq. (6)). While access to overseas equity financing may influence the innovation to investment due to the collapse of the domestic banking sector, the bias is one in which firms that issue ADRs have relatively better access to capital. That is, if anything, using ADRs as an instrument should reduce the negative relationship between foreign currency debt and investment. Table 5 column (1) shows this is not the case. The point estimates suggest that the negative effect of foreign currency debt is larger than for OLS and the coefficient on propensity to export increases.

Another concern regarding our benchmark results is that firms may disguise their true ex ante currency exposure through unobserved hedging mechanisms. In particular, in our benchmark regressions we do not measure balance sheet health directly, but rather use debt composition as a proxy. An alternative strategy is to use direct measures of changes to net worth and working capital. One issue with this approach is that measures of post-devaluation net worth may be correlated with unobserved investment opportunities (i.e., u_t). To avoid possible endogeneity, we use (lagged) debt composition as an instrument. The correlation of ex ante debt composition with ex post changes to net worth was documented in Table 3. Column (2) of Table 5 reports investment's relationship with changes in net worth and column (3) reports the impact of shocks to working capital. In both specifications, firms which showed a relative improvement in their balance sheet exhibited higher investment rates. Specifically, a change in net worth equal to 10% of

[13] For a study of debt composition in Mexico, see Gelos (2003).

Table 5
Investment rates — alternative specifications

Dep var: I_{1995}/K_{1994}	(1)	(2)	(3)	(4)	(5)
$(\text{Exports}/\text{Sales})_{1994Q3}$	0.394* (0.211)	0.187** (0.091)	0.156 (0.094)	0.214** (0.088)	
$\Delta\text{Networth}_{1994}/K_{1993}$ (IV)		0.113** (0.056)			
$\Delta\text{WorkingCap}_{1994}/K_{1993}$ (IV)			0.146* (0.082)		
$\Delta\text{Profits}_{1995}/K_{1994}$ (IV)					0.554** (0.256)
$(D^*_{\text{short}}/D_{\text{short}}+D^*_{\text{short}})$	−0.361 (IV) (0.242)			−0.145** (0.057)	−0.114* (0.063)
$\Delta\text{StdDev}(\%\Delta\text{Sales})$	−0.141*** (0.052)	−0.127* (0.074)	−0.140* (0.072)	−0.138** (0.067)	−0.093* (0.052)
$\text{StdDev}(\%\Delta\text{Sales})_{\text{pre}}$	−0.165*** (0.055)	−0.127* (0.073)	−0.128* (0.073)	−0.151** (0.068)	−0.092* (0.050)
$\ln(\text{Sales})_{1993/94}$				−0.001 (0.008)	
$(\text{TotalDebt}/K)_{1994Q3}$				−0.000 (0.019)	
$\text{I}/\text{K}_{1994Q3}$	0.072 (0.065)	−0.077 (0.065)	−0.029 (0.072)	0.039 (0.051)	−0.004 (0.049)
Constant	0.083 (0.067)	−0.046 (0.029)	−0.025 (0.024)	0.049 (0.121)	0.031 (0.031)
R^2	(IV)	(IV)	(IV)	0.11	(IV)
Observations	164	163	163	164	164

Note: Dependent variable in all regressions is I_{1995}/K_{1994}. Independent variables are defined in the Appendix A. Column (1) instruments for short-term debt composition using issuance of ADRs as instrument (see text). Column (2) uses short-term debt composition as an instrument for change in net worth. Column (3) uses short-term debt composition as an instrument for change in working capital. Column (4) is an OLS regression and column (5) uses propensity to export as an instrument for changes to the ratio of profits to capital. Robust standard errors are in parenthesis. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

capital leads to a 1.1 percentage point (p-value 0.05) decline in the investment rate, while a 10% drop in working capital implies a 1.5 percentage point decline in investment (p-value 0.08). The coefficient on propensity to export and sales volatility remain in line with those reported in Table 4.

An additional concern with the specifications of Table 4 concern omitted firm characteristics that are correlated with debt composition. In particular, large shares of foreign currency debt may be associated with large leverage ratios in general or the size of firm. Leverage and size may, in turn, influence the ability to invest after a crisis. To test whether these omitted characteristics are biasing the benchmark results, we include log total sales (averaged over 1993 and 1994) to control for firm size[14] and the total debt to capital ratio (measured before the devaluation) as additional controls. As reported in column (4) of Table 5, these additional controls have zero marginal impact on post-devaluation investment.

Our benchmark regressions use propensity to export as a proxy for the change in investment opportunities. Obviously, using a proxy implies we are measuring changes to the marginal product of capital with error. Moreover, our measure of propensity to export does not correct for imported inputs due to data limitations. An alternative measure of the relative change in marginal product of capital is the post-devaluation change in average profits. This measure will also reflect other relevant sources of income, such as from hedging instruments. Similar to the concerns regarding the use of post-devaluation net worth, post-devaluation profits may be correlated with the contemporaneous shock to investment (u_t) (and in general will also differ from marginal product). To obtain consistent estimates, we instrument with the pre-devaluation propensity to export.[15] The results reported in Table 5 column (5) confirm the validity of our benchmark regressions. A change in profits equal to 10% of capital is associated with a 5.5 percentage point increase in the investment rate (p-value=0.03), while dollar debt continues to have an elasticity of -0.11. Replacing the change in profits with the percentage change in sales yields similar results, namely, foreign currency debt significantly deters investment (coefficient=−0.13, p-value=0.02) while firms with positive sales growth exhibit stronger investment rates (elasticity of 0.19, p-value=0.01).[16]

While not reported to conserve space, we performed a battery of additional robustness checks. We checked for nonlinearities by including a quadratic term in dollar debt exposure as well as dummy variables indicating exposure greater than 70%, which represents the top 15% of firms. No evidence of a nonlinear effect was detected. We also included a dummy for whether the firm was part of a holding company. Castaneda (2001) has argued such firms outperformed other firms during the Mexican crisis. Given that only 15 of the 169 firms in the data set were so classified, the data allowed no precise conclusions to be drawn. It was also the case that firms which were partially foreign

[14] Using log capital stock or log assets as a measure of size yield similar results.

[15] Note that mismeasurement of propensity to export will not bias our IV results as long as the measurement error in net exports is orthogonal to the measurement error in profits.

[16] Our derivation of Eq. (5) assumed that current investment determined current production. If investment has a delayed effect on capital, we need to include next period's expected marginal product in our specification. To ensure that expected profits were in the $t-1$ information set, we also used lagged profits as instruments rather than tendency to export with no meaningful change in the coefficient on dollar debt.

owned through ADRs displayed the same investment behavior as their purely domestically listed compatriots. An additional concern is firm fixed effects. Specifically, any firm specific factor, such as an idiosyncratic adjustment cost c, would lead to correlation between the residual $u_{i,t}$ and lagged investment. We explored the relevance of this concern by taking first differences of Eq. (8) to eliminate the fixed effect and used twice lagged investment as an instrument for $\Delta(I/K)_{t-1}$ (see Hsiao (2003) Ch 4 for a discussion). We found no substantial change in the effect of propensity to export or debt exposure on investment rates.

Finally, we explore the relationship between real exchange rate movements and debt exposure throughout the 1990s. Specifically, we regress investment rates on the percentage change in the real exchange rate interacted with lagged foreign currency debt exposure. The regression also includes lagged investment, lagged foreign currency debt exposure independently and year dummies. The real exchange rate is defined as the year-end nominal exchange rate (expressed as peso/$) multiplied by the ratio of US to Mexican prices. The fourth quarter CPI for the US and Mexico are used to represent relative own currency prices. The percentage change in the real exchange rate is then the log first difference of this variable (where as usual the difference dated year t is the difference between the end of year t and the end of year $t-1$). Note that a positive change in the real exchange rate represents a depreciation of the peso. Following Bleakley and Cowan (2002) we first interact the contemporaneous change in the real exchange rate with lagged debt exposure. Column 1 of Table 6 indicates that for the period 1994–1995, firms that are relatively exposed to foreign currency liabilities experience relative *high* investment rates as the currency depreciates. Column 3 indicates this positive relationship holds for the entire sample (1993–2000).

The sign of this relationship appears at first glance to contradict the standard balance sheet intuition. However, a key issue is the timing of the effect. Consider that Mexico devalued in December of 1994. The real exchange rate during that year depreciated nearly 50%. There was essentially no real depreciation in the following year (as measured by year-end prices). As investment for exposed firms collapsed in 1995 relative to 1994, while at the same time the real exchange rate depreciated significantly

Table 6
Investment and the real exchange rate

Dep var: I_t/K_{t-1}	1994–1995		1993–2000	
	(1)	(2)	(3)	(4)
Coefficient on:				
$\Delta 1n(RER)_t$* $(D^*_{short}/D_{short}+D^*_{short})_{t-1}$	0.508** (0.236)		0.397** (0.190)	
$\Delta 1n(RER)_{t-1}$* $(D^*_{short}/D_{short}+D^*_{short})_{t-1}$		−0.464** (0.215)		−0.105 (0.229)
Observations	356	356	1295	1295

Note: OLS regression. Additional controls include lagged (one year) percentage of short term debt denominated in foreign currency, lagged investment, and year dummies. Real exchange rate (RER) is defined as end of year nominal exchange rate (peso/$) times fourth quarter US CPI divided by fourth quarter Mexican CPI. Robust standard errors are in parenthesis (clustered on firm). ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

in 1994 but not in 1995, the regressions naturally identify a positive relationship. Given that investment responds to balance sheet shocks with a lag (and the fact that the shock of 1994 occurred in December), a more natural specification interacts lagged changes in the real exchange rate with currency exposure. The results reported in column 2 for 1994–1995 indicate the negative relationship documented above. That is, firms with relatively large amounts of foreign currency debt experience a relative decline in investment the year after a real depreciation. Column 4 indicates that this relationship, albeit weaker statistically and in magnitude, continues to hold for the entire sample. Although not reported, the inclusion of propensity to export does not alter the results substantially. However, as before, the balance sheet effect holds primarily for short-term currency debt. Moreover, as would be expected from a model with adjustment costs, the inclusion of lagged investment is important. The results are robust to controlling for fixed effects through first differencing and instrumenting for lagged investment. In short, once we allow for a reasonable lag between asset price shocks and investment, we recover evidence of a strong balance sheet effect stemming from the combination of devaluation and foreign currency debt.

5. Conclusion

Traditional exchange rate theory as well as studies using sectoral level data suggest real devaluations ultimately lead to expansions in the tradable sector. Using firm-level data, this paper confirms that exporters led Mexico's post-devaluation recovery in terms of sales and profits. However, the data also imply exporting firms posted relatively high growth rates without increasing relative capacity.

This surprising cross-sectional pattern of investment stems in large part from the substantial shares of short-term foreign currency debt held by exporting firms on the eve of the devaluation. Such exposure translated into sharp drops in net worth and working capital and subsequently low levels of investment in the year after the peso's collapse. Compounding weakened balance sheets, exporters also faced increased sales volatility once the peso was allowed to float. This volatility translated into a further reduction in relative investment. A growing theoretical crisis literature emphasizes the combination of short maturities and foreign currency denomination in explaining contractionary devaluations. The evidence presented in this paper suggests that this "balance sheet effect" was at work during the peso crisis of 1994–1995.

Acknowledgement

I would like to thank Gita Gopinath, Erik Hurst, an anonymous referee, and seminar participants at Wisconsin, Purdue and Chicago for comments. I also thank Daniel Volberg for research assistance. This paper was written while the author was at the University of Chicago and I thank the Chicago GSB for research support. The views expressed are not necessarily those of the Federal Reserve Bank of Boston or the Federal Reserve System.

Appendix A. Definition of key variables

Note: All variables are reported in (CPI) inflation adjusted pesos with 2000 as the base year (items originally denominated in foreign currency are first converted to pesos a the contemporaneous exchange rate).

Capital stock (K)	Replacement value of property, machinery, and equipment plus inventories and construction in progress minus accumulated depreciation.
Operating profits	Sales less cost of goods sold and related operating expenses that are applied to the day-to-day operating activities of the company. It excludes financial related items (i.e., interest income, dividend income, and interest expense), extraordinary items, and taxes (same as operating income).
Net worth	Assets minus liabilities.
Sales (Net sales)	Revenues less discounts, allowances, returns, etc.
Working capital	current assets (comprised of cash and temporary investments, receivables and inventories) minus current liabilities (comprised of loans due within the next 12 months and accounts payable).
D_{short}, D^*_{short}, D_{long}, D^*_{long}	D refers to peso liabilities and D^* to foreign currency liabilities. Short refers to due within the next twelve months. Long refers to due in more than twelve months.
$\Delta\text{Networth}_{1994}$	Net worth reported 1994Q4 minus net worth reported 1993Q4.
$\Delta\text{WorkingCap}_{1994}$	Working capital reported 1994Q4 minus working capital reported 1993Q4.
$\Delta\text{Profits}_{1995}$	Four quarter operating profits reported at the end of 1995 minus the four quarter operating profits reported at the end of 1994.
$(I/K)_t$	Capital stock reported at the end of period t divided by the capital stock reported four quarters before all minus one.
$\text{StdDev}(\%\Delta\text{Sales})_i$, i=pre, post	$\%\Delta$Sales at each date is reported log sales minus log sales reported four quarters prior. For each firm, we calculate the standard deviation of this series for the "pre" and "post" devaluation periods. "pre" refers to 1991Q1–1994Q3 and "post" refers to 1995Q1–2000Q4.
$\Delta\text{StdDev}(\%\Delta\text{Sales})$	The difference between $\text{StdDev}(\%\Delta\text{Sales})_{\text{post}}$ and $\text{StdDev}(\%\Delta\text{Sales})_{\text{pre}}$.

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