

# “Credit Constraints, High Fixed Costs and the Asian Currency Crisis: Firm Level Evidence from Thailand ”

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Abstract

This paper examines the relative roles of financial constraints and average cost behavior in depressing output during the 1997 currency crisis in Thailand. We analyzed Thai firm level data between 1996-2000, and found robust evidence of decreasing short-run average costs. Taking the median estimate, a 50 percent decline in output raises average costs by 8-9 percent. We attribute the decreasing short-run average costs to high fixed costs of productions, such as high capital, labor and land costs that do not vary with output. We also found evidence that the crisis-induced deterioration in firm financial characteristics significantly raised the borrowing costs of Thai firms.

Key Words: Thai Currency Crisis, Financing Constraints, Over-investment, Credit Constraints

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## 1. Introduction.

Currency crises have devastating effects on economic growth and welfare. In the worst year of the Asian Currency Crisis--1998--real output *fell* by 6.9 percent in Korea, 10.8 percent in Thailand, 7.7 percent in Malaysia, and 14.1 percent in Indonesia. Many papers have analyzed the causes of the Asian Currency Crisis, and currency crisis in general (for a sample, see the papers in Edwards and Frankel, 2002). However, despite the variety of their approaches, most of these papers attribute the Asian crisis to just two underlying causes.

The first cause is the crisis-induced tightening of credit constraints facing domestic firms. Aspects of this “credit constraints” view are stressed in the models of Chang and Velasco (1999), Cole and Kehoe (1997), Radelet and Sachs (1998), Furman and Stiglitz (1998), and Aghion, Bacchetta, and Banerjee (2000). According to this view, the crisis started when international lenders refused to roll over their loans, resulting in a sudden drop in capital inflows to emerging markets. The domestic currency depreciated, leading to a sharp rise in foreign debt service obligations. Because of moral hazard, some lenders, particularly banks, based their lending decisions on observable firm financial characteristics, especially the level of foreign debt services. When these characteristics deteriorated, banks cut back their lending. Moreover, as the overall balance sheets of banks weakened, banks reduced their lending to all firms.

The second cause of the Asian currency crisis emphasizes the high fixed costs of domestic firms, because of overcapitalization and labor rigidity. According to this view, implicit government guarantees of international borrowing led to labor hoarding and excessive investment in physical capital and land. This “over borrowing and overcapitalization” view is stressed in the models of Corsetti, Pesenti, and Roubini (1998), Dooley (1998), McKinnon and Pill (1997), and Dekle and Kletzer (2002). The profitability of capital became low, and firms

broke even only with large (output) production scale. A slight increase in the price of inputs, say caused by a depreciation of the domestic currency, made production very expensive, leading to large profit losses. Observing these losses, foreign lenders cut off their lending, resulting in further output declines and profit losses and so on.

Despite the plethora of theoretical models, empirical work distinguishing between these related two causes of the Asian crisis are scarce. In this paper, we examine Thai firm level data during 1996-2000, to distinguish between these two causes of the Asian crisis. We estimate average cost functions for Thai firms to see whether credit constraints or high fixed were more important in raising production costs, and lowering output.

We find that during the Asian crisis, the financial characteristics of firms severely deteriorated, tightening credit constraints. Moreover, holding firm characteristics constant, overall credit tightened during the worst years of the crisis, 1997 and 1998. However, we estimate a rather small impact of tightening credit constraints on raising average costs and lowering output.

Rather, we find that high fixed costs are more responsible for the large declines in output observed during the Asian crisis. Elementary textbooks teach us that short-run average costs are likely to be downward sloping (decreasing with output) with high fixed costs. Say that an increase in the price of inputs results in a decline in output for the typical firm. If average costs are upward sloping, the initial decline in output lowers marginal costs, making it cheaper for the firm to expand production. However, if average costs are downward sloping (high fixed costs), the initial decline in output raises marginal costs, making it more expensive for the firm to offset the initial decline in output. In our estimates of firm cost functions, we find strong evidence of downward sloping short-run average costs. Our estimates of short-run average costs for Thailand

are especially econometrically well identified, since during the crisis, output has varied greatly, both across firms and over time. We find that a 50 percent decline in output raises short-run average costs by 8-9 percent. Our finding of high fixed costs and downward sloping short-run average costs also supports the contention of Young (1995) and others that the impressive growth rates for East Asia were primarily due to a fast rate of capital and labor accumulation, rather than to higher total factor productivity growth.

Some previous works have estimated the effects of credit constraints on output during the Asian crisis. Ito and Pereira da Silva (1999) used survey data for Thai commercial banks to argue in favor of a credit crunch that depressed output in Thailand. Dwor-Frecuat, Hallward-Driemeir, and Colaco (1998), however, analyzed a survey of East Asian firms and found that credit availability was not seen by the surveyed firms as a major constraint on production plans. Domac and Ferri (1999) argued that the widening of the spread between the bank lending rate and the rate on risk-free assets represented evidence that the credit crunch was widespread. Finally, Osangthammanout (2002), like this paper, used Thai firm level data to try to uncover the tightening of credit constraints during the crisis. As in this paper, he found that all firms were more credit constrained during the crisis. In addition, small non-tradeable firms were most credit constrained, while large tradable firms were least credit constrained during the crisis. However, unlike in this paper, Osangthammanout (2002) did not estimate the impact of tightening credit constraints on firm average costs and output.

Work examining the role of potential inefficiencies in physical investment, labor rigidity, and high fixed costs in worsening the East Asia crisis are scarce. Berg (1998) presents evidence showing that incremental capital-output ratios rose in the mid-1990s in the East Asian countries, implying that more investment was necessary for a given growth in output. Borenszstein and Lee

(2002) present evidence showing that conglomerate-affiliated firms in Korea enjoyed preferential access to credit prior to the crisis, leading to overinvestment in physical capital and labor hoarding. However, Hsieh (1997), after carefully estimating long-run (over several decades) cost functions for East Asian countries, finds high total factor productivity growth rates over the long run.

This paper is organized as follows. In Section 2, we show how we model credit constraints and average cost behavior at the firm level for an emerging market country like Thailand. In Sections 3 and 4, we show how increases in output and input prices, credit constraints and average cost behavior interact to depress firm output during currency crisis. Sections 5 and 6 describe the data, and the estimation specifications of the credit constraint and average cost functions. The estimation results are presented in Section 7. Section 8 concludes.

## 2. Credit Constraints and the Behavior of Firm Average Costs:

Our analysis rests on two assumptions regarding the typical firm in an emerging market like Thailand. First we assume that the firm is credit constrained, that the excess borrowing costs of firm  $i$  depends on the financial characteristics of the firm:

$$\tilde{R}_{it} = \tilde{R}(f_{it}). \quad (1)$$

$\tilde{R}_{it}$  are excess real borrowing costs, the ratio of nominal borrowing costs of firm  $i$ ,  $R_{it}$ , and the risk-free nominal interest rate,  $R_t$ ,  $\tilde{R}_{it} = R_{it}/R_t$ .  $f_{it}$  is a vector of financial characteristics of the firm that may affect the firm's ability to borrow, such as cash flow, asset size, and the ratio of debt to assets. Our specification of credit constraints follows Aguiar (2001) and others, and assumes that banks and other lenders differentiate between good- and poor credit risk borrowers by charging the poor risk borrowers, higher interest rates.

An alternative way to model credit market imperfections is to follow Stiglitz and Weiss (1981) and assume that lenders cannot differentiate among borrowers—all borrowers are charged the same common interest rate, and accept a common fixed loan size. In the Stiglitz and Weiss model, there is an induced tendency for firms with poor financial characteristics to borrow more, since these firms have higher default rates and lower expected interest costs. Given that the supply of all bank loans is fixed, credit is rationed to firms with poor financial characteristics, with the amount of rationing increasing with the deterioration in  $f_{it}$ . An implication of the Stiglitz and Weiss model is that rationed firms cannot increase their borrowing no matter what  $\tilde{R}_{it}$  they are willing to pay;  $\tilde{R}_{it}$  is effectively infinite at the fixed loan level.

Our assumption that excess borrowing costs  $\tilde{R}_{it}$  are related to  $f_{it}$  can be made consistent with the Stiglitz and Weiss (1981) model. Anecdotal evidence says that during the Thai and Korean crises, firms that were rationed from banks went to finance companies to borrow at higher interest rates; and those that were rationed from finance companies went to the curb market to borrow at even higher interest rates (Phongpaichit and Baker, 2000, p. 49-57; IMF, 1998). Thus, there is a hierarchy of lenders in Thailand and Korea (and in many other developing countries, with segmented financial markets). As their financial conditions  $f_{it}$  deteriorated, firms moved down the hierarchy of lenders (from banks to curb market money lenders), in turn, paying higher premia over the risk-free rate,  $\tilde{R}_{it}$ .<sup>1</sup>

The second set of assumptions relate to the technology of the firm. We assume that firm  $i$  belongs to industry  $j$ , such as non-tradable or construction, and that production is Cobb-Douglas;

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<sup>1</sup> Of course, there may be firms with financial characteristics so poor that no one will lend to them. These firms effectively go bankrupt, and drop out from the sample. In our empirical work, we examine how bankruptcies are related to  $f_{it}$ .

with factor inputs labor, intermediate goods, and capital; having factor prices  $W_{jt}, F_{jt}, R_{it}$  respectively. The cost function is then standard (Berndt, 1991, p. 69):

$$C_{it} = A_{it} * W_{jt}^{\delta} F_{jt}^{\theta} R_{it}^{1-\delta-\theta} * y_{it}^{\varepsilon} \quad (2)$$

where  $A_{it}$  is a productivity term,  $y_{it}$  is firm output, and  $\varepsilon$  describes how average and marginal costs change when output changes. Average costs *decrease, are constant, or increase* with increasing output, as  $\varepsilon < 1$ ,  $\varepsilon = 1$ ,  $\varepsilon > 1$ , respectively.<sup>2</sup> Marginal costs are proportional to average costs, with  $\mathcal{E}$  the constant of proportionality. Since marginal costs are not always constant, (2) should be interpreted as a short-run cost function, in which some factor inputs are fixed.

Our interpretation of *decreasing* average costs ( $\varepsilon < 1$ ) is the presence of high fixed costs, such as the fixed portion of the wage bill, or the rental costs of land, structures, and machinery that are incurred every year regardless of the output level. Young (1995) has argued that the impressive growth rates for East Asia are primarily due to a fast rate of factor accumulation.<sup>3</sup> That is, production in East Asian countries is highly intensive in fixed factors, especially in capital and labor that cannot be fired. With high levels of fixed capital, labor, and other factors, average costs are declining with increasing output levels (at least, within a given output range).<sup>4</sup> If so, slight decreases in demand or increases in variable (input) costs can lead to large changes

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<sup>2</sup> Also, it is well-known that for the cost-function to be well-behaved, the cost-function has to be homogeneous of degree one in input prices, so the exponents on the input prices sum to one (Berndt, p. 170).

<sup>3</sup> Hsieh (1997), however, takes issue with Young (1995), and attributes high East Asian growth rates to high total factor productivity growth, rather than to the rapid accumulation of productive factors.

<sup>4</sup> With Cobb-Douglas production, average costs always decline as output increases, implying that fixed costs must be “very” large, when  $\varepsilon < 1$ .

in output. Corsetti, Pesenti, and Roubini (1998), McKinnon and Pill (1997), and Dekle and Kletzer (2002) emphasize the role of overinvestment and high fixed costs in depressing output during the East Asian Crisis.

### 3. Credit Constraints and Depressed Output During Crisis (With Increasing Average Costs, $(\epsilon > 1)$ :

To fix ideas, we first examine the role of credit constraints in depressing output, in the simple, standard case of increasing average costs. Let firm  $i$  be a price-taker of domestic or international prices prevailing in the industry,  $p_{jt}$ . We can then express the profits of firm  $i$  in industry  $j$  at the beginning of any period  $t$ , namely,

$$\pi_{it} = p_{jt} * y_{it} - A_t * W_{jt}^\delta F_{jt}^\theta R_{it}^{1-\delta-\theta} * y_{it}^\epsilon. \quad (3)$$

Maximizing (3) with respect to  $y_{it}$  and simplifying, we obtain:

$$y_{it} = \left( \frac{p_{jt}}{A_t * W_{jt}^\delta F_{jt}^\theta R_{it}^{1-\delta-\theta} * \epsilon} \right)^{\frac{1}{\epsilon-1}}. \quad (4)$$

Let  $c_{jt} = W_{jt}^\delta F_{jt}^\theta R_{jt}^{1-\delta-\theta}$  represent the unit cost index for industry  $j$ . Then (4) can be

re-written as: 
$$y_{it} = \left( \frac{p_{jt}}{c_{jt} * A_{it} * \tilde{R}_{it}(f_{it})^{1-\delta-\theta} * \epsilon} \right)^{\frac{1}{\epsilon-1}} \quad (5)$$

That is, firm output *rises* with increasing industry prices,  $p_{jt}$ ; and *falls* with increasing industry unit costs,  $c_{jt}$ , and firm excess borrowing costs,  $\tilde{R}_{it}$ .

Currency crises are typically accompanied by dramatic changes in macroeconomic variables. In a typical currency crisis, there is a sharp depreciation of the domestic currency, and a large drop in net capital inflows (Edwards and Frankel, 2002). In Thailand during the first year of the currency crisis, the Baht depreciated about 34 percent against the U.S. dollar, and net capital inflows dropped from plus 4 billion dollars in 1997 to minus 15 billion in 1998. Similar patterns in macroeconomic variables were observed in other crisis countries. These changes in macroeconomic variables affect firm output through (5), by raising industry unit costs and prices,  $C_{jt}$  and  $P_{jt}$ , and the firm's excess borrowing costs,  $\tilde{R}_{it}$ . Industry unit costs,  $C_{jt}$ , will increase, since the crisis will raise most input prices. The currency depreciation will raise the prices of imported or internationally traded intermediate inputs ( $F_{it}$ ) such as petroleum, raw materials, and machinery.

How much industry prices,  $p_{jt}$  increase after currency depreciation depends on whether the industry produces tradeable goods that are highly integrated in international markets. The more integrated the good in international markets, the higher the price increases, because the law of one price is more likely to hold. However, even prices for so-called "non-tradeable" goods may increase somewhat, since most non-tradeable contain some tradable components. For example, during the first year of the crisis, tradable goods prices rose by 8.2 percent, 12.5 percent, and 6.0 percent in Korea, Thailand, and Malaysia. Non-tradeable prices rose by 5.1 percent, 9.3 percent, and 5.4 percent in Korea, Thailand, and Malaysia. While the ratio of prices to unit costs  $\frac{P_{jt}}{C_{jt}}$  may increase for some highly tradeable industries, that ratio is likely to fall for industries that are less integrated in international markets.

Borrowing costs can increase when the firm's balance sheets ( $f_{it}$ ) deteriorate (through (1)). Alternatively, when a crisis strikes, borrowing costs can tighten for all firms, resulting in an upward shift in the excess borrowing function,  $\tilde{R}'(f_{it}) > \tilde{R}(f_{it})$ . As an example of the former increase in borrowing costs, a currency collapse can damage a particular firm's balance sheets by raising foreign debt levels in domestic currency terms. In Thailand and in other countries, the collapse of the domestic currency sharply raised foreign debt levels. Just prior to the crisis at the end of the second quarter 1997, the Thai private sector foreign debt-GDP ratio stood at about 60 percent (Bank of Thailand, 2003). A year after the depreciation of the Thai baht, the same debt-GDP ratio increased to 93 percent. This channel is emphasized in the currency crisis models of Calvo (1998), Krugman (1999), and Aghion, Bacchetta, and Banerjee (2000) who show how risky debt denomination (too much foreign currency borrowing) can damage corporate balance sheets, when the domestic currency depreciates.

As an example of the latter tightening of borrowing costs, more generally, lending by domestic banks to all firms may decline in times of financial panic, resulting in an upward shift in the excess borrowing function (1). In Korea, while 99 percent of foreign short-term loans were renewed in December 1996, by December 1997, only 15 percent of foreign short-term loans were renewed (IMF, 1998). To explain these declines in rollovers, Chang and Velasco (1999) and Cole and Kehoe (1997) emphasize coordination problems among lenders in the presence of short-term debt. In these models, lenders refuse to rollover their loans, because they fear others may also refuse to do so, resulting in a sudden drop in capital inflows. Related to Radelet and Sachs (1998) and Furman and Stiglitz (1998) emphasize that currency crisis push highly leveraged borrowers to financial insolvency, creating a general financial panic, and discouraging

foreign and domestic lenders from rolling over their loans.

According to (5), real output falls when the ratio of industry prices to firm costs,  $\left(\frac{p_{jt}}{c_{jt} * A_{it} * \tilde{R}_{it} (f_{it})^{1-\delta-\theta} * \varepsilon}\right)$ , increases. As shown above, for goods that are less integrated in

international markets, this is highly plausible, since the ratio of industry prices to unit costs will be falling. However, if the deterioration in  $f_{it}$ , or the upward shift in  $\tilde{R}_{it}$  are sharp, output can decline even for highly tradeable industries.

#### 4. Effects of Currency Crisis on Firm Output (With Decreasing Costs, $\varepsilon < 1$ ):

With decreasing average costs, a firm cannot be a pure price taker (Novshek and Sonnenshein, 1987). We assume that the demand curve facing firm  $i$  in industry  $j$  is:

$$p_j = a_j - \gamma_j * \left( \sum_{k \neq i}^{N_j} y_{kj} + y_i \right), \quad (6)$$

where  $\sum_{k \neq i}^{N_j} y_{kj}$  is the output of firms other than firm  $i$ . We also assume that  $a_j = \beta_j * e$ , that

is, as before, a depreciation of the exchange rate raises domestic prices. Since tradeable prices are more integrated with international prices,  $\beta_j$  should be higher for the tradeable sector, than for the nontradeable sector.

Maximizing profits, and applying the implicit function theorem, we obtain<sup>5</sup>:

$$\frac{\partial y_i}{\partial e_t} = - \frac{(\varepsilon y_i^{\varepsilon-1} \frac{\partial(c_{jt} A_{it} \tilde{R}_{it} (f_{it})^{1-\delta-\theta})}{\partial e_t} - \beta_j)}{(2\gamma_j + \varepsilon c_{jt} \tilde{R}_{it} (f_{it})^{1-\delta-\theta} (\varepsilon-1) y_i^{\varepsilon-2})}. \quad (7)$$

The term in the denominator says that increases in marginal revenue must be larger than increases in marginal costs, for the firm to be maximizing profits. The term in the numerator says that a currency depreciation will lower output if the increase in industry prices ( $\beta_j$ ) is lower than the rise in firm costs  $\varepsilon y_i^{\varepsilon-1} \frac{\partial(c_{jt} A_{it} \tilde{R}_{it} (f_{it})^{1-\delta-\theta})}{\partial e_t}$ . Since nontradeable prices are unlikely to rise much, this is plausible for the nontradeable sector. Again, if the deterioration in  $f_{it}$  or the upward shift in  $\tilde{R}_{it}$  is sharp, output can decline for all firms, including for those in the tradeable sector.

With decreasing average costs,  $\varepsilon < 1$ , the value of the denominator in (7), although positive, will be low. For a given numerator value (excess of the change in costs over prices), the decline in output will be higher, with decreasing average costs. With *increasing average costs*, an initial crisis-induced output decline will raise prices, but also lower marginal costs. With lower marginal costs, the firm can produce more, and offset the initial output decline. However, with *decreasing average costs*, a crisis-induced decline in output will raise marginal costs.

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<sup>5</sup> We also imposed the Cournot assumption that  $\sum_{k \neq i}^{N_j} \frac{\partial y_k}{\partial y_i} = 0$ .

Without running losses, the firm cannot increase production. Thus, the output decline will be larger with decreasing average costs. In sum, with decreasing costs, depreciations are likely to result in large output declines, especially for firms producing goods not highly internationally integrated, or with tight excess borrowing constraints.

### 5. Estimation of the Average Cost and Excess Borrowing Functions for Thai Firms.

To examine these interacting effects of credit constraints and average cost behavior in depressing output during economic crisis, we jointly estimate the excess borrowing (1) and average cost functions (from (2)), using data from the Thai economic crisis of 1996-2000.

We assume that the excess borrowing costs for firm  $i$  at time  $t$  depend linearly on firm financial characteristics, the industry-affiliation of the firm, and the macroeconomic conditions prevailing at time  $t$ :

$$\ln \tilde{R}_{it} = a + w_j + d^* fc_{jt-1} + m' w_t + e_{it}. \quad (8)$$

where  $fc_{c,t-1}$  is a vector of firm financial characteristics;  $w_j$  is an industry-affiliation dummy variable;  $w_t$  is a vector of time dummy variables to control for macroeconomic shocks ( $D97, D98, D99, D00$  ( $m$  is vector of coefficients on these time dummies)); and  $e_{it}$  is an idiosyncratic shock.

The firm financial characteristics that are believed to affect excess borrowing costs are: the ratio of *cash flow to firm capital stock*, the *coverage ratio* (earnings/interest expenses), *log asset size*, and the *leverage ratio* (the ratio of debt to assets) (Hubbard, 1998; James and Houston, 2001; Aguiar, 2001). Following the earlier literature, these characteristics are lagged in our empirical specification to reduce endogeneity problems. Decreases in the cash flow and

coverage ratios, and in the log asset size; and increases in the leverage ratio should all raise excess borrowing costs.

We estimate the average cost function (from (2)), rather than the supply functions (4) or (7), since while the supply functions depend sensitively on market structure (perfect or Cournot competition, etc.), the average cost function is robust to different market structures.<sup>6</sup>

We take the logarithm of the cost function (2):

$$\ln(c_{it}) = \ln A_{it} + \delta \ln W_{ji} + \theta \ln F_{jt} + (1 - \delta - \theta) \ln R_{it} + \varepsilon \ln y_{it} , \quad (3')$$

and assume that log productivity can be expressed as a function of industry, firm specific, and time dummy variables:

$$\ln A_{it} = a + w_j + w_i + n' w_t + w_{it} \quad (9)$$

where  $a$  is a constant,  $w_j$  is a firm-specific dummy variable, and  $w_{it}$  is an idiosyncratic error.

In practice, it is difficult to obtain industry-level wages, rental rates, and especially other input prices, such as materials and land, for an emerging market country like Thailand. We thus follow the simplification of Berndt (1991, p. 72), and assume that the effects of the three input prices can be captured by the industry-specific GDP deflator:

$$\ln(\text{GDPDEF}_{jt}) = \delta \ln W_{ji} + \theta \ln F_{jt} + (1 - \delta - \theta) \ln R_{jt} + u_{jt} , \quad (10)$$

where  $u_{jt}$  is an approximation error.

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<sup>6</sup> In addition, while we have assumed that firm output is supply-determined, if output is demand-determined, say, due to sticky prices, then estimation of the supply function will in general be inconsistent. However, the estimation of the cost-function will still be consistent.

Substituting (9) and (10) into (3'), and dividing through by  $y_{it}$ , we obtain our measure of the log average cost function:

$$\ln(AVC_{it}) = a + w_j + w_i + n'w_t + (1 - \delta - \theta)\ln \tilde{R}_{it}(f_{it}) + (\varepsilon - 1)\ln y_{it} + v_{it}, \quad (11)$$

where  $v_{it} = w_{it} + u_{jt}$ .

Our econometric strategy is to estimate (8) (first-stage), and (11) by panel two-stage least squares, in which we treat  $w_i$  as a fixed effect.

By estimating (8) and (11) jointly, two important implications of our model will be examined. The first important implication is whether the credit constraints of firms indeed tightened during the financial crisis. Using Thai firm level data, we examine whether the ratios of cash flow to firm capital, debt to assets, and other financial characteristics deteriorated during the crisis; and whether changes in these characteristics raised excess borrowing costs.

In addition, we test if after holding these characteristics constant, excess-borrowing costs tightened during the crisis. For instance, in Thailand, economic conditions were worst in 1997 and 1998 (Pongpaichit and Baker, 2000; Osangthammanont, 2002). If during the worst years of the crisis, there was a fall-off in lending by banks and foreigners, then excess-borrowing costs should tighten for all firms, controlling for financial characteristics. We control for industry of affiliation as well. Since the depreciation of the currency should benefit firms more in the tradeable sector, lenders, knowing this, may be more lenient to firms in the tradeable industries. We examine whether there was a level shift up in the excess borrowing function for all firms in the worst years of the crisis, by testing whether the dummy variables, D97 and D98 in (8), are significantly positive.

The second important implication is the behavior of (short-run) average costs. From (11), we test whether average costs of Thai firms are increasing ( $\varepsilon > 1$ ), constant ( $\varepsilon = 1$ ), or decreasing ( $\varepsilon < 1$ ). The behavior of average costs should be especially econometrically well identified during the crisis, since  $\ln y_{it}$  has varied greatly, both across firms and over time.

## 6. Data and Descriptive Statistics.

The data to estimate (8) and (11) are from a CD-ROM obtained from the Thai Stock Exchange.<sup>7</sup> The CD-ROM contains balance sheet and income statement data between 1996-2000 for 220 firms listed on the Exchange. Industry-specific GDP deflators (10) were obtained from the Bank of Thailand. Total Costs is the sum of “Cost of Sales” and “Selling and Administrative Expenses.” Firm output ( $y_{it}$ ) is “Sales.”<sup>8</sup>  $AVC_{it}$  in (11) is then Total Costs divided by the product of the industry-specific GDP deflator and  $y_{it}$ . The “excess borrowing costs” for firm  $i$  is defined as the interest rate of firm  $i$ —the total interest paid by firm  $i$  divided by the firm’s liabilities—minus the risk-free interest rate, represented by the call money market rate.

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<sup>7</sup> We are aware of at least one other panel data set of Thai firms. The World Bank randomly selected 652 Thai firms in 1998, with retrospective questions for 1997 and 1996. The data set is described in Hallward-Driemeir (2000). The World Bank sample includes both listed and the smaller, unlisted firms, and contains balance sheet and income statement information. Hallward-Driemeir (2000) mentions some caveats in using the World Bank data set. Among her caveats is first that response rates were quite low. Second, the unit of observation is the plant or the enterprise, and not the firm. It is unclear how informative balance sheet and income statements are at the enterprise or firm level. The record keeping at the firm level is probably much better, since it is the firm that pays taxes, not the enterprise or plant. Finally, the data are not in accord with any standard accounting rule—each survey respondent answers each question subjectively. The accounting statements of our firms were audited by internationally accredited accountants.

<sup>8</sup> The value of production would be more appropriate as an output measure, but no production or inventory data are available in our database.

“Cash flow” is defined as earnings before interest plus depreciation minus capital expenditures. The “firm capital stock” is defined as the net value of the firm’s property, plant, and equipment stock. “Debt” includes all firm financial liabilities, including trade credits.

Table 1 depicts some descriptive statistics of the Thai firms in our sample. In general, almost all firm financial characteristics deteriorated between 1996-2000, with the deterioration most severe in 1997 and 1998. The average interest rate (in excess of the risk-free call rate) paid by firms increased from 5.6 percent in 1996 to 8.3 percent in 1998, and declined thereafter. This surge in the excess interest rate paid by Thai firms shows the tightening of credit constraints during the worst years of the crisis. The leverage ratio also surged in the midst of the crisis in 1997 and 1998, while declining slowly as the economy recovered. Part of the surge in the leverage ratio is related to the depreciation of the Thai baht, which raised foreign debt levels in baht terms.

The cash flow-capital stock ratio sharply declined in 1997, and has continued to remain low through 2000. Cash flow can decline either when sales decline or costs rise. Real sales, defined as total sales divided by the industry GDP deflator, increased in 1997. The Thai crisis started in the second half of 1997, so the rise in sales in 1997 is because of strong sales performance in the first half 1997. Real sales plummeted in 1998, but have subsequently strongly recovered. The continued decline in cash flow between 1999-2000 must therefore be related to the rise in real total costs, rather than to the decline in real sales.

Indeed, real total costs went up sharply between 1996-2000. Since we have controlled for the rise in the prices of variable inputs (by dividing by the industry GDP deflator); this increase in total costs may be related to the rise in excess borrowing costs. Our measure of average costs,

however, is relatively flat between 1996-2000, implying that the behavior of total costs is probably more related to firm scale ( $y_{it}$ ), rather than to higher excess borrowing costs. However, without controlling for firm-specific variables, we *cannot* conclude from our observed flat average costs that average costs are indeed constant ( $\varepsilon = 1$ ).

Finally, the number of firms in our sample (listed on the Thai stock exchange) drops from 220 in 1996 to 189 in 1999, mainly because of bankruptcies. Since the average costs of firms that went bankrupt during the crisis were plausibly higher than those of firms that survived, there may be attrition bias in our sample. In some of our econometric estimates, we control for this attrition bias by estimating a dynamic selection model. From the selection model, we can also identify the determinants of bankruptcies during the crisis.

In sum, we find significant deterioration in Thai firm financial characteristics, especially during the worst years of the crisis in 1997 and 1998. We now turn to estimating whether this deterioration in financial characteristics raised the excess borrowing and average costs of the typical Thai firm.

## **7. Estimation Results.**

Table 2 depicts the panel two-stage least squares fixed effect estimates of the excess borrowing (first stage), and the average cost functions (second stage). In the specifications that are depicted, we instrumented for the Log(Sales) variable by the lagged sales-capital stock ratio, since Log(Sales) may be correlated with the error term. On the whole, the coefficient signs show that the deterioration in firm financial characteristics raises the excess borrowing costs of the firm. The positive sign on the lag leverage ratio implies that a jump in firm indebtedness

significantly increases the interest rate that a firm pays in excess of the risk-free rate. The lag coverage ratio is always insignificant. When there are no industry and year controls, increases in lagged asset size and in lagged cash flow significantly lower the firm's log excess interest rate. The yearly dummy variables for 1997 and 1998 are as hypothesized, significantly positive, with and without industry controls, implying that during the worst years of the Thai crisis, there was an upward shift in the log excess interest rate.

With regards to estimates of the average cost function, a rise in the excess borrowing costs (log interest rates) of firms significantly increases (at the 10 percent level) average costs (in specifications with industry and/or year controls). This suggests that a tightening of credit constraints may have played some role in increasing costs and possibly lowering output during the Thai crisis. The coefficient on log interest rates,  $(1 - \delta - \theta)$  implies a capital share of about 6 percent. Although this may appear small, recall that this share measures only the capital stock that is not fixed, but can be varied over a given year, depending on the output level. Importantly, the coefficient  $(\varepsilon - 1)$  on log sales ( $y_{it}$ ) is always significantly negative, implying that the average costs of Thai firms are decreasing. The estimated value of  $(\varepsilon - 1)$  of -0.16 to -0.17 implies that a 50 percent decline in output raises average costs by 8-9 percent.

Shocks to firm productivity ( $w_{it}$ ) during currency crisis are likely to be serially correlated. Table 3 depicts the panel estimates of the average cost function that are corrected for first-order serial correlation in the error term of the average cost function. There is significant first-order serial correlation in shocks to firm productivity ( $\rho$  is negative and significant). When the log excess interest rate and log sales are not instrumented, the log excess interest rate variable is significantly positive with year/industry dummies. When the log excess interest rate and log sales are instrumented, the log excess interest rate is significant (at the 10 percent level)

only when the year dummies are included. Log sales is again highly significant and negative in all specifications.

As mentioned, for tradeable firms, their prices (and revenues) are likely to increase, when there is depreciation of the domestic currency. Lenders, knowing this, may be more lenient in lending to tradeable firms. If so, financial characteristics may matter less for tradeable firms borrowing. In Table 4, financial characteristics in the excess borrowing function are interacted with a dummy variable that is unity for tradeable firms. Although the significance of these dummy variables is mixed, on the whole, lending appears looser to firms in the tradeable sector. For instance, the tradeable dummy interaction terms for both the lag coverage and lag cash flow ratios are positive and significant. This means that for tradeable firms, improvements in these financial characteristics do not lower borrowing rates--these characteristics matter less for tradeable firms borrowing. However, the trade interaction terms are insignificant for the lag leverage and lag asset size variables; improvements in these characteristics have the same effect for tradeable and non-tradeable firms' borrowing. Finally, the cost-function is re-estimated, including the trade interaction terms as additional instruments. The log excess interest rate loses its significance, although log sales remains highly significant and negative in all specifications.

In sum, the results for the excess borrowing function imply that a deterioration in firm financial characteristics raises the premium that a firm pays over the risk-free market rate. Moreover, during the worst years of the crisis, in 1997 and 1998, there appears to be a level shift up in such premia for all firms. All estimates for the cost function strongly imply that firm average costs are decreasing with firm output. However, the results are somewhat mixed for the impact of firm excess borrowing costs on firm average costs, since the log excess interest rate

variable is often insignificant.

### **Correcting for Bankruptcy (Attrition) Bias.**

In our sample of firms listed on the Thai Stock Exchange, 1, 4, and 26 firms were delisted in 1997, 1998, and 1999, respectively, presumably because of bankruptcies. Bankruptcies may not entirely be random; the average costs of firms that go bankrupt, for example, may be highly responsive to log excess interest rates (high  $(1 - \delta - \theta)$  in (9)). If so, the average costs of firms that remain in the sample may be less responsive to log excess interest rates. This sample selection bias may explain why in our estimates of the average cost function (Tables 2-4), the coefficients on the log excess interest rate are often small or insignificant.

To correct for this sample selection bias, we estimate a dynamic selection model, and rewrite our log average cost function (11), following Wooldridge (2002, p. 586) as:

$$\Delta \ln(\text{AVC}_{it}) = \Delta w_{it} + (1 - \delta - \theta) \Delta \ln \tilde{R}_{it} + (\varepsilon - 1) \Delta \ln y_{it} + \rho_1 D97 \lambda_{i97} + \rho_2 D98 \lambda_{i98} + \rho_3 D99 \lambda_{i99} + \rho_4 D00 \lambda_{i00} + \Delta v_{it} \quad (12)$$

where  $\rho_1, \rho_2, \rho_3, \rho_4$  are coefficients to be estimated. (The firm- and industry-specific productivity shocks are removed by differencing).  $\lambda_{it}$  's are the inverse Mills ratios obtained from the  $t=1997 \dots 2000$  cross-section probits:

$$P(\text{nobk} = 1) = a + k * \text{fc}_{jt-1} + h * \ln \tilde{R}_{it} + mm * \ln(\text{lag}(\text{sales} / \text{cap})) + z_{it}, \quad (13)$$

where  $a, k, h,$  and  $mm$  are coefficients to be estimated,  $z_{it}$  is a random error term, and  $\text{nobk} = 1$  is an indicator variable that takes on a value of one when the firm has *not* gone bankrupt, and

remains in the sample. If none of the coefficients in (13) are significant, then financial characteristics do not explain a firm's attrition from the sample. In addition, Wooldridge (2002, p. 586) shows that if  $\Delta \ln \tilde{R}_{it}$  and  $\Delta \ln y_{it}$  in (12) are not strictly exogenous, they should be instrumented by the explanatory variables in the probits (13), and D97 – D00.

Since there was no attrition from the sample in 2000, there are three cross section probits, estimates of which are depicted in Table 5. The rate of attrition was very low until 1999, and none of the variables significantly explain attrition in 1997 and 1998. In 1999, a rise in cash flow lowers bankruptcy probabilities, and a rise in the lag leverage ratio raises bankruptcy probabilities. Thus, the deterioration of financial characteristics in prior years did contribute to the bankruptcy of firms in 1999. Below, we see if the firms remaining in the sample differ systematically (non-randomly) from the bankrupt firms, in their responsiveness of average costs to the log excess interest rate and output.

The estimates of the new average cost function (12) are depicted in Table 6. In column (1), none of the variables are instrumented. The  $\Delta \ln \tilde{R}_{it}$  is still barely significant, but  $\Delta \ln y_{it}$  is again highly significant and negative, implying decreasing average costs. For all specifications, none of the Mills ratios interacted with the time dummies are significant. Despite the relatively large number of bankruptcies in 1999, the estimated coefficients in Tables 2-4 are unlikely to be contaminated by attrition bias.<sup>9</sup>

In column (2),  $\Delta \ln \tilde{R}_{it}$  is instrumented, and all of the explanatory variables lose significance. In column (3), both  $\Delta \ln \tilde{R}_{it}$  and  $\Delta \ln y_{it}$  are instrumented, and although  $\Delta \ln \tilde{R}_{it}$

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<sup>9</sup> Note that the  $\lambda_{it}$ 's are generated from the cross-section probits; and may be subject to the usual generated regressors problem. However, Wooldridge (2002, p. 586) shows that if the  $\rho_i$ 's are jointly insignificant, no adjustment for generated regressors is necessary.

loses its significance,  $\Delta \ln y_{it}$  regains its strong significance and negative sign, implying decreasing average costs.

## **8. Conclusion.**

In this paper, we examined the relative roles of credit constraints and average cost behavior in depressing output during currency crisis. We analyzed Thai firm level data between 1996-2000, and found robust evidence of decreasing short-run average costs. Taking the median estimate, a 50 percent decline in output raises average costs by 8-9 percent. We attribute the decreasing short-run average costs to high fixed costs of production, such as high capital, labor, and land costs that do not vary with output.

We also found evidence that the crisis-induced deterioration in firm financial characteristics significantly raised the borrowing costs of Thai firms. However, we show that the effect of these higher borrowing costs on short-run average costs is rather negligible. A 10 percent increase in borrowing costs is estimated to increase short-run average costs by at most 0.6 percent. In fact, for many specifications, the impact of the log excess interest rate on average costs is insignificant. Thus, while credit constraints certainly exist, they probably played only a minor role in raising average costs, and in depressing output during the Thai crisis. The high fixed costs of production, by making production at lower output more expensive, appears to played a more important role in keeping output low during economic crisis.

We also find that the deterioration in financial characteristics may have substantially increased bankruptcies in 1999. Bankruptcies by themselves lower output, and we may be understating the effect of tightening credit constraints on output, by focusing only on the change in output by surviving firms, and neglecting the direct effect of bankruptcies on output.

Another caveat is that we have only analyzed firms listed on the Thai stock exchanges. On average, listed firms are larger and have stronger financial characteristics than unlisted firms (Osangthammanout, 2002). In fact, in the enormous academic literature on credit constraints (see Hubbard, 1998 for a review), emphasis is placed on how credit constraints are tightest for small- and medium-sized enterprises. During crisis, the deterioration in financial characteristics and the cutback in bank lending may have been most severe for Thai unlisted firms, many of them small (Phongpaichit and Baker, 2000).

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