Cheap Labor Meets Costly Capital: The Impact of Devaluations on Commodity Firms

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Abstract: This paper examines how devaluations affect the relative cost of labor and capital and therefore influence production levels, profitability, and investment decisions for firms in the "crisis" country as well as competitors in the rest of the world. The paper develops these ideas in a simple model and then performs a series of empirical tests using information for about 1,500 firms in 6 commodity industries between 1996 and 2000. The empirical tests support the model's main predictions for the impact of devaluations: 1) Firms in the crisis country have higher rates of output growth than competitors in other countries; 2) Firms in the crisis country have a greater increase in profits than competitors in other countries; 3) The effect on fixed capital investment (and therefore future expected output) is determined by capital/labor ratios and changes in the crisis-country cost of capital. For example, crisis-country firms invest more after devaluations (and competitors invest less) if crisis-country firms had lower capital/labor ratios and there was no substantial increase in their cost of capital. Even though crisis-country firms may benefit from cheaper labor immediately after devaluations, competitors in other countries may benefit in the longer-term if firms in the devaluing country used capital intensively and/or their capital becomes more costly.

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I. INTRODUCTION

In 1997 the rupiah was devalued and then allowed to depreciate. In 1998, Indonesia's economy contracted by about 14 percent. Several companies and industries, however, increased production and profits improved substantially. For example, in 1998 the plantation sector (which includes coffee, cocoa, rubber, palm oil and tea) grew by 6.5 percent. One of the largest plantations in the country reported that profits increased by a multiple of four in the same year.[1] Over the same period, however, numerous firms complained about a "credit crunch" and their inability to obtain financing to increase their productive capacity and take advantage of lower dollar export prices. Many firms even claimed that they were unable to obtain enough working capital to purchase inputs necessary to continue production at pre-devaluation levels.

Financial crises not only affect firms in the devaluing country, but can also impact competitors around the world. After Brazil devalued the real in January of 1999, Argentine firms were forced to reduce export prices for soya beans in order to compete with the cheaper Brazilian exports.[2] During the Asian and Russian crises, stock returns for companies that competed with exports from the devaluing countries were significantly lower than for other companies.[3] This suggests that after the Asian and Russian devaluations, investors expect a reduction in profits for competitors around the world.

This paper examines how devaluations affect relative costs and production decisions for firms within a "crisis" country as well as competitors in other countries (where a "crisis" country is defined loosely as a country that devalues its currency). More specifically, it analyzes how devaluations influence firms' output, profitability, and capital investment, as well as industry prices and quantities, in the short and long run. In the theoretical model, firms are assumed to use two variable inputs (labor and materials) and one fixed input (capital). Labor is priced in domestic currency. Materials and capital are priced in "dollars", and the price of capital also incorporates domestic risk and any local developments in capital markets. The immediate impact of devaluations is to lower the relative cost of labor in the crisis country. Firms in the devaluing country increase output and profits, while competing firms decrease output and profits. In the longer term, however, devaluations raise the cost of capital for firms in the crisis country (potentially by more than the relative exchange-rate movement.) If this increase in the cost of capital is large enough and the firm's capital/labor ratio is high enough, more expensive capital

[1] The previous statistics on Indonesia are from the *Asian Wall Street Journal* (1999).
[2] United Nations Conference on Trade and Development (1999).
[3] Forbes (2000).

could outweigh the benefits of relatively cheaper labor. Therefore, in the long run, devaluations could decrease output, profits, and capital investment for firms in the devaluing country, and increase output, profits and capital investment for competitors in other countries.

The empirical section of the paper uses data for about 1,500 firms in 6 commodity industries to test the model's main predictions during a series of devaluations between 1997 and 2000. It focuses on firm-level variation, instead of industry- or country-level variation, in order to control for any external shocks that are unrelated to the crisis. Results show that immediately after devaluations, firms in the crisis country have higher growth rates for output and profits than competitors in other countries. These effects are short-lived and tend to disappear within a year. Moreover, growth rates for capital investment (and therefore expected output in the future) are correlated with capital/labor ratios and changes in the crisis-country cost of capital. For example, crisis-country firms invest more after devaluations (and competitors invest less) if crisis-country firms had lower capital/labor ratios and their interest rates did not increase substantially. Therefore, although the empirical analysis is not a formal test of the theoretical model, the results agree with the model's central predictions. Even though crisis-country firms may benefit from cheaper labor immediately after devaluations, competitors in other countries may benefit in the longer-term if firms in the devaluing country used capital intensively and/or their capital becomes more costly.

This paper focuses on firms that produce commodities (or any undifferentiated product) mainly for export. Although it is possible to extend this framework to other industries, the paper maintains this narrow focus for three reasons. First, commodity exports are a large share of GDP in most countries that abruptly devalue their currency (including many countries that had crises in the late 1990's). Moreover, many of these countries rely heavily on commodity exports for tax revenues and foreign currency. Second, although there has been a substantial amount of research on the impact of currency movements on differentiated-goods firms (such as the pricing-to-market literature), there has been relatively little analysis for homogenous-goods firms. Third and finally, the production structure for most commodities is extremely useful in isolating some of the key effects of devaluations. For example, many commodities require a large, fixed investment in capital (such as planting trees or drilling mines) that must be made several years before the resulting output is sold. This structure helps differentiate between the short- and long-run impact of devaluations. Also, the production of most commodities requires imported inputs and capital, as well domestic labor, so that it is possible to capture how devaluations interact with relative input intensities and relative input costs to affect output, profits, and investment. These factors

appear to have played an important role in the impact of recent devaluations on firms around the world.

The remainder of the paper is divided into four sections. Section II briefly reviews several branches of related literature. Section III presents a theoretical model of how devaluations affect firms in the crisis country and rest-of-the-world in the short- and long-term. It establishes several conditions under which devaluations are more likely to increase firms' output, profitability, and investment levels. Section IV uses firm-level data for a series of devaluations between 1997 and 2000 to test three central predictions of the model. Section V concludes.

II. LITERATURE REVIEW

This paper is related to five diverse branches of literature: the impact of devaluations on exports; the effect of financial crises on domestic production; contagion and the international transmission of currency crises; the importance of exchange-rate exposure to stock returns; and the extent of pass-through from currency movements to goods prices. Each of these branches of literature is so extensive that this survey does not make any attempt to discuss all of the relevant papers. Instead, it simply highlights the different questions and approaches and refers to recent surveys and articles that are closely related to this paper.

The first branch of literature examines how devaluations affect export growth. A standard argument justifying devaluations is that they should reduce the relative cost of exports on international markets and thereby improve export growth. There are a number of reasons why devaluations may not have this desired effect, however, such as if demand for exports is relatively inelastic or imported inputs are a large component of production. Ghei and Pritchett (1999) provide a detailed summary of why devaluations may or may not improve export performance, as well as why it is difficult to measure these effects. After a review of the empirical work on this subject, they conclude that exports typically increase after a devaluation, and that most of this response occurs rapidly (in about one or two years).[4]

A closely related branch of literature examines how devaluations affect not only export growth, but also other macroeconomic variables such as output, income levels, investment, and inflation. Agénor and Montiel (1996) provide an excellent summary of this literature and develop a general-equilibrium model showing the various channels by which devaluations can affect the

[4] Rose (1991) uses more formal time-series techniques and finds little impact of exchange-rate movements on trade balances. Several papers have also examined specific examples of how devaluations affect export growth. For example, Duttagupta and Spilimbergo (2000), Higgins and Klitgaard (2000), and Barth and Dinmore (1999) examine the impact of the 1997-98 devaluations on Asian exports.

macroeconomy. They also survey empirical work on this subject and conclude that the evidence on whether devaluations are contractionary is mixed.[5] More recently, several papers extend this line of research to examine the impact of "crises" (which are generally defined to include movements in interest rates and/or foreign reserves, as well as exchange rates) on macroeconomic variables. Gupta, Mishra and Sahay (2000) is one of the most recent papers on this subject. Their results suggest that about 40 percent of the currency crises between 1970 and 1990 have been expansionary.

While these branches of literature focus on the domestic impact of devaluations and crises, a more recent and rapidly growing body of work examines "contagion" and how crises affect other countries. Many of these papers focus on "real" linkages between economies, such as trade competition or shifts in the demand for exports. Other papers focus on financial linkages, such as bank lending or mutual fund investment, or on changes in investors' beliefs and behavior. Claessens and Forbes (2001) include recent surveys of this literature, as well as a number of case studies and empirical tests of the different cross-country linkages.[6] While almost all of the empirical work on this subject uses macroeconomic data, one exception that is closely related to this paper is Forbes (2000). She examines how the Asian and Russian crises affected stock returns for a sample of over 10,000 companies located around the world. Her results suggest that trade linkages are important determinants of how crises are transmitted internationally.

A fourth relevant branch of literature also focuses on stock returns and measures the extent of exchange-rate exposure for various types of companies. This literature argues that exchange-rate movements can affect stock returns through a number of channels, such as import prices, export prices, and shifts in demand. Rather than estimate each of these channels separately, most of these papers estimate reduced-form, market models of how exchange-rate movements affect stock returns. Dominguez and Tesar (2001) is one of the most recent and thorough examples of this literature.[7] They perform an extensive series of tests to determine the percentage of firms affected by exchange-rate movements, as well as which firm characteristics affect a company's vulnerability. Their estimates of a fairly low level of exposure agree with

[5] Edwards (1989) also provides an excellent survey of this literature and detailed evaluation of the historical evidence on how devaluations impact a variety of macroeconomic variables. Kamin (1988) is another detailed study and shows that the impact of devaluations on macroeconomic variables fluctuates over time. Calvo and Reinhart (2000) compare the impact of currency crises on macroeconomic variables for emerging markets versus developed countries.

[6] In particular, Claessens, Dornbusch, and Park (2001) is an excellent survey of this literature. Glick and Rose (1999) and Forbes (2001) provide evidence of the importance of trade in transmitting crises internationally. Van Rijckeghem and Weder (2001) discuss the role of bank lending, and Kaminsky, Lyons and Schmukler (1999) discuss the role of mutual funds.

[7] Also see Bodnar and Wong (2000) for an overview of empirical issues in estimating exchange-rate exposure. Jorion (1990) is a classic example of this literature.

most work on this subject; they conclude that about 12-23 percent of firms are significantly exposed to exchange-rate movements.

A final literature closely related to this paper examines how exchange-rate movements affect output prices. This literature includes the work on pricing-to-market and pass-through and emphasizes the role of industrial structure and the form of competition. In certain situations, exchange-rate movements may be wholly absorbed in firms' price-cost margins and have no impact on product prices. Dornbusch (1987) develops these ideas in several simple models, and numerous papers have found evidence of pricing-to-market in specific industries. Goldberg and Knetter (1997) is an excellent survey of the empirical literature on this subject. They conclude that the impact of exchange-rate movements on local currency prices of foreign products varies widely by industry, and that for products shipped to the U.S, the average price response is about one-half the exchange-rate movement.[8]

Despite the range of theoretical frameworks and empirical tests used in these five branches of literature, none of these papers has explicitly addressed the key question explored in this paper: how do devaluations affect output growth, profitability and investment decisions of firms around the world? The first three branches of literature (how devaluations affect exports, how financial crises affect output, and how currency crises spread internationally) focus on macroeconomic relationships and country-level evidence. The literature on exchange-rate exposure and pricing-to-market uses firm-level models and data, but focuses on how exchange-rate movements affect stock returns or product prices and generally ignores the impact on other firm characteristics. Moreover, the pricing-to-market literature focuses on differentiated-goods industries in developed countries, undoubtedly due to data limitations for developing countries and its motivation from yen-dollar exchange-rate movements in the 1980's. Moreover, none of these branches of literature has focused on the key tradeoff analyzed in this paper: how devaluations simultaneously give exporters a relative cost advantage in terms of cheaper labor and a cost disadvantage in terms of more expensive capital. This tradeoff generates a number of interesting predictions for firms in the devaluing country as well as competitors in the rest of the world.

[8] Knetter (1993) and Marston (1990) are two excellent examples of this literature. One noteworthy study that combines this approach with the work on exchange-rate exposure is Allayannis and Ihrig (2000). They examine how market structure, including export and import competitiveness, affects the exchange-rate exposure of a large sample of U.S. firms.

III. THE THEORETICAL MODEL

This section develops a model to show how devaluations affect firms' output decisions, profits, and investment levels in the short and long run. It describes firms that produce commodities for export (or any undifferentiated product where the firm has no pricing power), and considers the impact of devaluations on not only firms in the crisis country, but also competing firms located in the rest of the world. Part A of this section models firms' decisions in the short run when their level of capital investment is fixed. Part B models firms' decisions in the long run when they can adjust their levels of capital investment. Part C examines the short-run impact of devaluations, and part D considers the long-run impact. This model and framework form the basis of the empirical tests in Section IV. Before developing the model in detail, the following few paragraphs briefly highlight its key components and central predictions.

Each firm uses three inputs (labor, materials, and capital) to produce the same commodity. Firms are located in two "countries", the crisis country (that devalues its currency) and the rest of the world (hereafter refereed to as r.o.w.). Each firm produces a small share of global output and has no impact on global prices.[9] There is no differentiation between any firms' output, nor any trade barriers or transportation costs. As a result, the commodity's price is determined by global supply and demand and all firms expect the same output price. Firms make their production decisions in two stages. In the short-run, each firm's level of capital is fixed. This fixed investment could include everything from planting rubber trees to exploring for natural resources and drilling mines. Given this fixed level of capital, each firm chooses its optimal level of labor and materials to maximize short-run profits. Labor is priced in domestic currency and can be interpreted as any local component of production, while materials are priced in r.o.w. currency and can be interpreted as imported inputs. Firms have company-specific productivity parameters, so that firms in the same country can have different levels of output and profits. In the longer term, each firm can also adjust its level of capital. Capital is priced in r.o.w. currency and includes a country-specific component (to capture differences in domestic risk and capital markets.)

Each firm chooses its level of capital expecting relative prices and exchange rates to remain constant (at least until the next chance to invest). Then the crisis country devalues its currency. In the short-run, the devaluation reduces the relative cost of labor in the crisis country. This causes crisis-country firms to increase output, and the increase in total production lowers the

[9] Duttagupta and Spilimbergo (2000) provide empirical support for this assumption during the Asian crisis. They find that export supply prices are insensitive to own quantities but very sensitive to nominal exchange-rate movements.

global price of the commodity. Firms in the r.o.w. respond by decreasing production, although by less then the aggregate increase by crisis-country firms. Therefore, the aggregate short-run impact of the devaluation on the commodity is to increase global production and decrease the global price. The magnitudes of these effects are determined by the crisis country's share of global production and the share of labor in output. The devaluation also decreases profits for firms in the r.o.w. and increases profits for firms in the crisis country (as long as the price elasticity of global demand is not too small and/or the crisis country's share of global production is not too large).

Over longer periods, however, each of these effects of the devaluation can be reversed. Firms can adjust their levels of capital investment to compensate for the changes in output prices and relative input prices. Since capital is priced in r.o.w. currency, the relative cost of capital increases for firms in the crisis country and can increase by even more than the exchange-rate movement if there is a simultaneous increase in domestic risk or a contraction in lending. If this increase in the cost of capital for crisis-country firms is large enough, it could outweigh the benefits of relatively cheaper labor. More specifically, if the firm's capital/labor ratio is large enough, or the increase in the cost of capital is large enough, the devaluation could actually raise the total cost of production for crisis-country firms so that they decrease output. This would raise the long-run price of the commodity and cause r.o.w. firms to increase production (although by less than the aggregate decrease by crisis-country firms.) In the long run, the devaluation could increase profits for r.o.w. firms and decrease profits for crisis-country firms.

On the other hand, if the cost advantage for crisis-country firms from relatively cheaper labor after the devaluation outweighs the cost disadvantage from relatively more expensive capital, then the key predictions from the short-run model will also apply in the long run. More specifically, if the firm's capital/labor ratio is small enough or the increase in the cost of capital is fairly small, crisis-country firms would increase output and r.o.w. firms would decrease output. The global commodity price would fall. Profits would increase for firms in the crisis country and decrease for firms in the r.o.w. Therefore, although the model's short-run predictions of the impact of devaluations on output and profits are fairly clear, the long-run predictions depend on capital/labor ratios and the relative changes in input costs.

Before developing this model in detail, it is worth mentioning what the model does not consider. First, it does not allow for any sort of strategic pricing behavior by firms. Firms are assumed to take the global output price as given and are unable to affect this price by adjusting production levels or forming cartels. Similarly, material inputs are priced in r.o.w. currency and exchange-rate movements are fully passed through into the price of these imported inputs. Second, although exogenous shocks can affect global demand for the commodity in each period,

the model does not incorporate any direct impact of the devaluation on global demand. More specifically, it assumes that firms export most of their output, so that any domestic contraction resulting from the devaluation will not affect demand. Fourth and finally, all prices are in real terms and there is no allowance for inflation differentials across countries. Therefore, the model assumes that the real impact of the devaluation on relative prices is not eroded by changes in inflation rates.

III.A. The Short-Run with a Fixed Level of Capital[10]

In order to produce most commodities, firms must make a large, upfront investment in fixed capital. After making this initial investment, there is often a substantial time lag before the firm can begin production and the first unit of output is sold. For example, there is about a six-year lag after coffee is initially planted until the beans can be harvested and sold. To capture this aspect of commodities, I model firms' decisions in two stages. In the short-run, defined as the periods from $t = 1 \ldots T$, a firm's level of capital is fixed. In the long run when $t>T$ (which is modeled in part B) a firm is able to choose its level of capital.[11]

Beginning with this short-run scenario, each firm i has a fixed level of capital $k_i>0$. A firm's output in each period t is determined by its choice of two variable inputs: domestic labor ($l_{i,t}$) and imported materials ($m_{i,t}$). Output is given by a Cobb-Douglas production function that has decreasing returns to scale[12]:

$$q_{i,t} = A_i k_i^{\alpha} l_{i,t}^{\beta} m_{i,t}^{\gamma} \qquad \text{with } \alpha+\beta+\gamma<1. \tag{1}$$

A_i is technology parameter (which varies across firms). The cost of labor is w_t and the cost of materials is s_t. The firm chooses a combination of the variable inputs to maximize short-run profits ($\pi_{i,t}^{SR}$) in each period:

$$\underset{l,m}{Max}\, \pi_{i,t}^{SR} = P_t q_{i,t} - w_t l_{i,t} - s_t m_{i,t} \tag{2}$$

where P_t is the sale price per unit of output.

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[10] This short-run version of the model is loosely based on Dornbusch (1987).

[11] Although the model does not explicitly include entry and exit, firms can set output and capital investment to zero in the long run and therefore "exit" the industry. Entry is captured by allowing firms to increase their level of capital investment in the long run.

[12] Decreasing returns to scale ensures that the most efficient firm does not produce all of global production.

Each firm produces identical goods and there is no differentiation between markets (such as barriers to trade or transport costs). In other words, there is one global market for the good and the price is determined by global supply and demand. Therefore, the global price of the good can be expressed as a function of total global output (Q_t), and to simplify the model solution below, assume that this global price is determined by a constant-elasticity demand function:

(3) $$P_t = Z_t Q_t^{-\varphi}$$

where Z_t is any period-specific shock to global demand and $1/\varphi$ is the elasticity of demand. The commodity is a normal good, so that $\varphi > 0$. Moreover, assume that each firm produces a relatively small fraction of global output and therefore takes input costs and the industry price as given. In other words, each firm assumes that any changes in its own input demands or output quantities will have no affect on input costs or the global output price. These assumptions are fairly accurate descriptions of competition in most commodity industries.

Without loss of generality, assume that firms are located in two "countries": the crisis country (which will devalue its currency) and the rest of the world (hereafter called r.o.w.). In the notation that follows, all variables for the crisis country that differ from the r.o.w. are written with a "~", and firms in the crisis country are indexed by j. Crisis-country and r.o.w. firms face the same price of output (P) and cost of imported materials (s), both of which are expressed in the r.o.w. currency that can be interpreted as dollars. In the short run, the only price that differs between the two countries is the domestic wage. The exchange rate can be expressed as the relative cost of labor in the two countries:

(4) $$e_t = \frac{\tilde{w}_t}{w_t},$$

so that a devaluation in the crisis country is a decrease in e. Equation (2) therefore refers to the profit function for firms in the r.o.w. If the r.o.w. wage is normalized to equal one, then the production function and profit-maximization equation for firms in the crisis country (corresponding to equations 1 and 2 for firms in the r.o.w) are:

(5) $$\tilde{q}_{j,t} = A_j \tilde{k}_j^{\alpha} \tilde{l}_{j,t}^{\beta} \tilde{m}_{j,t}^{\gamma}$$ and

(6) $$\underset{\tilde{l},\tilde{m}}{Max}\,\tilde{\pi}_{j,t}^{SR} = P_t\tilde{q}_{j,t} - e_t\tilde{l}_{j,t} - s_t\tilde{m}_{j,t}$$

Combining equations (1) through (6), it is straightforward to solve each firm's short-run profit-maximization problem. For a fixed level of investment and given output price, each firm chooses its optimal combination of the two variable inputs and output quantity in order to maximize profits in period *t*. The optimal output levels for firms in the r.o.w. and crisis country are:

(7) $$q_{i,t}^{SR} = \left[P_t^{\beta+\gamma} A_i k_i^{\alpha} \left(\frac{\beta}{w_t}\right)^{\beta} \left(\frac{\gamma}{s_t}\right)^{\gamma} \right]^{1/1-\beta-\gamma}$$

(8) $$\tilde{q}_{j,t}^{SR} = \left[P_t^{\beta+\gamma} A_j \tilde{k}_j^{\alpha} \left(\frac{\beta}{e_t}\right)^{\beta} \left(\frac{\gamma}{s_t}\right)^{\gamma} \right]^{1/1-\beta-\gamma}$$

Next, in order to obtain the global output price and quantity produced, assume that there are *n* firms in the r.o.w, and $\tilde{n}$ firms in the crisis country. Total global output can be expressed as:

(9) $$Q_t = \int_{i=1}^{n} q_{i,t} + \int_{j=1}^{\tilde{n}} \tilde{q}_{j,t}$$

If $\bar{q}$ and $\bar{\tilde{q}}$ are the average quantity produced by each firm in the r.o.w. and crisis country, respectively, the total quantity produced and industry price can be written as:

(10) $$Q_t = n\bar{q}_t + \tilde{n}\bar{\tilde{q}}_t \ , \qquad \text{so that}$$

(11) $$Q_t^{SR} = \xi_t \left[n\left(\frac{\bar{A}\bar{k}^{\alpha}}{s_t^{\gamma} w_t^{\beta}}\right)^{1/1-\beta-\gamma} + \tilde{n}\left(\frac{\bar{\tilde{A}}\bar{\tilde{k}}^{\alpha}}{s_t^{\gamma} e_t^{\beta}}\right)^{1/1-\beta-\gamma} \right]^{(1-\beta-\gamma)/(1-\beta-\gamma)+\varphi(\beta+\gamma)}$$

(12) $$P_t^{SR} = \xi_t' \left[n\left(\frac{\bar{A}\bar{k}^{\alpha}}{s_t^{\gamma} w_t^{\beta}}\right)^{1/1-\beta-\gamma} + \tilde{n}\left(\frac{\bar{\tilde{A}}\bar{\tilde{k}}^{\alpha}}{s_t^{\gamma} e_t^{\beta}}\right)^{1/1-\beta-\gamma} \right]^{-\varphi(1-\beta-\gamma)/(1-\beta-\gamma)+\varphi(\beta+\gamma)}$$

where $\xi_t = \left(Z_t^{\beta+\gamma}\beta^{\beta}\gamma^{\gamma}\right)^{1/1-\beta-\gamma+\varphi(\beta+\gamma)}$ and $\xi_t' = \left[\frac{Z_t^{1-\beta-\gamma}}{\left(\beta^{\beta}\gamma^{\gamma}\right)^{\varphi}}\right]^{1/1-\beta-\gamma+\varphi(\beta+\gamma)}$

and $\overline{A}, \overline{k}, \overline{\tilde{A}},$ and $\overline{\tilde{k}}$ are the productivity parameters and investment levels for the mean-quantity producing firm in the r.o.w. and crisis country, respectively. The equation for Q_t^{SR} yields the intuitive result that global output of the commodity is greater for: a lower cost of either variable input; a greater number of firms in either country; or a larger average output for firms in either country (which is, in turn, determined by average productivity levels and the amount of fixed capital investment.) The equation for P_t^{SR} shows that the global price is greater for a higher cost of either variable input or lower aggregate output from either country. The formula also has the appealing result that in the short-run, price is determined by the variable cost of production in each country weighted by total output in each country.

III.B. The Long-Run with Variable Capital

In periods longer than *T,* firms can adjust their level of capital investment. The cost per unit of capital investment is r_t and $\tilde{r}_t$ in the r.o.w. and crisis-country, respectively, and is fixed at the start of the period. Capital is priced in r.o.w. currency, but can vary across countries due to factors such as domestic risk, capital market liquidity, capital controls, etc. Firms chose their optimal level of capital ($k_i \geq 0$ and $\tilde{k}_j \geq 0$) to maximize long-run profits (π_T^{LR}) until the next opportunity to adjust their capital levels. To simplify the algebra, assume that there is no discounting and the profit-maximization equations for firms in the two countries are:

(13) $$\underset{k}{Max}\,\pi_{i,T}^{LR} = E\left[\int_{t=1}^{T}\left(P_t q_{i,t} - w_t l_{i,t} - s_t m_{i,t}\right) - rk_i\right]$$

(14) $$\underset{\tilde{k}}{Max}\,\tilde{\pi}_{j,T}^{LR} = E\left[\int_{t=1}^{T}\left(P_t \tilde{q}_{j,t} - e_t \tilde{l}_{j,t} - s_t \tilde{m}_{j,t}\right) - \tilde{r}\tilde{k}_j\right]$$

Next, assume that companies expect input prices and demand shocks to be constant (so that $E[w_t]=w$, $E[e_t]=e$, $E[s_t]=s$, and $E[Z_t]=Z$.) As a result, prices from t=1 to T are expected to be

constant and $E[P_t]=P$. Substituting the short-run solutions from equations (7), (8), (11), and (12) into equations (13) and (14), the optimal levels of capital investment for firms in the r.o.w. and crisis country are:

(19) $$k_i = \zeta\left(\frac{A_i P}{w^{\beta} s^{\gamma} r^{1-\beta-\gamma}}\right)^{\frac{1}{1-\beta-\gamma-\alpha}} \quad \text{and}$$

(20) $$\tilde{k}_j = \zeta\left(\frac{A_j P}{e^{\beta} s^{\gamma} \tilde{r}^{1-\beta-\gamma}}\right)^{\frac{1}{1-\beta-\gamma-\alpha}}$$

with $$\zeta = \left(\frac{T\alpha\left[\left(\beta^{\beta}\gamma^{\gamma}\right)^{1/1-\beta-\gamma} - \left(\beta^{1-\gamma}\gamma^{\gamma}\right)^{1/1-\beta-\gamma} - \left(\beta^{\beta}\gamma^{1-\beta}\right)^{1/1-\beta-\gamma}\right]}{1-\beta-\gamma}\right)^{\frac{1-\beta-\gamma}{1-\beta-\gamma-\alpha}}$$

As a result, firms will chose a greater level of capital investment if: they are more productive; the expected output price is higher; or any of the input prices are lower.

Next, using equations (19) and (20) it is possible to solve for each firm's optimal long-run output level at each time *t.* As long as the realization of each input price and the global demand shock are equal to their expected values, the solutions for firms in the r.o.w. and crisis-country are:

(21) $$q_i^{LR} = \Psi\left(\frac{A_i P^{\beta+\gamma+\alpha}}{w^{\beta} s^{\gamma} r^{\alpha}}\right)^{1/1-\beta-\gamma-\alpha}$$

(22) $$\tilde{q}_j^{LR} = \Psi\left(\frac{A_j P^{\beta+\gamma+\alpha}}{e^{\beta} s^{\gamma} \tilde{r}^{\alpha}}\right)^{1/1-\beta-\gamma-\alpha}$$

with $$\Psi = \left(\beta^{\beta}\gamma^{\gamma}\zeta^{\alpha}\right)^{1/1-\beta-\gamma}.$$

As a result, firms will chose a higher output level if: they are more productive; the output price is higher; or any input prices are lower. Finally, the global quantity and price in the long run is:

(23) $$Q^{LR} = \Phi\left[n\left(\frac{\overline{A}}{w^{\beta} s^{\gamma} r^{\alpha}} \right)^{1/1-\beta-\gamma-\alpha} + \tilde{n}\left(\frac{\tilde{\overline{A}}}{e^{\beta} s^{\gamma} \tilde{r}^{\alpha}} \right)^{1/1-\beta-\gamma-\alpha} \right]^{\frac{(1-\beta-\gamma-\alpha)}{(1-\beta-\gamma-\alpha)+\varphi(\beta+\gamma+\alpha)}}$$

(24) $$P^{LR} = \Phi'\left[n\left(\frac{\overline{A}}{w^{\beta} s^{\gamma} r^{\alpha}} \right)^{1/1-\beta-\gamma-\alpha} + \tilde{n}\left(\frac{\tilde{\overline{A}}}{e^{\beta} s^{\gamma} \tilde{r}^{\alpha}} \right)^{1/1-\beta-\gamma-\alpha} \right]^{\frac{-\varphi(1-\beta-\gamma-\alpha)}{(1-\beta-\gamma-\alpha)+\varphi(\beta+\gamma+\alpha)}}$$

where: $$\Phi = \left[\mathrm{Z}^{\beta+\gamma+\alpha} \left(\beta^{\beta} \gamma^{\gamma} \zeta^{\alpha} \right)^{1-\beta-\gamma-\alpha / 1-\beta-\gamma} \right]^{1/1-\beta-\gamma-\alpha+\varphi(\beta+\gamma+\alpha)}$$

and $$\Phi' = \left[\frac{\mathrm{Z}}{\left(\beta^{\beta} \gamma^{\gamma} \zeta^{\alpha} \right)^{\varphi/1-\beta-\gamma}} \right]^{1-\beta-\gamma-\alpha / 1-\beta-\gamma-\alpha+\varphi(\beta+\gamma+\alpha)}.$$

The equation for Q^{LR} yields the intuitive result that global output is greater for: a lower cost of any of the three inputs; a greater number of firms in either country; or a larger average output level in either country (which is, in turn, determined by average productivity levels.) The equation for P^{LR} shows that the global price is greater for a higher cost of any input or a lower aggregate output level in either country. The formula also has the appealing result that in the long run, the global price is determined by the total cost of production in each country weighted by total output in each country.

III.C. The Short-Run Impact of Devaluations on Firms around the World

The remainder of this section uses the model developed above to predict the impact of a devaluation in the crisis country on firms in the crisis country and the r.o.w. This subsection examines the short-run impact of devaluations (when capital is fixed) and the next subsection examines the long-run impact (when firms adjust their level of capital.) In the short-run, the main

impact of devaluations is to reduce the relative cost of labor in the crisis country. To simplify notation and clarify intuition, I use the abbreviations:

$$\hat{Q}_t^{Row,SR} = n\left(\frac{\bar{A}\bar{k}^{\alpha}}{w^{\beta}s^{\gamma}}\right)^{1/1-\beta-\gamma}, \quad \hat{Q}_t^{Crisis,SR} = \tilde{n}\left(\frac{\tilde{\bar{A}}\tilde{\bar{k}}^{\alpha}}{e_t^{\beta}s^{\gamma}}\right)^{1/1-\beta-\gamma}, \quad \text{and } \hat{Q}_t^{World,SR} = \hat{Q}_t^{Row,SR} + \hat{Q}_t^{Crisis,SR}$$

to represent functions of the total quantity produced in the r.o.w., crisis country, and entire world in the short run.

To begin, assume that firms have already chosen their level of investment (so $0<t<T$) and there is an unexpected devaluation in the crisis country. Also assume that there are no exogenous shocks to global demand for the commodity (i.e. there is no impact of the devaluation on Z_t in equation (3).)[13] The immediate impact of the exchange-rate movement on global output and prices is:

(25) $$\frac{dQ_t^{SR}}{de_t} = -\Gamma\frac{\beta}{e_t}\frac{\hat{Q}_t^{Crisis,SR}}{\left(\hat{Q}_t^{World,SR}\right)^{\varphi(\beta+\gamma)/1-\beta-\gamma+\varphi(\beta+\gamma)}} < 0$$

(26) $$\frac{dP_t^{SR}}{de_t} = \Gamma'\frac{\beta}{e_t}\frac{\hat{Q}_t^{Crisis,SR}}{\left(\hat{Q}_t^{World,SR}\right)^{1-\beta-\gamma+\varphi/1-\beta-\gamma+\varphi(\beta+\gamma)}} > 0$$

where $$\Gamma = \frac{\xi}{1-\beta-\gamma+\varphi(\beta+\gamma)} \quad \text{and} \quad \Gamma' = \Gamma\varphi.$$

In the short run, a devaluation in the crisis country (a decrease in e) causes global output of the commodity to increase and the global price to fall. The impact of devaluations on Q and P is proportional to the share of labor in production and the share of global output produced by firms in the crisis-country. Since the only impact of devaluations on input prices in the short-run is to reduce the relative cost of labor in the crisis country, it is intuitive that the impact of devaluations is proportional to the share of the relatively cheaper input in global production.

The effect of devaluations on short-run output quantities for firms in the r.o.w. and crisis country are:

[13] This assumption is realistic for commodity firms in most emerging markets since the majority of production is exported to developed countries, and most devaluations have minimal impact on growth, incomes and/or demand in these developed countries. In select cases, such as the Russian devaluation in August of 1998, this assumption is less realistic. For these situations, it is straightforward to extend the model and allow exchange-rate movements to affect global demand.

(27) $$\frac{dq_{i,t}^{SR}}{de_t} = \left(\frac{q_{i,t}^{SR}}{1-\beta-\gamma} \right) \left(\frac{(\beta+\gamma)}{P_t^{SR}} \frac{dP_t^{SR}}{de_t} \right) > 0$$

(28) $$\frac{d\tilde{q}_{j,t}^{SR}}{de_t} = \left(\frac{\tilde{q}_{j,t}^{SR}}{1-\beta-\gamma} \right) \left(\frac{(\beta+\gamma)}{P_t^{SR}} \frac{dP_t^{SR}}{de_t} - \frac{\beta}{e_t} \right) < 0$$

Movements in the exchange rate affect output quantities for firms in the r.o.w only through movements in the global commodity price. Therefore, a devaluation in the crisis country causes firms in the r.o.w. to reduce output in the short run. On the other hand, movements in the exchange rate affect firms in the crisis country through two channels in the short run: changes in the global commodity price and changes in the relative cost of labor (captured in the last term of equation (28).) The first effect is the same as for firms in the r.o.w. Counteracting this "output-price" effect, however, is an "input-price" effect. A devaluation reduces the cost of labor in the crisis country relative to the cost of the other inputs, as well as relative to firms in the r.o.w., and causes crisis-country firms to increase production. Some algebraic manipulation shows that this second "input-price" effect always dominates the first "output-price" effect. In other words, devaluations unambiguously cause crisis-country firms to increase output quantities in the short run. Finally, since global output increases and output by r.o.w. firms decrease, output by crisis-country firms must increase by even more than the increase in global production. In other words, after the devaluation, firms in the crisis country will sell to customers/markets that were previously serviced by firms in the r.o.w.

In order to more fully examine the impact of devaluations on individual firms, it is also useful to consider the effect on short-run profits. If short-run profits are defined in equations (2) and (6), which do not include the cost of capital investment, then the short-run impact of devaluations on profits for firms in the r.o.w. and crisis country are:

(29) $$\frac{d\pi_{i,t}^{SR}}{de_t} = \left(\frac{\pi_{i,t}^{SR}}{1-\beta-\gamma} \right) \left(\frac{1}{P_t^{SR}} \frac{dP_t^{SR}}{de_t} \right) > 0 \quad \text{and}$$

(30) $$\frac{d\tilde{\pi}_{j,t}^{SR}}{de_t} = \left(\frac{\tilde{\pi}_{j,t}^{SR}}{1-\beta-\gamma} \right) \left(\frac{1}{P_t} \frac{dP_t^{SR}}{de_t} - \frac{\beta}{e_t} \right) < 0 \text{ if } 1/\varphi > 1 \text{ and/or } \frac{\hat{Q}_t^{Crisis,SR}}{\hat{Q}_t^{World,SR}} < X \text{ ,}$$

where $X = \frac{1-\beta-\gamma+\varphi(\beta+\gamma)}{\varphi}$.

Therefore, devaluations unambiguously decrease short-run profits for firms in the r.o.w. This is not surprising because devaluations have no effect on r.o.w. input costs, while devaluations will lower r.o.w output quantities and the global price (as shown in equations (27) and (26), respectively). On the other hand, devaluations increase short-run profits for firms in the crisis country if the global elasticity of demand for the product is greater than one and/or if the crisis country has a small enough share of global output. In other words, if the price decline leads to a large enough increase in global demand, or if the impact of the devaluation on global prices is fairly small (since the crisis country only produces a small fraction of global output), then devaluations increase short-run profits for firms in the crisis country.

There is a lengthy debate in the development literature on whether the elasticity condition $(1/\varphi > 1)$ in equation (30) holds for most commodities. Estimates of the price elasticity of demand are highly dependent on characteristics of the individual commodity, how narrowly it is defined, and the length of time constituting "short run". In most cases, however, the output-share condition $\left(\hat{Q}_t^{Crisis,SR} / \hat{Q}_t^{World,SR} < X\right)$ is satisfied because the production of most commodities is widely dispersed across countries. Even for commodities with extremely low price elasticities of demand and extremely low output shares for labor and materials, this condition should be satisfied.[14] Even when a country is heavily specialized in a specific commodity, it rarely has a dominant share of global production. Agénor and Montiel (1996) make this point and document that only 16 developing countries have as much as 10 percent of the world market for any commodity (based on 3-digit SITC classifications). Most countries have little control over the prices at which they sell their commodity exports. Therefore, devaluations are generally expected to increase short-run profits for firms in the crisis country. Devaluations unambiguously decrease short-run profits for firms in the r.o.w.

[14] For example, if φ=5 so that the price elasticity of demand for the commodity is 0.2 (which is unrealistically low), and $\beta+\gamma$= 0.5 (which is also unrealistically low, especially for an emerging market), then X=.60. In other words, even using extreme parameter values which make it more difficult to satisfy this condition, a country would have to export over 60 percent of the global share of a commodity in order for $\hat{Q}_t^{Crisis,SR} / \hat{Q}_t^{World,SR} > X$.

III.D. The Long-Run Impact of Devaluations on Firms around the World

Over the longer term, however, the short-run impact of devaluations on output and profits can be reversed. Devaluations also affect the relative cost of capital in the crisis country, and when $t \geq T$, firms can adjust their capital investment accordingly. More specifically, assume that:

$$\frac{dr_t}{de_t} = 0 \qquad \text{and} \qquad \frac{d\tilde{r}_t}{de_t} < 0 \ . \tag{31}$$

In other words, devaluations in the crisis-country have no impact on the cost of capital for firms in the r.o.w., but increase the cost of capital for firms in the crisis country. The cost of capital could increase in the crisis country for a number of reasons. For example, if capital investment is financed in r.o.w. currency and/or imported from abroad, then the crisis-country interest rate would move in proportion to the devaluation. If devaluations also raise domestic interest rates, such as by increasing the country risk premium, contracting bank lending, and/or decreasing property and collateral values, then interest rates in the crisis country could increase by significantly more than the initial exchange-rate movement.

To simplify notation and clarify intuition in the remainder of this section, I use the abbreviations:

$$\hat{Q}_t^{Row,LR} = n\left(\frac{\overline{A}}{w^{\beta} s^{\gamma} r^{\alpha}}\right)^{1/1-\beta-\gamma-\alpha}, \quad \hat{Q}_t^{Crisis,LR} = \tilde{n}\left(\frac{\tilde{\overline{A}}}{e_t^{\beta} s^{\gamma} \tilde{r}_t^{\alpha}}\right)^{1/1-\beta-\gamma-\alpha}, \text{ and } \hat{Q}_t^{World,LR} = \hat{Q}_t^{Row,LR} + \hat{Q}_t^{Crisis,LR} .$$

These are functions of long-run output in the r.o.w., crisis country and world, respectively, and correspond directly to the short-run abbreviations in the last section. The long-run impact of a one-time exchange-rate movement on global output and the commodity price is:

$$\frac{dQ_t^{LR}}{de_t} = -\Lambda\left(\frac{\beta}{e_t} + \frac{\alpha}{\tilde{r}_t}\frac{d\tilde{r}_t}{de_t}\right)\frac{\hat{Q}_t^{Crisis,LR}}{\left(\hat{Q}_t^{World,LR}\right)^{\frac{\varphi(\beta+\gamma+\alpha)}{1-\beta-\gamma-\alpha+\varphi(\beta+\gamma+\alpha)}}} < 0 \quad \text{if} \quad \frac{\beta}{e_t} > \frac{\alpha}{\tilde{r}_t}\frac{d\tilde{r}_t}{de_t} \tag{32}$$

$$\frac{dP_t^{LR}}{de_t} = \Lambda'\left(\frac{\beta}{e_t} + \frac{\alpha}{\tilde{r}_t}\frac{d\tilde{r}_t}{de_t}\right)\frac{\hat{Q}_t^{Crisis,LR}}{\left(\hat{Q}_t^{World,LR}\right)^{\frac{1-\beta-\gamma-\alpha+\varphi}{1-\beta-\gamma-\alpha+\varphi(\beta+\gamma+\alpha)}}} > 0 \quad \text{if} \quad \frac{\beta}{e_t} > \frac{\alpha}{\tilde{r}_t}\frac{d\tilde{r}_t}{de_t} \tag{33}$$

where $\Lambda = \frac{\Phi}{1 - \beta - \gamma - \alpha + \varphi(\beta + \gamma + \alpha)}$ and $\Lambda' = \Lambda\varphi$.

In other words, devaluations can either increase or decrease global output and prices in the long run based on the relative shares of labor and capital in production and the impact of the devaluation on the crisis-country's cost of capital. If labor is a more important component of production than capital and/or if the impact of the devaluation on interest rates is small, then the devaluation is more likely to increase global production and decrease global prices. This result directly follows from the fact that relative prices remain constant in the r.o.w., while the relative cost of labor decreases and the cost of capital increases in the crisis country. If the cost advantage from cheaper labor outweighs the cost disadvantage of more expensive capital, then the total cost of production for crisis-country firms will decrease and cause the global price to fall (and demand for the commodity to increase.) Equations (32) and (33) also show the intuitive result that the impact of devaluations on global output and prices is greater (in either direction) when the crisis country produces a larger share of global output.

Next, the long-run impact of devaluations on output quantities and capital investment for firms in the r.o.w. is:

(34) $$\frac{dq_{i,t}^{LR}}{de_t} = \left(\frac{q_{i,t}^{LR}}{1-\beta-\gamma-\alpha}\right)\left(\frac{(\beta+\gamma+\alpha)}{P_t^{LR}}\frac{dP_t^{LR}}{de_t}\right) > 0 \quad \text{if} \quad \frac{\beta}{e_t} > \frac{\alpha}{\tilde{r}_t}\frac{d\tilde{r}_t}{de_t}$$

(35) $$\frac{dk_{i,t}^{LR}}{de_t} = \left(\frac{k_{i,t}^{LR}}{1-\beta-\gamma-\alpha}\right)\left(\frac{1}{P_t^{LR}}\right)\left(\frac{dP_t^{LR}}{de_t}\right) > 0 \quad \text{if} \quad \frac{\beta}{e_t} > \frac{\alpha}{\tilde{r}_t}\frac{d\tilde{r}_t}{de_t}$$

In the long run, exchange-rate movements continue to affect output quantities for r.o.w. firms, as well as investment levels, only through movements in the global commodity price. Therefore, a devaluation in the crisis country could cause r.o.w. firms to either increase or decrease their output quantities (and corresponding investment levels), based on whether the devaluation leads to a long-run increase or decrease in the global price as determined by the criteria to the right of equation (33). If production is relatively more capital intensive then labor intensive, or if the devaluation causes a large increase in the crisis country's interest rates, then there is a greater chance that the global price increases and r.o.w. firms subsequently increase output and capital investment.

For firms in the crisis country, the impact of the devaluation on output quantities and capital investment is:

$$(36)\qquad \frac{d\tilde{q}_{j,t}^{LR}}{de_t}=\left(\frac{\tilde{q}_{j,t}^{LR}}{1-\beta-\gamma-\alpha}\right)\left(\frac{(\beta+\gamma+\alpha)}{P_t^{LR}}\frac{dP_t^{LR}}{de_t}-\frac{\beta_t}{e_t}-\frac{\alpha}{\tilde{r}}\frac{d\tilde{r}}{de}\right)<0 \quad \text{if } \frac{\beta}{e}>\frac{\alpha}{\tilde{r}}\frac{d\tilde{r}}{de}$$

$$(37)\qquad \frac{d\tilde{k}_{j,t}^{LR}}{de_t}=\left(\frac{\tilde{k}_{j,t}^{LR}}{1-\beta-\gamma-\alpha}\right)\left(\frac{1}{P_t^{LR}}\frac{dP_t^{LR}}{de_t}-\frac{\beta}{e_t}-\frac{(1-\beta-\gamma)}{\tilde{r}}\frac{d\tilde{r}}{de}\right)<0$$
$$\text{if } \frac{\beta}{e}>\frac{\alpha}{\tilde{r}}\frac{d\tilde{r}}{de} \text{ and}\left(\frac{1}{\varphi}>\Theta \text{ and/or } \frac{\hat{Q}_t^{C,LR}}{\hat{Q}_t^{W,LR}}<\Theta'\right)$$

where $\Theta,\Theta'=f(\beta,\gamma,\alpha,\varphi,e,\tilde{r},d\tilde{r}/de)$.

Therefore, the devaluation affects output quantities and capital investment for crisis-country firms through the same global price effect as shown for r.o.w. firms in equations (34) and (35). The devaluation also has two additional effects on crisis-country firms in the long run, however, through changes in the relative costs of labor and capital. Algebraic manipulation shows that the criterion for $d\tilde{q}_{j,t}^{LR}/de_t<0$ is the same as the criterion for $dP_t^{LR}/de_t<0$. In other words, a devaluation only increases output for crisis-country firms in the long run if: the share of labor in output is relatively larger than the share of capital and the increase in the cost of capital is not too large. This is an intuitive result. Devaluations will only cause crisis-country firms to increase output if the cost advantage that they gain from relatively cheaper labor is greater than the cost disadvantage from relatively more expensive capital.

The criteria for the devaluation to increase capital investment in crisis-country firms are even more stringent. In this case, not only must the condition for a decline in the global price be satisfied, but some combination of two additional conditions must be met: the global price elasticity of demand must be sufficiently large and/or the share of global output produced by the crisis country must be sufficiently small. In other words, if the devaluation lowers the commodity price, crisis-country firms will only increase their capital levels if the price decline leads to a large enough increase in global demand, or if the impact of the devaluation on global prices is fairly small (since the crisis country only produces a small fraction of global output). As discussed at the end of Section III.C, the output-share condition (that $\hat{Q}_t^{Crisis,SR}/\hat{Q}_t^{World,SR}$ is sufficiently small) is usually satisfied because the production of most commodities is rarely concentrated in an individual country.

To complete this analysis of the long-run impact of devaluations, equations (38) and (39) report the effects on long-run profits for firms in the r.o.w. and crisis country, respectively. Long-run profits are defined as short-run profits plus the cost of capital.

$$(38) \qquad \frac{d\pi_{i,t}^{LR}}{de_t} = \left(\frac{\pi_{i,t}^{LR}}{1-\beta-\gamma-\alpha} \right) \left(\frac{1}{P_t^{LR}} \frac{dP_t^{LR}}{de_t} \right) > 0 \quad \text{if} \quad \frac{\beta}{e_t} > \frac{\alpha}{\tilde{r}_t} \frac{d\tilde{r}_t}{de_t}$$

$$(39) \qquad \frac{d\tilde{\pi}_{j,t}^{LR}}{de_t} = \left(\frac{\tilde{\pi}_{j,t}^{LR}}{1-\beta-\gamma-\alpha} \right) \left(\frac{1}{P_t} \frac{dP_t^{LR}}{de_t} - \frac{\beta}{e_t} - \frac{\alpha}{\tilde{r}} \frac{d\tilde{r}}{de} \right) < 0$$

$$\text{if } \frac{\beta}{e} > \frac{\alpha}{\tilde{r}} \frac{d\tilde{r}}{de} \quad \text{and} \left(\frac{1}{\varphi} > \Omega \quad \text{and/or} \quad \frac{\hat{Q}_t^{C,LR}}{\hat{Q}_t^{W,LR}} < \Omega' \right)$$

where $\Omega \text{ and } \Omega' = f(\beta, \gamma, \alpha, \varphi, e, \tilde{r}, d\tilde{r}/de)$.

The sign of $d\pi_{i,t}^{LR}/de$ is the same as the sign of dP_t^{LR}/de. Therefore, if the devaluation reduces the global commodity price, as specified in the condition to the right of equation (38), then profits decrease for r.o.w. firms in the long run. On the other hand, the sign of $d\tilde{\pi}_{j,t}^{LR}/de$ is the opposite of the sign of dP_t^{LR}/de if the global elasticity of demand for the commodity is large enough or the crisis country's share of global output is small enough. As discussed above, the output-share condition is satisfied for most commodities. Therefore, in most cases, devaluations will have the opposite impact on long-run profits for firms in the crisis country versus firms in the r.o.w. For example, if capital is used more intensively in production than labor and/or the devaluation substantially raises interest rates in the crisis-country, then the devaluation will: increase the global output price; increase profits for firms in the r.o.w.; and decrease profits for firms in the crisis country.

To summarize, Sections III.C. and III.D. have used the model developed in Sections III.A. and III.B. to explore the impact of devaluations on firms around the world. In the short-run, when each firm's level of capital investment is fixed, the model's predictions are fairly straightforward. The devaluation reduces the relative cost of labor in the crisis country and firms in the crisis country increase production. Lower input costs reduce the global price of the commodity, and this effect is proportional to the size of the crisis country in global production and the relative share of labor in production. Since the global output price falls and input prices for firms in the r.o.w. remain constant, firms in the r.o.w. reduce production. The increase in

output by crisis-country firms is greater than the decrease in output by r.o.w. firms, so that global production increases. Short-run profits unambiguously decrease for firms in the r.o.w. Short-run profits will generally increase for firms in the crisis country (as long as the country's share in global output is relatively small and/or the global elasticity of demand is not too small.)

In the long run, however, firms are able to adjust their levels of capital investment and the impact of devaluations will depend on production parameters and changes in relative input costs. Not only do devaluations reduce the relative cost of labor in the crisis country, but they also increase the relative cost of capital (possibly by more than the initial exchange-rate movement.) Therefore, the long-term impact of devaluations hinges on the relative importance of labor and capital in production and the impact of devaluations on crisis-country interest rates. If the cost advantage for crisis-country firms from relatively cheaper labor outweighs the cost disadvantage from relatively more expensive capital, then the key predictions from the short-run model also apply in the long run. Firms in the crisis country increase output and investment and their profits rise. Firms in the r.o.w. decrease output and investment and their profits decrease. On the other hand, if the cost disadvantage from relatively more expensive capital outweighs the cost benefit from reduced wages in the crisis country, then each of these predictions is reversed. Firms in the crisis country decrease production and investment, and their profits fall. Firms in the r.o.w. increase output and investment, and their profits rise. Therefore, the long-run impact of devaluations hinges on the importance of capital and labor in production and the relative changes in the costs of these two inputs.

IV. EMPIRICAL TESTS

This section tests three of the model's key predictions. Part A describes the data set, devaluation episodes, and commodity groups used for the analysis. Part B examines how devaluations affect output growth for firms in the crisis country and r.o.w. Part C analyzes how devaluations impact profits. Part D considers how devaluations affect firm's capital investment and changes in the firm's expected long-run output. This section also examines how capital/labor ratios and changes in the cost of capital determine the impact of devaluations on different groups of firms. Although this empirical analysis is not a formal test of the full theoretical model, the results support the model's predictions for how devaluations will impact output quantities, profitability and capital investment for firms around the world.

IV.A. The Events, Data, and Commodity Groups

The empirical tests focus on "major devaluations" in 8 countries between January 1, 1997 and December 31, 1999.[15] "Major devaluations" are defined as episodes where the local currency/$ exchange rate increased by 15 percent or more within a 4-week period. Table 1 lists the countries with major devaluations in chronological order, as well as the months when the devaluations occurred.[16] The exchange-rate data is from the *Datastream* database. This list of major devaluation episodes includes the standard events typically analyzed in the currency-crises literature: several Asian countries in 1997-98; South Africa and Russia in 1998; and Brazil in 1999.

The empirical tests focus on 6 commodity groups: natural rubber and related plantation products; silver and gold ores; nickel and other ferroalloy ores; natural gas and crude petroleum; edible fats and oils; and fertilizers.[17] These commodities are listed in Table 2, with the nearest corresponding SIC codes, SITC codes, and the share of global exports from each of the devaluing countries listed in Table 1. The firm-level information is from the *Worldscope* database on CD-ROM published by Primark (2001). Information on export volumes for each country by commodity group is compiled from the *Trade Analysis System for Personal Computers CD-ROM* published by the International Trade Centre/UN Statistics Division (2000). As shown in the table, many of the commodities are exported by more than one country that devalued its currency between 1997 and 2000. Although this overlap complicates the empirical analysis, it is also useful in identifying why devaluations in different countries can have varied effects on competing firms in other countries.

The remainder of this section uses these 6 commodity groups listed in Table 2 to examine the impact of the major devaluations listed in Table 1 on output, profits, and capital investment for firms around the world. It focuses on the model's predictions for firms, rather than industries, because global production and prices are affected by numerous shocks to supply and demand (other than the devaluation) that are extremely difficult to measure. For example, an unusually cold winter in the Northern hemisphere can increase the demand for natural gas and oil; a severe monsoon in Asia could decrease the global supply of edible oils; and technological advances

[15] This time period was chosen to correspond with the available firm-level data.

[16] After a major devaluation, the next four weeks are excluded so that there can be, at most, one devaluation event within any 4-week period. The only major devaluation that is not included in this analysis is Ecuador's crisis starting in January of 1999. This event is excluded because there is no firm-level data for Ecuador and Ecuador exports less than 1 percent of total global exports for each of the commodity groups in the sample.

[17] These commodity groups were chosen based on three criteria: (1) firm-level data for the industry was available; (2) at least 1 crisis country exported at least 10 percent of global output for the industry; (3) the industry roughly fits the characteristics of a "commodity" as described in the theoretical model.

(such as fiberoptics) can reduce the demand for specific minerals (such as copper.) By focusing on within-industry differences in firm performance, rather than on aggregate industry trends, it is possible to control for these exogenous shocks to global supply and demand and better identify the direct impact of the devaluations.

IV.B. Test of Prediction 1: The Short-run Impact of Devaluations on Firm Output

Model Prediction 1: Immediately after devaluations, commodity-exporting firms in the devaluing country increase output and competing firms in other countries decrease output. See equations (27) and (28).

To test this prediction, Table 3 begins by listing average output growth for firms in countries that devalued their currencies (either in the given year or previous year) versus firms in countries that did not devalue their currencies. Output growth is measured as the annual percent change in net sales and revenues (measured in local currency) for each year from 1996 through 2000.[18] The first row of the table reports unweighted averages of output growth for the two groups of firms for the entire sample. The lower rows disaggregate average output growth for the two groups of firms into the 6 commodity groups defined in Table 2. The table also reports standard deviations of output growth and the numbers of firms for each group.

Table 3 shows that average annual output growth for firms in countries that recently devalued was 18 percent, versus 13 percent for firms in countries that did not recently devalue. When average output growth is disaggregated by commodity group, firms in devaluing countries have higher output growth in 5 of the 6 industries. For example, for the edible oils and fats industry, output growth for firms in the devaluing countries averaged 12 percent, while output growth for firms in non-devaluing countries was only 4 percent. The only industry in which output growth is lower for firms in the devaluing countries is natural gas and crude petroleum.

Next, to control for annual shocks to output and differentiate between the immediate and lagged effect of devaluations, I estimate the model:

$$\Delta q_{i,t} = \theta_0 + \theta_1 Devalue_{i,t} + \theta_2 Devalue_{i,t+1} + \boldsymbol{\eta}_t + \varepsilon_{i,t} \tag{40}$$

where $\Delta q_{i,t}$ is output growth for company i in period t; $Devalue_{i,t}$ is a dummy variable equal to 1 if the country where firm i is based had a crisis in period t; $Devalue_{i,\,t+1}$ is a dummy variable equal to 1 if the country where firm i is based had a crisis in the previous period; $\boldsymbol{\eta}_t$ is a vector of period

[18] More specifically, net sales and revenues are defined as gross sales and other operating revenues less discounts, returns and allowances.

dummy variables (for 1996 through 1999, with 2000 the excluded year); and $\varepsilon_{i,t}$ is an error term. The period dummy variables capture any global shifts in supply or demand that affect all firms in the sample in any period. The *Devalue* variables capture whether firms in devaluing countries had significantly higher or lower output growth in the year of the devaluation or the year immediately following the devaluation.

Table 4 reports estimates of equation (40). The first row shows results when the model is estimated as a pooled cross-section of firms in all 6 commodity groups for the years 1996 through 2000. The second and third rows report results when the model is estimated with fixed or random effects for each industry group. The bottom part of the table reports estimates when equation (40) is estimated separately for each of the 6 commodity groups. When the model is estimated for the entire sample of firms, using either the pooled cross-section or fixed or random effects, $Devalue_{i,t}$ is always positive and significant at the 1 percent level. This suggests that when a country devalues its currency, firms in that country have significantly higher output growth (in that year) than firms in non-devaluing countries. Moreover, the size of this effect can be large. The pooled cross-section estimates show that annual output growth is 22 percent higher, on average, for commodity firms in the devaluing country. The coefficient on $Devalue_{i,t+1}$ is insignificant in each case, however, suggesting that this impact of devaluations on output growth is short lived. In the year immediately following devaluations, output growth is not significantly different for firms in the devaluing countries compared to firms located in the rest of the world.

When equation (40) is estimated separately for each of the 6 commodity groups, sample sizes are substantially smaller, but the coefficients on $Devalue_{i,t}$ remain positive for each of the industry groups (and are significant at the 5 percent level in half of the industries.) This suggests that within each industry, firms in countries that devalued had higher output growth than competitors in countries that did not devalue. For example, estimates for the first commodity group indicate that output growth for rubber plantations in devaluing countries was 35 percent higher than output growth in rubber plantations located elsewhere. The coefficients on $Devalue_{i,t+1}$ continue to be insignificant for each industry group, supporting the previous result that the lagged impact of devaluations on firm output growth is small.

To test the robustness of these results, I estimate a series of sensitivity tests. First, I exclude each industry, each country, and each major devaluation event from the base analysis. Then I add a control variable for firm size (assets in the current year or previous year, denominated in dollars). Finally, I add two additional dummy variables ($Devalue_{i,t-1}$ and $Devalue_{i,t+2}$) to control for any differences in output growth for firms in the crisis country in the year before the devaluation and/or two years after the devaluation. In each of these sensitivity

tests, the central results do not change. Immediately after devaluations, firms in the crisis country have higher rates of output growth than firms in the rest of the world.

IV.C. Test of Prediction 2: The Short-run Impact of Devaluations on Firm Profits

Model Prediction 2: Immediately after devaluations, operating profits for commodity-exporting firms in the devaluing country increase and operating profits for competitors in other countries decrease.[19] *See equations (29) and (30).*

To test this prediction, I use the same strategy as used in section B to analyze how devaluations affect firms' output growth. Table 5 begins by listing average growth in operating profits for firms in countries that devalued their currencies (either in the given year or previous year) versus firms in countries that did not devalue their currencies. Average growth in operating profits is measured as the annual percent change in net sales and revenues minus the cost of goods sold.[20] Operating profits do not include interest expense, depreciation, amortization, or taxes, and are therefore directly comparable to the definition of short-run profits used in the theoretical model. The first row of the table reports unweighted averages of profit growth for the entire sample. The lower rows disaggregate average profit growth into the 6 commodity groups defined in Table 5.

Table 5 shows that average annual profit growth for firms in countries that recently devalued was 16 percent, versus 12 percent for firms in countries that did not recently devalue. When average profit growth is disaggregated by industry, the differences are even more striking. Firms in devaluing countries have higher profit growth in all 6 industries. For example, for the edible oils and fats industry, profits increased 13 percent, on average, for firms in the devaluing countries, while profits decreased by 1 percent for firms in the rest of the world.

Next, to control for annual shocks to profits and differentiate between the immediate and lagged effect of devaluations, I estimate the model:

$$\Delta\pi_{i,t} = \theta_0 + \theta_1 Devalue_{i,t} + \theta_2 Devalue_{i,t+1} + \boldsymbol{\eta}_t + \varepsilon_{i,t} \tag{41}$$

where $\Delta\pi_{i,t}$ is the growth in operating profits for company i in period t; and each of the other variables are defined above. Results are reported in Table 6 and support the conclusions from

[19] Note that the first part of the prediction (for firms in the crisis country) assumes that the devaluing country produces a small share of global output and/or the global price elasticity of demand for the commodity is greater than or equal to 1.

[20] Net sales and revenues are defined above. The cost of goods sold is defined as the specific or direct manufacturing cost of materials and labor in the production of finished goods.

Table 5. When the model is estimated using a pooled cross-section, fixed industry effects or random industry effects for the entire sample of commodity firms (as reported in the top of the table), then operating profits for firms in the devaluing country are significantly higher (in the year of the devaluation) than for firms in other countries. Moreover, the magnitude of this effect can be large. The random-effects estimates suggest that operating profits grew by 17 percent more for firms in countries that devalued. This increase in profitability from devaluations, however, appears to be short-lived. In the year immediately following a devaluation, operating profit growth is lower (although the coefficient is insignificant) for firms in the devaluing country.

When equation (41) is estimated separately for each of the 6 commodity groups (in the bottom of the table), the coefficients on $Devalue_{i,t}$ remain positive for each of the industry groups (and significant in one-third of the groups.) The magnitude of the estimates continues to suggest that the impact of devaluations on operating profits can be large. For example, profit growth in firms producing edible oils and fats was 23 percent higher for firms in the devaluing country than in the rest of the world (during the year of the devaluation). The coefficients on $Devalue_{i,t+1}$ have mixed signs and are generally insignificant. The one exception is the significant positive coefficient for firms in the natural gas and crude petroleum industry.

To test the robustness of these results, I estimate a series of sensitivity tests. First, I exclude each industry, each country, and each major devaluation event from the base analysis. Then I add a control variable for firm size (assets in the current year or previous year, denominated in dollars). Finally, I add two additional dummy variables ($Devalue_{i,t-1}$ and $Devalue_{i,t+2}$) to control for any differences in profit growth for firms in the crisis country in the year before the devaluation and/or two years after the devaluation. In each of these sensitivity tests, the magnitude of the coefficients does fluctuate, but the central results do not change. Immediately after devaluations, firms in the crisis country have higher profits than firms in the r.o.w.

Moreover, the robustness of these results supports the assumption discussed in some detail in section III. C. One of the conditions for devaluations to increase short-run profits for firms in the crisis country is that the devaluing country must not export too large a share of global production (and/or the price elasticity of demand must be greater than 1). As mentioned above, the production of most commodities is not concentrated in any one country, so that in most cases, this condition should be satisfied and we would expect profits for firms in the crisis country to increase after devaluations. This series of empirical tests supports this conclusion. Immediately

after devaluations, operating profits are significantly higher for firms in the devaluing country than competitors in the rest of the world.

IV.D. Test of Prediction 3: The Impact of Devaluations on Firms' Capital Investment

Model Prediction 3: After devaluations, commodity-exporting firms in the devaluing country increase capital investment and competing firms in other countries decrease capital investment if: labor's share in output is greater than capital's share and the increase in the crisis-country's cost of capital is small. See equations (35) and (37).[21]

Since changes in capital investment signal expected changes in future output, and since the model's conditions for firms to increase or decrease long-run output are identical to the conditions for firms to increase or decrease capital investment, tests of this prediction can also be interpreted as tests of the long-run impact of devaluations on production.[22] For comparability with the previous two sections and as a preliminary analysis of this prediction, Table 7 lists mean growth in capital investment for firms in countries that recently devalued (either in the given year or previous year) versus firms in countries that did not devalue. Growth in capital investment is measured as the annual percent change in net plant, property and equipment.[23] In contrast to Tables 3 and 5 (that performed this comparison for growth in output and profits), there is no clear pattern in capital growth for firms in devaluing countries compared to firms in other countries. For the full sample, growth in capital investment is virtually identical for the two groups of firms. When the analysis is performed for specific commodity groups, growth in capital investment is greater for firms in devaluing countries in half the commodity groups, and smaller in the other half.

These patterns are not surprising. The model's predictions for the impact of devaluations on short-run growth in output and profits were unambiguous; devaluations would increase output and profits for firms in the devaluing country and decrease output and profits for firms in the r.o.w. in the short run. On the other hand, the model's predictions for the impact of devaluations

[21] Note that the first part of the prediction (for firms in the crisis country) assumes that the devaluing country produces a small share of global output and/or the global price elasticity of demand for the commodity is greater than or equal to 1.

[22] Unfortunately, since the "long-run" in the model is the amount of time before any new capital investment affects production (which can be several years for commodities), enough time has not elapsed to directly test the long-run impact of the devaluations listed in Table 1. Moreover, the firm-level dataset does not have sufficient historical coverage to analyze the long-run impact of devaluations that occurred before 1996.

[23] More specifically, gross plant, property and equipment is defined as tangible assets with an ecpsected useful life greater than 1 year which are expected to be used to produce goods for sale or for distribution of services. Net property, plant and equipment is gross plant, property and equipment less accumulated reserves from depreciation, depletion, and amortization.

on capital growth were ambiguous and depended on two factors: the relative shares of capital and labor in production and changes in the devaluing-country's cost of capital. Therefore, unless all industries had similar capital/labor ratios and devaluations had the same effect on interest rates in all of the crisis countries, there is no reason to expect the same impact of devaluations on capital growth in these different groups of firms.

To explore whether capital/labor shares and changes in the crisis-country cost of capital are related to changes in capital investment as predicted in the model, Table 8 performs a number of comparisons. The top of the table reports the average growth in capital investment for different groups of firms in countries that recently devalued their currencies, and the bottom of the table reports growth rates for different groups of firms in non-devaluing countries. The patterns for the devaluing-country firms are the most consistent with the model's predictions. The first two lines of the table divide the sample into two groups based on changes in the cost of capital during the crisis: firms in countries where the average lending rate increased by less than 20 percent after the devaluation, and firms in countries where the average lending rate increased by 20 percent or more after the devaluation.[24] Average growth in capital investment was 17 percent for the first group of firms, compared to 14 percent for the second group. Although the difference across the two sets of firms is small, these statistics support the model's prediction that after devaluations, capital growth is lower in crisis-country firms with a larger increase in the cost of capital (holding capital/labor ratios constant).

The next two rows of the table divide the sample of devaluing-country firms into two groups based on each firm's capital/labor ratio: firms with a capital/labor ratio less than 100 or firms with a capital/labor ratio greater than or equal to 100.[25] Average growth in capital investment was 19 percent for the first group of firms, compared to 15 percent for the second group. Once again, although the difference across the two sets of firms is small, the statistics support the model's prediction that after devaluations, capital growth is lower in crisis-country firms with higher capital/labor ratios (holding the cost of capital constant).

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[24] Interest rates are lending rates from line 60P..zf of the International Monetary Fund's *International Financial Statistics* on CD-ROM (2001). Data is not available for Brazil, so I substitute the money market rate (line 60B..zf).

[25] Capital/labor ratios are calculated as the ratio of total assets/total employees. Total assets are the sum of total current assets, long-term receivables, investment in unconsolidated subsidiaries, other investments, and net property, plant and equipment, calculated in U.S. $ using the fiscal year-end exchange rate. For several firms, information on employees was not available. For these companies, I substituted the average capital/labor ratio for all firms in the same 3-digit industry for the same country. If there was no firm with data available for the same country and industry, I substituted the average capital/labor ratio for firms in the same industry for the closest comparable country (based on per capita income levels and geographic location).

The last four rows in the top half of the table combine these two comparisons for an even more accurate test of model prediction 3. They report capital growth rates for devaluing-country firms when the sample is divided based on both changes in the cost of capital in the firm's country as well as the firm's capital/labor ratio. Firms with low capital/labor ratios located in countries that do not have large increases in interest rates have the fastest average capital growth rate: 19 percent. Firms with high capital/labor ratios located in countries with large increases in interest rates have the slowest average growth rate: 11 percent. The remainder of firms (with either high capital/labor ratios and no large increase in interest rates or with low capital/labor ratios and large increases in interest rates), have capital growth rates between these extremes: 15 percent. This provides strong support for the model's predictions. Changes in the cost of capital as well as the firm's capital/labor ratio are both critical determinants of how devaluations affect firms' investment decisions in the crisis country.

The bottom half of the table performs a similar set of comparisons for firms in non-devaluing countries. Changes in the crisis-country cost of capital (Δr^*) are calculated separately for each commodity group as the average change in the lending rate for each country that had a crisis in that year, weighted by the percent of global exports from that country. In other words, this statistic measures the weighted increase in interest rates for all countries that devalue, with the weights determined by each devaluing country's share of global trade for the relevant commodity. To be consistent with the previous analysis, the cutoff to qualify as a "large" increase in interest rates is a 20 percent increase in the cost of capital for a crisis country exporting 20 percent of global exports for a specific commodity.[26] The table shows that firms in non-devaluing countries had lower capital growth rates if they competed with firms in crisis countries with a large increase in interest rates (compared to firms in crisis countries without a large increase in interest rates.) This does not support the model's predictions, but could occur if the crisis reduced demand for the commodity and thereby lowered capital investment for firms in other countries (a channel which is not explicitly included in the model.)

The next pair of rows divides the sample of non-devaluing firms based on weighted capital/labor ratios for competing firms in the crisis country. Weighted capital/labor ratios (K/L^*) are calculated using the same methodology as above for interest rates. They are calculated by commodity group as the average capital/labor ratio for each country that had a crisis, weighted by the percent of global exports from that country. To be consistent with the analysis for firms in the devaluing country, the cutoff dividing "high" and "low" capital/labor ratios is 100. The table

[26] Twenty percent of global exports is close to the average share of total exports from the largest devaluing country for each of the 6 commodity groups in the sample.

shows that firms in non-devaluing countries had lower rates of growth in capital investment if they competed with crisis-country firms that had lower (instead of higher) capital/labor ratios. Although the difference in capital growth rates between the two groups of firms is small, this result agrees with the model's predictions. Devaluations are more likely to improve the long-term competitiveness of firms in a devaluing country if they have lower capital/labor ratios. In these situations, firms in non-devaluing countries are more likely to suffer a long-term loss in competitiveness and therefore reduce their growth in capital investment and future output capacity.

The final part of the table reports capital growth rates for firms in non-devaluing countries for different combinations of interest rate changes and capital/labor ratios in the relevant crisis countries. Some of these patterns agree with the model's predictions. Firms in non-devaluing countries had low capital investment growth rates if their competitors in the devaluing country had low capital/labor ratios and no large increase in interest rates. This is the combination of capital/labor ratios and interest rates when firms in the crisis country would gain most from the devaluation, and therefore be more likely to hurt the competitiveness of firms in non-devaluing countries. In comparison, firms in non-devaluing countries had higher capital growth rates if they competed with crisis-country firms that had either (but not both) a larger increase in interest rates or high capital/labor ratios. The one result that does not support that model is the final row of the table. When firms in the devaluing countries had high capital/labor ratios and there was a large increase in the cost of capital, firms in non-devaluing countries had the slowest rates of capital growth. This is the situation when the model predicts that crisis-country firms would be less likely to gain from the devaluation, and non-devaluing country firms would be most likely to gain. Once again, this unusual result may be driven by shocks to demand for the commodity that occurs simultaneously with the devaluations and large increases in interest rates.

A final noteworthy comparison in Table 8 is the capital investment growth rates for firms in devaluing countries versus firms in non-devaluing countries when the sample is divided by capital/labor ratios.[27] Firms with higher capital/labor ratios in devaluing countries have lower rates of capital growth (compared to firms in devaluing countries with lower capital-labor ratios). On the other hand, firms with higher capital-labor ratios in non-devaluing countries have higher rates of capital growth (compared to firms in non-devaluing countries with higher capital-labor ratios.) This strongly supports the model's predictions. Devaluations are less likely to boost the

[27] It is more difficult to make a similar comparison when the sample is divided by changes in interest rates since the cutoff for a "large increase in the cost of capital" is not directly comparable between firms in the devaluing and non-devaluing countries.

competitiveness of crisis-country firms that have higher capital/labor ratios, since the disadvantage of more costly capital is more likely to outweigh the advantage of cheaper capital. Competitors in non-devaluing countries, however, are most likely to gain a long-term competitive advantage in these situations. Therefore, firms in the devaluing country will have less incentive to increase capital investment, and competing firms in non-devaluing countries will be more likely to increase their growth in capital investment.

V. CONCLUSIONS

When a country devalues its currency, some firms and countries generally benefit from any resulting changes in relative prices, while other firms and countries are relatively unaffected or suffer a loss in competitiveness. This paper explores a number of conditions determining the impact of devaluations on firms around the world. It focuses on how devaluations affect relative input costs and therefore competitiveness on global markets. In the theoretical model, the immediate impact of devaluations is to lower the relative cost of labor in the crisis country. This improves the relative competitiveness of firms in the devaluing country, so that they increase output and have higher profits. Devaluations also reduce the relative competitiveness of firms in non-devaluing countries, so that they reduce output and have lower profits in the short-run.

Devaluations also raise the relative cost of capital for firms in the crisis country, however, potentially by even more than the exchange-rate movement if the devaluation causes a large increase in domestic risk or contraction in domestic lending. In fact, if this increase in the cost of capital for crisis-country firms is large enough, or the crisis-country firms use capital intensively in production, then the disadvantage from more costly capital could outweigh the benefits of relatively cheaper labor. More specifically, if the firm's capital/labor ratio is large enough, or the increase in the cost of capital is large enough, the devaluation could raise the total cost of production for crisis-country firms so that they decrease output and have lower profits. Firms in non-devaluing countries would increase output and have higher profits. On the other hand, if firms in the devaluing countries use labor relatively more intensively than capital and there is little impact of the devaluation on the domestic cost of capital, the benefits from cheaper labor will outweigh the benefits of more costly capital. Devaluing country firms would increase output and profitability in the long run, and firms in other countries would decrease output and profitability.

After developing these theoretical concepts, this paper uses data for about 1,500 firms in 6 commodity groups between 1996 and 2000 to test three of the model's key predictions.

Although the empirical analysis is not a formal test of the full model, estimates support its main conclusions. Immediately after devaluations, firms in the crisis country have higher growth rates for output and profits than competing firms in non-devaluing countries. These effects are short-lived, however, and disappear within one year. The impact of devaluations on capital investment, and therefore expected long-run output, are correlated with changes in interest rates and capital/labor ratios in the crisis country. More specifically, after devaluations crisis-country firms with low capital/labor ratios that are located in countries that do not have a large increase in interest rates have larger increases in capital investment. Crisis-country firms with higher capital/labor ratios located in countries with large increases in interest rates have lower capital investment growth rates. These results are intuitive. Firms are more likely to lose competitiveness after devaluations, and therefore decrease their productive capacity, if they are more reliant on capital (which becomes relatively more expensive), and/or if the increase in the cost of capital is greater. Patterns in capital investment for competitors in non-devaluing countries are less clear, which may reflect the impact of devaluations and currency crises on global demand.

Therefore, although devaluations unambiguously benefit crisis-country firms in the short-run, they could improve the long-term competitiveness of firms located in other countries in the longer term. The critical determinant of whether crisis-country firms benefit from devaluations (and competitors are harmed) is whether the cost advantage from cheaper domestic labor outweighs the cost disadvantage from more costly capital. Although this paper does not attempt to aggregate these firm-level effects to the macroeconomic level, the results could provide important insights on why some devaluations boost exports, improve economic growth, and spread to other countries, while other devaluations have little impact on the trade balance, are contractionary, and have little impact on the rest of the world.

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Table 1
Major Devaluation Events

	Devaluation Period
Thailand	7/97, 12/97, 1/98
Indonesia	10/97, 12/97, 1/98, 5/98, 6/98, 1/99
Philippines	12/97
Korea (South)	12/97, 1/98
Malaysia	1/98
South Africa	7/98
Russia	8/98, 10/98, 12/98, 1/99
Brazil	1/99

Notes: (a) "Major devaluation events" are episodes when the country's currency/$ exchange rate increases by 15 percent or more within a 4-week period. After a devaluation event occurs, the next four weeks are excluded, so that there can be, at most, one devaluation event within any 4-week period.
(b) Exchange rate data is from Datastream.
(c) Countries in the sample which do not have any major devaluation events are: Argentina, Australia, Austria, Bahrain, Bangladesh, Belgium, Britain, Canada, Chile, China, Colombia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Ireland, Israel, Italy, Japan, Jordan, Kuwait, Lebanon, Luxembourg, Malta, Mexico, Morocco, Netherlands, New Zealand, Norway, Poland, Portugal, Saudi Arabia, Singapore, Slovakia, Spain, Sri Lanka, Sweden, Switzerland, Taiwan, Turkey, United Arab Emirates, Uruguay, and Venezuela. Ecuador is the one country that has a major devaluation but is not included in the list of events since firm-level data is not available for the country and Ecuador exports less than 1 percent of global exports for each of the commodities studied.

Table 2
Commodity Information

Commodity Groups	SIC Codes	SITC Codes	% of Global Exports from Crisis Countries	
Natural rubber, gums, and related plantation products	083 (forest products)	231	Brazil	0.0%
			Indonesia	28.2
			Korea	0.1
			Malaysia	20.5
			Philippines	0.5
			Russia	0.0
			South Africa	0.0
			Thailand	36.8
Gold and silver ores-metal mining	104	289	Brazil	0.1%
			Indonesia	0.1
			Korea	0.0
			Malaysia	0.5
			Philippines	4.6
			Russia	1.3
			South Africa	11.9
			Thailand	0.2
Nickel ores-metal mining	106 (ferroalloy ores)	284	Brazil	0.0%
			Indonesia	14.8
			Korea	0.0
			Malaysia	0.0
			Philippines	1.8
			Russia	0.1
			South Africa	14.1
			Thailand	0.0
Natural gas and crude petroleum	131	333, 343	Brazil	0.0%
			Indonesia	4.5
			Korea	0.0
			Malaysia	2.3
			Philippines	0.0
			Russia	13.3
			South Africa	0.0
			Thailand	0.1
Edible fats and oils	207	421, 422, 431	Brazil	4.1%
			Indonesia	7.4
			Korea	0.1
			Malaysia	22.1
			Philippines	2.8
			Russia	0.2
			South Africa	0.3
			Thailand	0.1
Fertilizer	287 (agricultural chemicals)	562	Brazil	0.4%
			Indonesia	1.7
			Korea	1.9
			Malaysia	0.8
			Philippines	0.7
			Russia	12.5
			South Africa	1.3
			Thailand	0.1

Table 3
Trends in Firm Output Growth[a]:
Devaluing Countries versus Rest of World

		Firms in devaluing countries[b]	Firms in rest of world
Full sample	Mean output growth	0.18	0.13
	Standard deviation	0.77	0.57
	Number of firms	154	1435
Rubber plantations	Mean output growth	0.14	-0.01
	Standard deviation	0.30	0.36
	Number of firms	21	51
Silver & gold ores	Mean output growth	0.28	0.07
	Standard deviation	1.12	0.72
	Number of firms	35	353
Nickel ores	Mean output growth	0.44	0.06
	Standard deviation	0.45	0.23
	Number of firms	5	20
Natural gas & crude petroleum	Mean output growth	0.12	0.22
	Standard deviation	1.24	0.64
	Number of firms	26	591
Edible oils & fats	Mean output growth	0.12	0.04
	Standard deviation	0.33	0.25
	Number of firms	48	185
Fertilizer	Mean output growth	0.16	0.10
	Standard deviation	0.26	0.32
	Number of firms	19	235

Notes: (a) Output growth measured as percent change in net sales and revenues measured in local currency.
(b) "Devaluing countries" are countries that had a major devaluation (as defined in Table 1) in the current year or previous year.

Table 4
Regression Results: Firm Output Growth

	Devaluation Dummies			
	t	t+1	# Obs	R^2
Pooled cross-Section	0.220**	-0.123	1589	0.02
	(0.069)	(0.134)		
Fixed industry Effects	0.264**	-0.066	1589	0.02
	(0.064)	(0.087)		
Random industry Effects	0.220**	-0.123	1589	0.02
	(0.063)	(0.086)		
Rubber plantations	0.349**	0.150	72	0.14
	(0.104)	(0.313)		
Silver & gold ores	0.387	0.174	388	0.02
	(0.261)	(0.272)		
Nickel ores	0.356	---	25	0.31
	(0.229)	---		
Natural gas & crude petroleum	0.225	-0.926	617	0.06
	(0.213)	(0.591)		
Edible oils & fats	0.152**	0.045	233	0.04
	(0.077)	(0.053)		
Fertilizer	0.141**	-0.082	254	0.04
	(0.063)	(0.129)		

Notes: * indicates significance at the 10 percent level and ** indicates significance at the 5 percent level. Standard errors are White-adjusted for heteroscedasticity. R^2 is the within-R^2 for the fixed-effects estimates and the overall- R^2 for the random-effects estimates. Period dummy variables are included in each specification and are always jointly significant at the 1 percent level.

Table 5
Trends in Firm Operating Profits[a]:
Devaluing Countries versus Rest of World

		Firms in devaluing countries[b]	Firms in rest of world
Full sample	Mean profit growth	0.16	0.12
	Standard deviation	0.75	0.65
	Number of firms	135	1281
Rubber plantations	Mean profit growth	0.08	-0.03
	Standard deviation	0.59	0.59
	Number of firms	21	47
Silver & gold ores	Mean profit growth	0.08	0.03
	Standard deviation	1.21	0.79
	Number of firms	24	276
Nickel ores	Mean profit growth	0.69	0.09
	Standard deviation	0.72	0.66
	Number of firms	5	19
Natural gas & Crude petroleum	Mean profit growth	0.27	0.24
	Standard deviation	0.88	0.66
	Number of firms	21	548
Edible oils & fats	Mean profit growth	0.13	-0.01
	Standard deviation	0.50	0.56
	Number of firms	47	172
Fertilizer	Mean profit growth	0.19	0.09
	Standard deviation	0.43	0.48
	Number of firms	17	219

Note: (a) Operating profits measured as percent change in net sales and revenues less cost of goods sold (measured in local currency).
(b) "Devaluing countries" are countries that had a major devaluation (as defined in Table 1) in the current year or previous year.

Table 6
Regression Results: Firm Operating Profits

	Devaluation Dummies			
	t	t+1	# Obs	R^2
Pooled cross-Section	0.168**	-0.119	1416	0.01
	(0.080)	(0.130)		
Fixed industry Effects	0.224**	-0.020	1416	0.01
	(0.075)	(0.109)		
Random industry Effects	0.168**	-0.119	1416	0.01
	(0.074)	(0.109)		
Rubber plantations	0.202	0.066	68	0.02
	(0.221)	(0.347)		
Silver & gold ores	0.189	-0.309	300	0.02
	(0.292)	(0.387)		
Nickel ores	0.462	---	24	0.35
	(0.469)	---		
Natural gas & crude petroleum	0.013	0.753**	569	0.08
	(0.223)	(0.307)		
Edible oils & fats	0.228**	0.075	219	0.04
	(0.109)	(0.169)		
Fertilizer	0.198*	-0.003	236	0.04
	(0.120)	(0.171)		

Notes: * indicates significance at the 10 percent level and ** indicates significance at the 5 percent level. Standard errors are White-adjusted for heteroscedasticity. R^2 is the within-R^2 for the fixed-effects estimates and the overall- R^2 for the random-effects estimates. Period dummy variables are included in each specification and are always jointly significant at the 1 percent level.

Table 7
Trends in Capital Investment[a]:
Devaluing Countries versus Rest of World

		Firms in devaluing countries[b]	Firms in rest of world
Full sample	Mean capital growth	0.17	0.18
	Standard deviation	0.67	0.77
	Number of firms	161	1538
Rubber plantations	Mean capital growth	0.09	0.28
	Standard deviation	0.34	0.75
	Number of firms	21	51
Silver & gold ores	Mean capital growth	0.31	0.20
	Standard deviation	1.24	1.16
	Number of firms	40	450
Nickel ores	Mean capital growth	0.07	0.42
	Standard deviation	0.21	1.31
	Number of firms	5	25
Natural gas & crude petroleum	Mean capital growth	0.26	0.22
	Standard deviation	0.31	0.59
	Number of firms	28	590
Edible oils & fats	Mean capital growth	0.04	0.07
	Standard deviation	0.24	0.28
	Number of firms	48	185
Fertilizer	Mean capital growth	0.16	0.10
	Standard deviation	0.28	0.29
	Number of firms	19	237

Note: (a) Capital investment measured as percent change plant, property and equipment.
(b) "Devaluing countries" are countries that had a major devaluation (as defined in Table 1) in the current year or previous year.

Table 8
Capital Investment in Devaluing and Non-Devaluing Countries: Trends Based on Interest Rates and Capital/Labor Ratios

	Mean Capital Growth[1]	Standard Deviation	Number Firms
Firms in Devaluing Countries[2]			
Δ r < 20%	0.17	0.69	145
Δ r ≥ 20%	0.14	0.44	16
K/L Ratio < 100	0.19	0.85	78
K/L Ratio ≥ 100	0.15	0.43	83
Δ r < 20% & K/L Ratio < 100	0.19	0.90	67
Δ r < 20% & K/L Ratio ≥ 100	0.15	0.44	78
Δ r ≥ 20% & K/L Ratio < 100	0.15	0.53	11
Δ r ≥ 20% & K/L Ratio ≥ 100	0.11	0.18	5
Firms in Non-Devaluing Countries			
Δ r* < (20% weighted)[3]	0.18	0.78	1,349
Δ r* ≥ (20% weighted) [3]	0.15	0.66	189
K/L* Ratio[4] < 100	0.17	0.81	1,137
K/L* Ratio[4] ≥ 100	0.20	0.65	401
Δ r *< 20% weighted & K/L* Ratio < 100	0.17	0.80	1,069
Δ r *< 20% weighted & K/L* Ratio ≥ 100	0.25	0.74	280
Δ r *≥ 20% weighted & K/L* Ratio < 100	0.25	0.98	68
Δ r *≥ 20% weighted & K/L* Ratio ≥ 100	0.10	0.36	121

Notes: (1) Capital growth is measured as the percent change in net plant, property and equipment.
(2) A country is defined as a devaluing country if it had a major devaluation, as defined on Table 1, in the current year or previous year.
(3) r* is calculated by commodity group as the weighted change in the lending rate for all country's having a crisis in the period, weighted by the total share of exports from each crisis country. "Weighted" implies that the 20 percent increase in the cost of capital is weighted by 20 percent (which is close to the average share of global exports for the largest crisis-country exporter of each commodity.)
(4) K/L* is calculated by commodity group as the weighted capital/labor ratio for all firms in a country that has a crisis in that period, weighted by the total share of exports from each crisis country.