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## **Corporate Currency Hedging and Currency Crises**

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# Corporate Currency Hedging and Currency Crises\*

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## Abstract

We examine the impact of corporate currency hedging on economic stability by introducing hedging activity in a Mundell-Fleming-Tobin framework for analyzing currency and financial crises. The ratio between hedged and unhedged firms is modelled depending on firm size as well as hedging costs. The results indicate that, with an increasing fraction of hedged firms in an economy, the magnitude of a crisis decreases and from a specific hedging level onwards currency crises are ruled out. In order to improve corporate risk management access to hedging instruments should be made possible and hedging costs should be reduced.

*Keywords:* Mundell-Fleming-Tobin model, currency crises, currency hedging, hedging costs.

*JEL Classification:* **E32, E44, F31, F41.**

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# 1 Introduction

One of the key ingredients in financial crises according to Krugman (2000) is foreign-currency-denominated debt. Given such sort of debt a sudden currency depreciation - a rising price of foreign exchange - could have serious consequences for the balance sheets of firms. Those negative balance sheet effects may cancel out positive effects arising from the trade balance as described by the Marshall-Lerner condition.

Krugman (2000) sketches two possible channels for avoiding financial crises. The first possible solution is based on a growing integration of markets for goods and services. This would weaken the contractionary balance sheet effect of a currency depreciation and strengthen the positive effects on exports. The second channel deals with encouraging foreign direct investment. Multinational firms, which have subsidiaries in different countries and deal with a portfolio of different currencies, are more likely to resist pressures arising from a specific currency. Promoting foreign direct investment serves to decrease negative effects of adverse trends in foreign exchange markets. Hence, both channels focus on strengthening the independence of a firm's balance sheet to adverse exchange rate movements.

This paper pursues a new approach for reaching this objective. The main idea is that some independence of a firm's balance sheet from adverse exchange rate movements can be achieved by corporate risk management. In contrast to our firm-based approach, other authors, like Burnside, Eichenbaum and Rebelo (2001) focus on the role of banks in currency crises. Burnside, Eichenbaum and Rebelo (2001) investigate the conflict between government guarantees and banks' hedging activities and conclude that, the presence of guarantees eliminates banks' incentives to hedge. As the government guarantee serves as a kind of protection, additional risk management is dispensable.<sup>1</sup>

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<sup>1</sup>Another difference between the two approaches is simply the definition of hedging. In our paper, hedging activity is always bound to spot market activity, and thus to the risk management of specific capital flows exposed to exchange rate risk. In the investigation of Burnside, Eichenbaum and Rebelo (2001) banks can even enhance "their exposure to exchange rate risk via forward markets" (p. 1153). Hence, banks use forward markets not only for hedging activity but also for

Usually there are no government guarantees to firms. Therefore firms depend on financial markets to hedge their currency exposure. We examine the impact of risk management activities of nonfinancial firms on economic stability by introducing corporate hedging in a Mundell-Fleming-Tobin type model. More specifically we here extend the Flaschel and Semmler (2003) model to include hedging. Firms' hedging activity is modelled depending on firm size as well as hedging costs. Referring to the channels mentioned by Krugman (2000), the primary advantage of corporate risk management is the fact that, in general, it is not necessary to officially encourage risk management because it is a natural constituent of business. Furthermore, nowadays, financial derivatives are available in a great variety, providing almost perfect hedging possibilities. Hedging currency risk with financial derivatives gives companies a powerful protection tool, and might be a key instrument for avoiding "private sector crises"<sup>2</sup>.

The paper is organized as follows. Section 2 implements corporate risk management into a Flaschel and Semmler (2003) type Mundell-Fleming-Tobin model.<sup>3</sup> The decision whether to hedge or not is given exogenously by assuming that only large firms can hedge their currency exposure while small companies depend completely on foreign exchange markets. In Section 3 all firms can hedge and the hedging decision depends on hedging costs and expected losses due to currency depreciations. Section 4 contains concluding remarks. In the appendix we discuss hedging strategies using currency forwards and futures as well as some empirical facts concerning currency derivatives' market size and availability of financial derivatives in emerging markets.

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speculation. However, there is one similarity between these different approaches. In both papers, banks and firms can fully hedge exchange rate risk.

<sup>2</sup>Goodhart (2000, p. 108).

<sup>3</sup>For a detailed discussion of the Mundell-Fleming-Tobin model, see Rødseth (2000, Chapter 6).

## 2 Firm size approach

In this section, corporate hedging activity depends solely on firm size. The only hedging instruments available are linear over-the-counter (OTC) currency forward contracts. OTC products are “custom-made”<sup>4</sup> and allow therefore for perfect currency hedging. However, the main disadvantage of OTC products is the fact that they are not traded on organized exchanges. The products are not standardized and therefore generally not available to a large number of customers. Furthermore OTC derivatives, in general, deliver large amounts of the underlying asset. Smaller amounts of foreign exchange compatible to specific capital flows of smaller nonfinancial firms cannot be hedged perfectly with these products. Hence, in addition to restricted access to OTC derivatives, the contract size of OTC products poses a barrier to small firms’ hedging activity. In our model, we assume that only large firms have access to OTC derivatives and use these products to hedge their currency exposure perfectly. Small firms do not hedge at all. Empirical evidence supports this approach.<sup>5</sup> Mian (1996, p. 437) investigates corporate hedging policy and concludes: “I find robust evidence that larger firms are more likely to hedge. This evidence supports the hypothesis that there are economies of scale in hedging and that information and transaction considerations have more influence on hedging activities than the cost of raising capital.”<sup>6</sup>

Our model is based on the following assumptions:

1. There are two types of firms: Large ones and small ones.
2. Only large firms can hedge their currency exposure, and they hedge it perfectly.

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<sup>4</sup>Neftci (2000, p. 6).

<sup>5</sup>See Fender (2000b).

<sup>6</sup>However, Géczy, Minton and Schrand (1997, p. 1332) point out that the relationship between firm size and hedging activity might not be that unambiguous. Smaller firms might hedge more because of higher bankruptcy costs and greater information asymmetries. In our simple model, we adopt the mainstream opinion based on empirical evidence, that there is a positive relationship between firm size and hedging activity (see Pennings and Garcia (2004, p. 957)). The main reasons for this positive relationship are informational economies and economies of scale as well as access to necessary resources and the potential trading volume of large firms.

Small firms cannot hedge at all. Large firms are completely independent of exchange rate movements, while small firms are subject to adverse developments in foreign exchange markets.

3. There are no hedging costs.
4. Small and large firms are equal, except regarding their ability to hedge.
5. Banks and trading partners recognize hedged and unhedged firms by their size.

## 2.1 The investment function

In our model, hedging activity affects the investment function. The investment function of firm  $i$  is given by  $I_i(\theta, e)$ , where the hedging coefficient  $\theta$  and the exchange rate  $e$  enter in a multiplicative form ( $\theta * e$ ). The term  $\theta * e$  represents the sensitivity of investment to changes in the exchange rate, with hedging coefficient  $\theta$ :

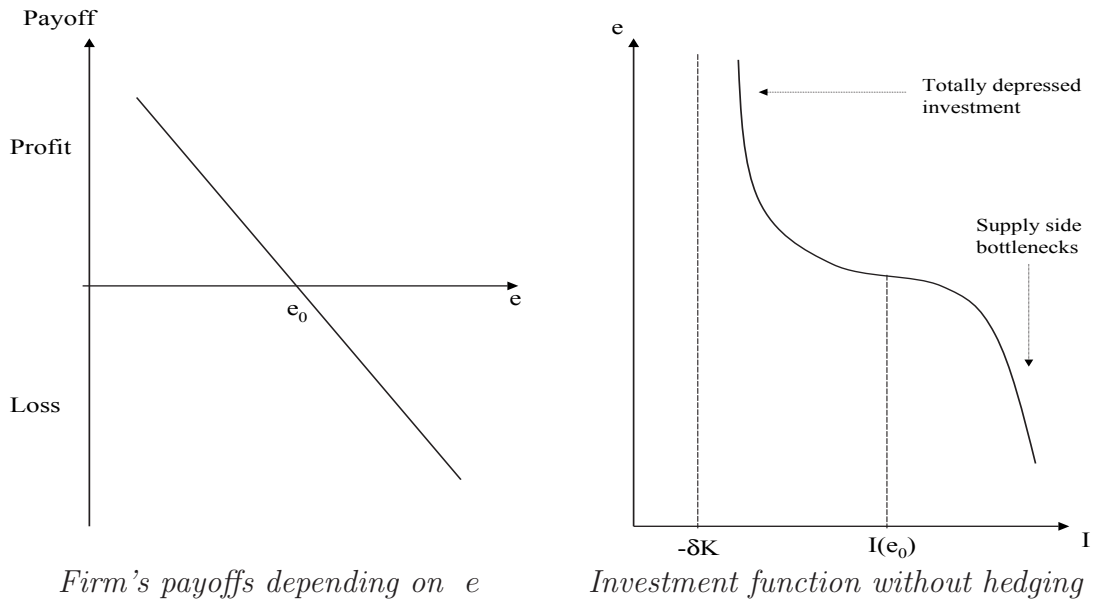
$$\theta = \begin{cases} 0 & \text{if firm } i \text{ is perfectly hedged (large firm).} \\ 1 & \text{if firm } i \text{ is not hedged (small firm).} \end{cases} \quad (1)$$

A perfectly hedged firm's investment function is therefore insensitive to exchange rate movements while unhedged firms are exposed to developments in the foreign exchange markets.

$$I_i = \begin{cases} \bar{I} & \text{if firm } i \text{ is perfectly hedged (large firm).} \\ I(e) & \text{if firm } i \text{ is not hedged (small firm).} \end{cases} \quad (2)$$

Figure 1 shows a firm's payoff and the investment function in the case without corporate hedging. This investment function is on par with Krugman's (2000) type investment function in which investment negatively depends on the nominal exchange rate  $e$ . The underlying idea is that firms in many developing countries have large amounts of debt denominated in foreign currency. A currency depreciation

will worsen these firms' balance sheets which will decrease their net wealth leading to an investment contraction. The result of such a development might be a balance sheet driven crisis in which sufficiently strong negative balance sheet effects outweigh positive competitiveness effects leading to a backward bending goods market curve.<sup>7</sup>



**Figure 1:** *Economy consisting of small firms*

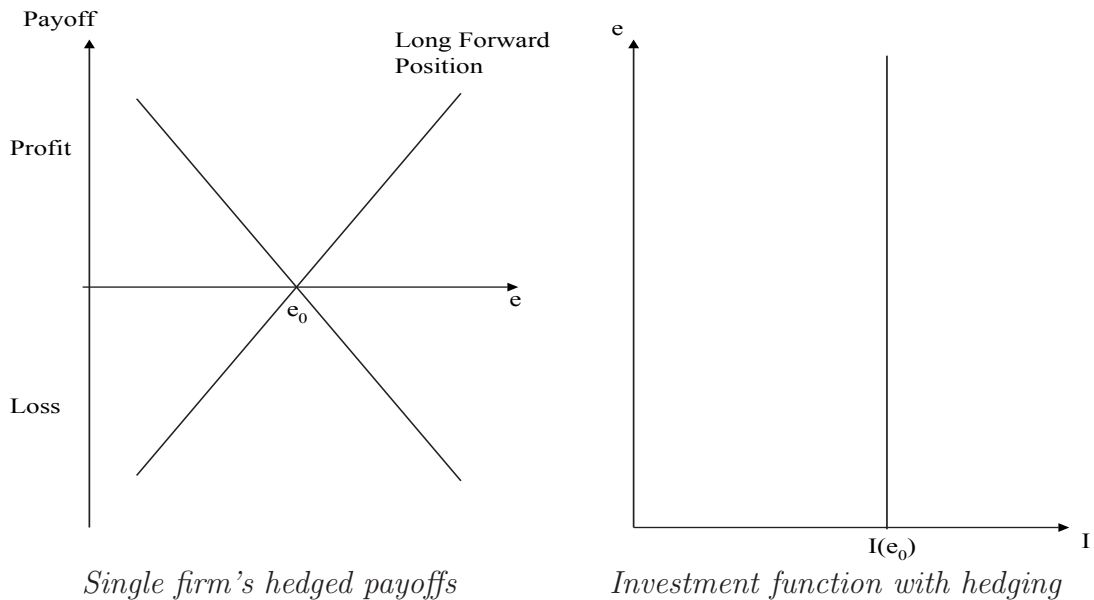
The payoff function in Figure 1 represents any cash flow connected to the liabilities held in foreign currency. In the case of a depreciation of the domestic currency the value of the liabilities increases, resulting in a loss, while an appreciation of the domestic currency decreases the value of the liabilities, which can be taken as profit. The payoff function in Figure 1 is linear for simplicity, in order to introduce simple linear hedging techniques to potentiate perfect hedging possibilities.<sup>8</sup> However, the investment function is not linear due to the balance sheet effect connected to the

<sup>7</sup>See Krugman (2000, p. 82-84).

<sup>8</sup>Perfect hedging possibilities can also be generated using nonlinear instruments such as swaps and options. One could also use structured notes, linking foreign currency risk to credit risk. Another approach are the so-called macro derivatives. They combine risks associated to contract specific variables like exchange rates, interest rates and counterparty default as well as more general variables such as GDP (see Schweimayer (2003)). Again, there are many possible hedging strategies but in this context it is appropriate to use simple linear currency forwards. An example how to conduct currency hedging using forwards and futures is presented in the appendix.

financial accelerator mechanism as discussed in Bernanke, Gertler and Gilchrist (1994).<sup>9</sup>

Figure 2 corresponds to the first line of equation (2), where  $I_i = \bar{I}$ . The payoff function shows a simple, linear currency forward hedging strategy. Here, the central idea is, that the forward position generates profits if the spot position generates losses. Profits and losses sum up to zero. If the spot position generates profits as the result of an appreciation the forward position generates losses, again summing up to zero.<sup>10</sup>



**Figure 2:** *Economy consisting of large firms*

Since foreign liabilities are perfectly hedged against adverse currency movements the investment function shown in Figure 2 is independent of the exchange rate. Large firms which have access to financial derivatives will hedge their currency exposure and hence, surrender potential gains by an appreciation. Fender (2000a, p. 10) describes the reason as follows: “It is a fundamental insight, that under uncertainty, risk-averse decision-makers will prefer stable income and consumption streams to

<sup>9</sup>See e.g. Proaño-Acosta, Flaschel and Semmler (2004, p. 4).

<sup>10</sup>For similar graphical representations of linear hedging strategies, see Grannis and Fitzgerald (1989, p. 102) and Gerke and Bank (1998, p. 444).



highly variable ones.” Furthermore, trading partners as well as banks recognize a hedged firm just by the fact that this specific firm is a large firm. By knowing this, negative balance sheet effects can be avoided even if the hedge position is off-balance sheet.

Assuming that there are  $n$  firms in the economy, the investment function depends on the average hedging coefficient of the economy

$$\phi = \frac{1}{n} \sum_{i=1}^n \theta_i \quad , \quad 0 \leq \phi \leq 1 \quad (3)$$

In a perfectly hedged economy, where all  $n$  firms hedge their currency exposure perfectly, the investment function is constant:  $I(\phi, e) = \bar{I}$ . In the case that no firm hedges, the investment function is  $I(\phi, e) = I(e)$ .

## 2.2 The goods market

We get the following representation of goods market equilibrium

$$Y = C(Y - \delta \bar{K} - \bar{T}) + I(\phi, e) + \bar{G} + NX(Y, \bar{Y}^*, e) \quad (4)$$

The shape of the IS curve with the dependent variable  $Y$ , and the independent variable  $e$ , is given by the Implicit Function Theorem<sup>11</sup>:

$$Y'(e) = -\frac{I_e + NX_e}{C_Y + NX_Y - 1} \quad (5)$$

Since  $C_Y + NX_Y < 1$  by assumption<sup>12</sup>, the term  $C_Y + NX_Y - 1$  is negative. Hence,  $Y'(e)$  is upward sloping if

$$NX_e > I_e \quad (6)$$

Equation (6) holds always true if  $\phi = 0$ , which means that all firms hedge their currency exposure perfectly. In this case there is no backward bending IS curve.

<sup>11</sup>See Flaschel and Semmler (2003, p. 7).

<sup>12</sup>See Flaschel and Semmler (2003, p. 4).

## 2.3 The financial markets

The financial markets are fully described by the following equations:<sup>13</sup>

$$\text{Private Wealth:} \quad W_p = M_0 + B_0 + eF_{p0} \quad (7)$$

$$\text{LM-Curve:} \quad M = m(Y, r), \quad m_Y > 0, m_r < 0 \quad (8)$$

$$\text{Demand for foreign bonds:} \quad eF_p = f(\xi, W_p), \quad f_\xi < 0, f_{W_p} \in (0, 1) \quad (9)$$

$$\text{Risk premium:} \quad \xi = r - \bar{r}^* - \varepsilon \quad (10)$$

$$\text{Expected depreciation:} \quad \varepsilon = \beta_\varepsilon \left( \frac{e_0}{e} - 1 \right), \quad \varepsilon_e \leq 0 \quad (11)$$

$$\text{Demand for domestic bonds:} \quad B = W_p - m(Y, r) - f(\xi, W_p) \quad (12)$$

$$\text{Foreign exchange market:} \quad \bar{F}^* = F_p + F_c \quad (13)$$

with the domestic interest rate  $r$ , the foreign interest rate  $\bar{r}^*$ , private foreign bond holdings  $eF_p$ , and the central bank's foreign bond holdings  $F_c$ . Equation (11) presents a typical formulation of regressive expectations as discussed in Rødseth (2000, p. 21) with  $\varepsilon_e \leq 0$  and  $\varepsilon(e_0) = 0$  for the steady state exchange rate level  $e_0$ . Economic agents have perfect knowledge of the future equilibrium exchange rate and therefore expect the actual exchange rate to adjust to the steady state value after the occurrence of a shock. Flaschel and Semmler (2003, p. 5) call these expectations allowing agents to behave forward looking “asymptotically rational”.

Solving equation (8) for  $r$ , inserting the result in equation (10), and inserting further equation (10) as well as equation (7) in equation (9) gives the Financial Markets Equilibrium Curve (AA-Curve):

$$eF_p = f(r(Y, M_0) - \bar{r}^* - \beta_\varepsilon \left( \frac{e_0}{e} - 1 \right), M_0 + B_0 + eF_{p0}) \quad (14)$$

The slope of the AA-curve is determined by the Implicit Function Theorem<sup>14</sup>

$$e'(Y) = - \frac{f_\xi * r_Y}{-f_\xi * \varepsilon_e + (f_{W_p} - 1) * F_{p0}} < 0 \quad (15)$$

<sup>13</sup>See Flaschel and Semmler (2003) and Proaño-Acosta, Flaschel and Semmler (2004).

<sup>14</sup>See e.g. Proaño-Acosta, Flaschel and Semmler (2004, p. 8).

The AA-curve is downward sloping since  $f_\xi < 0$ ,  $r_Y > 0$ ,  $\varepsilon_e \leq 0$ ,  $f_{W_p} \in (0, 1)$ , and  $F_{p0} \geq 0$ .

## 2.4 Case study

We obtain the adjustment process of the goods market equilibrium curve

$$\dot{Y} = \beta_Y [C(Y - \delta\bar{K} - \bar{T}) + I(\phi, e) + \bar{G} + NX(Y, \bar{Y}^*, e) - Y] \quad (16)$$

and the following dynamics of the financial markets:

$$\dot{e} = \beta_e [f(r(Y, M_0) - \bar{r}^* - \beta_\varepsilon(\frac{e_0}{e} - 1), M_0 + B_0 + eF_{p0}) - eF_{p0}] \quad (17)$$

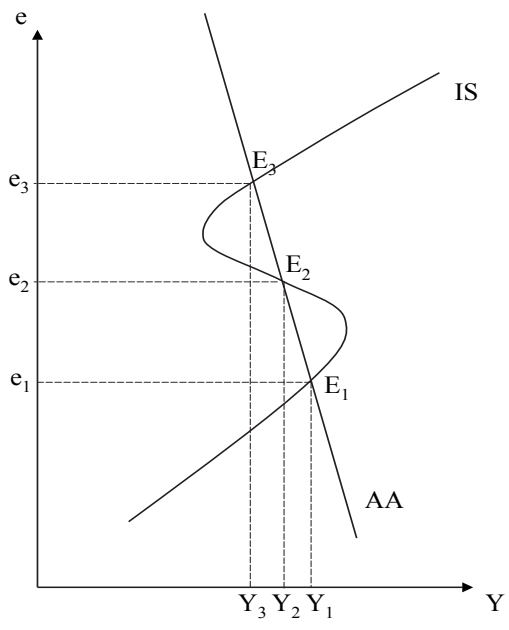
Figure 3 presents IS-AA diagrams for different values of the average hedging coefficient  $\phi$  (Cases A, B, C, D). In the following, we discuss the characteristics of Cases A, B, C, and D as well as the local stability properties.

- Case A:  $\phi = 1$

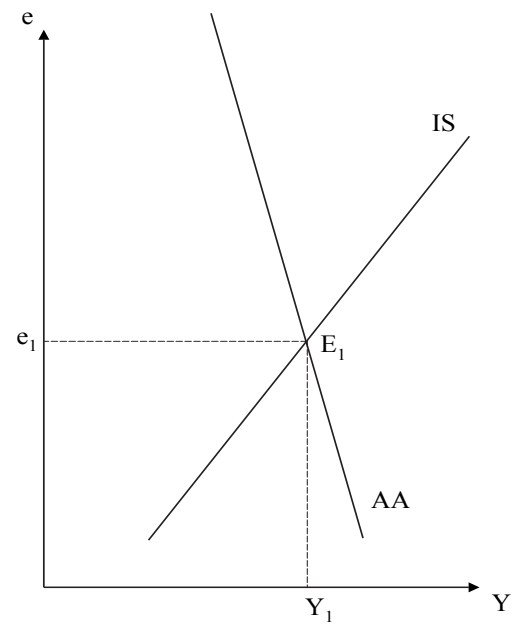
In this case no firm is hedged. Consequentially there are only small firms that do not have access to hedging tools. Hence, this case corresponds to the case presented in Krugman (2000) and Flaschel and Semmler (2003). The figure shows multiple equilibria with  $E_1$  representing the ‘good equilibrium’ with high output  $Y_1$  and low exchange rate  $e_1$ , and  $E_3$  represents the ‘crisis equilibrium’ with low output  $Y_3$  and high exchange rate  $e_3$ .

- Case B:  $\phi = 0$

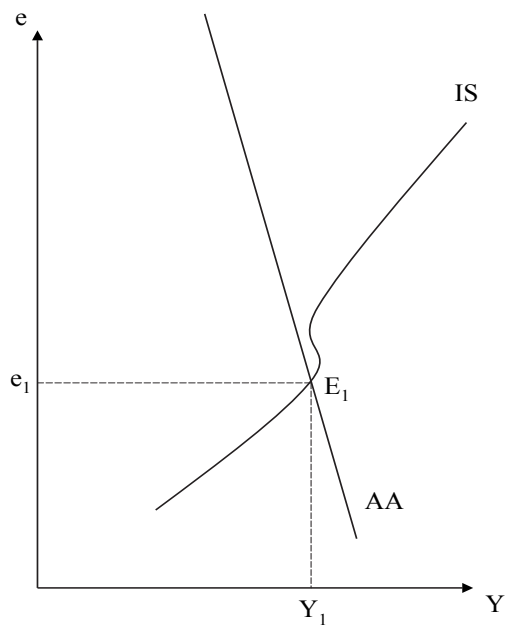
Case B illustrates the situation where all firms are hedged perfectly. With the investment function being independent of the exchange rate, net exports remain the only linkage between  $Y$  and  $e$ . In the case of a perfectly hedged economy there is no backward bending IS curve and thus, there are no multiple equilibria. In this framework a currency crises cannot occur.



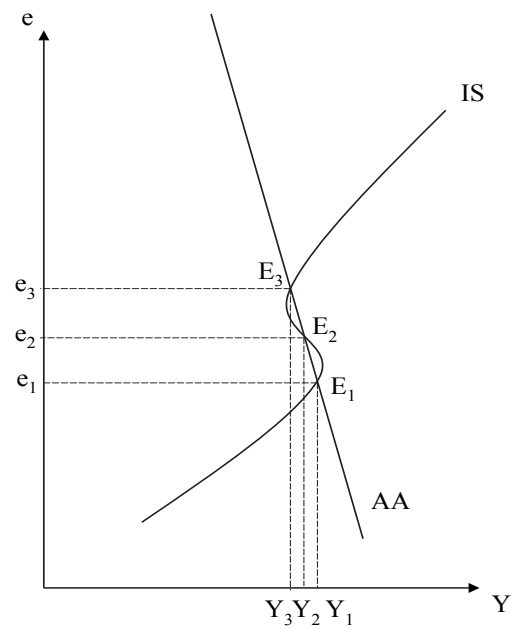
Case A:  $\phi = 1$



Case B:  $\phi = 0$



Case C:  $0 < \phi < 1$



Case D:  $0 < \phi < 1$

**Figure 3:** IS-AA diagrams for different values of  $\phi$

- Cases C and D:  $0 < \phi < 1$

Cases C and D present other possible outcomes depending on the value of  $\phi$ . With decreasing  $\phi$  the ‘bad equilibrium’  $E_3$  moves down the AA-curve towards higher values of  $Y$  and lower values of  $e$ . Hence, in the multiple equilibria case (Case D) the severity of a currency crisis decreases with growing hedging activity. In Case C the hedging activity is sufficient to avoid multiple equilibria. In this case a currency crisis does not occur.

## 2.5 Stability analysis

In order to study the stability of the system the Jacobian matrix is derived:

$$J = \begin{bmatrix} \beta_Y[C_Y + NX_Y - 1] & \beta_Y[I_e + NX_e] \\ \beta_e[f_\xi * r_Y] & \beta_e[-f_\xi * \varepsilon_e + (f_{W_p} - 1) * F_{p0}] \end{bmatrix}$$

Considering  $f_\xi < 0$ ,  $r_Y > 0$ ,  $f_{W_p} \in [0, 1]$  and  $\varepsilon_e \leq 0$ , we obtain the following signs:

$$J = \begin{bmatrix} - & ? \\ - & - \end{bmatrix}$$

Referring to the four cases mentioned above, it depends on the sign of ‘?’ whether a specific equilibrium ( $E_1, E_2, E_3$ ) is stable or unstable:

- Case A:  $\phi = 1$

$$? = \beta_Y[I_e + NX_e]$$

If  $I_e$  dominates  $NX_e$  ( $E_2$ ), ‘?’ is negative. The determinant and the trace of the Jacobian are both negative ( $\det(J_{E_2}) < 0, \text{tr}(J_{E_2}) < 0$ ). Hence,  $E_2$  is a saddle point.<sup>15</sup>

If  $NX_e$  dominates  $I_e$  ( $E_1, E_3$ ), ‘?’ is positive. Hence,  $\det(J_{(E_{1,3})}) > 0$  and  $\text{tr}(J_{(E_{1,3})}) < 0$ , which gives a stable steady state.

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<sup>15</sup>See the ‘Trace-Determinant Plane’ in Hirsch, Smale and Devaney (2004, p. 63).

- Case B:  $\phi = 0$

Since  $I_e = 0$ , we get  $? = \beta_Y[NX_e] > 0$ .

We have a single equilibrium ( $E_1$ ) which is stable since  $\det(J_{E_1}) > 0$  and  $\text{tr}(J_{E_1}) < 0$ .

- Cases C and D:  $0 < \phi < 1$

Case C, the single equilibrium case, is similar to Case B. In the equilibrium point ( $E_1$ )  $NX_e$  dominates  $I_e$ , the sign of ‘?’ is positive,  $\det(J_{E_1}) > 0$ , and  $\text{tr}(J_{E_1}) < 0$ . The equilibrium  $E_1$  is stable.

The dynamics of the multiple equilibria, Case D, equal the dynamics of Case A. If  $I_e$  dominates  $NX_e$  ( $E_2$ ), we get  $\det(J_{E_2}) < 0, \text{tr}(J_{E_2}) < 0$ . Consequently  $E_2$  is unstable. If  $NX_e$  dominates  $I_e$  ( $E_1, E_3$ ), then  $\det(J_{(E_1,3)}) > 0$  and  $\text{tr}(J_{(E_1,3)}) < 0$ . Hence, the ‘good equilibrium’  $E_1$  and the ‘crisis equilibrium’  $E_3$  are both stable.

### 3 Hedging costs approach

In the previous section the firms’ decisions whether to hedge currency risk or not is given exogenously by assuming that small firms cannot hedge while large firms are able to hedge their currency exposure perfectly. In this section all firms have the ability to hedge their currency exposure perfectly. Standardized hedging instruments like currency futures are tradeable on organized exchanges and, thus, available to all firms.<sup>16</sup> The decision whether to hedge or not is based on hedging costs and expected losses due to adverse exchange rate movements.

Again, the investment function of firm  $i$  is given by  $I_i(\theta_i, e)$ , where  $\theta_i$  depends on hedging costs  $c_h$  and expected losses  $L(e)$ :

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<sup>16</sup>For more details on hedging with currency forwards and futures, see the appendix.

$$\theta_i = \begin{cases} 0 & \text{if } c_h < L(e) \\ 1 & \text{if } c_h \geq L(e) \end{cases} \quad (18)$$

Since main hedging tools can be traded at low costs, the hedging costs  $c_h$  consist almost solely of costs of information and costs of implementing sophisticated risk assessment procedures. In fact, most over-the-counter (OTC) derivatives are ‘zero-sum games’, which means that no upfront fees are payable. The costs of exchange traded derivatives do not pose a barrier either. Taking a futures position costs an initial margin, which is “seldom more than a small fraction of the costs of the underlying securities, although it does vary from contract to contract.”<sup>17</sup> Additionally, most OTC derivatives are off-balance sheet items.<sup>18</sup> Hence, the costs connected to OTC transactions do not appear in firms’ balance sheets, and costs arising from trading exchange traded derivatives are neglected because of their small size.

Losses  $L(e)$  depend positively on the nominal exchange rate  $e$ . The payoff function presented in Figure 1 can be interpreted as an inverse loss function. In the case of an appreciation of the domestic currency the loss function becomes negative, which has to be equated with profit. In this context, feared losses can be taken as a measure of risk aversion among firms. Increasing risk aversion decreases risky business and thereby has an overall positive effect on investment.

The main idea presented in equation (18) consists of the assumption that firms will only hedge if the expected loss due to a currency depreciation  $L(e)$  exceeds the hedging costs  $c_h$ . If firms expect the domestic currency to appreciate they will not hedge because of hedging costs as well as missed gains due to corresponding losses of the hedge position.<sup>19</sup>

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<sup>17</sup>Chew (1996, p. 15).

<sup>18</sup>Garber (1998, p. 6) points out that the only exception are contracts where financial flows occur at the time of the trade, for instance when a collateral is demanded by a market maker. For a discussion about off-balance sheet derivatives, ‘shadow transactions’ and the resulting problems concerning the balance sheet as a measure for risk and creditworthiness, see Dodd (2000, 2002).

<sup>19</sup>See the payoff function in Figure 2.

The balance sheets shown in Tables 1 and 2 illustrate this. The unhedged firm's balance sheet presented in Table 1 equals the balance sheet presented in Flaschel and Semmler (2003). Investment depends solely on foreign liabilities and thus on currency developments. However, exchange rates can move in two directions as presented in Figure 1: A depreciation of the domestic currency worsens the balance sheet while an appreciation has the opposite effect.

**Table 1:** *Unhedged Firm's Balance Sheet*

Assets	Liabilities
$pK$	$eF_f$

Table 2 shows a hedged firm's balance sheet. Here, the value of the foreign liabilities is independent of exchange rate movements. Hence, there is no loss by a currency depreciation and no gain by an appreciation. The costs for this guaranteed stable values of the liabilities are the hedging costs payed by the firm. The hedging costs reduce the value of the firm's assets, therefore it is very important for any firm to calculate potential losses induced by adverse exchange rate movements and to compare them to the hedging costs.

**Table 2:** *Hedged Firm's Balance Sheet*

Assets	Liabilities
$pK - c_h$	$F_f$

### 3.1 The case of $n$ homogeneous firms

In an economy with  $n$  homogeneous firms, with identical hedging costs and loss functions, we have the following investment function:



$$I = \begin{cases} \bar{I} & \text{if } c_h < L(e). \\ I(e) & \text{if } c_h \geq L(e). \end{cases} \quad (19)$$

Because of the homogeneity, all firms act equally with respect to their hedging activities. If the expected loss due to a depreciation of the domestic currency exceeds the hedging costs, firms will attempt to hedge their currency exposure perfectly. However, if the hedging costs exceed the expected losses or, if the firms expect an appreciation of the domestic currency that would decrease the value their liabilities, they will not hedge at all.

Again, the Jacobian is given by

$$J = \begin{bmatrix} \beta_Y[C_Y + NX_Y - 1] & \beta_Y[I_e + NX_e] \\ \beta_e[f_\xi * r_Y] & \beta_e[-f_\xi * \varepsilon_e + (f_{W_p} - 1) * F_{p0}] \end{bmatrix}$$

with

$$I_e = \begin{cases} 0 & \text{if } c_h < L(e). \\ I_e & \text{if } c_h \geq L(e). \end{cases} \quad (20)$$

In the case of a perfectly hedged economy, i.e.  $I_e = 0$ , the signs of the Jacobian are as follows:

$$J = \begin{bmatrix} - & + \\ - & - \end{bmatrix}$$

Here, a currency crisis cannot occur because there is no backward bending goods market curve. The single equilibrium is stable since  $\det(J) > 0$  and  $\text{tr}(J) < 0$ . However, with  $c_h \geq L(e)$ , we obtain the multiple equilibria case already discussed (*Case A* in Figure 3). In this setting, we can only investigate the cases  $\phi = 0$  and  $\phi = 1$ .

### 3.2 The case of $n$ heterogeneous firms

In this section we discuss a more general hedging costs approach compared to the last section. Here, hedging costs and loss functions vary among firms. Again, the investment function of firm  $i$  is given by  $I_i(\theta_i, e)$ , where the hedging coefficient  $\theta_i$  and the exchange rate  $e$  enter in a multiplicative form ( $\theta_i * e$ ), with  $\theta_i \in [0, 1]$  for all  $i = 1, \dots, n$ . The hedging coefficient  $\theta_i$  depends on hedging costs  $c_{h,i}$  and losses  $L_i(e)$  with<sup>20</sup>

$$\theta_i = \begin{cases} 0 & \text{if } c_{h,i} < L_i(e) \\ 1 & \text{if } c_{h,i} \geq L_i(e) \end{cases} \quad (21)$$

Because of firms' heterogeneity and corresponding individual hedging costs  $c_{h,i}$  and losses  $L_i(e)$ , it is possible that firm  $j$  hedges its currency exposure while firm  $k$  abstains from hedging. Therefore there are hedged as well as unhedged firms in the economy. The average hedging coefficient of the economy is

$$\phi = \frac{1}{n} \sum_{i=1}^n \theta_i \quad , \quad 0 \leq \phi \leq 1 \quad (22)$$

Reducing hedging costs, such as costs of information and costs connected to derivative trading, in general leads to more hedging activity by the individual firm ( $\theta_i \nearrow$ ), and thus to a higher hedging level of the entire economy ( $\phi \nearrow$ ). This in turn reduces the sensitivity of investment to the exchange rate ( $I_e \searrow$ ). Decreasing  $I_e$  reduces the backward bending part of the goods market curve, and therefore the probability of crisis. Hence, the lower hedging costs ( $c_{h,i}$ ) and the higher feared losses of a devaluation ( $L_i(e)$ ), the more firms will hedge their currency exposure and the less risk is there for the entire economy. Compared to the previous section, the assumption of heterogeneous firms allows us to discuss all cases  $0 \leq \phi \leq 1$ . Given a large

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<sup>20</sup>Remember that,  $\theta_i = 0$  corresponds to a perfect hedge while  $\theta_i = 1$  is the unhedged case, respectively.

number of firms hedge, in our model, a currency crisis is ruled out by the fact that the IS-curve crosses the AA-curve only once.<sup>21</sup> Increasing risk aversion, providing information as well as risk management techniques and access to risk management instruments such as derivatives are the key factors in order to avoid financial crises.

## 4 Conclusions

The main result of this investigation is that economic stability can be increased by enhancing corporate hedging either by directly simplifying access to hedging instruments (Firm size approach) or indirectly by lowering hedging costs as well as increasing the awareness of specific risks (Hedging costs approach). Under the assumption that firms can limit currency risk by hedging, currency depreciations are more manageable and less likely to result in currency and financial crises. In our model, corporate hedging decreases the backward bending segment of the goods market curve “that is key to the possibility of crisis”<sup>22</sup>.

Referring to this result the main duty of officials appears to be the achievement of more transparency and the improvement of information flows. This could be realized by regulating transactions of OTC derivatives leading to easier access to OTC products and reducing the costs of information, and thus the costs of hedging.

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<sup>21</sup>See Case C in Figure 3.

<sup>22</sup>Krugman (1999, p. 6).

## A Some notes on currency hedging

In this appendix we take a closer look at different hedging strategies using foreign exchange forwards and futures. Since forwards and futures exhibit completely different trading characteristics, this is to be valued highly. As we assume their payoff functions to be identical, the differences in how they are traded become more relevant regarding the different approaches in this paper.

In the ‘Firm size approach’ we assume that only large firms have access to hedging products. Furthermore, large firms hedge their currency exposure perfectly. These characteristics fit to custom-made over-the-counter (OTC) products such as forwards.<sup>23</sup> Moreover, hedging costs do not play any role or as Hull (2000, p. 59) puts it: “The value of a forward contract at the time it is first entered into is zero.”

The ‘Hedging costs approach’ gives all firms the possibility to hedge. This approach is better applicable to hedging products traded on organized exchanges like futures. Getting access to futures is much easier than getting access to OTC products. However, trading futures costs an initial margin.

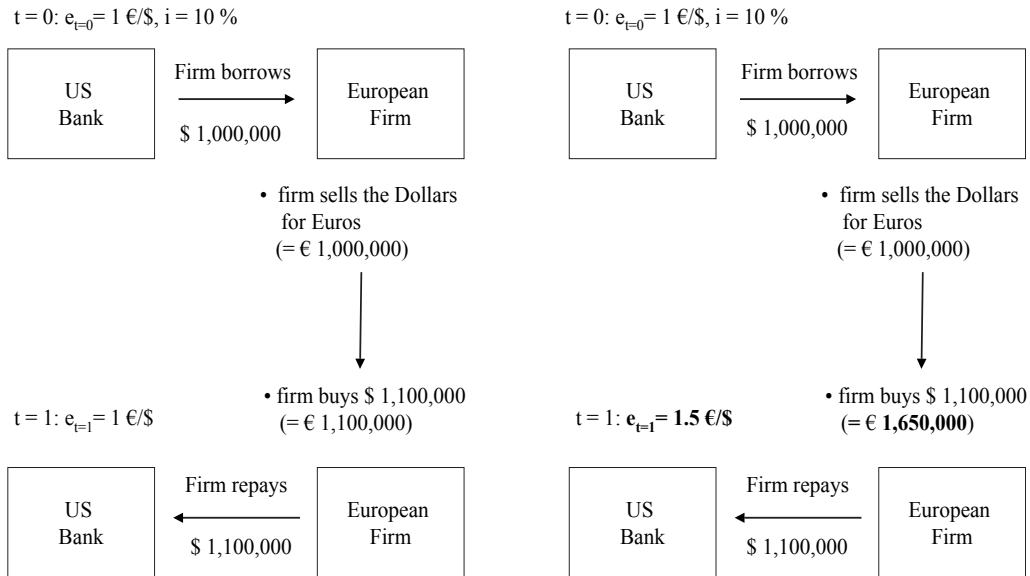
The problem with futures hedging is that it does not necessarily lead to perfect hedges. In this section we show that, using a very simple numerical example, under simplified assumptions, the futures hedging strategy is at least asymptotically perfect. We also show at the end of this section that currency forwards and futures play a dominant role among currency derivatives and that, nowadays, derivative products are available in many emerging markets, too.

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<sup>23</sup>In this paper perfect hedges are ‘equal and opposite’ hedges. Perfect hedges can generally be achieved in many ways. Jorion (2001, p. 12) points out that, “The breadth of coverage against risks is astonishing. Hedging with derivatives is similar to purchasing insurance”. In their empirical paper, Fung and Leung (1991, p. 89) state that: “The result implies that financial managers of multinational firms can avoid spending time and resources to estimate the optimal hedge ratio but simply adopt the naive (one-to-one) strategy when using forward markets for hedging currency risk.” In the context of the simple model used in this paper, we will only discuss the ‘naive’ hedging strategy.

## A.1 Setting up a simple scenario

We begin the explanation of currency hedging with a simple scenario. An European firm borrows \$1,000,000 in  $t = 0$  from an U.S. bank and sells the dollars for euros immediately. In  $t = 1$  the firm has to buy \$1,100,000, the amount received plus interest ( $i = 10\%$ ), to repay the debt. If the exchange rate is constant over the time horizon ( $e_{t=0} = e_{t=1}$ ), the firm repays exactly the expected debt value, i.e. borrowed amount plus interest. If the domestic currency depreciates, the price of the dollar per euro increases ( $e_{t=0} < e_{t=1}$ ), which results in an increased debt value in terms of the domestic currency.



a) Constant exchange rate:  $e_{t=0} = e_{t=1}$

b) Depreciation:  $e_{t=0} < e_{t=1}$

**Figure 4:** Debt denominated in foreign currency

Figure 4 shows the debt value in terms of the domestic currency (€) in the case of a stable exchange rate ( $e_{t=0} = e_{t=1} = 1 \frac{\text{€}}{\text{\$}}$ ) and in the case of a depreciation of the domestic currency ( $e_{t=0} = 1 \frac{\text{€}}{\text{\$}} < e_{t=1} = 1.5 \frac{\text{€}}{\text{\$}}$ ). In the case of the depreciation, compared to the stable one, the price of a dollar per euro increases, leading to a higher debt value in euros. The loss due to the steep domestic currency depreciation

is the debt value to be repayed in dollars times the difference between the exchange rate at the date of the spot contract  $e_{t=0}$  and the actual exchange rate at the spot commitment date  $e_{t=1}$ :

$$\$1,100,000 * \left(1 \frac{\text{€}}{\text{\$}} - 1.5 \frac{\text{€}}{\text{\$}}\right) = \text{€}-550,000 \quad (23)$$

## A.2 A simple forward hedging strategy

The firm has to enter into a long forward contract in  $t = 0$ , to buy \$ 1,100,000 in  $t = 1$ , in order to hedge the spot position:

$$\$1,100,000 * \left(1.5 \frac{\text{€}}{\text{\$}} - 1 \frac{\text{€}}{\text{\$}}\right) = \text{€}550,000 \quad (24)$$

where  $e_{t=0} = 1 \frac{\text{€}}{\text{\$}}$  is the delivery price and  $e_{t=1} = 1.5 \frac{\text{€}}{\text{\$}}$  is the spot price of the U.S. dollar per euro at maturity of the contract. The forward contract gives the holder the obligation to buy the underlying (\$1,100,000) at the delivery price  $e_{t=0} = 1 \frac{\text{€}}{\text{\$}}$  on the spot commitment date  $e_{t=1}$ . The \$1,100,000 receivable will be sold immediately for euros on the spot foreign exchange market at the spot exchange rate  $e_{t=1} = 1.5 \frac{\text{€}}{\text{\$}}$ . Hence, the forward position ends up with a profit (€550,000). The hedged return equals the sum of spot and forward returns:

$$\text{€}-550,000 + \text{€}550,000 = 0 \quad (25)$$

The simple hedging strategy presented here results in a perfect hedge. However, we made some assumptions for simplicity that shall be discussed in the following:

- The firm puts on the hedge at the date when the debt is borrowed ( $t = 0$ ) and removes it when the debt is repayed ( $t = 1$ ). Hence, for this specific time frame currency forwards must be available. In our model this does not cause problems because forwards are traded over-the-counter, which means that they exactly meet the hedgers' requirements.

- The size of the spot position equals the forward position ('equal and opposite' position: \$1,100,000). Again, this is no problem since OTC derivatives are individually arranged.

### A.3 A simple futures hedging strategy

Futures hedging is not as simple as hedging with forwards, and, on average, it does not lead to a perfect hedge. The reason for this is that futures are standardized products, traded on organized exchanges and thus, generally, do not exactly meet the hedgers' requirements. If the size and the timing of the futures position are not equal to the spot commitment, it is almost impossible to completely eliminate the currency risk. In this case an 'equal and opposite' hedge is not available and the hedger has to compute the risk minimizing hedging position<sup>24</sup>

$$h = -Q * \beta \tag{26}$$

with  $Q$  the size of the spot commitment and  $\beta$  the hedging coefficient

$$\beta = \frac{\text{cov}(f_{t=1}, s_{t=1})}{\text{var}(f_{t=1})} = \frac{\text{covariance of futures price change with spot price change}}{\text{variance of futures price change}} \tag{27}$$

As already mentioned there are two main problems when hedging with futures: The timing and the size of the hedging position. First, we examine the timing problem. An arbitrage free environment requires that spot prices equal futures prices at delivery ( $s_{t=1} = f_{t=1}$ ) if the spot commitment date coincides with the futures delivery date ( $t = 1$ ). Hence, we can write equation (27) as<sup>25</sup>

$$\beta = \frac{\text{cov}(f_{t=1}, s_{t=1})}{\text{var}(f_{t=1})} = \frac{\text{var}(f_{t=1})}{\text{var}(f_{t=1})} = 1 \tag{28}$$

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<sup>24</sup>For a detailed look at futures hedging, see Duffie (1989, Chapter 7).

<sup>25</sup>See Duffie (1989, p. 207).

In this case we, again, obtain an ‘equal and opposite’ strategy:

$$h = -Q * \beta = -Q \quad (29)$$

If we further assume that prices in spot and futures markets are perfectly correlated, equation (28) holds for all points in time  $t$ . Hence, it is not necessary that futures delivery date equals spot commitment date to achieve a perfect hedge. In the case that the futures position matures after the spot commitment date, the hedger offsets the position before maturity in  $t = 1$ . On the other hand, if the horizon of the futures position is too short, the hedger can ‘roll-over’ the contract and, again, offset the position in  $t = 1$ .

The second problem is the size of the futures position. In our numerical example above the hedging position has a total value of \$1,100,000. However, futures that exactly deliver \$1,100,000 are, on average, not available on the futures exchange. Instead smaller futures contracts are traded, e.g. delivering \$10,000. In this case our hedging position consists of:

$$h = \$1,100,000 = \$10,000 * 110 \text{ contracts} \quad (30)$$

The firm takes a futures position of 110 contracts.

Now, consider the case where only futures delivering \$15,000 are available. Here, the optimal hedging position is:

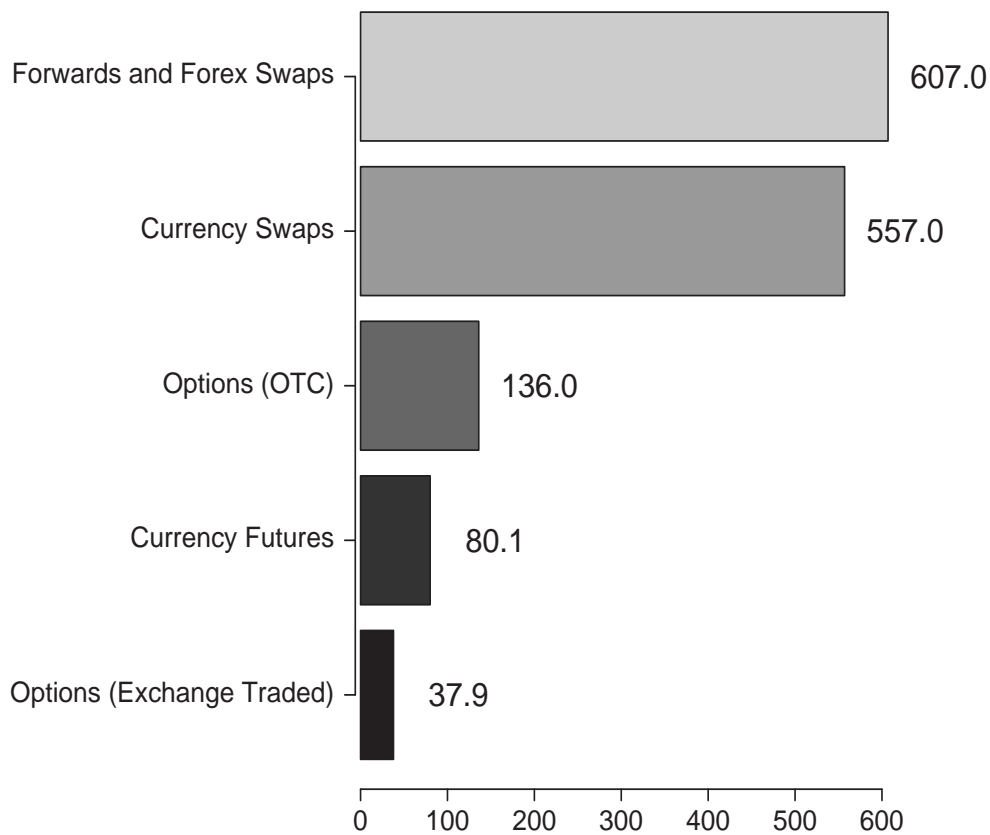
$$h = \$15,000 * 73 \text{ contracts} = \$1,095,000 \neq \$1,100,000 \quad (31)$$

This hedging strategy does not lead to an ‘equal and opposite’ hedge. However, 99.54% of the spot position are hedged with this strategy, which is very close to a perfect hedge. Hence, we can argue that, with a growing variety of futures contracts available, hedging strategies of firms become asymptotically perfect.



## A.4 Empirical facts

Figure 5 illustrates the size of foreign exchange derivatives markets and the key role played by currency forwards and futures. The amounts outstanding, presented in Figure 5, are gross market values of the OTC derivatives, i.e. forwards and forex swaps, currency swaps and OTC options, and notional principal of exchange traded futures and options.



Data source: BIS Quarterly Review, September 2004.

**Figure 5:** *Amounts Outstanding of Foreign Exchange Derivatives (December 2003; in billions of U.S. dollars)*

Table 3 shows that today derivatives products are also available in many emerging markets. Most of the exchanges presented in Table 3 were founded in the 1990s.

**Table 3: Derivatives Exchanges in Emerging Markets\***

Country	Name & Year of Formation	Products	www
Argentina	Bolsa de Comercio de Rosario (ROFEX)	Futures, Options	www.rofex.com.ar
Brazil	Bolsa de Mercadorias & Futuros (BM&F), 1985	Futures, Options, Swaps, Forwards	www.bmf.com.br
Chile	Bolsa de Santiago, 1990/1994	Futures (1990), Options (1994)	www.bolsadesantiago.com
China	Dalian Commodity Exchange, 1993 Zhengzhou Commodity Exchange (ZCE), 1990 Shanghai Futures Exchange	Futures, Forwards	www.dce.com.cn www.czce.com.cn
Israel	Tel-Aviv Stock Exchange (Tase), 1993	Futures, Options	www.tase.co.il
Korea	Korean Stock Exchange (KSE), 1996	Futures, Options	www.kse.or.kr
Mexico	Mexican Derivatives Exchange (MexDer), 1994	Options	www.mexder.com
Poland	WGT, 1999	Futures, Options	www.wgt.com.pl
Romania	Romanian Commodities Exchange (BRM), 1998	Futures, Options	www.brm.ro
Russia	Moscow Interbank Currency Exchange (MICEX), 1994	Futures	www.micex.com
South Africa	South African Futures Exchange (SAFEX), 1987/1995	Futures	www.safex.co.za
Thailand	Thailand Futures Exchange (TFEX)	Futures, Options	www.tfex.co.th
Czech Republic	Prague Stock Exchange (PSE), 2001	Futures	www.pse.cz
Hungary	Budapest Commodity Exchange (BCE), 1989	Futures, Options	www.bce-bat.com
Indonesia	Surabaya Stock Exchange, 2001	Futures	www.bes.co.id

\*The aim of this presentation is not to give a complete overview of all derivatives exchanges in all emerging markets worldwide.

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