Systematic Risk and Exchange-rate exposure of pair arbitrage portfolios

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Outline

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Introduction

- Systematic risk or beta, holds a fundamental place in financial theory and practice.
- Financial managers use betas in capital budgeting and investors in managing their portfolios.
- The importance of the topic leads to the objective of this article, which is to study the beta of individual stocks and pair arbitrage portfolios in an international duopoly and examine its relation with exchange rates.

Introduction

- In the consumable goods category: the Detergent market is dominated by the British Unilever (UN) and the US Procter & Gamble (P&G).
- In the durable goods category: the large jet airliner market is dominated by Airbus and Boeing since the 1990s.
- We study exchange-rate exposure and systematic risk of individual stocks and pair arbitrage portfolios in an international duopoly of firms offering differentiated goods and there is demand uncertainty in both home and foreign market.

Main results

- An increase in the exchange rate, that is, a currency depreciation in the home country, leads to
  - ✓a price increase by the home firm and a price decrease by the foreign firm.
  - ✓an increase (decrease) in the value of the home (foreign) firm.
  - ✓a decrease (increase) in the systematic risk of the firm from the currency depreciating (appreciating) country

- As demand uncertainty decreases
  - ✓the home and foreign equilibrium prices increase, namely, price competition is relaxed.
  - ✓in the home (foreign) market, the exchange-rate exposure for the home (foreign) firm increases (decreases).

Main results

- The addition of a domestic competitor does not alter the qualitative results.
- The exchange-rate exposure of the pair arbitrage portfolio is positive and increases when the home or foreign demand uncertainty decreases.
- Its systematic risk is decreasing in the exchange rate.
- The portfolio exposure is increasing in the exchange rate for high values of the exchange rate and otherwise decreasing.
- The systematic risk of the pair arbitrage portfolio is increasing in foreign but decreasing in home demand uncertainty for intermediary or low values of home and foreign uncertainty.

Literature

Our work contributes to three strands of literature.

- The *first* one integrates the theory of the firm in *product and financial markets* (see O'Brien, 2011; Subrahmanyam and Thomadakis, 1980; Thomadakis, 1976).
- Use of the CAPM to derive the relationship between product market characteristics and the firm's systematic risk. Impact of exchange rates?
- The *second* strand studies *arbitrage portfolios*. A long/short equity is an investment strategy which entails buying (going long) equities that are likely to increase in value and selling short equities that are likely to decrease in value (Jacobs, et al., 1999).
- A pair portfolio contains two stocks of firms that produce close substitutes (see Gatev, et al., 2006). Pair arbitrage portfolios, exchange rate exposure and beta?

Literature

- The *third* relevant strand of literature studies *international oligopolies*. The earliest competition models between domestic and foreign firms assume perfect substitutability: Krugman (1987), Froot and Klemperer (1989), and Yang (1997), while more recent models assume imperfect substitutability (Bodnar et al, 2002; Bartram et al., 2010). Exchange rate pass-through. Demand uncertainty and beta?

Literature

- Bodnar et al. (2002) study pass-through and exposure in a model where the exporting firm cannot sell in its own market and the domestic firm cannot produce abroad. In an extension, Bartram et al., (2010) firms produce and compete in foreign and domestic markets. In their model exposure depends on market share, product substitutability, and pass-through.
- Marston (2001) and Floden et al. (2008) emphasize the importance of market structure on the firms' pass-through and exposure. Marston (2001) also studies the case of exposure under uncertainty, where the uncertainty comes from the exchange rate only in the case of a monopoly, while we study demand uncertainty in the case of an oligopoly.
- Andrikopoulos and Dassiou (2020) examine exposure in an international "*Rule of Three*" market structure that allows both *within* and *between* countries competition. They conclude that the addition of a domestic competitor increases the exposure of both international competitors relative to duopoly unless the pass-through of one of its rivals is elastic.

International duopoly

- A home (h) and a foreign firm (f) produce differentiated goods and compete in prices.
- As the foreign (home) currency appreciates (depreciates) the exchange rate (S) increases.
- The demand functions:

$$\begin{bmatrix}\tilde{q}_h(P_h, P_f; S, \tilde{k}) \\ \tilde{q}_f(P_h, P_f; S, \tilde{u})\end{bmatrix} = \begin{bmatrix}(1+\tilde{k})\theta_0 \\ (1+\tilde{u})\lambda_0\end{bmatrix} + \begin{bmatrix}\theta_h & \theta_f S \\ \lambda_h \frac{1}{S} & \lambda_f\end{bmatrix}\begin{bmatrix}P_h \\ P_f\end{bmatrix}$$

where $\tilde{k}$ $(\tilde{u})$ is the demand uncertainty in the home (foreign) country with $E(\tilde{k}) = 0, Var(\tilde{k}) = \sigma_k^2, E(\tilde{u}) = 0, Var(\tilde{u}) = \sigma_u^2, Cov(\tilde{k}, \tilde{u}) = \rho_{k,u}\sigma_k\sigma_u$ and $\theta_h, \lambda_f < 0, 0 < \theta_f < |\theta_h|, 0 < \lambda_h < |\lambda_f|$

International duopoly

- Profits:

$$\tilde{\Pi}_h = (P_h - c_h)\tilde{q}_h\left(P_h, P_f; S, \tilde{k}\right), \tilde{\Pi}_f = \left(P_f - c_f\right)\tilde{q}_f\left(P_h, P_f; S, \tilde{u}\right)$$

- Random rate of return on firms' stock:

$$\tilde{r}_h = \frac{\tilde{\Pi}_h}{v_h} - 1, \tilde{r}_f = \frac{\tilde{\Pi}_f}{v_f} - 1$$

where the value of each firm v_h, v_f is the present value of the end of period profits.

International duopoly

- From CAPM:

$$E(\tilde{r}_h) = RF_h + MP_h Cov(\tilde{r}_h, \tilde{r}_{mh}), E(\tilde{r}_f) = RF_f + MP_f Cov(\tilde{r}_f, \tilde{r}_{mf})$$

where

RF_h, RF_f the risk-free rates

$MP_h \equiv \frac{E(\tilde{r}_{mh})-RF_h}{Var(\tilde{r}_{mh})}$,$MP_f \equiv \frac{E(\tilde{r}_{mf})-RF_f}{Var(\tilde{r}_{mf})}$ is the market price of risk

$\tilde{r}_{mh}, \tilde{r}_{mf}$ is the random rate of return on the h and f market portfolio

$K \equiv 1 - MP_h Cov(\tilde{k}, \tilde{r}_{mh}), U \equiv 1 - MP_f Cov(\tilde{u}, \tilde{r}_{mf})$ certainty equivalents of 1+$\tilde{k}$ & $1 + \tilde{u}$

International duopoly

- From the previous expressions we obtain:

$$v_h = \frac{(P_h - c_h)(\theta_0 K + \theta_h P_h + \theta_f S P_f)}{1 + RF_h}$$

$$v_f = \frac{\left(P_f - c_f\right)(\lambda_0 U + \lambda_h \frac{1}{S} P_h + \lambda_f P_f)}{1 + RF_f}$$

Each firm i=h,f maximizes v_i with respect to P_i, thus we get the equilibrium prices at this Bertrand game, P_h^D, P_f^D.

Pass-through (on prices)

- $dP_h^D/dS > 0, dP_f^D/dS < 0$

Firm *h* increases its price by taking advantage of the local currency depreciation and firm *f* decreases its price to restore competitiveness.

- $0 < \varepsilon_{P_h^D,S} < 1, -1 < \varepsilon_{P_f^D,S} < 0$

where $\varepsilon_{P_i,S} \equiv \frac{dP_i}{d\mathrm{S}}\frac{S}{P_i}$ is the price elasticity with respect to *S*

- $dP_h^D/dK > 0, dP_f^D/dK > 0, dP_h^D/dU > 0, dP_f^D/dU > 0$

As demand uncertainty decreases, price competition is relaxed.

Exchange-rate exposure

- $\frac{dv_h^D}{dS} = \frac{(P_h^D - c_h)}{1+RF_h}\theta_f P_f^D(1 + \varepsilon_{P_f,S})$ > 0
- $\frac{dv_f^D}{dS} = \frac{(P_f^D - c_f)}{(1+RF_f)S^2}\lambda_h P_h^D(\varepsilon_{P_h,S} - 1)$ < 0

Under home country depreciation, firm *f* reduces its price but this reduction does not offset the increase in *S* (since $|\varepsilon_{P_f^D,S}| < 1$) leading to an increase in the value of firm *h*, i.e. positive $\frac{dv_h^D}{dS}$.

On the other hand, firm *h* increases its price but at a level that does not restore its competitiveness gains via the increase in *S* (since $\varepsilon_{P_h^D,S} < 1$), thus, $\frac{dv_f^D}{dS}$ is negative. In other words, as the home currency depreciates, the home firm will gain at the expense of her overseas rival.

Exchange-rate exposure

- $\frac{dv_h^D}{dS} = \frac{1}{1+RF_h}\frac{d\Pi_h^D}{dS}$

- $\frac{dv_f^D}{dS} = \frac{1}{1+RF_f}\frac{d\Pi_f^D}{dS}$

where

$$\Pi_h^D = \left(P_h^D - c_h\right)(K\theta_0 + \theta_h P_h^D + \theta_f S P_f^D), \Pi_f^D = \left(P_f^D - c_f\right)(U\lambda_0 + \lambda_h \frac{1}{S} P_h^D + \lambda_f P_f^D)$$

and $\frac{d\Pi_h^D}{dS}$ $(\frac{d\Pi_f^D}{dS})$ measures the profit exposure for the home (foreign) firm under K and U.

The value exposure of the firm (domestic or foreign) is the discounted profit exposure at the risk-free rate (domestic or foreign).

Exposure & uncertainty

- $\frac{d^2 v_h^D}{dSdK} > 0, \frac{d^2 v_h^D}{dSdU} > 0$

- $\frac{d^2 v_f^D}{dSdU} < 0, \frac{d^2 v_f^D}{dSdK} < 0$

A home currency depreciation, increases (decreases) the value of the home (foreign) firm, and this mechanism is more intense when uncertainty in the home (foreign) country is lower.

Systematic risk (beta coefficient)

- $\beta_h \equiv \frac{Cov(\tilde{r}_h, \tilde{r}_{mh})}{Var(\tilde{r}_{mh})}, \beta_f \equiv \frac{Cov(\tilde{r}_f, \tilde{r}_{mf})}{Var(\tilde{r}_{mf})}$

…

- $\beta_h^D = -\frac{(1+RF_h)}{E(\tilde{r}_{mh})-RF_h} \frac{\theta_0(1-K)}{\theta_h m_h^D} > 0, \beta_f^D = -\frac{(1+RF_f)}{E(\tilde{r}_{mf})-RF_f} \frac{\lambda_0(1-U)}{\lambda_f m_f^D} > 0$

where $m_i^D \equiv (P_i^D - c_i)$ is the equilibrium price-cost margin of firm i.

Systematic risk & exchange rate

- $\frac{d\beta_h^D}{dS} = \frac{(1+RF_h)(1-K)\theta_0}{(E(\tilde{r}_{mh})-RF_h)\theta_h} \frac{\varepsilon_{P_h,S}}{Sm_h^D L_h} < 0$

- $\frac{d\beta_f^D}{dS} = \frac{(1+RF_f)(1-U)\lambda_0}{(E(\tilde{r}_{mf})-RF_f)\lambda_f} \frac{\varepsilon_{P_f,S}}{Sm_f^D L_f} > 0$

where $L_{\mathrm{i}} \equiv \frac{P_i^D - c_i}{P_i^D}$ is the Lerner index of firm i. As the home currency depreciates, the optimal level of systematic risk of the home (foreign) firm decreases (increases).

Systematic risk & exchange rate

An increase in *S,* increases the price-cost margin and hence, the firm has more market power in the product market. Consequently, the firm can offer a lower return to investors in order to attract them to contribute capital.

In contrast, its rival loses competitiveness so that investors are willing to supply capital only at higher costs. Given the CAPM, stock returns and beta are directly linearly related.

Pair arbitrage portfolios

- Portfolio with a long (short) position at the stock from the home (foreign) country.
- The portfolio is the nonzero tuple $(w_{\mathrm{h}}, w_{\mathrm{f}})$, where $w_{\mathrm{h}} + w_{\mathrm{f}} = 0$
- Zero cost portfolio with a long (short) position at the stock from the home (foreign) country.
- Equilibrium value of the portfolio: $v_p^D = v_h^D - v_f^D$
- We examine: $\frac{dv_p^D}{dS}$, β_p^D, $\frac{d\beta_p^D}{dS}$

Pair arbitrage portfolios

- $\frac{dv_p^D}{dS} > 0$

- $\frac{d^2 v_p^D}{dSdK} > 0, \frac{d^2 v_p^D}{dSdU} > 0$

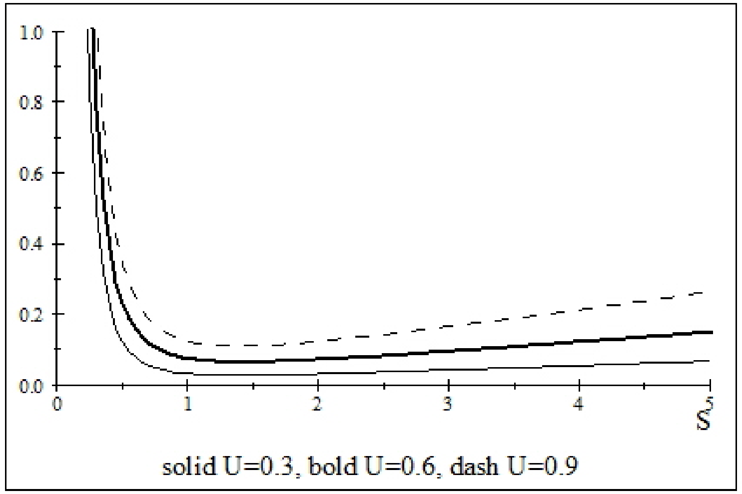
- $\frac{d\beta_p^D}{dS} < 0$

The exchange-rate exposure of the pair arbitrage portfolio is positive and increases when the home or foreign demand uncertainty decreases (K or U increase). The beta of the pair arbitrage portfolio is decreasing in the exchange rate.

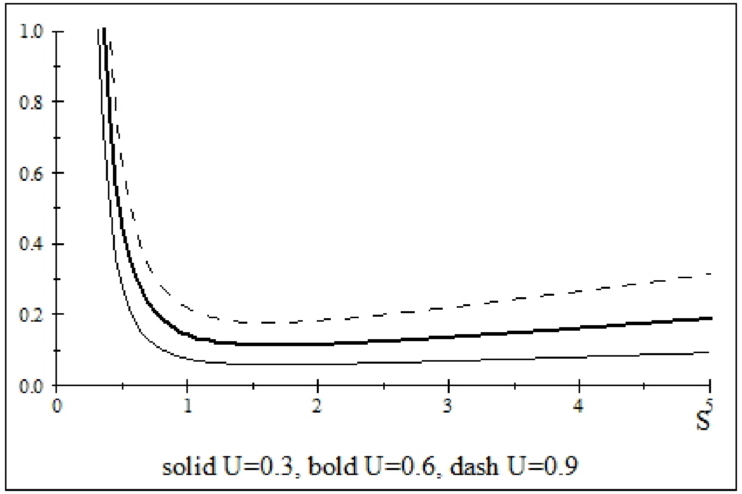
Numerical examples

- Since the expressions are too complex, we offer some numerical examples where we calibrate some of the parameters under symmetry to illustrate the application and practical importance for portfolio management

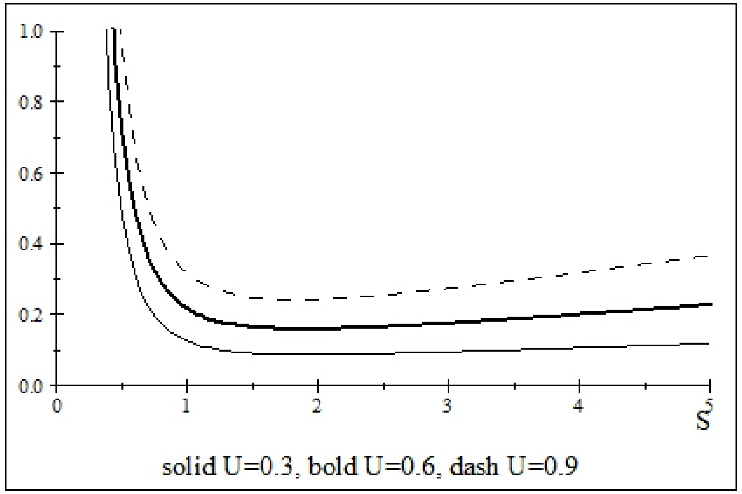
A. Exposure $\frac{dv_p^D}{dS}$ for different levels of home and foreign demand uncertainty.



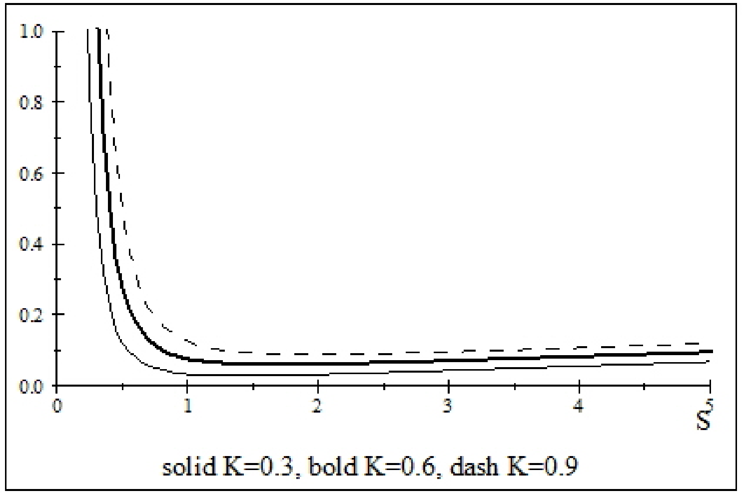
K=0.3



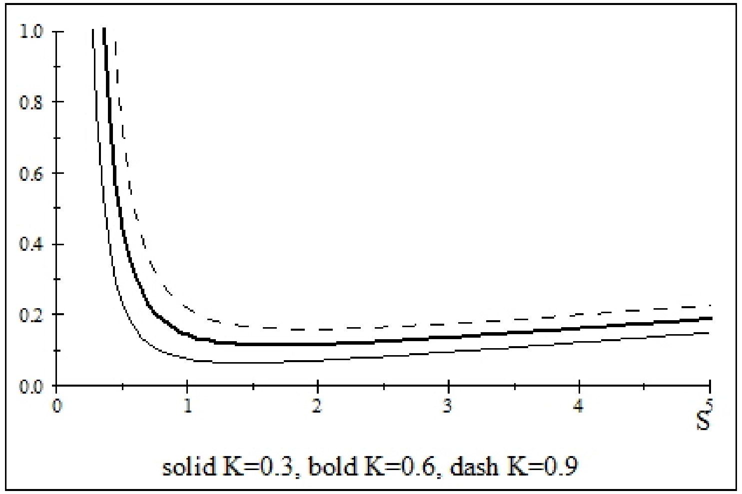
K=0.6



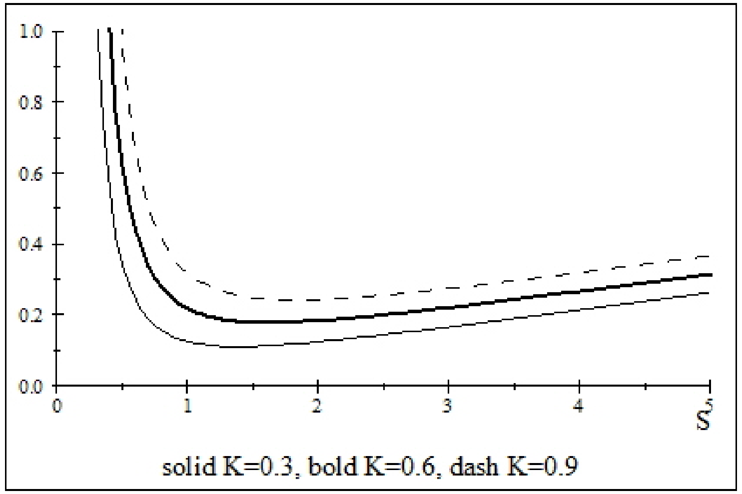
K=0.9



U=0.3

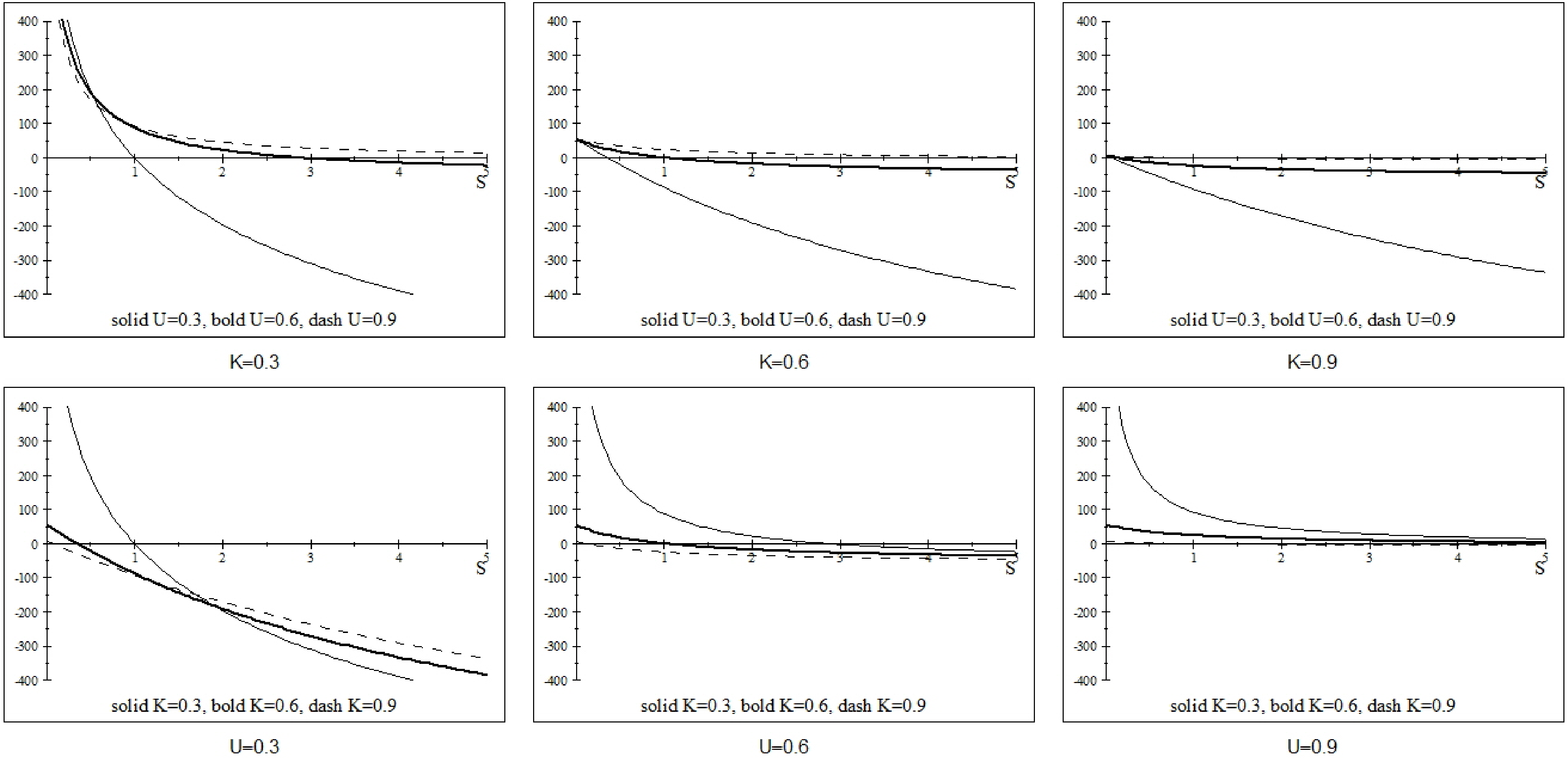


U=0.6

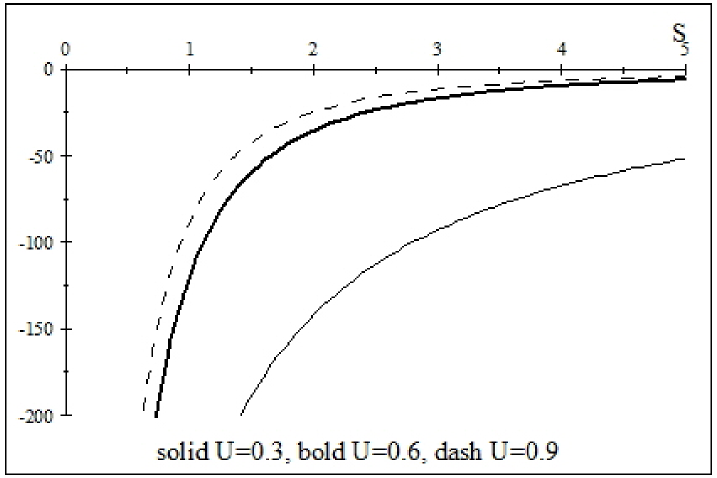


U=0.9

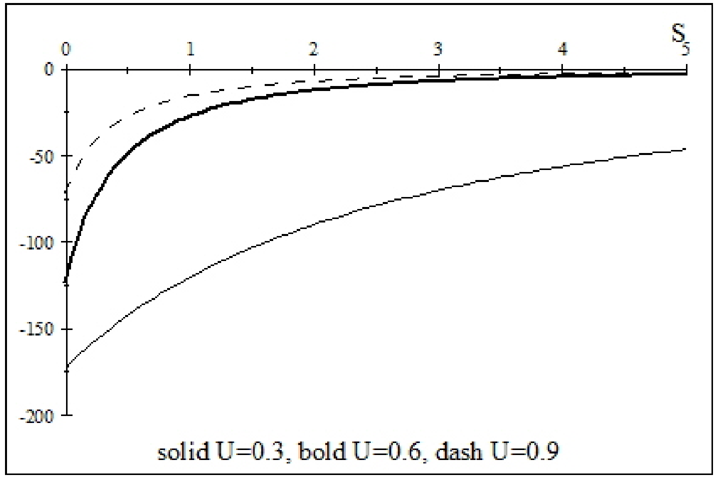
B. Beta β_p^D for different levels of home and foreign demand uncertainty.



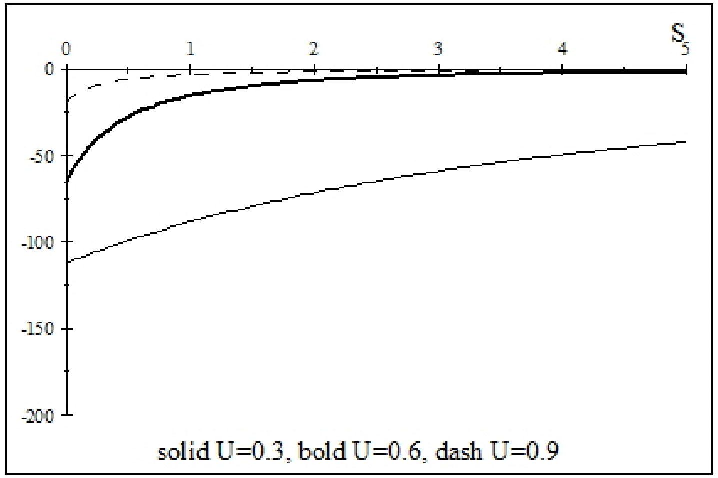
C. $\frac{d\beta_p^D}{dS}$ for different levels of home and foreign demand uncertainty.



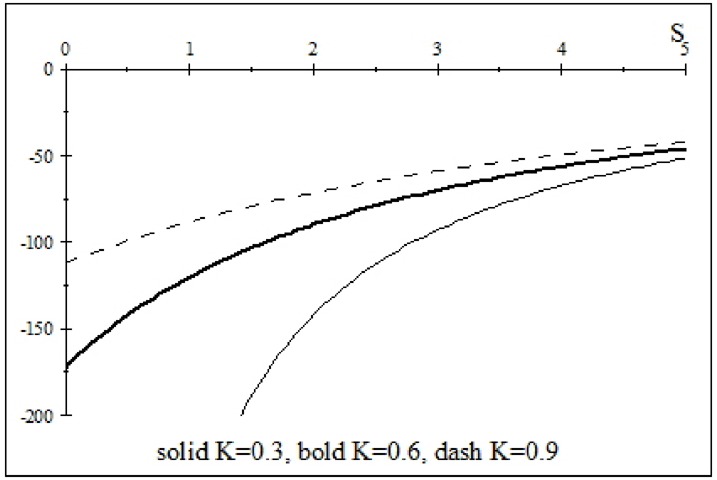
K=0.3



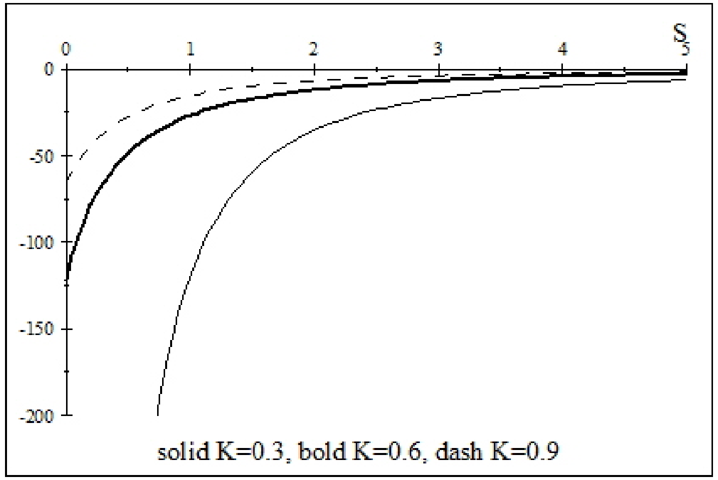
K=0.6



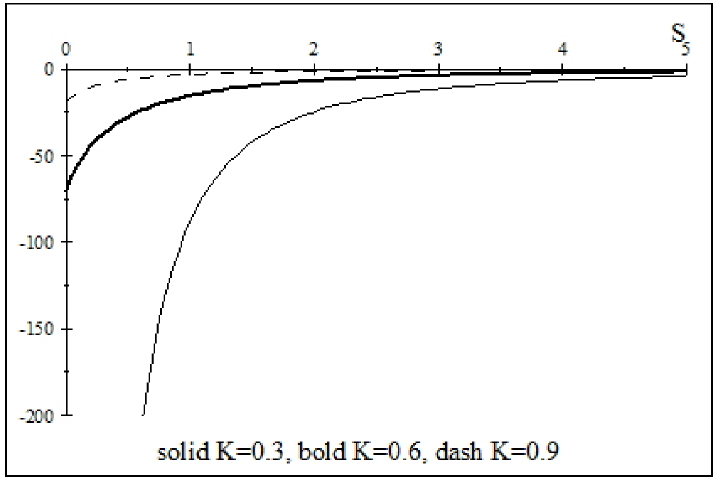
K=0.9



U=0.3



U=0.6



U=0.9

Notes. The figures in Panels A, B and C were produced calculating $\frac{dv_p^D}{dS}$, β_p^D, and $\frac{d\beta_p^D}{dS}$ respectively, for $\theta_h = \lambda_f = -1, \theta_f = \lambda_h = 0.5, c_h = c_f = 0.3, \theta_0 = \lambda_0 = 1, RF_f = RF_h = 0.01, E(\tilde{r}_{mh}) = E(\tilde{r}_{mf}) = 0.05$ and three different levels of home (*K*) and foreign (*U*) demand certainty equivalents, which correspond to high, medium and low levels of uncertainty in the home and abroad, respectively at different levels of *S* (*horizontal* axis). θ_h, λ_f^D are the own and θ_f, λ_h are the cross effects in the demand functions, θ_0 and λ_0 are the constant terms that embody the effects of all factors other than price that affect demand,c_h and c_f are the constant marginal costs, RF_h, RF_f are the risk-free rates and $E(\tilde{r}_{mh})$ and $E(\tilde{r}_{mf})$ are the expected rates of return on the home and foreign market portfolios, respectively.

Conclusion

- This study enhances our knowledge of the relationship between exchange rates, systematic risk, and exposure of individual stocks and pair arbitrage portfolios.
- Our model emphasizes the mode of competition in international markets and its impact on the link between exchange-rate exposure and beta.
- Model extensions
- Dynamic model
- Data