Asymmetric Exchange Rate Exposures: A Search for the Effect of Real Options

Alliances and Confrontations: Globalisation and the Logic of Trading Blocs

Global Risk Management

Competitive Paper

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Abstract

Real options like the ability to reallocate production resources can lead to an asymmetric exchange rate exposure. Using a stock market approach in which the exchange rate exposure is derived from the information content in the stock prices this study examines the extra-market exchange rate exposures of a group of blue chip, industrial companies listed on the Copenhagen Stock Exchange. In these companies the existence of real options is an integrated part of the exchange rate exposure management process.
The result of the stock market approach is mixed. Statistically significant asymmetric exchange rate exposures are identified successfully but the asymmetries can only to a limited extent be explained by the existence of real options. Financial options and pricing to market are competing explanations. Omitted variable bias further blurs the picture. These problems and the concept of path dependency in real options decision analysis partly disqualifies the stock market approach as a potent vehicle for identifying asymmetric exchange rate exposures caused by real options.

Keywords: Real options, exchange rates, asymmetric exposure, stock market approach.

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1. Introduction

Exchange rate exposure is divided into three different exposures: translation exposure, transaction exposure, and operating exposure (e.g. Eiteman, Stonehill, and Moffet, 2001). Translation exposure is an accounting exposure arising because of the need to "translate" financial statements of foreign affiliates into a single currency when consolidating. Transaction exposure is a nominal exposure arising because of contractual obligations. Operating exposure (also called economic exposure, competitive exposure or strategic exposure) is a real exposure arising because of the impact from unexpected changes in exchange rates on the operations of the company and thus on the operating profits, the cash flows, and the value of the company.

A European company exporting to the US is exposed to the development in the EUR/USD exchange rate. As a simple example the EUR/USD exchange rate is expected to be 1.00 EUR per USD but could go down to 0.75 EUR per USD in case of a USD depreciation and could go up to 1.25 EUR per USD in case of a USD appreciation. If the European company exports goods to the US worth USD 100 million a year the company may loose / win EUR 25 million on an annual basis in case of a depreciation / appreciation of the USD.

The USD exposure for the above company is symmetric. In the short run the exposure could easily be offset by a symmetric financial hedge (e.g. by selling USD forward against EUR). However, in the long run such financial hedges are not suitable because the underlying

transactions may not materialize as business conditions change - thus transforming what ought to be a financial hedge into a financial speculation without underlying business rationale. Empirical studies show that transaction exposures are often hedged while hedging of the longer term operating exposures are hedged more sporadically (e.g. Bodnar, Marston, and Hayt, 1998).

The European exporter is not restricted to financial hedging. If the USD depreciates, a real option for the company could be to shut down production facilities in Europe and start producing in the US. The combination of a symmetric exposure to the USD from exports and a real option to switch production site constitute an asymmetric exposure profile:

> The USD depreciates => the company switches production sites and does not loose.
>
> The USD appreciates => the company continues exporting and wins.

Depending on the set-up and size of the specific company such an option may be an illusion (e.g. if the company is too small to establish production in the US) or a reality (e.g. if the company already has production facilities in the US and is able to increase production). At a specific time the real options held by a company constitute a constant "stock" (for a description of real options see Dixit and Pindyck, 1994). However, this "stock" of real options can be altered by actions from the managers of the company. Capel (1992) shows how *"uncertainty may favor a market-servicing mode which is more expensive in terms of expected production and adjustment costs but which gives the firm more flexibility*". As such it may prove optimal to "buy" real options by being more flexible than e.g. large scale cost savings considerations would imply.

A practical example of the latter is described in The Economist Intelligence Unit (1993) where an *"American power-tool maker has made the leading-edge decisions to (1) build flexible production lines capable of producing virtually any segment of the product line and (2) include excess capacity at these factories in order to facilitate shifts to a low-cost producer."* A spokesman for the company is quoted as saying: *"It's a strategic decision, but it's one we're very comfortable with. At any given time there may be individual arguments against it, but in the long run it is proving to be the right strategy."*

According to Adler and Dumas (1984) exchange rate exposure can be measured by the regression coefficient (or coefficients if more than one currency) when a stock's price is regressed on exchange rate(s). Authors have used this stock market approach to measure the extra-market exchange rate exposure of companies on an industry level (e.g. Bodnar and Gentry, 1993 and Bartov and Bodnar, 1994) as well as on a company level (e.g. Jorion, 1990).

Exchange rate exposures may not be symmetric. Due to the pricing behaviour of companies the exchange rate exposures of companies can be asymmetric (e.g. Froot and Klemperer, 1989). Kanas (1997) finds empirical evidence for this asymmetry.

As illustrated above another reason for asymmetry in exchange rate exposure can be the existence of real options. *The aim of this paper* is to investigate whether or not an asymmetric exchange rate exposure can be identified through a stock market approach for a group of companies that have explicitly expressed that their possession of real options interfere with their exchange rate exposure management.

Section 2 introduces the companies in the study. Section 3 reports the results of the study. Section 4 elaborates on the results of the study and highlights the limitations of the stock market approach. Section 5 concludes.

2. Companies in Study

The group of companies in this study consists of the eight blue-chip industrial companies listed on the Copenhagen Stock Exchange as of the end of 1997 (Bang & Olufsen Holding a/s, Carlsberg A/S, Coloplast A/S, Danisco A/S, FLS Industries A/S, GN Store Nord as, Novo Nordisk A/S, and Superfos a/s).

The group of companies is restricted to blue-chip companies in order to secure that the information content in the stock prices is high and based on intense surveillance from investors and analysts. The group of companies is further restricted to include only non-financial companies because the exchange rate exposures of financial companies are based primarily on financial assets, liabilities and cash flows and therefore unique. Finally, the group of companies is restricted to include only industrial companies as these companies generally are more exposed to changes in exchange rates than is the case for trade and service companies (see remarks on turnover below).

The companies in this study cover a broad specter of branches producing a variety of products (beer, cement, enzymes, food ingredients, pharmaceuticals, roads, soft drinks, sugar, telecommunication equipment, televisions, etc.). The companies have an average turnover of USD 2.1 billion and they are all heavily internationally oriented as two thirds or more of the turnover of each company originates from foreign markets (published accounts 1997/1998 or 1998).

The companies took part in a cross-case study of exchange rate exposure management conducted in 1999 (Aabo, 2001a and 2001b). The study was based on interviews with finance

managers (or treasurers) of the companies. To facilitate aggregation of data the informal interviews were supplemented with closed-end questionnaires filled out during the interviews.

Asked for the likely reasons why the companies sometimes or frequently did not hedge an operating exposure, the main reason emerged to be that the operating exposure was managed by real means (e.g. change in sourcing and production). This reason was the most important reason for two companies, the second most important reason for five companies, and the third most important reason for one company. As such, all eight companies possess real options to such a degree that the decision of financial hedging is affected.

3. Results of Study

Using a stock market approach this section examines the exchange rate exposure of Danish industrial blue-chip companies. More specifically this section examines whether or not there seems to be an asymmetric extra-market exchange rate exposure - an asymmetric exposure caused by real options.

Using continuously compounded monthly return data from 1990 to 1999 in an augmented market model this paper analyses the company level extra-market exchange rate exposure of the eight companies. Table l lists the eight companies (or rather stocks) and the time horizons considered.

Table 1 Industrial Blue-Chip Stocks on CSE [1]

Name of Stock	Abbr.	Start	End	Obs.
Bang&Olufsen Hold. B	BO	1990:1	1999:12	120
Carlsberg B	CAR	1990:1	1999:12	120
Coloplast B	COL	1990:1	1999:12	120
Danisco	DAN	1990:1	1999:12	120
FLS Industries B	FLS	1990:1	1999:12	120
GN Store Nord	GN	1990:1	1999:12	120
Novo Nordisk B	NOV	1990:1	1999:12	120
Superfos [2]	SUP	1990:1	1999:06	114

[1] All blue-chip (KFX) industrial stocks of Copenhagen Stock Exchange (CSE) end 1997.

[2] Superfos was delisted in August 1999 due to a takeover by a US company.

Following the tradition in the field, the exposures that are measured through the regression analysis are extra-market exposures as the return on the All-Share Index (TOTAL) is included as an independent variable in order to reduce omitted variable bias. The stock prices and the All-Share Index (end of month observations) are obtained from Danish Stock Data

and are corrected for dividends and capital changes. The stock prices and the index are stationary in their first differences ($\ln(\text{stock price}_t)$-$\ln(\text{stock price}_{t-1})$).

Exchange rates representing the main world currencies (USD, DEM, and JPY) and the currencies of the main Danish export markets (DEM, SEK, GBP) are included as independent variables. As DEM counts in both terms a total of five currencies are included. The exchange rates (end of month observations) are obtained from Danmarks Statistik Tidsserie Bank and are stationary in their first differences (e.g. $\ln(USD_t)$-$\ln(USD_{t-1})$).

A correlation matrix on the returns of the five exchange rates show a maximum, absolute correlation of 0.40 during the period. As such, multicollinearity between the exchange rates is a minor problem. An alternative approach would be to use the effective DKK as a sole exchange rate indicator. However, such an approach would fail to address the complexity of the exchange rate exposures of individual companies.

The extra-market exchange rate exposure of a company can be estimated (OLS) through the time series regression,

$$\begin{aligned} \text{dlog(Company)}_t = \quad & C + \beta_1 \text{dlog(TOTAL)}_t + \beta_2 \text{dlog(USD)}_t + \beta_3 \text{dlog(DEM)}_t \\ & + \beta_4 \text{dlog(JPY)}_t + \beta_5 \text{dlog(SEK)}_t + \beta_6 \text{dlog(GBP)}_t + \varepsilon_t \end{aligned} \qquad (1)$$

where dlog(Company)_t is the continuously compounded monthly return on the individual stock, C is a constant, dlog(TOTAL)_t is the continuously compounded monthly return on the All-Share Index, and e.g. dlog(USD)_t is the continuously compounded monthly return on the DKK/USD exchange rate.

A regression analysis in such a symmetric approach is shown in Appendix A. More than half of the companies seem to have significant extra-market exchange rate exposures.

However, this is not the focus of the paper. As put forward in the introduction a symmetric approach fails to address the existence of real options in relation to exchange rate exposure management. The existence of real options can cause the exchange rate exposure coefficients to differ between depreciations and appreciations.

The extra-market exchange rate exposures can be asymmetric and follow a time series regression,

$$\begin{aligned} dlog(Company)_t = \quad & C + \beta_1 dlog(TOTAL)_t + \beta_2 dlog(USD)plus_t \\ & + \beta_3 dlog(USD)minus_t + \beta_4 dlog(DEM)plus_t \\ & + \beta_5 dlog(DEM)minus_t + \beta_6 dlog(JPY)plus_t \\ & + \beta_7 dlog(JPY)minus_t + \beta_8 dlog(SEK)plus_t \\ & + \beta_9 dlog(SEK)minus_t + \beta_{10} dlog(GBP)plus_t \\ & + \beta_{11} dlog(GBP)minus_t + \varepsilon_t \end{aligned} \qquad (2)$$

where $dlog(Company)_t$ is the continuously compounded monthly return on the individual stock, C is a constant, $dlog(TOTAL)_t$ is the continuously compounded monthly return on the All-Share Index, e.g. $dlog(USD)plus_t$ is the continuously compounded monthly return on the DKK/USD exchange rate in case of an appreciation of the USD and $dlog(USD)minus_t$ is the continuously compounded monthly return on the DKK/USD exchange rate in case of a depreciation of the USD.

An OLS regression analysis in such an asymmetric approach is shown in Table 2.

Table 2 Regression Analysis for Industrial Blue-Chip Companies - Asymmetry 1990-1999 [1]

Company	BO	CAR	COL	DAN	FLS	GN	NOV	SUP
Coefficients[2] [3]:								
C	0.02	0.00	0.01	0.02	0.01	0.00	0.02	0.00
dlog(TOTAL)	0.63 **	0.99 ***	0.63 ***	0.80 ***	1.28 ***	1.27 ***	0.77 ***	1.26 ***
dlog(USD)plus	-1.85 ***	-0.05	0.20	-0.10	0.29	-0.06	0.24	0.43
dlog(USD)minus	0.68	-0.16	0.36	0.15	0.03	0.67	0.29	0.35
	**							
dlog(DEM)plus	-0.49	0.63	2.72 ***	-0.13	-2.98 **	3.18 **	-0.21	-2.31 ***
dlog(DEM)minus	-5.70	-1.97	2.27	-0.74	3.43	0.75	0.63	-0.09
					**			
dlog(JPY)plus	-0.54	-0.14	-0.12	-0.95 ***	-0.16	0.54	-0.05	-0.59 **
dlog(JPY)minus	0.31	-0.18	-0.11	0.41	0.80	-0.31	-0.32	0.22
				***				
dlog(SEK)plus	2.08 **	-0.64	0.10	-0.18	1.10	-0.09	-0.21	0.28
dlog(SEK)minus	-2.03 ***	0.62 *	-1.01 ***	-0.48	-0.57	0.34	0.14	0.52
	***	*			*			
dlog(GBP)plus	1.31	-0.11	-0.37	0.04	-0.45	-0.12	-0.24	-0.22
dlog(GBP)minus	2.05 **	-0.35	0.80 *	-0.15	-0.25	-0.63	0.33	-2.13 ***
								***
R-squared	0.29	0.38	0.36	0.41	0.44	0.44	0.38	0.54
Durbin-Watson stat	2.19	1.99	1.84	2.07	1.93	2.10	1.98	2.12

[1] Equation: dlog(Company) = C dlog(TOTAL) dlog(USD)plus dlog(USD)minus ..... dlog(GBP)minus

[2] Level of significance is indicated below the coefficient (1%: ***, 5%: **, 10%: *)

3 Boxes indicate asymmetry (Wald test). Level of significance is indicated below the box (1%: ***, 5%: **, 10%: *)

Table 2 shows that several companies are sensitive to a depreciating or an appreciating currency. The focus of this paper, however, is to detect asymmetries. As such, a Wald test for asymmetry between the coefficient for a depreciating and the coefficient for an appreciating

currency is done for each currency / each company (the null hypothesis being that the coefficients are similar). Boxes in Table 2 indicate statistically significant asymmetries.

Table 2 shows seven cases of asymmetry at a 10% significance level. Looking at the three cases where the asymmetry is at the strongest significance level (1% = three stars below the box),

1) Bang & Olufsen (BO) seems to benefit from an appreciating SEK and also to benefit from a depreciating SEK.
2) Danisco (DAN) seems to be hurt by an appreciating JPY but does not seem to react significantly to a depreciating JPY.
3) Superfos (SUP) seems to benefit from a depreciating GBP but does not seem to react significantly to an appreciating GBP.

Bang & Olufsen has all its production facilities in Denmark and exports to among others Sweden. As such, Bang & Olufsen should benefit from an appreciating SEK. However, that Bang & Olufsen also should benefit from a depreciating SEK does not seem to have an immediate explanation.

Danisco´s main markets are located in Western Europe. From a fundamental point of view there is no immediate reason why Danisco should be particularly sensitive to the development in the JPY exchange rate. And given the setup of Danisco a real option approach fails to explain why Danisco should be hurt by an appreciating JPY but not react to a depreciating JPY.

In its second largest business area, packaging, Superfos has production outlets in 10 European countries including UK. In 1997 Superfos Packaging bought a company in England in order to further strengthen its position on the British market. Having production outlets in England and in other countries a real option approach could explain the asymmetric exposure to the GBP. If the GBP depreciates, Superfos increases its production in England and benefits due to cost advantages. If the GBP appreciates, Superfos reduces its production in England and increases its production from outlets outside the UK and does not loose (depending on the competitive structure of the market).

In some cases a real option approach can explain asymmetries, in some cases it cannot. The examples from Table 2 of statistically significant asymmetries highlight the inadequacy of resting the explanation of asymmetry on real options alone. Other factors must substitute or complement the existence of real options as an explanation for statistically significant exchange rate exposure asymmetries.

4. Elaboration on Results of Study

As put forward in the previous section, an elaboration on possible explanations to the results obtained is necessary. Fundamentally we have four different possibilities:

1) Asymmetries are detected and asymmetries exist.
2) Asymmetries are detected but asymmetries do not exist.
3) Asymmetries are not detected but do exist.
4) Asymmetries are not detected and do not exist.

There is no reason to discuss the fourth item, as this is trivial. But the three first possibilities are elaborated upon below.

Asymmetries are detected and asymmetries exist

An asymmetry is detected using the stock market approach above and in reality such an asymmetry does exist. One reason for the existence of this asymmetry could be the existence of real options as explained earlier but two other possibilities exist:

- Financial options
- Pricing to market

Financial options (or more specifically currency options) are per definition asymmetric in their exposure profile. If the companies in this study use financial options intensively, this could be the reason behind the detected asymmetric exchange rate exposures. However, the

interviews with the finance managers showed that financial options are used only as a supplement to symmetric derivatives such as forwards. Two companies stated that forwards was the only financial derivative that they used what so ever. In principle financial options could be behind asymmetric exchange rate exposures but for non-financial companies this is not likely to be the case.

Pricing to market can lead to asymmetric exchange rate exposures. Under certain conditions depreciation of the domestic currency leads to an increase in the export price of x per cent, while an appreciation of the domestic currency leads to a decrease in the export price of y per cent, where x is different from y (e.g. Froot and Klemperer, 1989). Empirical evidence supports the hypothesis that exporters may face asymmetric exchange rate exposure between depreciations and appreciations of their currency (Kanas, 1997).

Asymmetries are detected but asymmetries do not exist

Including a market index factor reduces the problem of omitted variables in the stock market approach. But the problem is only reduced, not solved. Several factors except from the development in the market index and the development in five exchange rates affect the development of the stock price of an individual company - e.g. changes in management, technology, and specific market structures.

As such, the detection of a statistically significant asymmetry may be caused by depreciating or appreciating exchange rates trying to compensate (in a statistical sense) for the missing independent variables. The result of omitted variables can be exchange rate exposure coefficients that are biased to such a degree that they are fundamentally flawed.

Asymmetries are not detected but do exist

The stock market approach may fail to detect asymmetric exchange rate exposures that actually exist. As before, the existence of asymmetry may be due to

- Financial options
- Pricing to market
- Real options

Financial options may at times constitute such an impact on the exposure of a specific exchange rate for a particular company that an asymmetry exists. This is, however, not likely to be the case for a 10 year period. A massive impact of financial options is a possibility but more as an exception than as a rule in a 10-year time horizon.

Pricing to market can cause an asymmetric exchange rate exposure. However, the sign of the coefficients (in case of depreciations and appreciations) are still expected to be similar (the company does not win / win or loose / loose), so in a statistical sense it may prove difficult to find statistically significant asymmetries even when the coefficients are in fact different as the magnitude of the difference is supposedly fairly small.

A fair amount of logic can be put to the case of real options creating an asymmetric exchange rate exposure for a particular company at a specific time or in a specific period. The European company which exports to the US and which presently has many of its costs in EUR may react to a depreciating USD by establishing production in the US and thus change

(some of) its EUR costs to USD costs. The competitiveness of the company is restored (in case of US competitors) or improved (in case of European competitors).

This simple example is, however, well suited to illustrate two connected aspects that may disqualify the detection of asymmetric exchange rate exposures as in the stock market approach above:

- Size of change
- Path dependency

Seen in isolation small changes in exchange rates are not enough to trigger the exercise of real options. The concept of real options has emerged because most investment decisions share three characteristics: irreversibility, uncertainty, and flexibility in timing (Dixit and Pindyck, 1994). When investments share the above mentioned three characteristics "*waiting has positive value. In the evolving environment, time brings more information about the future prospects of the project. As long as the opportunity to invest remains available, a later decision can be a better one. And because there are sunk costs, it does not always pay to take a less perfect action now and change it later*" (Dixit, 1992). This could lead to the conclusion that the approach should be only to consider changes in exchange rates, which are of a magnitude above a certain threshold.

However, a small change in an exchange rate may be the successor of a lot of small changes that together have moved the exchange rate past the threshold. This leads us to the concept of path dependency and hysteresis.

Dixit (1989) defines hysteresis *"as the failure of an effect to reverse itself as its underlying cause is reversed. For example, the foreign firms that entered the U.S. market when the dollar appreciated did not exit when the dollar fell back to its original levels.*" As such, the market is not only a function of present conditions but also of past conditions.

Path dependency is not addressed properly in the stock market approach above. Thus, the approach may fail to detect asymmetries that do exist at least within a certain time frame or within a certain range of exchange rates.

To summarize we can say that asymmetric exchange rate exposures can be caused by real options, financial options, or pricing to market. Even if there is an asymmetry it is not certain that a stock market approach can detect the asymmetry. Or an asymmetry may be detected even if it does not exist - because of omitted variable bias.

Specifically on real options a short conclusion is that real options can be behind asymmetric exchange rate exposures, but that it is not the only possible cause for asymmetry. Even if there is asymmetry caused by real options it is not for certain (or maybe unlikely) that it is detectable in a statistical sense using a stock market approach. As such, we should not put too much emphasis on the stock market approach in addressing the interaction between real options and exchange rate exposure management in industrial companies.

5. Conclusion

Real options like the ability to reallocate production resources can lead to an asymmetric exchange rate exposure in non-financial companies. Using a stock market approach in which the exchange rate exposure is derived from the information content in the stock prices this study examines the extra-market exchange rate exposures of a group of blue chip, industrial companies listed on the Copenhagen Stock Exchange. In an earlier cross-case study the companies in the study explicitly stated that real means like a change in sourcing and production interfere with their decision on whether or not to financially hedge an operating exchange rate exposure.

The result of the stock market approach is mixed. Statistically significant asymmetric extra-market exchange rate exposures are identified successfully but the asymmetries can only to a limited extent be explained by real options. Real options, financial options, and pricing to market are all possible causes of asymmetric exchange rate exposures. And the fact that statistically significant asymmetries are detected in the stock market approach does not assure that these asymmetries exist in real life - the problem of omitted variables is lurking.

The topic of real options in an exchange rate exposure management context is relevant in a real business setting. However, if the aim is to detect asymmetries that are caused by real options, path dependency and the existence of alternative causes for asymmetry partly disqualify the stock market approach as it is applied in this paper.

More sophisticated stock market approaches may be a possible route for further research but no matter how sophisticated the stock market approach is, it always depends on the

information content in the stock prices - and for the majority of companies changes in exchange rates are only one of many risk factors affecting the performance of the companies and thus the performance of their stock prices.

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Appendix A

Regression Analysis for Industrial Blue-Chip Companies - Symmetry 1990-1999 [1]

Company	BO	CAR	COL	DAN	FLS	GN	NOV	SUP
Coefficients[2]:								
C	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.00
dlog(TOTAL)	0.84 ***	0.97 ***	0.68 ***	0.78 ***	1.24 ***	1.32 ***	0.77 ***	1.20 ***
dlog(USD)	-0.59	-0.13	0.29	0.01	0.19	0.27	0.23	0.42 *
dlog(DEM)	-1.89	-0.13	2.56 ***	-0.16	-1.02	2.39 **	-0.05	-1.51 *
dlog(JPY)	-0.35	-0.16	-0.14	-0.46 ***	0.22	0.20	-0.15	-0.24
dlog(SEK)	-0.44	0.16	-0.58 **	-0.36	0.04	0.20	0.02	0.40
dlog(GBP)	1.71 ***	-0.27	0.25	0.12	-0.13	-0.55	0.06	-1.13 ***
R-squared	0.18	0.36	0.33	0.36	0.39	0.42	0.37	0.50
Durbin-Watson stat	2.13	1.95	1.77	1.97	2.02	2.07	2.00	2.13

[1] Equation: dlog(Company) = C dlog(TOTAL) dlog(USD) ..... dlog(GBP)

[2] Level of significance is indicated below the coefficient (1%: ***, 5%: **, 10%: *)