

# New Evidence on Exchange Rate Exposure

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November 2002

## Abstract

This paper analyzes the currency exposure of industry stock returns. We show that when measuring currency exposure in regressions including the local stock market, one has to first, account for the currency exposure of the local market itself in the estimates, second, account for possible regime changes by the monetary authorities in exposure estimations, and third, use individual currencies of the major trading partners instead of a currency basket. When these issues are accounted for, exposure estimates are important in both an economic and statistical sense. These results are illustrated using data for Norway. The Norwegian case is particularly well suited for investigating these aspects of currency exposure since the economy is very open, has mainly dollar denominated exports and ECU denominated imports, and has had three official exchange rate policy regimes over the sample period.

**JEL Codes:** F3, F36, G12, G18

**Keywords:** Currency exposure, exposure estimation methods, exchange rate policy regimes.

There are theoretical and anecdotal reasons to expect a firm's value to be affected by changes in exchange rates. What is surprising and somewhat puzzling, especially in light of large observed deviations from purchasing power parity and increasing globalization, is the lack of empirical evidence that stock returns are exposed to changes in exchange rates. This observation is generally robust across countries, industries, individual firms, multinational corporations and portfolios formed on firm characteristics related to the extent of foreign activities. In this paper we show that the lack of evidence regarding exchange rate exposure can be explained by the methodological approach of extant studies. In particular, we find that not accounting for exchange rate policy regimes in the exposure estimation, and the use of a currency basket rather than individual currencies in exposure estimation are very important issues. Using methods that account for these

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issues we find exchange rate exposures to be economically and statistically important. Exposures tend to be more important in times of free, relative to floating exchange rate. We illustrate these claims using a data set of Norwegian industries.

Theoretically, exposure will depend, amongst other things, on a firm's terms of trade in different currencies and the competitive nature of the industry. Furthermore, it is possible that the extent of exposure can be asymmetric over different regimes. For example, suppose the monetary authorities currently peg the exchange rate and that potential exporters face entry costs into a foreign market. A change in the peg through, for example, a change in weights or constituents, or there being a change in the par value of the currency, or a move to a floating system, may make the exchange rate change to a level such that the benefits of entering the market now exceed the entry costs. In this case, in the first regime the firms are not exposed because entry costs keep firms from exporting. In the second regime firms are exposed because the exchange rate has changed and firms begin exporting. Thus, changes in the management of a currency could conceivably affect a firm's exchange rate exposure if it leads to a change in firm behavior.

Norway is particularly well suited for investigating these aspects of currency exposure because it has a relatively specialized economy which is very open. It is a large net exporter, which is a result of sales of oil and oil related products that are denominated in dollars. Net of oil products, however, Norway is a large net importer, with the vast majority of imports coming from the European Union (EU). These differences are likely to make dollar and ECU exposures different and therefore warn against using a currency basket. Additionally, the Norwegian currency, the krone, has experienced three distinct exchange regimes over the period of analysis.

The paper makes three main contributions. First, we show that the extant literature's failure to find statistically and economically significant exposure coefficients is due, in part, to methodological reasons. We show that it is important to carefully adjust exchange rates and stock returns for common economy-wide factors that are unrelated to firm exposure and to consider the exposure of the market portfolio before it is possible to consider the exposure of individual firms.

Secondly, we document that the economic importance in terms of explanatory power, statistical significance, size and estimated sign of exchange rate exposure is dependent on the exchange rate regime followed by the monetary authorities. Changes in the way authorities peg the exchange rate and movements from a peg to a floating system affects estimated exposures. By bunching together different regimes potential intertemporal variation in exposure coefficients is masked and the statistical and economic significance of exposure coefficients in the different regimes are not uncovered. This issue may have general implications for estimation of exposures in other countries where the currency has been subject to changes in exchange rate regime. Similarly, currencies which have been through prolonged periods of appreciation and/or depreciation may have very different exposure coefficients in the various periods.

Thirdly, we show that Norwegian sectors are exposed to exchange rates and that this exposure is important economically (as well as statistically) if the exchange rates of the krone relative to the US dollar and the ECU are used rather than a currency basket. Furthermore, using individual currencies as a measure of exchange rate movements uncovers some extremely interesting and variable exposures of stock returns to different currencies that are not observed when using a currency basket. This variability relates to their

economic importance in terms of their explanatory power, their size and sign, and also their statistical significance. ECU and dollar exposures are opposite in many industries reflecting differences in currency denominations of trade. Importantly, we find reasonable economic explanations for the sign and size of different sectors' exposures.

An added benefit of our proposed methodological approach is the improved interpretability of currency exposure coefficients. By orthogonalizing the market portfolio relative to the exchange rate we can interpret the currency exposure coefficient as the total currency exposure. Not orthogonalizing produces the exposure of the individual stock over and above the market exposure. Therefore, in this case a finding of a zero exposure coefficient only tells us that the firm does not have an exchange rate exposure different from the market, which is very different from concluding, as most studies do, that exposure is small and statistically insignificant. Additionally, estimating total exposure as we do allows for easy interpretation of what the coefficient means, which may be important in practical applications such as hedging, the investigation of cross-sectional explanations of exposure coefficients, and the use of currency exposure coefficients as independent variables in tests of the pricing of exchange rate risk.

Our results are interesting and timely because of the increasingly important role exchange rates in financial decision making. This is due in one respect to the collapse of the Bretton Woods system of fixed exchange rates in the 1970s and more recently to the globalization of financial markets and firms. Massive growth in cross border trade and investment in both physical and financial assets has sharpened the focus of corporate managers, investment managers and regulators on the issue of how exchange rates and exchange rate regimes affect corporate profitability and through that asset prices. Introduction of major currency unions, like the euro, also makes currency exposure between areas an issue of more importance. Our results are also important because they illustrate that the extant literature's failure to uncover exposure effects seems to be related to the methodological issues raised in this paper, and not because firms are not exposed.

The rest of the paper is organized as follows. A general discussion of exchange rate exposure is given in section 1. Section 2 discusses features of the Norwegian economy that are relevant for exposure estimation. The data are discussed in section 3. Empirical results from estimation using individual currencies are presented and discussed in section 4. Section 5 considers the effect of exchange rate regimes. Some robustness tests are undertaken in section 6. Section 7 concludes.

## 1 Currency Exposure of Stock Returns

The currency exposure of a stock is its sensitivity to changes in an exchange rate. We define the exchange rate as the number of home currency units required to purchase one unit of the foreign currency. An increase in the Norwegian krone rate relative to an individual currency thus represents a devaluation of the krone. In this setup a negative exposure implies that stock prices will fall if there is a devaluation and positive exposure implies that stock prices will rise if there is a devaluation.

## 1.1 Empirical Evidence

Existing empirical evidence reports estimated exchange rate exposures that are small and statistically insignificant and with no consistently estimated sign. This evidence is fairly robust across countries, industries, multinational corporations, and portfolios formed on firm characteristics which proxy the extent of foreign activities. For example, Jorion (1990) examines the exchange rate exposure of a large sample of US multinationals and finds small, insignificant exposures, as do Bodnar and Gentry (1993). Bartov and Bodnar (1994) find no contemporaneous exchange rate exposure for a sample of US firms. They do, however, find evidence of a lagged effect, which they claim is a result of investors being unable to quickly incorporate exchange rate information into stock returns. Chow et al. (1997) and Bodnar and Wong (2000) find that while over short horizons there is no statistically significant relationship between returns and changes in the exchange rate, over long horizons there is. What is particularly puzzling is that the estimated short and long horizon relationships often have different signs. Other studies (see, for example, Amihud (1993) and Gao (2000)) find limited, if any, support for the notion that exchange rates have a statistically significant effect on stock returns.

A puzzling feature of the results from estimation of exposure on US data (see, for example, Jorion (1990), Bodnar and Gentry (1993) and Bodnar and Wong (2000)) is that a depreciation of the dollar predicts a fall in share prices. Theoretical models tend to predict a negative relationship between firm value and the exchange rate (see, for example, Clarida (1992) and Hung (1992)) because the annual profits of U.S. firms are positively related to dollar depreciations. It seems strange that these results do not pass over into estimates of exposure. Allayannis and Ihrig (2001) show that taking account of the industry structure in terms of export and import shares and its level of competitiveness can help improve the precision of exposure measurement.

Bodnar and Wong (2000) claim that it is the choice of a value weighted market index that causes exposure to be positive. Their argument rests on the observation that a value weighted index includes large firms who are more likely to be multinationals with a higher export orientation. Such firms are more likely to experience a negative cash flow reaction to dollar appreciations than other US firms. When the value weighted index is included, the average firm will consequently have a positive exposure. Bodnar and Wong (2000) therefore suggest the use of an equally weighted index instead of a value weighted index, since this removes only the equally weighted average impact of the exchange rate. In their empirical results they find that exposure estimates indeed become negative. However, a problem remains in that they find whilst exposures become negative, the driving force behind this is not whether a firm is heavily involved in foreign trade, but rather firm size: large firms with no foreign operations have more negative exposures than small firms with large foreign operations.

Non-US evidence regarding exposure is consistent with US evidence. Griffin and Stulz (2001), using industry returns from developed markets, and Doidge et al. (2000), using individual stocks, and portfolios formed on the basis of some aspect of foreign trade from developed and emerging markets, find, outside of periods of very high exchange rate volatility, very little evidence of statistically significant exposure. Using the change in the adjusted  $R^2$  when adding exchange rate changes to a regression of an industry return on the market portfolio as a means of measuring the economic significance of exchange

rate changes, Doidge et al. (2000) find for developed markets the increase to be only 1.1%. This supports the findings of Griffin and Stulz (2001) who document that only a very small proportion of the variance of industry returns is explained by exchange rate movements.

He and Ng (1998) find that only 25% of a sample of 171 Japanese multinationals have statistically significant exposure coefficients. Williamson (2001) finds that Japanese and US automotive firms have significant exposures, which vary over time. However, this industry appears to be exceptional (Griffin and Stulz, 2001).

There are a number of potential explanations for the extant results. First, firms may simply not be exposed to exchange rate shocks because they hedge their positions. However, the empirical evidence indicates that there are few companies which use hedge instruments to offset all currency exposure.<sup>1</sup> Secondly, many studies employ a currency basket to measure exposure. This presupposes that the exchange rate exposure is the same for all currencies. As noted earlier, bunching all these effects together in a currency basket may lead to cancelling out effects which obscure the economic importance, sign and statistical significance of the exposures of a stock to different currencies. Third, estimating exposures over different currency policy regimes (whether these be formal regimes such as pegging currencies, or free floating, or regimes of long periods of appreciation or depreciations) may result in insignificant exposure coefficients if exposures are sensitive to regime changes.

Fourth, empirical models may be misspecified. For example, under a depreciating currency, a regression of stock returns on exchange rates raises the problem that the exchange rates may appear to be important because the depreciation is associated with an expansionary monetary policy that leads to higher economic activity from which all firms benefit (see, for example, Dornbusch (1976)). It is therefore typical to include the stock market portfolio in the estimation of exposure coefficients. However, as we show, the statistical significance of exposure coefficients is related directly to the specification of the relationship between exchange rates and the market portfolio: failure to orthogonalize the market portfolio and the exchange rate factor results in insignificant exposure coefficients; orthogonalization results in much more significant coefficients.

## 1.2 Exchange Rate Regimes

Since the collapse of Bretton Woods in the beginning of the 1970s many currencies have undergone numerous currency regimes based on free floating, pegging, and exchange rate systems such as the ERM. Furthermore, countries have tended to opt in and out of these systems over time or undergo realignments. The actual exchange rate policy regime that a country adopts should affect the exposure of local firms. For instance, firms in a country that adopts a regime of a fixed nominal exchange rate through pegging to a trade weighted basket should have a lower exposure than firms in a country with a freely floating regime. This is because in the former case the exposure a firm faces is with respect to changes in relative prices. Whilst they are smaller than changes in exchange

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<sup>1</sup>Géczy et al. (1997), Allayannis and Weston (2001) and Allayannis and Ofek (2001) document the use of currency derivatives for hedging exposure. Evidence inconsistent with hedging eliminating all exposure is reported in Doidge et al. (2000). They show that exposures are greater in large firms where hedging would be expected to be more prevalent.

rates, they are however still potentially sources of exposure. Furthermore, realignments to the peg could also be a source of exposure in a fixed nominal exchange rate regime.

In addition to policy regimes of pegging or not pegging, a change in regime from an existing peg to a currency basket, to being pegged to only a subset of the basket should alter a firm's exposure. This is due to the fact that whilst it is still nominally fixed to the subset and hence only price differences are important, it is free floating against the remaining currencies and hence is exposed to exchange rate changes with respect to these currencies. Therefore, using a trade weighted currency basket when measuring exposure, as is commonly done in the literature, is unlikely to uncover these changes in exposure. It is likely to be much more informative to use individual currencies to measure currency exposure. As discussed below, this could be particularly important for Norway since imports tend to be ECU denominated and exports dollar denominated.

The arguments above suggest that firm exposure may be different across regimes because of how the monetary authority acts. It is also possible that a firm may act differently under different exchange rate regimes. For example, suppose the monetary authorities currently peg the exchange rate and that there are entry costs into a foreign market for exporters. It may take a change in the peg (or a movement to a free floating regime) before the benefits of exporting outweigh these costs. In this case, in the first regime firms are not exposed because the entry costs keep them from exporting, in the second regime firms are exposed because the exchange rate has changed and they begin exporting. This type of scenario also applies to imports. Thus, changes in the management of a currency could conceivably affect a firm's exchange rate exposure through affecting their behaviour.

In general, regimes need not be related to monetary authorities fixing or pegging the exchange rate. A currency may experience a prolonged period of depreciation or appreciation. For example, the US dollar had a general appreciation regime in the late 1970s up to early 1985 and a general depreciation regime from early 1985 to the end of the decade. Since the competitive structure of an industry is an important determinant of a firm's exposure (Marston, 2001), firms who are net exporters will benefit from a depreciation regime while firms that are net importers see their costs rise under a depreciation regime and thus suffer in this case. As the currency moves from a depreciation regime to an appreciation regime this will effect the exposure of firms in different industries given the relative competitiveness of the industry and whether they are exporters or importers. Thus, capturing regimes should be important for determining a firm's exposure and warrants empirical attention.

## 2 Currency Exposure in Norway

Understanding how exchange rates are expected to affect stock returns in Norway is not a straightforward exercise. Norway has a small but very open economy. In 1999 imports and exports were respectively 33% and 39% of GDP. The annual average trade balance was 58 billion kroner for the period 1990 to 1998.<sup>2</sup> However, the existence of a positive trade balance is due to the exporting of oil, gas and shipping. For example, of the exports 45% were oil. Excluding these items from trade numbers produces an

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<sup>2</sup>At the end of 1998 the exchange rate between the kroner and the dollar was 7.58.

annual average trade deficit of 57 billion kroner over the same period. Moreover, there are some interesting patterns in the export/import currency denomination. All oil and a large part of shipping revenues are in dollars. By themselves, oil exports amounted to an average of 98 billion kroner per year over the 1990-1998 period. On the import side of the Norwegian economy, in 1998 74% of imports came from the EU and hence were non-dollar denominated. Only 8% of imports came from the US and hence were most likely to be dollar denominated.

The effect on an industry of a change in the value of the Norwegian krone will depend to some degree on the extent of importing or exporting. For example, it is possible that a devaluation of the krone relative to the dollar may be good for some industries. A similar devaluation relative to the ECU (where most imports come from) may have different effects across industries. Intuitively this tells us that industry level analysis should be important.

Using a currency basket may not be helpful in detecting exposures (in terms of the economic importance, correct sign and the significance levels). This is because the exposure to the dollar and the ECU are likely to be opposite due to the relative terms of trade between Norway and these two trading partners.

Another important issue is the exchange rate policy regimes that the krone has had over the recent past. From 1982 to 1990 the krone was pegged to a basket of fourteen currencies with weights according to export and import importance. The influence these fourteen countries had as competitors for Norwegian exporters to third party countries also played a role in the weights. Changes in the weights occurred when there were changes in trade patterns. The krone was allowed to move 2.5% from the basis value set according to the weights. Intervention occurred for deviations greater than 2.5%. This pegging regime survived (with a small number of devaluations) until 1990.

In 1990 the exchange rate policy shifted from a peg set according to trade weights to a peg against the ECU. The effect of this was dropping of the dollar from the peg and an increase in the weight of ECU members. In essence the krone was now freely floating against the dollar. The exchange rate policy of pegging to the ECU was abandoned in December 1992. This followed the turmoil in the ERM earlier in 1992 which saw the exit or suspension of the UK, Italy and Sweden from the system. Devaluations of these currencies placed increasing pressure on the krone and the decision was made to allow the krone to float freely. The final exchange rate policy regime, which has existed from 1993 to the present day, is essentially a freely floating one which has seen a depreciation relative to the USD and ECU.

In summary, the dollar and ECU may have greatly different effects on stock prices because of the currency denomination of imports and exports. The effects can be industry specific because currency denomination of cash flows tends to be industry specific. Furthermore, they could be confounded by the changes in exchange rate policy regimes the krone has undergone. These issues motivate the use of individual currencies instead of the use of a currency basket as done in the majority of extant studies.<sup>3</sup> The fact that the regimes are likely to lead to different exposures should provide more power in attempts to uncover exposure.

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<sup>3</sup>Strictly speaking the ECU was not an individual currency, but the predecessor of the European single currency, the euro.

### 3 Data

Many industries compete internationally and it is thought that changes in exchange rates should affect the relative competitiveness of industries across countries and hence their exchange rate exposure. Therefore, like many studies in this area we use stock returns at the industry level. Datastream provides 10 industry classifications which cover all companies in each country. For Norway there are seven industries available plus one other (Telecommunications and Media) which is a sub-industry of one of the major industries that is not available over the entire sample. The industries are: Resources, Basic, General, Non-Cyclical Consumer Goods, Cyclical Services, Financial, Telecommunications and Media, and Utilities.<sup>4</sup> Total returns (including dividends) are collected at a monthly frequency over the period January 1983 to December 1998. Excess returns are calculated by subtracting the one month interbank rate from the actual returns.

Table 1 provides some summary statistics on the equity and currency data. Panel A reports the mean and standard deviations for the stock market variables over the sample period. The cross-sectional spread of excess returns is from  $-0.1\%$  per month in the Telecommunication and Media industry to  $1.3\%$  per month in the utilities sector. Panel B reports summary statistics of the log differences for the three currencies over the whole sample and the three subperiods. The exchange rates relative to the ECU and the dollar are the number of kroner needed to buy 1 unit of foreign currency. Hence an increase in the currency represents a depreciation of the krone and a decrease represents an appreciation. To aid comparison with prior studies we also perform analysis using a currency index. The currency index is a nominal effective index geometrically weighted against Norway's twenty-five most import trade partners.<sup>5</sup> The index is constructed such that an increase in the index represents a depreciation of the krone.

Over the entire sample period the krone has depreciated relative to the currency index, the dollar and ECU. This period includes a devaluation of  $9.2\%$  by the monetary authorities in 1986. Turning to the individual currencies reveals that the pattern for the currency index is not mirrored by the dollar, where in the first subperiod the kroner appreciated relative to the dollar, and in the other periods the kroner depreciated relative to the dollar. These patterns are different for the ECU. It is possible that this could affect both interpretations of exposures using a currency index and interpretations of exposure against the dollar and the ECU.

### 4 Estimating Exchange Rate Exposure

This section of the paper discusses the empirical methodology and results for the estimation of exchange rate exposure.

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<sup>4</sup>The data for the Telecommunications and Media industry begins at the start of 1984.

<sup>5</sup>The currency index and the exchange rates is provided by Norges Bank, the Norwegian Central Bank.



**Table 1** Summary statistics for market variables in the period 1983 to 1998

Panel A: Excess Returns on the market and industry indices

|                                   | Mean   | St.Dev |
|-----------------------------------|--------|--------|
| Market index                      | 0.007  | 0.07   |
| Resources (RE)                    | 0.005  | 0.09   |
| Basic (BS)                        | 0.006  | 0.09   |
| General (GE)                      | 0.008  | 0.09   |
| Non-Cyclical Consumer Goods (NCG) | 0.011  | 0.11   |
| Cyclical Services (CS)            | 0.005  | 0.10   |
| Financial (FI)                    | 0.003  | 0.10   |
| Telecommunications and Media (TL) | -0.001 | 0.10   |
| Utilities (UT)                    | 0.012  | 0.09   |

Panel B: Currency Changes

|                | 1983–1998         | 1983–1989          | 1990–1992         | 1993–1998         |
|----------------|-------------------|--------------------|-------------------|-------------------|
| Currency Index | 0.001<br>(0.016)  | 0.002<br>(0.014)   | 0.0008<br>(0.009) | 0.0006<br>(.0128) |
| NOK/USD        | 0.0004<br>(.030)  | -0.0008<br>(0.003) | 0.0014<br>(0.037) | 0.0012<br>(0.025) |
| NOK/ECU        | 0.0014<br>(0.013) | 0.0017<br>(0.0174) | 0.0017<br>(0.008) | 0.001<br>(0.0148) |
| <i>n</i>       | 192               | 84                 | 36                | 72                |

Panel A of the table reports the mean and standard deviation of the excess returns for eight sectors in the Norwegian stock market. The excess returns are calculated as the actual returns, including dividends, less the one month interbank rate. Panel B reports the percentage changes in the currency index, the krone dollar and the krone ECU exchange rates, as well as the sample size  $n$ . The currency index is a trade weighted index. Whole and sub-samples are reported. The subsamples are determined by the exchange rate policy regimes adopted by the Norwegian monetary authorities. The numbers in parentheses are standard deviations.

#### 4.1 Simple Exposure Measurement

Adler and Dumas (1983) show that total exchange rate exposure can be estimated from the following linear regression:

$$r_{it} = \alpha_{i0} + \alpha_{i1}^T x_{ECU,t} + \alpha_{i2}^T x_{USD,t} + \varepsilon_{it} \quad (1)$$

where  $r_{it}$  is the excess return on asset  $i$ ,  $x_{ECU,t}$  is the percentage change in the kroner/ECU exchange rate,  $x_{USD,t}$  is the percentage change in the kroner/USD exchange rate,  $\alpha_{i0}$  is a constant,  $\alpha_{i1}^T$  is the estimate of the total exchange rate exposure to the ECU,  $\alpha_{i2}^T$  is the estimate of the total exchange rate exposure to the USD, and  $\varepsilon_{it}$  is an error term.

The second and third columns of table 2 report estimates of dollar and ECU exposures ( $\alpha_{i1}^T$  and  $\alpha_{i2}^T$ ) from this regression. Considering the USD exposures first, Resources, Basic Industries, Non-Cyclical Consumer Goods, and Cyclical Services all have a positive and statistically significant exposure coefficient. The average coefficient across all industries is 0.451 and all are positive. As the mean value of the NOK/USD rate is 0.04, the average impact of the USD on the returns of Norwegian industries is 0.02% per month. The largest impact is in the Cyclical Services and Noncyclical Consumer Goods industries. Resources, which also includes oil (and hence has strong USD revenues) has a high exposure coefficient. The lowest exposure is in the utilities sector which is to be expected as

this industry is relatively closed to international competition, especially in terms of the dollar. The general impact of the USD is small over the entire sample.

**Table 2** Currency exposure estimates without and with the market portfolio

| Sector | Without the market portfolio |                  |             | With the market portfolio |                  |                       |
|--------|------------------------------|------------------|-------------|---------------------------|------------------|-----------------------|
|        | USD                          | ECU              | $\bar{R}^2$ | USD                       | ECU              | Change in $\bar{R}^2$ |
| RE     | 0.552<br>(2.67)              | -2.147<br>(4.50) | 10.46       | -0.014<br>(0.44)          | 0.075<br>(0.31)  | -0.03                 |
| BS     | 0.504<br>(2.34)              | -1.582<br>(3.18) | 5.78        | -0.035<br>(0.11)          | 0.457<br>(1.36)  | 0.01                  |
| GE     | 0.395<br>(1.87)              | -1.842<br>(3.77) | 6.84        | -0.090<br>(0.61)          | 0.062<br>(0.17)  | -0.01                 |
| NCG    | 0.631<br>(2.54)              | -2.047<br>(3.58) | 7.28        | 0.080<br>(0.47)           | 0.091<br>(0.20)  | 0.04                  |
| CS     | 0.864<br>(3.53)              | -2.510<br>(4.45) | 12.08       | 0.373<br>(1.94)           | -0.585<br>(1.26) | 0.02                  |
| FI     | 0.203<br>(0.88)              | -1.989<br>(3.73) | 5.94        | -0.257<br>(1.40)          | -0.181<br>(0.41) | 1.13                  |
| TL     | 0.357<br>(1.51)              | -1.546<br>(2.78) | 3.70        | 0.050<br>(0.22)           | -0.424<br>(0.79) | -0.01                 |
| UT     | 0.103<br>(0.45)              | -1.001<br>(1.93) | 0.92        | -0.263<br>(1.33)          | 0.435<br>(0.91)  | 0.01                  |

The table shows coefficient estimates  $\alpha_{i1}$  and  $\alpha_{i2}$  from exposure estimates using two different methods. Columns 2 and 3 are coefficients from the regression without the market:

$$r_{it} = \alpha_{i0} + \alpha_{i1}^T x_{ECU,t} + \alpha_{i2}^T x_{USD,t} + \varepsilon_{i,t}$$

where  $r_{it}$  is the excess return of industry index  $i$ ,  $x_{ECU,t}$  and  $x_{USD,t}$  are changes in the exchange rates of the ECU and the USD, respectively, and  $\varepsilon_{i,t}$  is an error term. Column 4 shows the adjusted  $R^2$  of this regression. Columns 5 and 6 shows similar estimates for regressions with the market portfolio added:

$$r_{it} = \alpha_{i0} + \alpha_{i1}^T x_{ECU,t} + \alpha_{i2}^T x_{USD,t} + \beta_{im} r_{mt} + \varepsilon_{i,t},$$

where  $r_{m,t}$  is the return on a Norwegian market index. Column 7 report the percentage increase in the adjusted  $R^2$  when moving from a regression of the sector excess return on the excess market return to the same regression but also including the ECU and dollar exchange rates. Figures in parentheses are t-ratios. Industries are abbreviated as: RE: Resources, BS: Basic, GE: General, NCG: Non-Cyclical Consumer Goods, CS: Cyclical Services, FI: Financial, TL: Telecommunications and Media, and UT: Utilities.

All of the ECU exposures are negative and all except the Utilities industry are statistically significant. The average exposure is  $-1.832$  and it is clear that the ECU exposures are larger than the USD exposures. Those industries that have the largest exposures to the ECU also have the largest exposures to the USD. The average movement in the ECU over the sample period is 0.14 which translates into the ECU having an average affect on the returns of Norwegian industries of  $-0.256\%$  per month. In comparison to the USD, the ECU has a much greater impact on Norwegian industries. This is consistent with the make up of Norwegian trade with the EU and US. The fourth column of table 2 reports the adjusted  $R^2$  which range from 12.08 in the cyclical services sector to 0.92 in the utilities sector and the average is 6.62.

In the light of these results the analysis above would seem to suggest that Norwegian industries are affected by exchange rates and that this affect is both statistically and economically important. Both these affects appear to be greater for the ECU than the USD.

To make economic sense it must be possible to interpret the coefficients in terms of

the expected exposures given the make up of imports and exports in Norway. Recall that the kroner devalued against both currencies over the whole sample. A depreciation is good for exporters and bad for importers. Excluding oil, most Norwegian trade is with European countries and there is a large trade deficit. That is, Norway imports much more from Europe than it exports. As the kroner depreciates these goods become more expensive. If these imports are input costs for firms then we would expect stock prices to fall. Additionally, we would expect that the trade goods sector is affected more. This is the pattern we observe in the data.

How is it possible to reconcile an opposite exposure coefficient for the USD? One potential explanation is that many Norwegian firms have dollar revenues and the depreciation of the kroner increases the value of these revenues. Whilst this affect is common across all industries, note that it is not statistically significant in all cases and the impact is small.

An alternative explanation of the affects we uncover in the simple Adler and Dumas (1983) model is that there is an omitted variable problem. For example, it is possible that changes in exchange rates affect the economy in general which has an affect on stock prices. Suppose the economy becomes fundamentally weaker and assume that this also corresponds to a weakening of the kroner. Due to the weakening economy stock prices fall. In a regression analysis it will appear that stock returns and exchange rates are linked simply because both related to the weakness of the economy. This link has nothing to do with exchange rate exposure.<sup>6</sup> Therefore, to avoid such problems the local stock market portfolio is typically added to equation (1)<sup>7</sup>, and regression (2) is estimated:

$$r_{it} = \alpha_{i0} + \alpha_{i1}x_{ECU,t} + \alpha_{i2}x_{USD,t} + \beta_{i1}r_{mt} + \varepsilon_{it} \quad (2)$$

where  $r_{mt}$  is the excess return on the market portfolio.

Columns 5, 6 and 7 of table 2 report results from estimating (2). The results are in line with the extant literature in that we now find that none of the exchange rate exposure coefficients are statistically significant. Furthermore, none are economically important as judged from column 7 that reports the change in adjusted  $R^2$  when moving from the model with just the market portfolio to the model that includes the market portfolio and the exchange rates. All these are around zero and in some case negative. Results such as these have led researchers to conclude that stock returns are not exposed to exchange rates.

## 4.2 Orthogonalizing Stock Returns and Exchange Rates

Including the market portfolio in the exposure regression as done in (2) raises a number of problems. First, if stock returns are exposed to the exchange rate, then through aggregation the market portfolio will also be exposed. In this case the exposure estimates can no longer be interpreted as total exposure. Instead, it is the amount of exposure asset  $i$  has over and above that of the local stock market portfolio. A finding that exposure estimates are equal to zero should therefore not be interpreted as companies

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<sup>6</sup>Whenever the exchange rate is correlated with variables that may affect stock returns, for example, interest rates, these effects must be accounted for in order to rule out spurious findings of exposure.

<sup>7</sup>An exception here is Jorion (1991) who uses a set of macroeconomic variables rather than the market portfolio.

having no exposure. In this specification the interpretation of a negative estimate of the exposure coefficient is that the asset has an exposure less than the market and a positive estimate is that the asset has an exposure greater than the market. Therefore, for corporate managers who wish to assess the extent of exposure for cost of capital calculations or hedging reasons, and for investors assessing risk, this estimate of exposure is not particularly useful.

Estimating (2) also entails a problem if the interest is in the cross-sectional properties of exposure coefficients. For example, He and Ng (1998) estimate (2) and then run a cross-sectional regression of exposure coefficients on firm specific variables with the aim of explaining the variation in exposure. Of course, given the inclusion of the market portfolio in (2), regressing  $\alpha_{i1}$  on firm specific variables only provides information about the exposure that is different from the general market level and may have little relation to total exposure. An alternative methodology is required to estimate total exposure.

We propose an empirical methodology for estimating exchange rate exposure which attempts to overcome the above mentioned problems and importantly allows for the crucial measurement of total exposure which is of interest to corporate managers, investors and those interested in examining cross-sectional patterns in exposure coefficients. To motivate this methodology note that the stock market index used in equation (2) also contains an exchange rate component, since to the degree that the individual companies constituting the index are exposed to exchange rates, this will spill over into the index.<sup>8</sup> One can estimate the exposure of the index to the exchange rate as

$$r_{mt} = a_{1m}x_{ECU,t} + a_{2m}x_{USD,t} + u_{mt} \quad (3)$$

The residuals  $u_{mt}$  of this regression measures the variation of the index that is not due to exchange rate movements. Note that this regression is estimated without a constant term to preserve the mean of the exposure regression.<sup>9</sup> When we estimate (3) we find that  $a_{1m} = -1.989(t = 5.02)$  and  $a_{2m} = 0.526(t = 3.21)$ . Therefore, the market portfolio appears to be exposed to exchange rates.<sup>10</sup> We could then use these residuals in an exposure estimation regression:

$$r_{it} = \alpha_{i0} + \alpha_{i1}^{TO}x_{ECU,t} + \alpha_{i2}^{TO}x_{USD,t} + \beta_{i1}u_{mt} + \varepsilon_{it} \quad (4)$$

Such orthogonalizations have been used by Allayannis (1996), Griffin and Stulz (2001), and Jorion (1991). However, the problem with this type of orthogonalization is that it does not rule out the possibility that the estimated effect of the exchange rates on the market portfolio arises due to a link between a downturn in the economy that results in a weakening of the currency and fall in stock prices. This has nothing to do with exposure of the firms cash flows to changes in exchange rates. In the light of this it is necessary to attempt to adjust for this possibility.

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<sup>8</sup>Causality should flow from exchange rates to stock prices, at least from an industry point of view. This can be seen from the dividend discount model. Exposure arises because a firm's future cash flows are affected by a depreciation or appreciation. This effects price and hence returns.

<sup>9</sup>One could alternatively do a regression with a mean term in it and then add the mean back into the residuals. We have experimented with this and it does not materially change our results.

<sup>10</sup>As we discuss later, including a set of domestic and international risk factors does not alter this finding. It is therefore unlikely to be a result of omitted variables.

We therefore propose to adjust *both* the stock returns and the exchange rates for common macroeconomic factors that could eliminate this link between the two that is unrelated to exposure. That is, the common macroeconomic factors should proxy a general change in the economy. We first estimate:

$$r_{mt} = a_{1m}x_{ECU,t} + a_{2m}x_{USD,t} + \gamma_m z_t + u_{mt} \quad (5)$$

where  $z_t$  is a vector of macroeconomic factors, and second estimate:

$$x_{ECU,t} = \gamma_{ECU} z_t + u_{ECU,t} \quad (6)$$

and

$$x_{USD,t} = \gamma_{USD} z_t + u_{USD,t} \quad (7)$$

to remove the common macroeconomic factors from the exchange rates. We can then proceed to estimate the exposure regression as:

$$r_{it} = \alpha_{i0} + \alpha_{i1}^{TO} u_{ECU,t} + \alpha_{i2}^{TO} u_{USD,t} + \beta_{i1} u_{mt} + \gamma_i z_t + \varepsilon_{it} \quad (8)$$

The remaining issue is then the choice of the relevant macro variables. This is no an obvious choice. An important issue is whether to include only domestic variables or should one also include international macro factors. If the relevant factors affecting both equities and currencies are believed to stem from domestic sources, only, the relevant macro factors are limited to domestic ones. If potentially also international economic conditions may influence both the domestic stock market and the domestic currency, one should also include international macro variables. For robustness purposes we consider both cases.

We first consider the case of only domestic macro variables and include the term structure of interest rates, inflation, the change in industrial production and the price of oil as elements of  $z_t$ . Table 3 reports the estimates of the exposure coefficients in columns 2 and 3.<sup>11</sup> The results show that exchange rate exposures are now very similar, in terms of size and statistical significance, to those reported in columns 2 and 3 of table 2 which did not include any additional factors. The change in the adjusted  $R^2$  when adding the exchange rates range from 34.67 in the Telecommunications and Media industry to 3.57 in the Utilities industry. These increases in adjusted  $R^2$  are somewhat greater than the case when only exchange rates were included. The average is 17.15%, as opposed to just over 6% when only including exchange rates.

It is still possible that the results are spurious in the sense that some other factor is missing from the equation and exchange rates proxy this factor. To our knowledge all studies of exchange rate exposure essentially assume that the local market is segmented from international factors and include the exchange rate as a risk factor along with the

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<sup>11</sup>As some of the regressor in equation (8) are derived from auxiliary regressions there is a generated regressors problem that could affect the standard errors (see Pagan (1984)). We can think of the problem of estimating exposure in terms of having a regression with an endogenous variable (the market return). Therefore, a way around the generated regressors problem would be to estimate the model using instrumental variables. We experimented with this but found it very difficult to convincingly argue for instruments related to the market portfolio which are independent of exchange rates.

**Table 3** Currency exposure estimates with an orthogonalization against the Norwegian and International Factors

| Sector | Domestic macro factors |                     |                    | International macro factors |                     |                    | Currency basket    |                    |
|--------|------------------------|---------------------|--------------------|-----------------------------|---------------------|--------------------|--------------------|--------------------|
|        | $\alpha_{USD}^{TO}$    | $\alpha_{ECU}^{TO}$ | $\Delta \bar{R}^2$ | $\alpha_{USD}^{TO}$         | $\alpha_{ECU}^{TO}$ | $\Delta \bar{R}^2$ | $\alpha_{CB}^{TO}$ | $\Delta \bar{R}^2$ |
| RE     | 0.661<br>(7.15)        | -2.056<br>(9.46)    | 16.47              | 0.710<br>(7.63)             | -2.115<br>(9.86)    | 16.90              | -0.687<br>(2.79)   | 0.72               |
| BS     | 0.582<br>(4.19)        | -1.347<br>(4.13)    | 10.56              | 0.572<br>(4.00)             | -1.369<br>(4.15)    | 8.77               | -0.304<br>(0.80)   | -1.54              |
| GE     | 0.365<br>(2.61)        | -1.813<br>(5.50)    | 13.50              | 0.296<br>(2.08)             | -1.802<br>(5.51)    | 10.71              | -0.920<br>(2.44)   | 1.63               |
| NCG    | 0.657<br>(3.71)        | -1.893<br>(4.54)    | 15.21              | 0.625<br>(3.44)             | -1.885<br>(4.51)    | 13.40              | -0.579<br>(1.21)   | 1.09               |
| CS     | 0.866<br>(4.62)        | -2.409<br>(5.46)    | 30.76              | 0.799<br>(4.16)             | -2.422<br>(5.47)    | 27.50              | -1.383<br>(2.71)   | 3.44               |
| FI     | 0.255<br>(1.41)        | -1.816<br>(4.26)    | 12.50              | 0.175<br>(0.94)             | -1.825<br>(4.28)    | 9.75               | -0.636<br>(1.29)   | 0.22               |
| TL     | 0.310<br>(1.40)        | -1.863<br>(3.46)    | 34.67              | 0.324<br>(1.46)             | -1.656<br>(3.19)    | 14.28              | -1.160<br>(1.98)   | 4.17               |
| UT     | 0.108<br>(0.54)        | -0.925<br>(2.00)    | 3.57               | 0.104<br>(0.52)             | -1.062<br>(2.32)    | 3.44               | -0.847<br>(1.60)   | 2.04               |

The table shows coefficient estimates of currency exposure, estimated using three different methods. Columns 2 through 4 shows results from estimation using

$$r_{it} = \alpha_{i0} + \alpha_{i1}^{TO} u_{ECU,t} + \alpha_{i2}^{TO} u_{USD,t} + \beta_{i1} u_{mt} + \gamma_i z_t + \varepsilon_{it},$$

Here  $r_{it}$  is the excess return on industry  $i$ , and  $u_{ECU,t}$ ,  $u_{USD,t}$ ,  $u_{mt}$  are the orthogonalized versions of respectively ECU changes, USD changes and the return on a Norwegian stock market index. The orthogonalizations are shown in equations (6), (7) and (5). The vector  $z_t$  contains the macro-factors: The term structure of interest rates, inflation, the change in industrial production and the price of oil. Columns 2 and 3 shows coefficient estimates and t-values for estimates of  $\alpha_{i1}^{TO}$  and  $\alpha_{i2}^{TO}$ . Column 4 shows the percentage increase in the adjusted  $R^2$  when moving from a regression of the sector excess return on the excess market return to the same regression but also including the ECU and dollar exchange rates. Columns 5 through 7 contains results from estimation using the same method, but adding two international macro factors: The spreads of the Norwegian interest rate relative to the US 3 month T-bill rate and the 3 month ECU rate. Columns 8 and 9 contains results from a regression using a currency index instead of the two currencies ECU and USD:

$$r_{it} = \alpha_{i0} + \alpha_{i1}^{TO} u_{x,t} + \beta_{i1} u_{mt} + \gamma_i z_t + \varepsilon_{it},$$

where  $u_{x,t}$  are orthogonalized version of (log) changes in a currency index. The currency index is a geometric index with weights determined by trade patterns. Industries are abbreviated as: RE: Resources, BS: Basic, GE: General, NCG: Non-Cyclical Consumer Goods, CS: Cyclical Services, FI: Financial, TL: Telecommunications and Media, and UT: Utilities.

local market portfolio. In fact, exchange rate factors arise from international versions of the CAPM (see, for example, Adler and Dumas (1983)). Therefore, it seems more natural that we should also adjust (local) stock returns for international factors. To this end we extend the adjustment of the stock returns and the exchange rates to include the spreads of the Norwegian interest rate relative to the US 3 month T-bill rate and the 3 month ECU rate, i.e. we add these variables to the vector  $z_t$ . The results are reported in columns 5, 6 and 7 of table 3. We now observe that five of the exposures to the USD are statistically significant and they are the same as those that were statistically significant when the market portfolio was not included, as is the cross-sectional spread in the exposures. The ECU exposures are all negative, very similar to those estimated without the market portfolio. All but the utilities industry are statistically significant although somewhat reduced in size. The average is now  $-1.767$ , which translates into an average affect on stock returns of just over 0.2% per month. Interestingly, this is close to the estimates of the currency risk premium for the ECU reported in Hardouvelis et al. (1999) and Giorgio de Santis and Hillion (1999). The changes in the adjusted  $R^2$  indicate that the exposure coefficients are economically as well as statistically significant and are now in line with those obtained from the first regression.

To conclude, we have shown that the Adler and Dumas (1983) model provides both statistically and economically significant exposure coefficients for a number of Norwegian industries. This is a result of either the industries being truly exposed to changes in the exchange rate, or there is an omitted variables problem. When we include the market portfolio in the regression to proxy for the omitted variables problem we find none of the exposures are statistically significant. This method of measuring exposure is, however, flawed since if firms are actually exposed then logically by aggregation the market will be exposed. We show that this is indeed the case. Past research has used residuals from regressing the market on exchange rates. However, there is a problem with this method since if stock returns and the exchange rate have a common factor that is not exposure related then this could lead to the spurious finding that stock returns are exposed to exchange rates. We therefore have proposed an alternative methodology that removes common factors, unrelated to exchange rate exposure, from the exchange rates and stock returns. We then use these adjusted variables to measure exposure.

### 4.3 Currency Basket

It is interesting to compare the results we have obtained so far using the orthogonalization to those that proxy currency risk with a currency basket. Of course, it is clear that the currency basket will not be able to replicate the results of the two bilateral rates because in this case the exposures were opposite in sign. The final two columns of table 3 report these results. The estimated exposures to the currency basket are clearly dominated by the ECU since all are negative, but only four are statistically significant and the average size is smaller than the ECU exposures. Furthermore, as the change in the currency basket over the entire sample is somewhat smaller than the change in the ECU, the use of a currency basket tends to underestimate the impact of currencies on stock returns. This impact can also be seen from observing that the change in the adjusted  $R^2$  are on average 1.5%, much lower than with the use of bilateral rates and more in line with the extant literature. Thus, a richer picture of exchange rate exposure is uncovered when

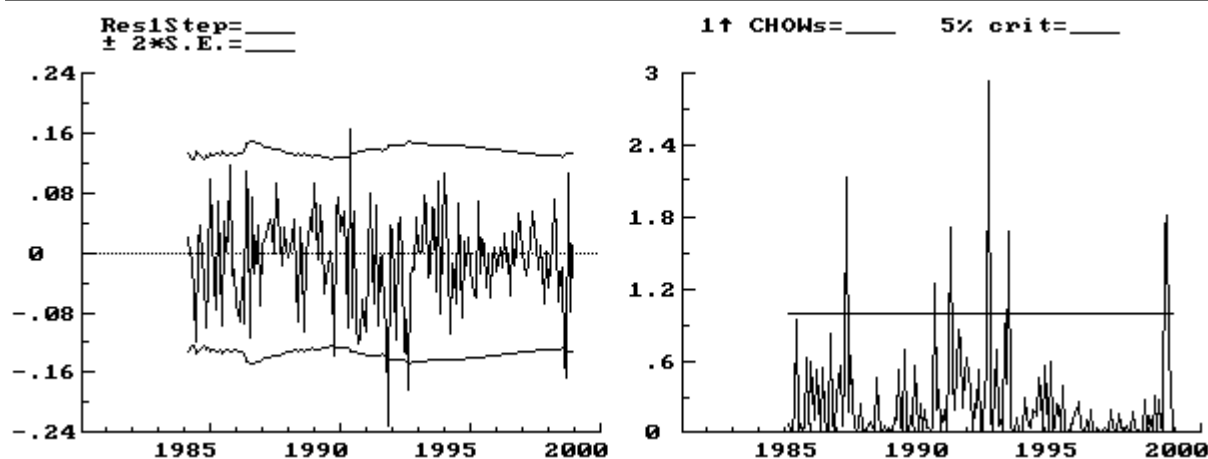
using bilateral rates.

## 5 Exchange Rate Regimes and Exchange Rate Exposures

We noted earlier that the krone has been through three distinct exchange rate regimes during the sample period and that these regimes may have affected the exchange rate exposure. As a preliminary exercise we attempt to establish whether, in the estimation of the currency exposure, it is necessary to split the time series into the three regimes we have identified from policy shifts by the monetary authorities. This is achieved by estimating a regression of the market excess return on a constant and the two currencies using recursive least squares.

Recursive estimation proceeds by estimating the model for a sample of  $t < T$  observations. The model is then re-estimated using  $t + 1$  observations,  $t + 2$  observations and so on until all  $T$  observations have been used. This generates a time series of estimated parameters and associated standard errors, which allows for an examination of the stability of the 1-step residuals and the construction of 1-step Chow tests. The hypothesis of structural stability is tested by plotting the 1-step residuals and their standard error bands and by plotting the Chow tests and the 5% critical values.<sup>12</sup>

**Figure 1** Stability Test



Testing for stability of the regression  $r_{mt} = a_1x_{USD,t} + a_2x_{ECU,t} + u_{mt}$ , where  $r_{mt}$  is the return on the market index,  $x_{USD,t}$  is the percentage change in krone dollar exchange rate,  $x_{ECU,t}$  is the percentage change in krone ECU exchange rate, and  $u_{mt}$  is an error term. Data from 1982 through 1998. The left hand panel reports the 1-step residuals and two times their standard error bands. The right hand panel of figure 1 reports the 1-step Chow tests along with the 5% critical value which is reported as a horizontal straight line.

Figure 1 report the results of these two tests. The left hand panel reports the 1-step residuals and two times their standard error bands. Evidence of instability is reflected in the 1-step residuals breaking the two times standard error bands. This occurs in the early 1990s which correspond to changes in exchange rate policy. The right hand panel of figure 1 reports the 1-step Chow tests along with the 5% critical value, which is shown as a horizontal straight line. The Chow tests confirm that there is instability in the

<sup>12</sup>The 1-step Chow tests are scaled by their critical values at the 5% level at each  $t$ . This gives a 5% critical value as a straight line independent of  $t$  and the changing degrees of freedom.



exposure regression in the early 1990s corresponding to the policy changes.<sup>13</sup> The data and exposure regression therefore seem to support our priors that policy changes by the authorities have affected the extent of exchange rate exposure. This should therefore be taken into account in estimation of exposure.

Turning to the sub-periods determined by the regimes reveals some interesting temporal instability in the exposure coefficients. We reestimate the model with orthogonal macro factors as defined in equations (5), (6), (7) and (8) for the three regimes. The macro factors include both domestic and international variables. Table 4 reports the resulting exposure coefficients. Panel A reports the dollar exposures. When the dollar is part of the basket to which the kroner is pegged (1983-1990) only the Resources industry has a statistically significant exposure. Recall that resources includes Oil which is the sector that is most likely to suffer from an appreciation. There are another three industries which have negative exposure. The remaining four industries have positive exposure. This presents the first piece of evidence that regimes are important since we now have different signs across different industries. Whilst it is not necessary that this should be the case in order to rule out spurious affects caused by correlations amongst the economy, exchange rates and stock returns that are unrelated to exposure, it certainly makes this potential explanation less likely.

The average size of the exposure coefficient is smaller than that of the whole sample estimates and reflects the notion that pegging reduces exposure. This idea is further illustrated when we consider the second regime, which is characterized by the dollar falling out of the peg and the kroner depreciating. There are three exposure coefficients that are statistically significant. (Another two at the 10% level.) Generally the size of the exposures have increased relative to the first sub-period. For example, the average exposure in the first period was 0.311 for the positive exposures and  $-0.279$  for the negative exposures. In the second period the average is more than double at 0.717. This suggests that when the kroner is no longer pegged to the dollar, a depreciation of the kroner relative to the dollar increases stock returns. The effect (exposure) is greater than under a pegged system. Again this must be related to the dollar revenues that many firms in Norway have. The differences in magnitudes of the exposures across different sectors is similar to that of the first regime.

In the final free-floating period, the dollar exposures are very similar to the 1990-1993 period and four are statistically significant (a further one at the 10% level). Utilities, which in Norway have no relationship to the oil sector, has the smallest exposure and it is not statistically significant. When there is no change in regime with respect to the dollar, as in this case, there is no change in exposure. Therefore, it is unlikely that our results reflect some other effect on stock returns.

The ECU exposures over the sub-period 1983-1990 are all negative and statistically significant, suggesting that a depreciation of the kroner relative to the ECU decreases stock returns, as in the whole sample. Relative to the whole sample the exposures are larger in the first period. Note that in the first period there was a one off devaluation of 9%. When the dollar is dropped from the basket to which the kroner is pegged in 1990-

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<sup>13</sup>Preliminary analysis indicated instability around the 1987 stock market crash as well as at times of exchange rate regime changes. In order to abstract from the crash we first regressed the market excess return on an October 1987 and a November 1987 dummy using OLS, and subsequently regressed the residuals from this regression on the two exchange rates using RLS to perform the stability tests.

**Table 4** Exposure estimates in different regimes

## Panel A: Dollar Exposures

|     | 1983 through 1989 | 1990 through 1992 | 1993 through 1998 |
|-----|-------------------|-------------------|-------------------|
| RE  | 0.457<br>(2.96)   | 0.357<br>(1.81)   | 0.776<br>(4.14)   |
| BS  | 0.436<br>(1.78)   | 0.412<br>(1.24)   | 0.616<br>(2.46)   |
| GE  | -0.192<br>(0.80)  | 0.362<br>(1.25)   | 0.865<br>(3.47)   |
| NCG | 0.198<br>(0.73)   | 0.646<br>(1.42)   | 0.673<br>(1.74)   |
| CS  | 0.152<br>(0.39)   | 0.985<br>(2.67)   | 0.845<br>(3.55)   |
| FI  | -0.373<br>(1.39)  | 0.999<br>(2.64)   | 0.466<br>(1.31)   |
| TL  | -0.356<br>(1.03)  | 1.445<br>(2.29)   | -0.040<br>(0.11)  |
| UT  | -0.198<br>(0.55)  | 0.527<br>(1.70)   | 0.007<br>(0.02)   |

## Panel B: ECU Exposures

|     | 1983 through 1989 | 1990 through 1992 | 1993 through 1998 |
|-----|-------------------|-------------------|-------------------|
| RE  | -2.445<br>(6.41)  | -2.297<br>(2.01)  | -2.187<br>(7.47)  |
| BS  | -2.456<br>(4.06)  | -0.573<br>(0.30)  | -0.824<br>(2.08)  |
| GE  | -2.854<br>(4.82)  | 1.157<br>(0.69)   | -2.009<br>(5.11)  |
| NCG | -1.416<br>(2.13)  | -0.869<br>(0.33)  | -3.097<br>(5.06)  |
| CS  | -3.792<br>(3.98)  | -3.555<br>(1.67)  | -1.726<br>(4.59)  |
| FI  | -1.597<br>(2.40)  | 1.754<br>(0.80)   | -2.650<br>(4.74)  |
| TL  | -2.111<br>(2.34)  | -1.096<br>(0.30)  | -0.903<br>(1.71)  |
| UT  | -1.666<br>(1.88)  | -2.102<br>(1.17)  | -0.335<br>(0.53)  |

The table shows coefficient estimates of currency exposure in the equation

$$r_{it} = \alpha_{i0} + \alpha_{i1}^{TO} u_{ECU,t} + \alpha_{i2}^{TO} u_{USD,t} + \beta_{i1} u_{mt} + \gamma_i z_t + \varepsilon_{it},$$

Here  $r_{it}$  is the excess return on industry  $i$ , and  $u_{ECU,t}$ ,  $u_{USD,t}$ ,  $u_{mt}$  are the orthogonalized versions of respectively ECU changes, USD changes and the return on a Norwegian stock market index. The orthogonalizations are shown in equations (6), (7) and (5). The vector  $z_t$  contains the macrofactors: The term structure of interest rates, inflation, the change in industrial production and the price of oil, and finally the spread of the Norwegian interest rate relative to respectively the US 3 month T-bill rate and the 3 month ECU rate. The results are reported for the three regimes. Panel A reports the dollar exposures and panel B the ECU exposures. The tables lists the coefficient estimates with t-values in parenthesis Industries are abbreviated as: RE: Resources, BS: Basic, GE: General, NCG: Non-Cyclical Consumer Goods, CS: Cyclical Services, FI: Financial, TL: Telecommunications and Media, and UT: Utilities.

1993 and the kroner is pegged against the ECU, we observe that the exposures in all but two cases are statistically insignificant and in all but one case negative. The coefficients are also generally smaller. This is likely to reflect closer pegging to the ECU. In sharp contrast, when the kroner is free to float in the period of 1993-1998, all exposures are negative and all but one (utilities) are statistically significant. The empirical evidence thus suggests that freely floating exchange rates increase the exposure of firms, as would be expected.

Comparing all the three regimes, estimated exposures are highest for the dollar when it is freely floating relative to the kroner. There are also more statistically significant exposure coefficients in the second two regimes (free floating regimes). Therefore, regimes do appear to be important.

It is important to show that exposures are economically important across the regimes. Table 5 reports analysis into this issue. Panel A reports the partial  $\bar{R}^2$  of the exchange rates with respect to sectors in the sub periods. The partial  $\bar{R}^2$  measure the influence of an independent variable on the dependent variable holding the influence of the other variables constant. It thus provides a measure of how important one independent variable is relative to another, and can be used to demonstrate the economic importance of the regimes on exposure. For example, as regimes change between different currencies, if the regimes are important, then the exposures of different currencies should be different across regimes.

In the first regime of pegging to both the dollar and the ECU the partial  $\bar{R}^2$ 's are largest for the ECU which suggests the ECU has a larger impact than the dollar. In fact, the Resources industry is the only one which has an important dollar exposure. In the second regime when the dollar is floating and the ECU is the peg there is a large increase in the partial  $\bar{R}^2$  with respect to the dollar and a fall with respect to the ECU. This reflects the economic role of the regime on the exposure: once a currency is free floating it becomes more important in terms of exposure. The ECU partial  $\bar{R}^2$ 's fall because the peg is entirely in terms of this currency in the second regime.

In the final free floating regime we observe an increase in the ECU's partial  $\bar{R}^2$  relative to the two earlier regimes when the kroner was pegged to the ECU. This provides further evidence that regimes and the exchange rate exposures in them have an important economic impact on industry stock returns.

We also measure the overall impact of exchange rates on the sectors in the different regimes by reporting in panel B the percentage increase in the  $\bar{R}^2$  in the three regimes.<sup>14</sup> As was the case over the whole sample period, the exchange rates have important economic effects in all regimes. However, as one would expect, the economic impact is more important in the free floating regime.

Another way to assess the economic importance of exchange rates is to compute the average percentage impact the exchange rates have on returns by multiplying the exposure coefficient with the average change in the exchange rate. For the dollar the effects, in percent per month are:  $-0.025\%$  for the positive exposures,  $-0.022\%$  for the negative exposures in the first period;  $0.10\%$  in the second period and;  $0.07\%$  in the final period (ignoring the one negative exposure). For the ECU the effects are:  $-0.38\%$  in the first sub period;  $-0.29\%$  for the negative exposures and  $0.24\%$  for the positive exposures in

<sup>14</sup>Recall that this is the percentage change in the  $\bar{R}^2$  when moving from the model with the orthogonal market portfolio to the model with the orthogonal market portfolio and the two exchange rates.

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**Table 5** Economic Importance of Exposures Across Regimes

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Panel A: Partial  $\bar{R}^2$ 

|     | 1983 through 1989 |       | 1990 through 1992 |       | 1993 through 1998 |       |
|-----|-------------------|-------|-------------------|-------|-------------------|-------|
|     | ECU               | USD   | ECU               | USD   | ECU               | USD   |
| RE  | 35.50             | 10.56 | 13.44             | 11.19 | 47.36             | 21.65 |
| BS  | 17.82             | 4.00  | 0.30              | 5.58  | 6.55              | 8.89  |
| GE  | 23.94             | 0.85  | 1.79              | 5.66  | 29.63             | 16.26 |
| NCG | 5.77              | 0.73  | 0.42              | 7.19  | 29.14             | 4.60  |
| CS  | 17.63             | 0.21  | 9.68              | 21.52 | 25.61             | 16.89 |
| FI  | 7.22              | 2.54  | 2.40              | 21.13 | 26.59             | 2.65  |
| TL  | 6.94              | 1.41  | 0.34              | 16.78 | 4.45              | 0.19  |
| UT  | 4.55              | 0.41  | 5.00              | 10.00 | 0.45              | 0.00  |

Panel B: Percentage change in  $\bar{R}^2$ 

|     | 1983–1989 | 1990–1992 | 1993–1998 |
|-----|-----------|-----------|-----------|
| RE  | 11.84     | 3.95      | 29.03     |
| BS  | 14.28     | −0.63     | 16.38     |
| GE  | 31.70     | 0.00      | 22.03     |
| NCG | 1.88      | 0.70      | 44.73     |
| CS  | 31.25     | 20.75     | 34.09     |
| FI  | 12.90     | 11.67     | 39.47     |
| TL  | 22.72     | 56.25     | 7.14      |
| UT  | 3.03      | 16.12     | −1.66     |

The table gives additional diagnostics to the regression reported in table 4. Panel A lists partial  $\bar{R}^2$  between excess industry returns and the two currencies US dollar and ECU. Panel B contains the percentage change in the adjusted  $R^2$  when moving from a regression of the sector excess return on a constant and the orthogonalized market portfolio to a regression of the sector excess return on a constant, the orthogonalized market portfolio and the percentage changes in the exchange rates. Industries are abbreviated as: RE: Resources, BS: Basic, GE: General, NCG: Non-Cyclical Consumer Goods, CS: Cyclical Services, FI: Financial, TL: Telecommunications and Media, and UT: Utilities.

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the second period; and 0.17% in the final period.

In summary we have shown through this analysis that regimes are important in terms of determining the sign of exposure coefficients in the sense that there is some cross-sectional differences in the signs of exposure coefficients when we allow for regimes. The size, economic and statistical importance of exchange rate exposure coefficients is also different across regimes.

## 6 Investigating the robustness of the results

This section provides a short summary of a number of robustness tests we have undertaken.<sup>15</sup>

The industry classifications we have chosen are very broad and a finer classification may reveal a different cross section of exposure coefficients. We assessed whether this was important by collecting data on 16 classifications at a level where there are 48 industry classifications.<sup>16</sup> Whilst this finer set of industry classifications provides a greater cross-sectional distribution of the exposure coefficients, our findings are basically the same as those for the broader industry definitions.

A potential problem with our results is that if we have omitted an important variable then the exposure results could be spurious. To assess the likelihood of this, we therefore include alternative factors when orthogonalizing the exchange rates and the stock returns. We consider Norwegian versions of the Fama and French SMB and HML factors since these factors are known to do a very good job in describing the time series of returns. The inclusion of these factors has no effect on the exposure coefficients.

We have also estimated the exposure coefficients using a seemingly unrelated regression (SUR) model in order to allow of cross-equation correlation of the residuals. However, this had no impact.

Our final robustness check was to estimate exposure of size portfolios, both equally and value weighted. We found that the use of these portfolios does not affect the results either. There is some slight evidence to suggest that exposure coefficients get larger with firm size which could reflect the notion that large firms are more likely to be involved in international trade.

## 7 Conclusion

In this paper we have used data from the Norwegian equity market to investigate currency exposure. The Norwegian market is particularly well suited for such an investigation since Norway has a very open economy with exports and imports between 30 and 40 per cent of GDP over the period considered. Comparing our results across estimation methodologies, a currency basket and two currencies, and across different currency policy regimes, reveals some important insights. First, estimation of exposure coefficients is sensitive to whether the market portfolio is included in the regressions, and to whether we orthogonalize the exchange rate factor and the market portfolio. We find important economic and statistical exposure when we adjust stock returns and exchange rates for potential

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<sup>15</sup>Detailed results are available on request.

<sup>16</sup>There are only 16 of the 48 industries available for the entire sample period.

common covariation based on economic variables that are unrelated to firm exposure. In addition, orthogonalization provides the all important total exposure measures which are of interest to managers, investors and regulators.

Second, by using two individual currencies, the US dollar and the ECU, instead of a currency basket, we have been able to show that exposure depends on the currency in question. Typically Norwegian industries have a negative exposure to the kroner/ECU rate and a positive exposure to the kroner/dollar rate. These exposures can be explained by the relative importance in Norway of oil and hence the different roles of the dollar and the ECU. Important lessons here are that the signs of exposures are not consistent across currencies. It is therefore important to consider individual currencies if we are to get an indication of the true total exposure. For the actual end users of exposure coefficients these issues are extremely important.

Thirdly, the currency policy regime for the krone has affected the exposures of industries to the dollar and the ECU. In the period when the krone was pegged to a basket that included the dollar, the sign of the (dollar) exposure was mixed across industries and only three were significant. However, we saw that when the dollar was dropped from the basket to which the krone was pegged, (dollar) exposures became positive. This pattern continued in the free floating period. For the ECU we found that when the krone was pegged against the ECU only, the (ECU) exposure coefficients became statistically insignificant. In the final regime of free floating all (ECU) exposures became statistically significant.

Overall, our results provide comprehensive evidence that exchange rate exposure is statistically significant and economically important. The variations in industry exchange rate exposures over various regimes and currencies are easily interpretable in the light of economic events and facts. The empirical results underlining these observations are robust to omitted variables and lagged exchange rate effects. Our results should have important implications for extant studies which have concluded that exchange rate exposure is not important, either statistically or economically.

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