Estimating short term exchange rate exposure for New Zealand firms*

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Abstract

Using daily stock market data, we examine short term exchange rate exposure for New Zealand firms, allowing for an asymmetric response to changes in the exchange rate. Unlike previous studies, which typically use monthly data, we categorise periods of appreciation and depreciation in five bilateral exchange rates, and an index, using the underlying trends in the rates. Using this methodology, we find very few firms with significant exposure, despite many of these firms being net importers or exporters. To a large extent, the sign on the exposures are predictable, based on categorisation of firms as importers or exporters. We also examine exposure of industry-based portfolios.

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1 Modelling exchange rate exposure

Any firm trading in a domestic market, whose profit relies on imported raw materials or exported final product, or indeed who is competing with any such firm, is potentially exposed to exchange rate movements. This may be particularly relevant for firms in a small open economy such as New Zealand's.

Exchange rate exposure has been defined as the sensitivity of stock returns to changes in the exchange rate (Adler & Dumas 1984). This is typically estimated in a regression framework by measuring the coefficient of exchange rate movement in a predictive model for stock returns; see for example Jorion (1990), Bartov & Bodnar (1994), Chow & Chen (1998). Estimation of a significant relationship has largely been unsuccessful for US data, possibly due to the lesser importance placed on international trade by US firms (Griffin & Stulz 2001).

Study of the relationship between equity returns and exchange rate movements has largely been restricted to the US and Japanese markets, and to a model where the reaction to increases and decreases in exchange rates is symmetric. There are various theories that suggest that asymmetric response should be expected, and these are summarised by Koutmos & Martin (2003). Examples include: *pricing to market*, where export prices are affected by the degree of competition in foreign markets, and may be destination-specific, with the effect that equity in the domestic market would decrease less with domestic currency appreciation than their expected increase with depreciation; *hysteretic behaviour*, where effects might persist after original causes of the effects cease to exist, e.g. irreversibility of investment, where a firm induced to enter a foreign market by a favourable exchange rate does not leave when the domestic currency depreciates; *asymmetric hedging behaviour*, where a firm protects against currency movements in one direction, but not the other. Here, we follow recent studies by Di Iorio & Faff (2000), Koutmos & Martin (2003) and Bartram (2004) and allow asymmetric exposure to exchange rate movements.

2 Methodology and results

We choose to analyse firms in a small open economy: New Zealand, using data from 2004. In that year, New Zealand imported 34,905 $NZ million and exported 30,729 $NZ million. Of the total trade, 21.7% was with Australia (45% of that were exports), 12.7% with the USA (53% exports), 11.2% with

Japan (47% exports), followed by the People's Republic of China, and the United Kingdom. An additional 11.7% to economies using the Euro currency (Statistics New Zealand 2004).

New Zealand's dollar was floated in March 1985, and its value has been determined by market forces since. While the Reserve Bank of New Zealand intervened directly in currency market operations in June 2007, such intervention was unprecedented until then. The relative importance of overseas trade, and the absence of intervention, make the New Zealand equity market a prime target for analysis of exchange rate exposure.

Following Di Iorio & Faff (2000) and Koutmos & Martin (2003), we use an augmented market model to estimate foreign exchange exposure. Specifically, we fit

$$R^e_{it} = \beta_{i0} + \beta_{i1} R^e_{mt} + (\beta_{i2} + \beta_{i3} D_t) RFX_t + (\beta_{i4} + \beta_{i5} D_{t-1}) RFX_{t-1} + \varepsilon_{it} \quad (1)$$

where $R^e_{it} = R_{it} - R_{ft}$ is the excess return of firm i on day t, with observed return $R_{it} = \Delta \log P_{it}$ and risk-free rate R_{ft}, $R^e_{mt} = R_{mt} - R_{ft}$ is the excess return on the market portfolio, D_t is a dummy variable, equal to zero in a period of currency appreciation, and one otherwise, and $RFX_t = \Delta \log FX_t$ is the return on the exchange rate, where FX_t is measured as the price of one New Zealand dollar in the foreign currency. We give a precise definition of D_t in Section 2.2.

2.1 Data selection

We estimate (1) for the individual constituents of the NZX 50 index, and the following 18 industry indices: Building materials and construction, Consumer, Energy, Finance and Other Services, Food and beverages, Forestry and forest products, Goods, Intermediate and Durables, Investment, Leisure and Tourism, Media and Telecommunications, Mining, Primary, Property, Ports, Services, Transport, and Textiles and apparel. The market portfolio is defined to be the value-weighted portfolio of all stocks traded on the NZX. Stock and market price data are obtained from Datastream.

Unlike previous studies, we choose to use daily data for the analysis. A weakness of using monthly data to estimate exchange rate exposure is that a large time span must be used. A year's daily equity data typically amounts to in excess of 250 returns, or the equivalent of over 20 years' monthly data. While an individual firm's exposure to movements in a single foreign exchange series may reasonably be assumed constant over the period of one year, this

cannot confidently be said over two *decades*, in general. In particular, Jorion (1990) reports evidence of changing exposure for his sample of US stocks. Use of daily data, and a short data period is consistent with recommendations given by Wright, Mason & Miles (2003), who, in the context of estimating CAPM betas, recommend a short data period of one to two years and the use of daily data.

Use of daily data typically results in heteroskedasticity in the residuals. Rather than modelling this feature parametrically, we instead use heteroskedasticity and autocorrelation consistent estimates of the covariance matrix of the regression residuals (Andrews 1991). This has no effect on the point estimates of the parameters, but does affect their statistical significance.

Non-synchronous market data have lead us to include the lagged foreign exchange rate returns in (1). The stock prices used in this study are closing prices, recorded at 5:00pm, the end of each trading day. In contrast, the exchange rates are recorded by the Reserve Bank of New Zealand at 11:10am. Due to the overlap between the day t stock return (5:00pm yesterday[1] to 5:00pm today), and the day t exchange rate return (defined as 11:10am today to 11:10am tomorrow), we include the lagged exchange rate return, so that in total, we relate today's stock return to changes in the exchange rate from 11:10am yesterday to 11:10am tomorrow.

Theoretical models of exchange rate exposure typically posit relationships in terms of real exchange rates. The Reserve Bank of New Zealand targets inflation to be within 1 to 3% per annum. As a result, the corresponding inflation rate per day is likely to be very small, and thus safely ignored, i.e. on a daily scale, the real and nominal exchange rate returns will be almost identical. Consequently, we use the nominal rates available from the Reserve Bank.

We consider five currencies: the American dollar, the Australian dollar, the British pound, the Japanese yen, and the Euro. In addition, we include a trade weighted index (TWI), based on the five bilateral rates. The USD/NZD rate is a directly traded exchange rate, while the other four bilateral rates are cross rates. The data are daily, and sourced directly from the Reserve Bank of New Zealand, and are indicative market mid-rates collected at 11.10am, published by Reuters. The regression equation (1) is estimated separately for each exchange rate.

[1]Yesterday is defined to be the previous trading day.

2.2 Defining exchange rate regimes

One of the previous benefits of using monthly data was to allow an obvious definition of periods of appreciation and depreciation in the exchange rate, i.e. a period of appreciation is one over which the price of the NZD in the foreign currency goes up (the New Zealand dollar becomes more valuable), and a period of depreciation is one over which its price goes down. Using monthly data, the relevant period is the month over which the return is calculated.

For each of the five currencies, and the trade weighted index, the observed price is FX_t which represents the number of units of foreign currency needed to purchase \$1NZ. If this number goes up, i.e. if $\Delta FX_t \equiv FX_t - FX_{t-1} > 0$, then the New Zealand dollar has become more expensive, and we say it has appreciated. While these changes make sense from day to day, the theory behind asymmetric exchange rate exposure tends to focus on "periods of appreciation" and we question whether a single day is in the spirit of this.

Applying the definition

$$D_t = \begin{cases} 0 & \Delta FX_t > 0 \\ 1 & \Delta FX_t \leq 0 \end{cases}$$

directly to daily data results in an indicator D_t which is highly volatile, and does not reflect the underlying direction of the currency. For example, daily changes in the USD/NZD rate in 2004 yield an indicator whose median duration of periods of appreciation is 1 day (maximum 5 days, over 64 complete cycles) and of periods of depreciation is 1.5 days (maximum 9 days, over 64 complete cycles).

Instead, we define the dummy variable as follows

$$D_t = \begin{cases} 0 & \Delta\widetilde{FX}_t > 0 \quad \text{(appreciation)} \\ 1 & \Delta\widetilde{FX}_t \leq 0 \quad \text{(depreciation)} \end{cases} \tag{2}$$

where $\widetilde{FX}_t$ is the estimated trend in the exchange rate series, and $\Delta = 1 - B$ is the difference operator. Since FX_t measures the price of one NZ dollar in the foreign currency, $\{D_t = 0\}$ indicates periods of appreciation in the NZ dollar, and $\{D_t = 1\}$ periods of depreciation. This specification allows the exchange rate to exhibit short term decreases during periods of appreciation, and short term increases during periods of depreciation, without recategorising the current state.

	Daily - app			Daily - dep			Monthly - app			Monthly - dep		
Currency	Med	Max	#	Med	Max	#	Med	Max	#	Med	Max	#
USD	1	5	64	1.5	9	64	19.0	64	5	12.0	32	5
GBP	1	6	66	1.0	11	65	13.0	59	5	15.0	36	6
AUD	2	7	62	1.5	8	62	18.5	45	6	16.5	36	6
JPY	1	6	64	1.5	9	64	18.0	27	7	12.0	40	7
EUR	1	5	66	2.0	6	65	17.0	37	6	13.0	30	6
TWI	1	4	67	1.0	7	67	21.5	39	6	11.5	32	6

Table 1. Lengths of periods of appreciation and depreciation in the five currencies and the trade weighted index. The median length of period, maximum length of period, and number of periods (#) are given daily, based on the raw figures, and monthly, based on a 21-pt moving average.

Various methods are available for estimating the trend of the exchange rate series $\widetilde{FX}_t$. We have used a symmetric 21-pt moving average with a triangular weight function (the convolution of a symmetric 11-pt moving average). For this study we used a non-robust estimator, however if the exchange rates were particularly volatile the robust smoothing algorithm loess (Cleveland, Grosse & Shyu 1992) may provide more reliable trend estimates. Generally, a trend based on any symmetric moving average with span sufficient to ensure a smooth trend estimate should suffice. We use a symmetric moving average, i.e. based on past, present and future prices, to best enable us to detect turning points in the foreign exchange price. However, we assume that investors are able to determine these exactly using only past and present prices. We use additional data at the ends of the time series to avoid end effects.

The estimated dummy variables are represented graphically in Figure 1 along with the observed price series. Periods of depreciation are shown in grey. As we can see in the graph, the grey periods typically encompass the sections of the data when the price is moving downwards, and the white periods typically encompass sections which the price is moving upwards. In contrast, Figure 2 shows the dummy variable defined according to movements over individual days. The erratic nature of the variable under that definition is clear.

2.3 Exposure estimates

First New Zealand Capital are an investment bank operating in New Zealand. Wong (2008) provides their classification of the current NZX50 firms according to their net importing behaviour. These classifications are shown in Table 2, and are as follows: *Net importers of products* who "benefit from a

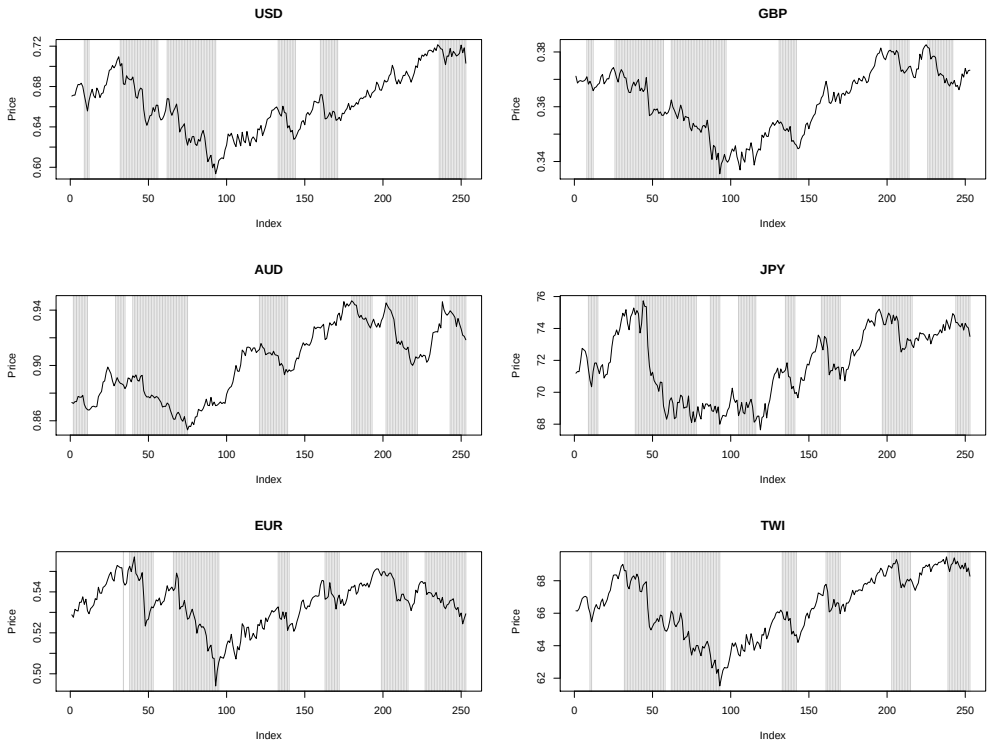

Figure 1. Daily foreign exchange rates for New Zealand's major trading partners for 2004. From the top, left to right: United States Dollar, Great Britain Pound, Australian Dollar, Japanese Yen, Euro, and the Trade Weighted Index. The grey periods indicated estimated periods of depreciation ($D_t = 1$), the white periods, periods of appreciation ($D_t = 0$), based on a 21-pt triangular weighted average.

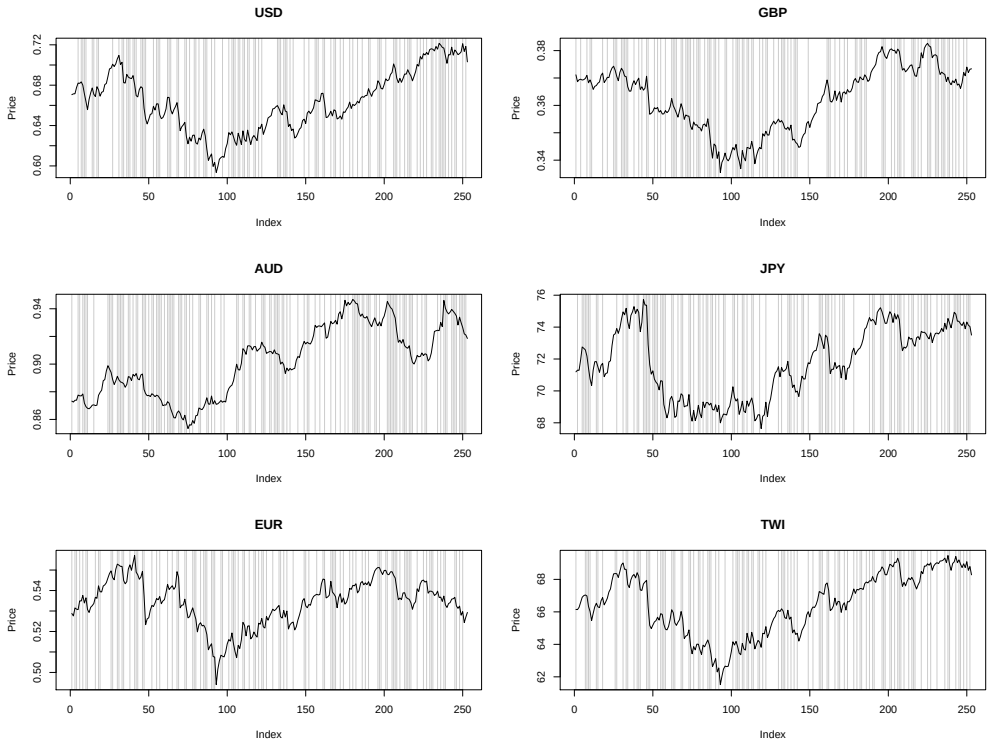

Figure 2. Daily foreign exchange rates for New Zealand's major trading partners for 2004. From the top, left to right: United States Dollar, Great Britain Pound, Australian Dollar, Japanese Yen, Euro, and the Trade Weighted Index. The grey periods indicate days of depreciation $\Delta FX_t \leq 0$, the white periods, days of appreciation.

Net importers	Little exposure	Small exposure
Air New Zealand (AIR)	Contact Energy (CEN)	Auckland Internat. Airport (AIA)
Briscoe Group (BGR)	Freightways (FRE)	Fletcher Building (FBU)
Hallenstein Glasson (HBY)	Property Companies	Infratil (INF)
Hellaby Holdings (HLG)	Renaissance Corp	Lyttelton Port Company (LPC)
Sky Network Television (SKT)	Restaurant Brands (RBD)	PGG Wrightson
Warehouse Group (WHS)	Ryman Healthcare (RYM)	Port of Tauranga (POT)
	Telecom NZ (TEL)	Sky City Entertainment (SKC)
	Trustpower (TPW)	Steel and Tube (STU)
	Vector	Tourism Holdings (THL)
	Export focus	Significant exporter
	Cavalier Corp (CAV)	Cavotec
	F&P Appliances (FPA)	Delegat's Group
	Guinness Peat Group	F&P Healthcare (FPH)
	Mainfreight (MFT)	NZ Oil and Gas (NOG)
	Nuplex Industries (NPX)	Pike River Coal
	Pumpkin Patch (PPL)	Rakon
		Rubicon (RBC)
		Sanford (SAN)
		Tenon (TEN)

Table 2. Classification of firms by First New Zealand Capital according to their net importing behaviour, and their subsequent exposure to the NZD price.

stronger NZD"; *Little direct or indirect exposure* to foreign currency; *Small direct or indirect exposure* to foreign currency, who prefer a weak NZD; *Export or overseas focus* who "directly benefit from weaker NZD"; and *Significant export or overseas focus* who are "major beneficiaries of weak NZD". These classifications are independent of this work, and the source of them is undisclosed. Assuming that the methodology is not based on a regression analysis such as the one that follows, it gives us a direct way of testing the validity of this work.

We proceed by estimating (1) for each of the firms and industry portfolios in our sample. We estimate it separately for each of the six exchange rates. Recall the regression equation is

$$R^e_{it} = \beta_{i0} + \beta_{i1} R^e_{mt} + (\beta_{i2} + \beta_{i3} D_t) RFX_t + (\beta_{i4} + \beta_{i5} D_{t-1}) RFX_{t-1} + \varepsilon_{it}$$

and we define a firm to have significant exposure to the currency if the F-test of $H_0 : \beta_{i2} = \beta_{i3} = \beta_{i4} = \beta_{i5}$ is rejected. Exposure will be asymmetric if either of $H_0 : \beta_{i3} = 0$ or $H_0 : \beta_{i5} = 0$ is rejected. We will also consider whether or not the coefficients β_{ij}, $j = 2, 3, 4, 5$ are significantly different from zero, even if the overall F-test is not rejected. The signs of estimates will be reconciled with the classification in Table 2.

The results of the F-tests are shown, by currency, in Table 3. Featured in the table are all firms whose F-test p-values were below 10%, with significance at the 5% and 1% levels indicated. Comparison of the firms with significant ex-

USD	GBP	AUD	JPY	EUR	TWI
AXA*	MFT*	AMP**	CEN*	CAV	KIP
FBU	MHI	ANZ**	MFT*	FPA*	MFT*
FRE*	SKC	MFT**	RYM	MFT**	NOG
KIP	TLS*	TLS**		NOG	TLS*
MFT*	THL*			TLS**	
TLS					
WBC*					

Table 3. Firms with significant exchange rate exposure parameters, based on an F-test of $H_0 : \beta_{ij} = 0, j = 2, 3, 4, 5$ for the estimated regression model (1). Assets whose F-test p-values are less than 10% are included in the table; significance levels of less than 5% and 1% are also indicated (by * and ** respectively).

posure to the classifications provided by Wong (2008) yields some interesting results.

2.3.1 Individual firms

Of the importers, none are exposed to any of the currencies based on the F-test. As importers, we would expect the exposure coefficients β_{i2} and β_{i4} to be positive, since an increasing price for the NZD in the foreign currency should be good news for domestic equity returns. Examining individual coefficients, AIR has significant exposure to the contemporaneous USD rate and the TWI, only these are both of the wrong sign. HLG has significant exposure to the contemporaneous pound (wrong sign) and the lagged pound (correct sign). SKT has mildly significant exposure to the pound (contemporaneous, correct sign), the yen (lagged, correct sign), the Euro (contemporaneous, correct sign). WHS has significant exposure to the lagged Euro, of the correct sign. The exposure is significantly asymmetric in this case.

Of the firms with an export focus (the fourth category), we would expect an appreciating NZD to be bad for them, and so we would expect negative exposure coefficients β_{i2} and β_{i4}. Based on the F-test, MFT is exposed to all five individual currencies (but not the TWI), and CAV and FPA are exposed to the Euro. CAV has significant exposure to the Euro (contemporaneous, incorrect sign). FPA has significant exposure to the USD, pound, Euro and TWI (lagged, correct sign). The exposure to the Euro is asymmetric. While overall exposed, MFT's significant coefficients are limited to the Yen (contemporaneous, correct sign). NPX has USD, pound, Yen and TWI exposure (lagged, correct sign). PPL has no significant coefficients.

USD	GBP	AUD	JPY	EUR	TWI
Investment	Transport*	Investment*	Energy	Consumer	Mining
Transport*		Mining*	Transport*	Mining*	Transport*
				Transport	
				Text & apparel*	

Table 4. Industry portfolios with significant exchange rate exposure parameters, based on an F-test of $H_0 : \beta_{ij} = 0, j = 2, 3, 4, 5$ for the estimated regression model (1). Assets whose F-test p-values are less than 10% are included in the table; significance levels of less than 5% and 1% are also indicated (by * and ** respectively).

Of the firms with a significant export focus, only NOG is exposed to the Euro, and the TWI based on the F-tests. FPH, RBC and TEN have no significant coefficients. NOG has significant exposure to the USD, pound, Euro, and TWI (lagged, incorrect sign). These are all significantly asymmetric. SAN has significant exposure to the USD, pound, Yen, and TWI (contemporaneous, correct sign), with the USD exhibiting lagged significance as well.

2.3.2 Industry portfolios

We now examine the 18 industry portfolios of the NZX using the same methodology as for the individual firms.

Based on the F-tests, very few industry portfolios have significant exposure. the transport sector is exposed to all currencies except the AUD, while Investment is exposed to the USD and AUD, Mining is exposed to the AUD, the Euro and the TWI, Energy is exposed to the Yen, and Textiles and Apparel, and Consumer are exposed to the Euro. This is summarised in Table 4, along with indicated significance levels.

Five industry portfolios have no significant coefficients at all. These are: Food and Beverages, Goods, Media and telecommunications, Primary, and Services.

Of the others, the following industries are loosely classified as Importers: Building materials and construction (contemporaneous asymmetric exposure to the USD), Consumer (lagged exposure to the pound, and lagged asymmetric exposure to the Euro), Finance and other services (lagged exposure to the pound, Euro and TWI; contemporaneous asymmetric exposure to the Yen; lagged *negative* exposure to the AUD), Mining (lagged asymmetric exposure to the USD; lagged exposure to the pound and Euro; lagged *negative* exposure to the AUD), Property (lagged exposure to the TWI), Ports (lagged

asymmetric exposure to the Yen), and Textiles and apparel (contemporaneous exposure to the pound, and contemporaneous asymmetric exposure to the Euro).

The remaining industries are loosely classified as Exporters: Energy (contemporaneous asymmetric exposure to the yen, and lagged asymmetric exposure to the Euro), Forestry and forestry products (contemporaneous asymmetric exposure to the USD), Intermediate and durables (lagged exposure to the Euro), Investment (lagged asymmetric exposure to the USD, contemporaneous asymmetric exposure to the AUD, and lagged exposure to the yen), Leisure and tourism (lagged exposure to the USD, pound, yen, Euro and TWI), Transport (contemporaneous exposure to the USD, pound and TWI).

3 Conclusions

These preliminary results show some promise, in that the signs on estimated coefficients often accord with the actual trading behaviour of the firm in question. However, the results also indicate that either New Zealand firms engaged in net import or export activity are not exposed to foreign currency movements, or that they are exposed but the methodology is failing to detect it. If foreign exchange hedging is prevalent, we might expect to see lack of direct exposure, however, theory predicts asymmetric exposure even in this case.

A Postscript

This research is "work in progress" and is based on a masters thesis completed in 2005. The data are somewhat out of date. A full data set should be obtained which contains all firms in Table 2, and it should be checked that regression-based classifications endure over time. Although preliminary results indicate that asymmetry may not actually be important, use of a Markov Switching model to define periods of appreciation and depreciation should be considered.

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