Over the hedge:
Do exporters practice selective hedging?

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Abstract

What determines exporters' exchange rate hedging decisions and do exporters attempt to "time the market"? We use a unique unit record longitudinal administrative dataset on firm exports to find the determinants of exporters' currency hedging choices. Determinants include financial fragility, prior hedging experience, and natural hedge opportunities. In addition, firms alter their hedging ratios when the currency has recently trended in one direction. We test whether such behaviour reflects firm characteristics (such as pricing power). We find that these responses are ubiquitous for all but large firms and for all times other than when the exchange rate is near its extreme high or low historical values. These results are consistent with most firms practicing selective hedging (market timing) behaviour that reflects a belief in exchange rate momentum effects. However, this behaviour appears sub-optimal since momentum effects are statistically absent from the underlying exchange rate data.

JEL codes

D21; F31; G15

Keywords

Currency hedging; optimal hedging; selective hedging; momentum trading

1 Introduction

Exporting potentially exposes firms to substantial risk from currency fluctuations. Under the efficient markets hypothesis, there is no gain in firm value through hedging these risks (Modigliani and Miller 1958). In practice, however, many exporters do hedge foreign exchange risk, and a body of theoretical and empirical work seeks to explain why this behaviour may represent an optimal strategy. Recently, it has also been postulated that some firms appear to alter their hedge positions in an attempt to "time the market." This behaviour is often dubbed selective hedging. Such behaviour has implications not only for individual firm outcomes, but also for market efficiency with the potential to create herd behaviour in currency markets (Shiller 2005).

We analyse the currency hedging behaviour of exporters, testing for the presence of selective hedging at the firm level, whilst controlling for static and dynamic optimal hedging determinants. We focus on a single trade and currency relationship: New Zealand firms' exports to Australia denominated in Australian dollars (AUD). We do so using data covering virtually all New Zealand goods exporters. The data include mandatory daily merchandise trade shipment filings providing the currency in which each trade was contracted, and whether the trade was hedged back into New Zealand dollars (NZD).

We model firms' hedge ratios – the proportion of AUD exports hedged back into NZD – as a function of firm characteristics, foreign exchange market risk and changes in the NZD/AUD[1] exchange rate. Standard theories of optimal hedging are supported by the data. In addition, we find that firms' hedge ratios are responsive to lagged currency movements. Firms increase (decrease) their hedge ratios in response to a recent trend of a rising (falling) exchange rate, consistent with a belief in a momentum trading effect. However, they do so only when the NZD/AUD is within its central two quartiles, indicating that firms selectively hedge in response to recent trends provided there is perceived room for these trends to continue, but not when historical experience suggests that the trend may not continue further.

While hedge ratio responses to the exchange rate indicate that firms engage in dynamic currency hedging behaviour, that does not necessarily mean that the firm is engaged in selective hedging. Firms may have opti-

[1]We express the exchange rate in its mathematical sense; ie, NZD/AUD=x $\Rightarrow$ 1NZD=xAUD. Thus, ceteris paribus, a rise in NZD/AUD is unfavourable for a New Zealand exporter with exports denominated in AUD.

mising reasons for changing their hedge ratio as the currency rises or falls. For instance, a firm with pricing power in the Australian market may adopt a different dynamic hedging strategy from one with no pricing power. Our modelling strategy tests whether observed dynamic hedging behaviour reflects differing firm circumstances (optimising behaviour) or whether it may instead reflect market timing behaviour.

Specifically, we interact each firm characteristic with the lagged momentum exchange rate variable. If optimal dynamic hedging theories explain the responsiveness of hedge ratios to the level and changes in the exchange rate, then firms with different characteristics (eg, price-maker versus price-taker) should respond differently to exchange rate dynamics. Instead, across firms with different characteristics, we find an almost uniformly consistent hedging responsiveness to the exchange rate. While we cannot definitively rule out some unobserved optimising factor driving these results, our results are consistent with ubiquitous market timing behaviour as suggested by prior survey findings on selective hedging.

Section 2 outlines prior theoretical, empirical and survey findings in relation to hedging behaviour and provides context on New Zealand's trading relationships. In section 3, we present hypotheses and discuss specific modelling issues. Section 4 describes the data and provides descriptive statistics including tests of the time series properties of the exchange rate. Section 5 presents estimation results, both with respect to standard optimal hedging determinants and dynamic hedging practices; determinants of the latter are examined in depth. Section 6 concludes and discusses potential future research directions.

2 Context

2.1 Prior literature

Firms may optimally choose to hedge some or all of their currency exposures to maximise firm value in the presence of deviations from frictionless, full information markets. Such deviations include: the existence of financial distress costs which may increase hedging by highly leveraged firms and firms with poor liquidity (Smith and Stulz 1985; Nance et al. 1993); underinvestment costs which may increase hedging by firms with strong growth prospects, so preserving internally generated funds for expansion (Bessembinder 1991; Froot et al. 1993); scale and export intensity, leading to increased hedging by larger firms and/or firms with large ratios of exports to sales (Graham and Rogers 2002; Marsden and Prevost 2005); convex tax schedules which may induce greater hedging by firms with existing tax losses (Smith and Stulz 1985); and accounting conventions and regulatory restrictions (Bodnar and Gebhardt 1999; Bodnar et al. 2003).

In some cases, hedging may reflect maximisation of the managerial value function (rather than that of shareholders), being impacted by managerial risk aversion and governance characteristics (Breeden and Viswanathan 1999). This can lead to hedging decisions that are not necessarily in the interests of shareholders. For example, managers' remuneration may be more closely tied to upside performance relative to budget (through bonuses) than to downside results. Maximisation of the managerial value function may affect both the level and the timepath of the hedge ratio. The latter raises the prospect of selective hedging.

Firms may selectively hedge profitably if they possess a comparative advantage relative to other firms in a market with respect to information on future price trends, eg, because of specialised supply-side knowledge. Based on Working (1962) and Stulz (1996), Brown et al. (2006) and Meredith (2006) examine whether selective hedging occurs for commodities in the gold and the oil/gas industries respectively. Evidence of selective hedging is found in both studies when prices deviate from historical averages. However, neither study finds evidence indicating that selective hedging leads to superior operating or financial performance, which would represent *prima facie* evidence of trading based on superior information.

Survey evidence indicates that use of selective hedging in financial markets is much more widespread than can be explained solely by firms' comparative advantage in specific markets (Dolde 1993; Bodnar et al. 1996; Glaum 2000; Faulkender 2005). For instance, a majority of German firms that claim to use derivatives solely for hedging purposes actively adjust their hedge ratios in response to perceived market opportunities based on expectations of exchange rate movements (Glaum 2002). These practices may be influenced by managerial characteristics and incentive sets (Beber and Fabbri 2012), ie, by the managerial value function.

Alternatively, while exchange rates are commonly considered to follow a random walk, managers may believe that currency values are mean-reverting or display momentum effects. A small body of evidence provides some support for these beliefs. For instance, Engel and Hamilton (1990) find evidence of mean reversion in currency markets while Okunev and White (2003) find evidence of short-run momentum effects. Chiang and Jiang (1995) find evidence for both phenomena. Serban (2010) proposes a profitable trading strategy to take advantage of these effects. Exporters may (implicitly or explicitly) alter their hedge ratios to mimic such a strategy. For example, Brookes et al. (2000) report that a sizeable proportion of New Zealand exporters selectively hedge their exposures using forward exchange rate contracts, basing their hedging choices on the exchange rate relative to historical averages, ie, on mean-reverting exchange rate behaviour.

Using aggregate data on hedge ratios of New Zealand exporters, Fabling and Grimes (2010) found that hedge ratios for AUD exports decrease as the NZD/AUD rises, but found no evidence that exporters, in aggregate, benefit financially through changing their hedge ratios.[2] That study, however, did not control for firm characteristics or for other forms of hedging such as natural hedges.

2.2 The New Zealand-Australia economic relationship

We focus on currency hedging decisions of New Zealand firms that export merchandise goods to Australia. Over the sample period (July 2000 to March 2011) Australia was New Zealand's largest trading partner, accounting for 21.4 percent of merchandise exports in 2012 (Statistics New Zealand 2013). On a trade-weighted basis, around 40 percent of exports are invoiced in each of the NZ and Australian dollars (Fabling and Sanderson 2013).[3] Over the sample period the monthly proportion of AUD-denominated exports hedged back to NZD varied between 7.2 and 32.7 percent.

New Zealand and Australia have free inter-country migration flows, and enacted a free trade agreement (Australia New Zealand Closer Economic Relations Trade Agreement) in 1983. Each country has its own central bank and floating currency. Both currencies are amongst the twelve most widely traded global currencies (Bank for International Settlements 2007). Bilateral NZD/AUD fluctuations are muted relative to currency fluctuations against other major currencies.[4] Both countries are predominantly commodity exporters with New Zealand's economic cycles similar to those of Australian

[2] The study found no evidence that changes in forward points alter firms' hedging decisions.

[3] The remaining 19 percent is predominantly invoiced in US dollars. On an unweighted basis, though, USD invoicing only accounts for three percent of monthly shipments (Fabling and Sanderson 2013), suggesting that USD-denominated exports are not an important consideration for most New Zealand exporters to Australia.

[4] The standard deviation of monthly percentage changes in NZD/AUD over the sample period was 1.9% compared with between 2.5% and 4.1% for NZD versus each of USD, GBP, JPY, EUR; rates for USD against AUD, JPY, GBP, EUR had a range of 2.3% to

states (Björksten et al. 2004). Accordingly, short-term interest rates are highly correlated across the two countries.[5] Over the sample period, both New Zealand and Australia had higher than average short-term interest rates relative to the major economies,[6] resulting in net capital inflows through the "carry trade."[7]

3 Hypotheses and modeling issues

3.1 Optimal and selective hedging

We estimate the determinants of exporters' exchange rate hedging decisions as a function of variables posited by both the optimal hedging literature and prior selective hedging studies. In order to clearly specify a test of selective hedging, we first define optimal hedging behaviour.

Let $V_{i\mathbf{XM}t}$ be the market value of firm i, with a set of characteristics, $\mathbf{X}$, and with foreign exchange market conditions, $\mathbf{M}$, in period t. The firm chooses an optimal hedging policy, h^*, from a feasible set of hedging choices, $\mathcal{H}$, such that $V_{i\mathbf{XM}t}|h^* = \sup(V_{i\mathbf{XM}t}|h \in \mathcal{H})$. If firm i has the same characteristics, $\mathbf{X}$, in period $t+1$ as in period t and if foreign exchange market conditions, $\mathbf{M}$, are unchanged then, with efficient markets, h^* will again be the optimal hedging choice. If, after controlling for firm characteristics, the firm varies its hedging choice in response to $\mathbf{M}$, the firm is potentially practicing selective hedging.

To differentiate changes in the hedge ratio that are part of an optimal dynamic hedging strategy from those that are determined by a firm's view of likely future exchange rate movements relative to the present exchange rate (selective hedging), we hypothesise that only certain categories of firm (defined by $\mathbf{X}$) should alter h^* in response to changes in $\mathbf{M}$. For example,

3.3% (data source: Reserve Bank of New Zealand).

[5]The correlation of short-term interest rates between New Zealand and Australia over the sample period is 0.92. By contrast, the correlation between each other pair from the set of economies: New Zealand, Australia, United States, United Kingdom and Euro-area, ranges from 0.48 to 0.84 (data source: OECD).

[6]New Zealand and Australian short-term rates averaged 6.7% and 5.6% respectively, compared with 3.3% (United States), 4.8% (United Kingdom), 3.3% (Euro-area) and 0.35% (Japan).

[7]Nozaki (2010) states (pg 4): "For example, before the onset of the jitters in global financial markets in the summer of 2007, a typical carry trade strategy comprised a short position in the Japanese yen and a long position in the New Zealand dollar."

financially secure and financially fragile firms may have differing reactions of h^* to $\mathbf{M}$ since the former group has greater ability to withstand exchange rate induced revenue volatility than the latter.

For example, consider a financially fragile firm that has expected profit π at exchange rate E, but the exchange rate can take one of two values (with equal probability) next period: $(E-\alpha, E+\alpha)$ resulting in profits $(\pi+\beta, \pi-\beta)$ without hedging. The firm may hedge this exchange rate to guarantee profit, π^*. If the same firm initially faced a higher exchange rate, $E + \alpha$, with expected profit $\pi - \beta$, and next period could face exchange rates $(E, E + 2\alpha)$ with profits $(\pi, \pi - 2\beta)$ in the absence of hedging, it will again choose to hedge since, being financially fragile, it will be particularly susceptible to the negative outcome. Thus a financially fragile firm will not reduce its hedge just because the current profit is less than desired. By contrast, a financially secure firm may relax its hedge in the second instance so that it does not lock in a lower than desired profit. A secure firm is therefore more likely to alter its dynamic hedging strategy than a fragile firm.

Similarly, a firm with market power may alter h^* in response to $\mathbf{M}$ because it can set its own market price, whereas a firm with no market power cannot change its price and so will have no cause to alter h^*. The ability to vary prices, or make other decisions to mitigate the effect of currency movements, will differ across firms. While we include a large number of firm characteristics in our regressions, doing so will not control fully for differing responses to the exchange rate by firms with different characteristics (eg, because of pricing power). Thus observing a full sample response of the hedge ratio to the exchange rate cannot distinguish between dynamic optimal hedging behaviour and selective hedging (market timing).

To distinguish between these two possibilities, we split the sample across each available firm characteristic (such as product differentiation and exporting experience). We then test whether a significant response to the exchange rate is found across each of these splits, and whether the responses to the exchange rate are consistent across each split. If responsiveness to the exchange rate is seen for some classes of firms (eg, those likely to have pricing power) but not for others, we can conclude that the estimated full sample exchange rate responsiveness is most likely to represent optimal dynamic hedging behaviour. Conversely, if we observe a consistent relationship between hedging behaviour and the exchange rate across many or all classes of firms, then we infer broad-based selective hedging behaviour.

3.2 Estimation

We adopt a two stage modelling approach. We first estimate a selection equation for whether firm i undertakes an AUD-denominated export in period t. Then we estimate a structural equation to identify the determinants of the hedge ratio for AUD exports. This second stage accounts for truncation in the dependent variable and, using the first stage results, for selection effects. We model both optimal hedging determinants and possible selective hedging decisions together in order to control fully for factors influencing the hedging choice.

Let H_{it} be the proportion of firm i's AUD-denominated exports to Australia in month t that is hedged, given that firm i exports in AUD in t. Estimating the determinants of this variable presents a truncated regression problem caused by selection and a limited range for the observed dependent variable ($0 \leq H_{it} \leq 1$). Selection issues occur because we are conditioning only on firms that export in AUD in month t.

More formally, consider two latent variables, H^*_{it} and Z^*_{it}, generated by the bivariate process in (1) where we only observe $H_{it} = H^*_{it}$ when $Z^*_{it} > 0$ so that firm i exports in AUD in t. $\mathbf{X}_{it}$ and $\mathbf{W}_{it}$ are vectors of observations on exogenous (or predetermined) variables, $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are unknown parameter vectors, σ is the standard deviation of μ_{it}, and ρ is the correlation between μ_{it} and ν_{it}. The variance of ν_{it} is restricted to one since only the sign of Z^*_{it} is observed.

$$\begin{bmatrix} H^*_{it} \\ Z^*_{it} \end{bmatrix} = \begin{bmatrix} \mathbf{X}_{it}\boldsymbol{\beta} \\ \mathbf{W}_{it}\boldsymbol{\gamma} \end{bmatrix} + \begin{bmatrix} \mu_{it} \\ \nu_{it} \end{bmatrix}, \qquad \begin{bmatrix} \mu_{it} \\ \nu_{it} \end{bmatrix} \sim NID\left(\mathbf{0}, \begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}\right). \tag{1}$$

To account for selection and truncation we use Heckman's two-step (Heckit) method involving a selection equation plus a structural equation estimating the parameters of interest (Davidson and MacKinnon 2004).[8] The selection equation is a probit where the dependent variable is a binary dummy $ExportAUD_{it}$ equal to one when firm i exports in AUD at time t (ie, when $Z^*_{it} > 0$). This equation is used to obtain consistent estimates of $\boldsymbol{\gamma}$ which, in turn, are used to construct estimates of ν_{it}.

Our major focus is on the determinants of the hedge ratio, H_{it}, henceforth $HedgeRatio_{it}$. The structural equation estimates the parameters of the

[8] Full information maximum likelihood (FIML) provides an alternative estimation method. In a recent application using both full sample and truncated sample data, Johansson (2007) finds that, while similar point estimates are obtained, the FIML estimates are less efficient (in his specific application) than those obtained from the Heckit method.

hedging function given the decision to export in AUD. Specifically, we estimate the tobit equation

$$HedgeRatio_{it} = \mathbf{X}_{it}\boldsymbol{\beta} + \rho\sigma\nu_{it} + \epsilon_{it}, \qquad (2)$$

where the inverse Mills ratio, derived from $\mathbf{W}_{it}$ and the estimated $\boldsymbol{\gamma}$ from the probit equation, is used to proxy ν_{it}. This approach yields consistent estimates of $\boldsymbol{\beta}$ conditional on the assumption of bivariate normality. Since $\sigma \neq 0$, the t-statistic on the inverse Mills ratio in (2) can be used to test the null hypothesis of $\rho = 0$. The precision of estimates is dependent on the information in $\mathbf{W}_{it}$ relative to $\mathbf{X}_{it}$. Accordingly, we include extra elements in the selection equation that do not appear in the structural equation. The elements of $\mathbf{X}_{it}$ comprise hypothesised determinants of the optimal hedging decision together with an NZD/AUD exchange rate variable. Variables in $\mathbf{W}_{it}$, but not $\mathbf{X}_{it}$, include predictors of whether a firm exports to Australia and in AUD.[9]

3.3 Firm-specific explanatory variables

Variables hypothesised to influence optimal hedging decisions include firm size, industry, ownership type, past hedging experience, natural hedge positions, diversity of international trading relationships, financial fragility, growth prospects, the proportion of differentiated goods exported by the firm, and the level of foreign exchange market risk. All variables are listed in the appendix and are described briefly here.

Accountability processes differ across firms of different ownership types. We differentiate between firms that are domestically-owned private registered companies (the omitted category in the equations), partnerships and sole proprietorships (*NotCompany*), state-owned enterprises (*StateOwned*), and foreign-owned companies (*Foreign*).[10] Prior literature finds that larger firms are more likely to hedge export receipts. We represent firm size by the logarithm of real sales, *lnSales*. Prior hedging experience, which is likely to be positively correlated with firm size, indicates that a firm has knowledge of hedging methods which we hypothesise has a positive impact on the current hedge ratio. We include two hedging experience variables: *HedgeBefore* is a dummy variable indicating whether a firm has ever hedged an export before; and *HedgeLast* is the inverse of the number of months since the firm last

[9] Firm and time subscripts are henceforth suppressed where the meaning is clear.

[10] Data are not available to distinguish between listed and unlisted companies.

hedged an export. A long lag may indicate a loss of firm-specific hedging knowledge.

Optimal hedging theories relating to financial fragility and preservation of earnings are represented by six variables: *QuickRatio* is the ratio of total current liabilities to total current liabilities plus total current assets less closing stocks. If the denominator is zero, we set *QuickRatio* to zero and represent the firm by a dummy variable, *QuickZero*= 1 (0 otherwise). The firm's ratio of liabilities (excluding equity) to assets is included as *DebtRatio*. Firms with recorded liabilities exceeding recorded assets have *DebtRatio* capped at one, and are represented by a dummy variable, *DebtExcess*= 1 (0 otherwise). A firm that is in a tax-loss carry-forward position may attempt to lock in positive profits, and is represented by a dummy variable, *TaxLoss*= 1 (0 otherwise). Financially fragile firms (*TaxLoss*= 1, high *QuickRatio*, *QuickZero*= 1, high *DebtRatio*, and/or *DebtExcess*= 1) are hypothesised to hedge more than other firms. Firms with high growth prospects may also hedge more in order to protect cashflows for internally-financed future growth opportunities. We proxy these growth prospects using the ratio of intangible assets to total assets of the firm (*Intangibles*).

The degree of product differentiation of the firm's export goods may be an important determinant of a firm's hedging choice. Firms with monopolistic power may be able to alter their AUD price and so be less likely to hedge exchange rate movements than other firms. We proxy a firm's pricing power by the variable, *MarketPower*, being the proportion of a firm's exports classified as differentiated goods, following Rauch (1999).[11] Additionally, we include a full set of 96 industry dummies at the Harmonised System (HS) Chapter (two-digit) level where the dummy = 1 if the firm ever exports that good during the sample period (0 otherwise).[12] Together the *MarketPower* variable and sector dummies provide detailed controls for the nature of goods exported by each firm.

Firms have a set of currency exposures and natural hedges that may impact on their explicit currency hedging choice. The firm's exposure to AUD-denominated trade is represented by *ExposureAUD*, being the differ-

[11] Bastos and Silva (2010) provide empirical support for Rauch's categorisations, concluding that, as expected, prices for "differentiated" goods are much more heterogeneous than for "reference price" and "homogeneous" goods. For New Zealand, Fabling and Sanderson (2013) find that product dummies explain less of the variation in unit values for differentiated goods than they do for undifferentiated goods.

[12] Sector controls are jointly significant (p=0.000) in both the selection and structural equations. Trade in HS Chapters 98 (NZ miscellaneous provisions) and 99 (non-merchandise trade) are dropped from the analysis.

ence in AUD-denominated exports less AUD-denominated imports as a ratio of total sales. The firm's exposures to NZD-denominated and other currency-denominated trade are calculated accordingly, and represented by *ExposureNZD* and *ExposureOther* respectively. We represent the range of firms' currency exposures by two variables: *ExportCurrencies* (number of currencies used in exporting over the past year, excluding AUD and NZD) and *ImportCurrencies* (number of import currencies, excluding AUD, NZD and currencies used for export).

A firm's hedging knowledge may relate to its breadth of trading experience. We represent this experience in two ways. First, *TradeExperience* is the first principal component of four series: the number of (HS ten-digit) goods exported, number of countries exported to (excluding Australia), number of goods imported and number of countries imported from.[13] Second, firms lacking recent export experience are represented by a dummy variable, *NewExporter*, equal to one when the firm has not exported over the past year (0 otherwise).[14] The natural hedge and currency exposure variables itemised above may also proxy for exporting knowledge and experience. We hypothesise that firms with diversified trading relationships and/or natural hedges will have lower explicit hedge ratios. However firms more experienced in exporting may have greater currency management knowledge and so hedge more. Since these effects act in competing directions, we do not have strong priors on the coefficient signs on this subset of variables, and include them solely to control for the cited factors.

Extra variables in the selection equation (ie, in $\mathbf{W}$ but not $\mathbf{X}$) include binary dummies capturing whether the firm has ever exported prior to month t (*EverExported*), has ever exported in AUD prior to t (*EverExportAUD*), and has exported to Australia prior to, or in, t (*AustExportPrior* and *AustExportCurrent* respectively). We also include variables indicating the (inverse of the) length of time since these actions occurred (*EverExportLast*, *AUDExportLast* and *AustExportLast* respectively).

Goldberg and Tille (2009) use an exporter-importer bargaining model to hypothesise that larger transactions are more likely to be invoiced in the importer's currency. Accordingly, we add *lnShipmentSize*, defined as the logarithm of the average real export value per shipment in the last year, to the selection equation. Monthly seasonal dummy variables are included

[13] Ten-digit goods categories are harmonised over time to HS2012, following Fabling and Sanderson (2010).

[14] This variable also controls for the fact that some variables, such as *MarketPower*, are undefined (set to zero) for firms without recent export experience.

given export seasonality. All variables appearing in the structural equation are included in the selection equation; however, we replace *HedgeBefore* and *HedgeLast* (ie, variables indicating whether the firm has hedged before, and time since hedging) with their respective industry averages (denoted with a suffix, *_ind*) to ensure that we have an independent predictor of currency hedging experience not based on the firm's own hedging experience.

3.4 Foreign exchange market explanatory variables

The level of risk prevailing in the foreign exchange market is hypothesised to influence hedging decisions, with firms increasing their hedging at times of heightened foreign exchange market risk. We use an options market measure of foreign exchange risk, being the log of the monthly average of the one month option volatility for the NZD/USD (*OptionRisk*).[15]

The variable that proxies firms' exchange rate perceptions is the log change in the NZD/AUD from period $t-X-1$ to period $t-1$ (ln_AUD_DX), where X is the span over which the change is measured. We show how results differ according to the choice of X.

If exporters act as if the NZD/AUD follows a random walk then we expect the coefficient on ln_AUD_DX to be zero for all X. If, instead, they act as if there are momentum effects in the foreign exchange market (ie, that past trends are likely to continue into the future), we expect that the coefficient on ln_AUD_DX will be positive in the structural equation (so as to hedge against an expected appreciation), but negative (or zero) in the selection equation. The latter effect may arise because the (expected) exchange rate influences the profitability of the decision to export (Fabling et al. 2012).[16] If exporters instead believe in (full or partial) mean reversion in the exchange rate, then we would expect that firms will increase (decrease) their hedge ratios when the NZD/AUD is low (high) relative to historical average levels.

In section 4, we examine the actual time series properties of the NZD/AUD

[15] We use the NZD/USD option measure (rather than that for the NZD/AUD) since it is a more frequently traded instrument.

[16] More generally, we don't interpret selection equation coefficients since invoice currency may be determined by trade partners or be jointly determined with the exporter. In contrast, given an AUD exposure, the exporter wholly determines whether to hedge, so enabling clear interpretation of structural equation coefficients, subject to including the inverse Mills ratio.

to test whether either momentum effects or mean reversion may be reasonable statistical representations of reality.

Our null hypothesis is that firms do not change their hedge ratio in response to recent changes in (or levels of) the exchange rate. Selective hedging based on expected momentum effects is consistent with a significant positive coefficient on ln_AUD_DX in the structural equation. Conversely, hedging based on anticipated mean reversion generates a negative (positive) coefficient on ln_AUD_DX when the NZD/AUD is historically high (low).

However, it is conceivable that some form of optimal dynamic hedging behaviour could also result in rejection of the null hypothesis for firms with particular characteristics or constraints. It is difficult to test for all possibilities in this regard since we cannot specify, ex ante, all potential reasons that a firm may optimally change its hedging position in reaction to past exchange rate movements. If the exchange rate follows a random walk, however (as tested for in section 4), we would not expect most firms to exhibit dynamic hedging behavior in response to lagged exchange rate outcomes. Thus we test for the prevalence of any selective hedging (detected initially across the full sample of firms) to see whether specific firm characteristics or constraints explain any tendency to change hedge positions in reaction to lagged exchange rate changes.

Specifically, we interact the exchange rate variable with dummy variables that split firms according to: firm size and characteristics (*lnSales*, *Foreign*, and *NotCompany*); financial fragility (*QuickRatio*, *DebtRatio* and *TaxLoss*); growth prospects (*Intangibles*); pricing power (*MarketPower*); diversification, exporting and hedging experience.[17] We also test whether dynamic hedging behavior differs according to the level of risk in the foreign exchange market (*OptionRisk*) and whether it differs according to the level of the exchange rate.

4 Data

All data are obtained from New Zealand's Longitudinal Business Database (LBD), maintained by Statistics New Zealand as part of the Integrated Data Infrastructure. The panel comprises all New Zealand firms that ever exported goods to Australia between July 2000 and March 2011 (the estima-

[17] *StateOwned* is excluded from this list because there are insufficient observations to estimate interaction terms.

tion period), subject to minimum threshold requirements.[18] This period (129 months) covers the onset of the recent financial crisis, and is determined by the availability of accounting variables, noting that we use lagged financial data to minimise endogeneity issues.[19]

One feature that sets our analysis apart from prior studies of firm hedging behaviour is the comprehensive population coverage. Instead of covering only large firms (eg Bodnar and Gentry 1993; Geczy et al. 1997; Allayannis and Ofek 2001; Hentschel and Kothari 2001; De Ceuster et al. 2000) or firms in specific commodity markets (Tufano 1996; Haushalter 2000; Brown et al. 2006; Meredith 2006), we cover all exporters across all merchandise categories. Furthermore, we utilise monthly longitudinal unit record data rather than a single cross-section as in many prior studies (eg, Geczy et al. 1997). Subject to the exporting requirement, a firm is included in the panel if it is active over two consecutive financial years, resulting in an unbalanced panel of 14,883 firms.[20] The selection equation includes 1,153,419 firm-month observations, while the structural equation – which includes only firms that export in AUD in month t – comprises 65,466 firm-month observations.

Table 1 summarises variables for the full population (selection equation), as well as for the tobit subsample (strutural equation), and for firms hedging at time t.[21] Several key observations can be made regarding these summary statistics in relation to optimal hedging theories. First, firms that export in AUD are, on average, larger (higher *lnSales*) than other firms, and firms that hedge are, on average, larger than other exporting firms. Figure 1 shows the size distribution of exporters across the three samples, with a clear rightward shift of firm size from the full (probit) sample, to the tobit (export in AUD) sample to the hedge sample (positive AUD hedge ratio). Second, firms that hedge, on average, export less differentiated products (lower *MarketPower*) than exporting firms that do not hedge, consistent with exporters of differentiated products having market pricing power in AUD terms that reduces their need to hedge NZD/AUD fluctuations. Third, firms that hedge have considerably greater breadth of export experience (high *TradeEx-*

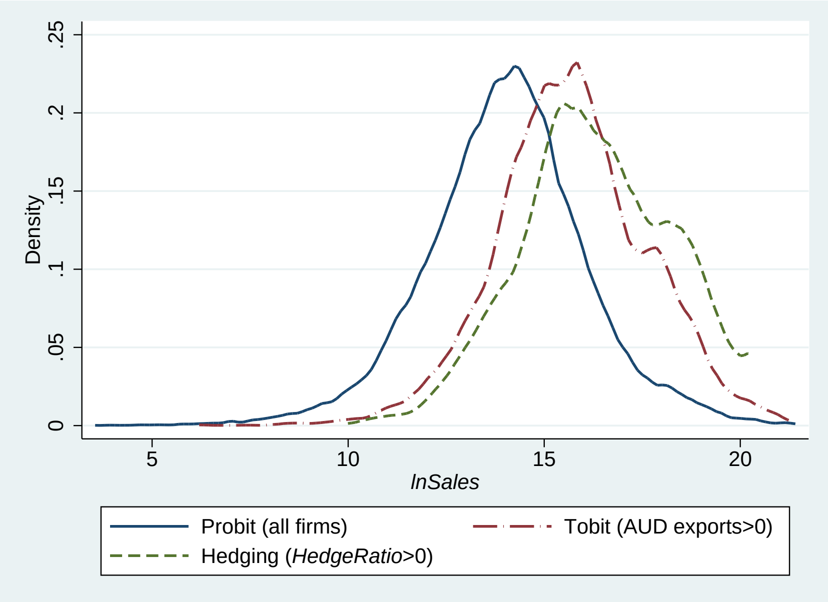
[18] The key threshold requirements are at NZD40,000 p.a. of income, and NZD1,000 shipment value (Fabling 2009 provides further background on the LBD). On average over the observation period 1NZD=0.848AUD.

[19] Linked trade data back to August 1997 is used to calculate trade experience variables.

[20] A firm is active if we observe sales, purchases of intermediates, employment or physical capital during the year. Legal units outside the private-for-profit business sector (household and not-for-profits) are excluded.

[21] The hedge ratio is relevant only to the tobit sample so is omitted for the full population. We present only the mean for dummy variables.

Figure 1: Distribution of log sales by currency and hedging behaviour



Kernel density plot using Epanechnikov kernel function. A small number of observations are dropped from the top and bottom tails of each distribution in compliance with Statistics New Zealand confidentiality rules.

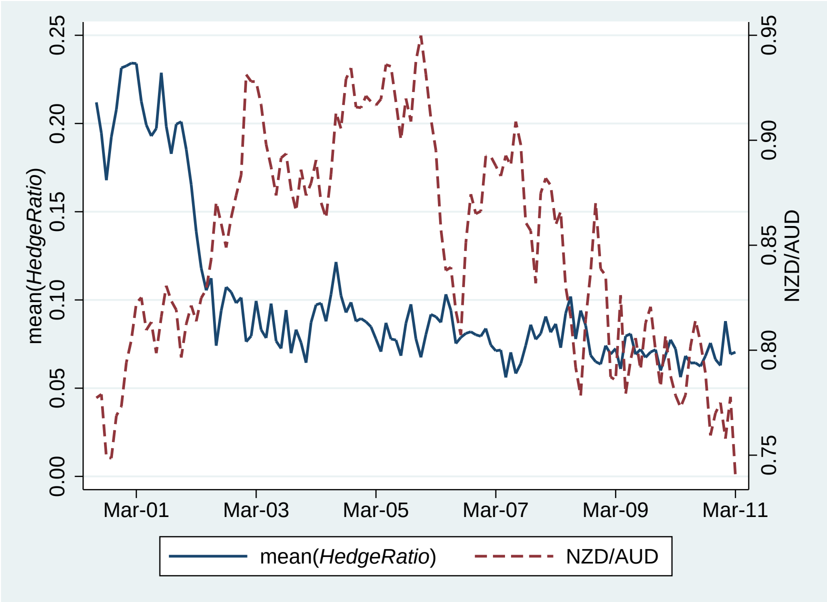
perience, *ExportCurrencies* and *ImportCurrencies*) than other export firms. Fourth, firms that have hedged before (*HedgeBefore*= 1) and more recently (high *HedgeLast*) are more likely to hedge a current AUD export, consistent with hedging knowledge and experience being a relevant factor in the hedging decision.

Of exporters that hedge, *HedgeRatio* varies considerably, with a standard deviation of 0.31, a 5th percentile of 0.07 and a 25th percentile of 0.74. Thus hedging is not necessarily an all or nothing decision. Figure 2 demonstrates that the mean hedge ratio varies over the sample period from a low of 0.055 to a peak of 0.238 (for the tobit sample).

Figure 2 also plots the NZD/AUD exchange rate. Prior to estimating the selection and structural equations, we analyse the time series properties of the NZD/AUD, in part to ensure that we include this variable in an econometrically appropriate form in the selection and structural equations. The tests are also useful for demonstrating whether exporters might reasonably infer mean reversion or momentum behaviour from the data.

An Augmented Dickey-Fuller (ADF) unit root test on $ln(NZD/AUD)$, with one lag of the dependent variable, $\Delta ln(NZD/AUD)$, does not reject a

Figure 2: Mean hedge ratio and the NZD/AUD exchange rate



unit root in the log-level of the exchange rate (p= 0.4151).[22] Furthermore, the coefficient on the lagged dependent variable ($\Delta ln(NZD/AUD)$) is just 0.030 (p= 0.7269). Thus there is no evidence either of mean reversion or of momentum in the exchange rate, consistent with efficient markets theory. Since the exchange rate is non-stationary, we include only log-changes in the NZD/AUD in our equations. However, we test whether reactions to exchange rate changes vary according to whether the level of the NZD/AUD is "high/mid/low" relative to its sample mean to test whether exporters may consider that currency dynamics differ depending on the exchange rate level.

5 Results

Table 2 presents results for both the selection (probit) and structural (tobit) equations, where these are estimated initially with no interaction terms. In each case, standard errors (shown in brackets) are clustered on firms. Both

[22]The Schwarz Information Criterion specifies zero lags for the ADF test, but we explicitly include one lag to test for momentum effects. A unit root is also not rejected when using an ADF test with zero lags or when using a Phillips-Perron test. $\Delta ln(NZD/AUD)$ is stationary (p< 0.0001) using an ADF test. Almost identical results are found using NZD/AUD in place of $ln(NZD/AUD)$.

equations include a full set of (unreported) HS Chapter (two-digit) dummies and the selection equation also includes (unreported) month-of-the-year dummies to account for seasonality of exports. The tobit equation includes the inverse Mills ratio (*InverseMills*) derived from the selection equation to control for selection effects.

The exchange rate variable in both equations is *ln_AUD_D9*, that is the nine-month log change in the NZD/AUD from t–10 to t–1. This variable is significant in both equations. Table 3 shows the effect of varying the span covered by the exchange rate momentum variable. *ln_AUD_DX* remains significant (at $p < 0.05$) in the selection equation for any span from 2 to (at least) 12 months and in the structural equation from 6 to (at least) 12 months. A nine-month span is chosen for the equations in Table 2 as this corresponds to the peak coefficient (and significance level) on *ln_AUD_DX* in the structural equation.

Two important results stand out from the selection equation. First, five of the variables included exclusively in the probit equation are significant (at $p < 0.05$), providing identification in adjusting for selection bias in the structural equation. Accordingly, *InverseMills* is significant at $p = 0.01$ in the structural equation. Second, the coefficient on *ln_AUD_DX* is negative, which is to be expected if at least some firms' decision to export is influenced by the bilateral exchange rate.

Turning to the structural equation, the significant results for the non-exchange rate variables accord with optimal hedging theories. Financially fragile firms (*DebtExcess*$= 1$ and *QuickZero*$= 1$) have higher hedge ratios, *ceteris paribus*, than other firms. The existence of natural hedges, diversification and international trade experience (*ExportCurrencies*, *NewExporter*, *ExposureAUD*) all have significant impacts on the decision to hedge but, as discussed in section 3, it is difficult to distinguish between motivations based on natural hedges and diversification versus firm experience of international trade. Firms with prior hedging experience (*HedgeBefore*), especially if it is recent experience (*HedgeLast*), are unambiguously more likely to hedge than other firms.

The inclusion of these two hedging variables account for the lack of a significant firm size effect on average hedge levels. Large firms are more likely to have already hedged in the past, thus displaying higher hedge ratios than smaller firms (the correlation between *lnSales* and *HedgeLast* is 0.241 in the tobit subsample). If hedging experience variables are omitted from the structural equation, the coefficient on *lnSales* is positive and becomes significant ($p < 0.01$).

We find no evidence that other (non-exchange rate) variables have any systematic effect on hedge ratios. However, this does not preclude significant interaction effects of some of these variables with the exchange rate variable, as tested below.

Having controlled for these hedging influences and for selection effects, we still find a significant exchange rate influence on the hedge ratio. The coefficient on *ln_AUD_D9* is positive ($p < 0.01$) consistent with exporters hedging as if they expect a momentum effect in the exchange rate.

If the estimated response to exchange rates reflects an optimal dynamic hedging strategy by firms with particular characteristics or constraints, we would expect to see heterogeneity in the response to lagged exchange rate changes across firm types. To examine this further, we estimate the full model with the addition of interaction terms of firm characteristic variables with the exchange rate variable (*ln_AUD_D9*). As shown in Table 4, some interaction terms take the form of a dummy variable that splits the sample into two groups (Low/High) according to some specified characteristic. For instance, we split the sample according to whether firms are foreign or domestically owned. For some variables there is a natural third category, eg, for *MarketPower* where some firms have not exported in the previous year (*NewExporter*= 1) and the variable is unobserved (set to zero). In these cases, we split the sample into three groups (Low/High/Other). We also split continuous variables into three categories where the Low (High) group captures the bottom (top) quartile. The middle two quartiles are assigned to the group labelled Other.

For each (two- or three-way) split we test, in a pairwise manner, the null hypothesis that the coefficient on *ln_AUD_D9* is the same between subgroups. Table 4 defines the splits used for the test on each interacted variable and presents the results of the tests. "REJECT" indicates rejection of the null hypothesis of identical coefficients (at $p = 0.05$), whilst "–" indicates that we do not reject the null.

The null hypothesis is rejected for only three variables, only one of which is firm-specific. Large firms (top quartile of lagged sales) differ from small firms in their hedging response to past exchange rate movements. Table 5 presents the estimated coefficients and significance levels for the three variables where the splits are significant.[23] Small and moderately-sized firms (ie, three-quarters of exporters) engage in significant dynamic hedging activities,

[23] We do not do so where the splits are not significant since, statistically, a single coefficient applies to each of these terms across the sample.

while the largest firms do not. Furthermore, smaller firms show a more active response to past exchange rate movements than moderately-sized firms. Given that no other firm characteristics variables show significant differences across firm type, size cannot here by proxying for financial fragility, growth opportunities or market power. Instead, we conjecture that large exporters have hedging policies in place that lead to a consistent hedging outcome whereas the bulk of (small and medium-sized) firms hedge more opportunistically based on perceptions of exchange rate trends in the absence of set internal policies.

Firms do not change their hedging positions when option risk is low, but are prone to do so when risk is higher. In high risk times, any extrapolation of past trends (reflecting a perception of a momentum effect) may lead to a magnified hedging response whereas in low risk conditions, firms may perceive that exchange rates are unlikely to jump materially.

Importantly for the purposes of this study is the manner in which the hedging response differs according to the current $(t-1)$ level of the exchange rate. When the NZD/AUD is within the middle 50% of its historical distribution, the dynamic hedging response to lagged exchange rate movements is positive and significant, consistent with a belief that the exchange rate exhibits a positive momentum effect. Firms therefore increase their hedging in response to an observed (lagged) increase in the exchange rate and decrease their hedging in response to an observed fall.

By contrast, when the NZD/AUD level is historically low (bottom quartile) or high (top quartile) there is no significant change in hedging based on past trends. In these two cases, it seems reasonable to conjecture that firms see less prospect of past exchange rate trends continuing as the exchange rate nears historical extremes. The positive (negative) coefficients on ln_AUD_D9 when the NZD/AUD is low (high) are consistent also with a belief in mean reversion when the exchange rate reaches extremes. However, neither coefficient is significantly different from zero.

These results, and those for firm size and option risk, coupled with the lack of any differences in dynamic hedging behavior associated with other firm characteristics, are in keeping with the hypothesis that the bulk of firms vary their hedge positions in a manner that reflects a belief in exchange rate momentum effects except when the exchange rate is at extreme levels. However, this belief is shown to be erroneous by the unit root tests in section 4 which indicate that the NZD/AUD (over the sample period) displays neither momentum nor mean-reverting behaviour.

6 Conclusions

Firms that have currency exposures must decide whether they should hedge those exposures. Costs of financial distress, under-investment risks, tax considerations, the presence of natural hedges, firm size, trading experience, pricing power and market risk all potentially impact on the optimal hedging decision. Firms must also decide whether to maintain a consistent hedging policy or whether to vary their position in response to currency movements. Variation in the hedge ratio in response to currency movements may reflect optimising decisions within the firm (eg, due to an ability to offset currency movements through pricing strategies) or may reflect a firm's decision to "time the market", ie, selective hedging.

This study is the first to examine both optimal and selective currency hedging behaviour by exporters across a comprehensive longitudinal panel of exporting firms. By using official statistical, tax and trade data for almost all private sector firms in the economy, we control for selection issues and track each firm's currency hedging choices over 129 months (July 2000 – March 2011). We focus on the hedging decisions of New Zealand exporters exposed to NZD/AUD risk through denomination of exports to Australia in AUD. The panel contains over 65,000 firm-month observations on exporters' currency hedging choices drawn from over a million firm-month observations on exporting and non-exporting firms' activities.

Our estimates support several existing theories regarding the determinants of firms' optimal currency hedging choices. We find that hedging is influenced by a firm's financial fragility, its prior hedging experience (which, in turn, is associated with firm size), and its trade experience and diversification. In addition, we find that exporters' hedge ratios are influenced positively by recent changes in the exchange rate.

We test whether these hedging dynamics in response to lagged exchange rate movements differ according to firm type and/or market risk conditions. The conclusion from these tests is that responsiveness of hedge ratios to exchange rate changes is ubiquitous for all but large (top quartile) firms. Small and moderately-sized firms respond to exchange rate developments no matter whether they are a price-maker or price-taker, financially fragile or not, experienced in trade or an exporting novice, domestic or foreign owned. In terms of risk, dynamic hedging responses are observed in all but lower quartile risk periods in the currency markets.

The finding that the hedge ratios react to lagged exchange rate changes when exchange rates are towards the middle of the historical exchange rate distribution, but not when it is near historical extremes, adds weight to the hypothesis that firms act as if the exchange rate displays a momentum effect except when it is nearing an historically extreme level and so may be perceived as being unable to trend any further. We take the consistency of responses across firm types (other than for large firms, which are more likely to have systematic hedging policies in place) as adding empirical support to the prior survey evidence that many exporters routinely engage in a degree of selective hedging when making their hedging decisions.

The time series properties of the exchange rate indicate, however, that this practice of selective hedging will not be a profitable strategy (consistent with the findings of Fabling and Grimes 2010). Unit root tests show that the NZD/AUD displays neither mean reverting nor momentum effects over the sample period. Instead, it behaves as a random walk, consistent with the efficient markets hypothesis.

The question then arises as to why exporters display hedging behaviour that is consistent with a momentum effect in the NZD/AUD when the actual rate shows no such behaviour. One possibility, is that it is commonplace for currency "strategists" (eg, from banks or foreign exchange advisory firms) to talk of exchange rate trends and advise their clients to position themselves accordingly. Tests of the nature (and predictive power) of the advice of such "strategists" is an extension to pursue given the observed exporter hedging behaviour and the observed time series properties of the exchange rate.

Another natural extension is to apply the methods used here to other markets where similarly comprehensive data on exporters' characteristics, export currency denomination and hedging decisions are available. The current dataset can be applied, in this respect, to New Zealand's other trading relationships. A key question then to be tested is whether, if selective hedging is indicated, this behaviour again reflects the actual underlying currency dynamics of the relevant currency pair. This analysis would provide extra clarity on the question of whether exporters, or their currency advisors, have any predictive ability regarding the exchange rate or whether they instead follow simple rules that reflect a belief in the existence of momentum effects which do not, statistically, exist.

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Table 1: Summary statistics by currency and hedging behaviour

	Probit (All firms)					Tobit (AUD Exports > 0)					Hedging (*HedgeRatio* > 0)				
	Mean	SD	5th	50th	95th	Mean	SD	5th	50th	95th	Mean	SD	5th	50th	95th
ln_AUD_D9	-0.003	0.050	-0.079	-0.006	0.075	-0.006	0.050	-0.080	-0.008	0.072	-0.003	0.049	-0.079	-0.006	0.072
DebtRatio	0.604	0.321	0.061	0.631	1.000	0.573	0.290	0.095	0.577	1.000	0.576	0.268	0.148	0.552	1.000
DebtExcess	0.169					0.102					0.095				
ExportCurrencies	0.425	1.098	0.000	0.000	2.000	1.937	2.246	0.000	2.000	6.000	2.785	2.972	0.000	2.000	8.000
ExposureAUD	-0.035	0.141	-0.290	0.000	0.024	0.052	0.212	-0.251	0.014	0.433	0.072	0.189	-0.150	0.029	0.410
ExposureNZD	0.040	0.163	-0.021	0.000	0.323	0.072	0.178	-0.051	0.021	0.405	0.098	0.190	-0.037	0.031	0.536
ExposureOther	-0.104	0.226	-0.577	-0.002	0.013	-0.053	0.262	-0.493	-0.025	0.454	0.047	0.322	-0.445	0.000	0.760
Foreign	0.131					0.223					0.196				
HedgeRatio						0.092	0.279	0.000	0.000	1.000	0.817	0.313	0.067	1.000	1.000
HedgeBefore	0.161					0.581					0.928				
HedgeLast	0.024	0.126	0.000	0.000	0.071	0.163	0.321	0.000	0.014	1.000	0.749	0.382	0.000	1.000	1.000
ImportCurrencies	1.229	1.557	0.000	1.000	4.000	2.449	2.139	0.000	2.000	7.000	2.805	2.642	0.000	2.000	8.000
Intangibles	0.042	0.118	0.000	0.000	0.294	0.041	0.110	0.000	0.000	0.284	0.038	0.103	0.000	0.000	0.284
lnSales	14.026	2.061	10.704	14.062	17.402	15.701	1.947	12.573	15.658	18.891	16.419	2.069	13.093	16.342	19.958
MarketPower	0.508	0.490	0.000	0.717	1.000	0.806	0.362	0.000	1.000	1.000	0.701	0.422	0.000	0.999	1.000
NewExporter	0.421					0.029					0.016				
NotCompany	0.069					0.018					0.014				
OptionRisk	2.574	0.262	2.252	2.521	3.101	2.584	0.265	2.252	2.528	3.109	2.582	0.248	2.264	2.551	3.077
QuickRatio	0.480	0.242	0.061	0.480	0.910	0.459	0.204	0.102	0.470	0.796	0.475	0.188	0.161	0.482	0.787
QuickZero	0.013					0.010					0.013				
StateOwned	0.002					0.002					0.000				
TaxLoss	0.264					0.247					0.256				
TradeExperience	0.000	1.522	-0.901	-0.524	2.638	1.725	2.909	-0.753	0.826	7.489	2.724	4.158	-0.742	1.378	10.785
AUDExportLast	0.089	0.240	0.000	0.000	1.000	0.717	0.388	0.000	1.000	1.000	0.803	0.343	0.024	1.000	1.000
AustExportCurrent	0.169					0.982					0.975				
AustExportLast	0.255	0.361	0.000	0.063	1.000	0.820	0.323	0.083	1.000	1.000	0.865	0.288	0.125	1.000	1.000
AustExportPrior	0.754					0.979					0.985				
EverExportAUD	0.332					0.936					0.954				
EverExport	0.818					0.986					0.992				
EverExportLast	0.355	0.405	0.000	0.143	1.000	0.878	0.276	0.167	1.000	1.000	0.929	0.217	0.333	1.000	1.000
HedgeLast_ind	0.052	0.019	0.031	0.048	0.086	0.057	0.018	0.038	0.052	0.090	0.067	0.021	0.042	0.062	0.103
HedgeBefore_ind	0.316	0.056	0.232	0.313	0.414	0.344	0.050	0.267	0.340	0.431	0.347	0.055	0.261	0.344	0.442
lnShipmentSize	5.190	4.534	0.000	7.570	10.826	9.306	2.003	7.036	9.583	11.448	9.870	1.680	7.878	10.107	11.724

5th, 50th, 95th column headings refer to percentiles; SD is the standard deviation.

Table 2: Baseline selection and structural equation estimates

	Selection	Structural
Foreign	-0.047*	-0.202
	[0.021]	[0.104]
StateOwned	-0.215*	-1.230
	[0.108]	[1.042]
NotCompany	-0.101**	0.143
	[0.033]	[0.254]
MarketPower	-0.045	-0.145
	[0.033]	[0.160]
QuickRatio	-0.096**	0.342
	[0.032]	[0.210]
QuickZero	0.038	0.736**
	[0.044]	[0.261]
DebtRatio	0.067*	-0.040
	[0.026]	[0.155]
DebtExcess	0.028	0.241*
	[0.021]	[0.121]
TaxLoss	-0.008	-0.056
	[0.013]	[0.083]
Intangibles	0.062	0.241
	[0.054]	[0.293]
lnSales	-0.018**	-0.006
	[0.005]	[0.031]
HedgeBefore	0.494**	0.938**
	[0.131]	[0.101]
HedgeLast	0.152	5.307**
	[0.367]	[0.355]
ExposureNZD	-0.374**	0.162
	[0.037]	[0.184]
ExposureAUD	0.680**	-0.391*
	[0.050]	[0.191]
ExposureOther	0.284**	0.243
	[0.032]	[0.163]
ExportCurrencies	0.066**	-0.139**
	[0.005]	[0.026]
ImportCurrencies	-0.011*	0.044
	[0.005]	[0.025]
TradeExperience	0.003	0.013
	[0.006]	[0.025]
NewExporter	0.285**	0.438*
	[0.070]	[0.184]
OptionRisk	-0.027*	0.049
	[0.013]	[0.105]
ln_AUD_D9	-0.172**	1.236**
	[0.067]	[0.415]
InverseMills		0.765**
		[0.066]
lnShipmentSize	0.040**	
	[0.007]	
EverExport	-0.052	
	[0.037]	
EverExportLast	-0.050	
	[0.029]	
AustExportLast	-0.901**	
	[0.032]	
AustExportCurrent	2.602**	
	[0.031]	
AustExportPrior	-0.057	
	[0.032]	
EverExportAUD	0.513**	
	[0.017]	
AUDExportLast	2.321**	
	[0.025]	
N	1,153,419	65,466
Psuedo-R^2	0.688	0.378

Robust standard errors (clustered on firm) in square brackets (**; * significant at 1%; 5% level respectively). Both regressions include an unreported constant and Harmonised System Chapter (ie, 96 two-digit) dummies. In the probit regression there are also monthly seasonal dummies, and *HedgeBefore* and *HedgeLast* are industry average values (denoted with an *_ind* in the main text).

Table 3: Response to exchange rate by exchange rate change span

	Lag length X (exchange rate change estimated over $t-1$ to $t-X-1$)											
	1	2	3	4	5	6	7	8	9	10	11	12
Selection equation												
ln_AUD_dX	-0.160	-0.230*	-0.230**	-0.185**	-0.169*	-0.219**	-0.247**	-0.189**	-0.172**	-0.141*	-0.128*	-0.126*
	[0.155]	[0.099]	[0.080]	[0.072]	[0.067]	[0.067]	[0.066]	[0.066]	[0.067]	[0.065]	[0.061]	[0.057]
Structural equation												
ln_AUD_dX	-1.155	-0.866	0.047	-0.229	0.492	0.822*	0.804*	1.051**	1.236**	1.024*	0.917*	1.016**
	[0.702]	[0.507]	[0.439]	[0.384]	[0.390]	[0.398]	[0.394]	[0.393]	[0.415]	[0.403]	[0.377]	[0.363]

The table reports coefficients on *ln_AUD_DX* estimated in specifications where this variable has different lag length (ranging from one to twelve). Each column of the table represents a separate pair of probit-tobit regressions. **; * indicates the coefficient is significantly different from zero at 1%; 5% level respectively (robust standard errors in brackets, clustered on firm).

Table 4: Response to *ln_AUD_D9* by firm and market characteristics

Variable	Subgroup definitions			H_0: Identical *ln_AUD_D9* coefficients		
	Low (L)	High (H)	Other (O)	L=O	O=H	L=H
lnSales	<25th	≥75th	25th-75th	–	–	REJECT
OptionRisk	<25th	≥75th	25th-75th	REJECT	–	REJECT
DebtRatio	<25th	≥75th	25th-75th	–	–	–
NZD/AUD	<25th	≥75th	25th-75th	REJECT	REJECT	–
Intangibles	= 0	≥50th	<50th	–	–	–
Foreign	= 0	= 1		–	–	–
NotCompany	= 0	= 1		–	–	–
TaxLoss	= 0	= 1		–	–	–
QuickRatio	<50th	≥50th	QuickZero= 1	–	–	–
HedgeLast	<50th	≥50th	= 0	–	–	–
ExposureAUD	< 0	> 0	= 0	–	–	–
ExposureNZD	< 0	> 0	= 0	–	–	–
ExposureOther	< 0	> 0	= 0	–	–	–
MarketPower	< 0.5	≥ 0.5	NewExporter= 1	–	–	–
ExportCurrencies	= 0	> 0	NewExporter= 1	–	–	–
ImportCurrencies	= 0	> 0	NewExporter= 1	–	–	–
TradeExperience	<50th	≥50th	NewExporter= 1	–	–	–

The table reports results of hypothesis tests based on structural equation coefficients on *ln_AUD_D9* where this variable has different coefficients based on the value of another independent variable. Each row of the table represents a separate regression (with subgroup dummies included). The column labelled Variable lists the variable over which the coefficient on *ln_AUD_D9* is allowed to vary, with the following three columns listing the criteria used to determine subgroups. "REJECT" indicates that the coefficient differs between the two groups listed at the head of the column at the 5% level (robust standard errors clustered on firm); "–" indicates no rejection of the null hypothesis of identical coefficients across the two groups. We have also split the sample for *DebtRatio* as: Low (<50th), High (>50th), Other (*DebtExcess*= 1), and again fail to reject the null in all three cases.

Table 5: Estimated *ln_AUD_D9* coefficients where subgroup equality rejected

Variable	Subgroup definitions			Coefficients on ln_AUD_D9		
	Low	High	Other	Low	High	Other
lnSales	<25th	≥75th	25th-75th	2.674**	0.027	1.269*
OptionRisk	<25th	≥75th	25th-75th	-1.078	1.833	2.155**
NZD/AUD	<25th	≥75th	25th-75th	1.019	-1.267	3.296**

The table reports structural equation coefficients on *ln_AUD_D9* corresponding to Table 4 for those variables for which one or more of the null hypotheses of identical coefficients is rejected. **; * indicates the coefficient is significantly different from zero at 1%; 5% level respectively (robust standard errors clustered on firm).

Appendix: Variable definitions

Variable	**Reference period**	**Description**
ln_AUD_DX	Current month	Log change in NZD/AUD over the prior X months
AUDExportLast	Aug'97-prior month	1/N(months since last exported in AUD), =0 if never
AustExportCurrent	Current month	Dummy=1 if firm exports to Australia
AustExportLast	Aug'97-prior month	1/N(months since last exported to Australia), =0 if never
AustExportPrior	Aug'97-prior month	Dummy=1 if firm has prior Australia export
DebtRatio	Prior fin. year	Total liabilities/total assets, capped at 1
DebtExcess	Prior fin. year	Dummy=1 if *DebtRatio* capped at 1
EverExportAUD	Aug'97-prior month	Dummy=1 if firm has prior AUD export
EverExported	Aug'97-prior month	Dummy=1 if firm has prior exports
EverExportLast	Aug'97-prior month	1/N(months since last exported), =0 if never
ExportCurrencies	Prior 12 months	N(export currencies, excl. NZD and AUD)
ExposureAUD	Prior fin. year	Net AUD-denominated trade (ie, NZD-value of exports - imports)/total sales
ExposureNZD	Prior fin. year	Net NZD-denominated trade/total sales
ExposureOther	Prior fin. year	Net other currency trade/total sales
Foreign	Current fin. year	Dummy=1 if firm is foreign-owned
HedgeRatio	Current month	Proportion of AUD exports hedged into NZD
HedgeBefore	Aug'97-prior month	Dummy=1 if firm has previously hedged
HedgeBefore_ind	Aug'97-prior month	Industry average of *HedgeBefore*
HedgeLast	Aug'97-prior month	1/N(months since last hedged any export), =0 if never
HedgeLast_ind	Aug'97-prior month	Industry average of *HedgeLast*
ImportCurrencies	Prior 12 months	N(import currencies, excl. NZD and AUD) - *ExportCurrencies*
Intangibles	Prior fin. year	Intangible assets/total assets
InverseMills	Current month	Inverse Mills ratio
lnSales	Prior fin. year	ln(real sales)
lnShipmentSize	Prior 12 months	ln(real export value/N(shipments)), set to 0 if exports=0
MarketPower	Prior 12 months	Proportion of export value in differentiated goods, classified following Rauch (1999), set to 0 if exports=0
NewExporter	Prior 12 months	Dummy=1 if exports=0
NotCompany	Current fin. year	Sole proprietor or partnership
OptionRisk	Current month	Option-implied monthly volatility in NZD/USD
QuickRatio	Prior fin. year	Current liabilities/(current liabilities + current assets - closing stocks), set to 0 if denominator=0
QuickZero	Prior fin. year	Dummy=1 if QuickRatio set to 0
StateOwned	Current fin. year	Dummy=1 if firm is state-owned
TaxLoss	Current fin. year	Dummy=1 if firm has tax-loss carry forward
TradeExperience	Prior 12 months	First principal component of: N(export goods, HS10); N(export countries, excl. Australia); N(import goods); and N(import countries incl. Australia)

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