RESERVE BANK
OF NEW ZEALAND

DP2009/XX

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July 2009

JEL classification: F10, F31, L11

www.rbnz.govt.nz/research/discusspapers/

Discussion Paper Series

ISSN 1177-7567

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The evolution of export unit values: Some stylised facts DRAFT PRESENTED AT NZAE'09*

Richard Fabling, Sophie Joyce and Lynda Sanderson†

Abstract

Using detailed Customs data, we examine changes in unit values for merchandise trade. We observe these values for narrowly defined goods according to the exporting firm, destination and currency of invoice. This detailed definition gives us some ability to distinguish between real changes in prices and compositional changes in products and destinations. Such controls are important, since we show that firms often trade the "same" product to multiple countries at very different unit values – differences that are only partially explainable by common proxies for trade costs.

We find that unit values of export goods tend to be reasonably flexible over time and that changes in unit values are similar across New Zealand Dollar (NZD)- and foreign currency-denominated contracts. However, NZD trades tend to be smaller and more likely to be one-off so that, on a trade-weighted basis, contracts written in foreign currencies are dominant. Focussing on this sub-population, we reject the possibility that NZ firms negotiate the foreign (contracted) value of their goods in order to completely smooth the (realised) NZD value – that is, we reject complete exchange rate pass through. As a consequence, the NZD-converted income from foreign trades is impacted by currency appreciations and depreciations. These results are consistent with earlier research (Fabling and Grimes 2008) showing that New Zealand firms actively manage foreign exchange risk in ways that suggest short-run currency movements have implications for their bottom line.

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* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Reserve Bank of New Zealand. The authors wish to thank Statistics New Zealand for access to the data.

† *Richard Fabling:* RBNZ (richard.fabling@rbnz.govt.nz); Motu Economic and Public Policy Research. *Sophie Joyce:* RBNZ summer intern. *Lynda Sanderson:* RBNZ (lynda.sanderson@rbnz.govt.nz); University of Waikato.

ISSN 1177-7567

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1 Introduction

We present analysis on the dispersion and evolution of unit values in New Zealand merchandise trade. The analysis is descriptive, examining the relationship between export unit values, the currency of invoice, and exchange rate movements. Our work is motivated, in part, by the importance that traded goods' prices often play in small open macro-economy models, particularly the central role these prices play in the transmission of shocks and the determination of optimal monetary policy (eg, Obstfeld and Rogoff (1995) and Betts and Devereux (2000)).

We calculate the proportion of "sticky" (ie, unchanged) export unit values and the distribution of the magnitude of unit value changes, as measured in the currency of invoice. We then estimate an exchange rate pass-through (ERPT) relationship at the firm-level, since responses to currency movement are a prime candidate for explaining unit value changes.

When considering the ERPT relationship over the short run, it is unlikely that the bilateral exchange rate is the relevant currency for understanding changes in the unit value received by New Zealand firms. Instead, we use the currency of invoice to estimate the ERPT relationship – using this dataset it is clear that most trade contracts are not denominated in the destination currency, implying that use of the bilateral exchange rate is not likely to be a good proxy for the short-term risk faced by exporters.[1]

Most earlier studies have estimated this relationship at the product-country level. Our primary unit of observation is the month-on-month change in unit values indexed on firm, detailed good, destination market, and currency of invoice. To provide context for the importance of a disaggregated unit of observation, we also present evidence of significant dispersion in export unit values across firms trading the same good, controlling for destination market and currency of invoice. In addition, we document significant dispersion in the export unit values of firms trading the same good, in the same currency, to three or more destination markets. Furthermore, we find that for these firms, GDP per capita and distance of destination market are positively related to export unit values. These facts suggest that results from aggregate and most firm-level studies of price stickiness are likely to be affected by changing export composition over time. Indexing over a firm, product, destination market, and currency of invoice helps isolate a constant good over time, reducing these concerns as much as practicable given the available data.

[1] See Fabling, Sanderson, and Taglioni 2009 for a fuller exposition of this argument.

Our results suggest that only a small proportion of export unit values are sticky (ie, unchanging over consecutive trades), and that the proportion of sticky trades is quite similar for the subsets of contracts written in New Zealand Dollars (NZD) and foreign currencies. However, weighted by value, most trade is not contracted in NZD. For foreign invoiced trade, we find a significant, though incomplete, exchange rate pass through mechanism applying.[2] As a consequence, the NZD-converted value of that trade is substantially impacted by currency movements.

Section 2 outlines two literatures that our paper contributes to. Section 3 explains the data that we use and presents the export unit value dispersion results that motivate our detailed level of disaggregation. Section 4 examines the distribution of unit value changes over time and presents simple statistics on the proportion of "sticky" unit values, drawing a distinction between contracts denominated in NZD and foreign currencies, and the NZD-converted value of foreign-denominated contracts. Section 5 relates unit value changes to movements in the bilateral exchange rate with the currency of invoice, while section 6 summarises our findings.

2 Literature Review

Our paper relates to both the trade literature – studying the dispersion of prices within product categories and across destination and origin markets – and the literature on the stickiness of traded goods' prices and the currency of invoice (including the empirical estimation of ERPT). This section reviews these two literatures.

2.1 Trade

Dispersion of export unit values within disaggregate product categories, across destination and origin markets, has been widely documented and studied.[3]

[2] We do not estimate the ERPT relationship on the import side. Because ERPT for imports prices has been linked to domestic inflation, this relationship is traditionally of more interest to central bankers. The contribution of our paper is in controlling for firms when estimating pricing to market behaviour. Given we lack firm-level controls for foreign exporters in the import data, we believe such estimates are subject to our composition critique. Estimates of ERPT into New Zealand's import prices are left to future work.

[3] See, eg, Hallak (2006), Hummels and Klenow (2005), and Hallak and Schott (2008).

On the supply side, Schott (2004) finds a positive relationship between import unit values, and exporter country GDP per capita and factor endowments. Schott suggests this is evidence of specialisation by countries within products ("new trade theory"), rather than across products ("old trade theory").

The observed dispersion in export unit values across countries has led some to suggest differences in product quality explain the dispersion in unit values. Furthermore, several authors have studied the role of product quality in trade flows. In particular, Hallak (2006) suggests countries with a higher GDP per capita demand higher quality products. He produces an index of quality for each sector and country. This is an export price index based on cross-country differences in export unit values. Fontagné et al (2008) are similarly motivated by different unit values within a product category, but focus on the distinction between advanced/high-income ("North") and less developed ("South") countries. They consider indicators of export similarity across countries at the level of sector, HS6[4] product and varieties.[5] While they find that there are large similarities between North-South countries at the sectoral level, there is much greater distinction between varieties suggesting countries specialise within products.

Co (2007) tests whether US exporters charge different prices depending on destination. Thus, instead of linking differences in good quality within product categories with unit value dispersion, her method groups destination countries together if they share similar characteristics, and tests whether export price differentials increase or decrease. Using aggregate trade data, Co groups countries on the basis of income, common language, and currency behaviour, to see if price differentials are reduced when controlling for these factors.[6] Since price differentials decline when countries are grouped according to currency behaviour, Co takes this evidence as suggesting "pricing to market" behaviour.[7]

Our paper, in particular our estimate of the dispersion in unit values within firms, across destinations, relates to Heterogeneous Firms Trade (HFT) models like those proposed by Melitz (2003). More recently, variants of the HFT model place a central role on quality, rather than price, competitiveness of firms. In Quality Heterogeneous Firms Trade (QHFT) models (proposed by

[4] HS is the Harmonised System classification system for trade goods, with HS6 being the six-digit disaggregation. We make use of the 10-digit version of this system in our empirical analysis.

[5] Varieties refer to products shipped at different unit values.

[6] Currency behaviour refers to a currency appreciation or depreciation of the destination market.

[7] Pricing to market is formally defined on page 7.

Baldwin and Harrigan 2007) firms send more "expensive" goods to markets with higher trade costs. Thus unit values are positively related with distance if trade costs rise with distance of the market. By contrast, under the HFT model increasing distance lowers unit values. Baldwin and Ito (2008) empirically test both of the HFT and QHFT models by estimating a distance-price equation using prices at the HS6 level indexed by country of destination and time. Results suggest that for a majority of EU countries a large share of exports are "quality" competition goods, that is, higher distances of destination market are associated with higher prices.

Another trade paper studying the dispersion in export unit values across countries of destination is Hummels and Skiba (2004). They test the Alchian-Allen hypothesis which posits that an increase in per unit transport costs lowers the relative price of quality and, as a result, high quality goods are exported and low quality goods are sold domestically. Hummels and Skiba (2004) find that increasing transportation cost are associated with increasing demand for high "quality" goods (ie, higher unit values), relative to low quality goods. Implicit in their result is the assumption that goods with higher unit values reflect higher quality goods. Hummels and Skiba (2004) firstly provide evidence that transport costs are per unit rather than "iceberg".[8] They use cross-section data for six importing countries and relate average prices for a HS6 good indexed by an exporter and importer country to freight and tariff costs to test the Alchian-Allen hypothesis. They find empirical confirmation for Alchian-Allen effects in the form of a positive coefficient on the apportioned freight rate; higher freight costs are associated with higher free-on-board (FOB) prices, and higher tariffs with lower FOB prices.

2.2 Export Prices and Exchange Rates

If prices are sticky (fixed) in the currency of invoice, there are potentially consequences for both trading parties when there are fluctuations in the exchange rate. In this paper, we adopt the convention of describing apparent producer currency (local currency) pricing when prices appear to be stickier (more stable) in the currency of the exporter (importer). A recent study by Gopinath and Rigobon (2008) documents significant stickiness in the prices of US imports and exports (the median price duration for export goods is slightly over a year). The authors use firm-level survey data on import and

[8] The iceberg transport costs assumption is common in theoretical models and assumes costs are proportionate to the unit value of the goods shipped.

export product prices collected by the Bureau of Labor Statistic. In Gopinath and Rigobon (2008), because most transactions for imports and exports are invoiced in US dollars (USD),[9] and import and export prices are sticky, they conclude US exporters exhibit producer currency pricing, and US importers local currency pricing.

A recent paper by Friberg and Wilander (2008) uses survey data and settlement reports for Swedish firms to present evidence on Swedish importers' and exporters' currency of invoice practices. This includes evidence suggesting Swedish firms do not convert foreign currency transactions into Swedish Kronas immediately after a sale, that the same currency is often used for price-setting, invoicing, and payment.[10] In addition, they find rigidity in prices and that the majority of exports are invoiced in a foreign currency, suggesting local currency pricing by Swedish firms. Across a broad range of 24 countries, Goldberg and Tille (2008) a sizeable share of trade is invoiced in USD rather than the producer or importer currency.

Related to export unit values and the currency of invoice, is the extent of pass through of changes in the exchange rate into traded goods' prices. The relationship between exchange rates and traded goods' prices is known as the exchange rate pass-through relationship. Specifically, the ERPT relationship is defined as the *"percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries"* (Goldberg and Knetter 1997, p 1248).[11]

Goldberg and Knetter (1997) and Goldberg and Hellerstein (2008) review the micro-foundations of ERPT from the perspective of pass through to *import* prices. Exporters set prices in their domestic currency (the producer currency) and those prices depend on costs and the firms' mark-up (because firms are imperfectly competitive they are able to price above marginal cost). The exchange rate at time t enters the equation for the export goods' price denominated in the local currency. Complete exchange rate pass-through occurs when the variation in the local currency price of the good mirrors the change in the exchange rate. Incomplete pass-through occurs when a change in a bilateral exchange rate is not completely transmitted into the local currency price of a traded good. For incomplete pass-through to occur,

[9] 90 percent for imports and 97 percent for exports

[10] Unfortunately, we are unable to determine when (or if) firms convert foreign earnings into NZD or when export contracts are signed. Instead our reference date is the time the shipment leaves New Zealand and we assume that this is the month during which payment would be received.

[11] In our empirical analysis we test a modified version of this definition.

a change in the exchange rate must affect either (or both) the firms' mark-up or marginal cost. Goldberg and Hellerstein (2008) further decompose incomplete pass-through into mark-up adjustment, marginal cost changes, and costs associated with re-pricing.

The empirical literature estimating the ERPT relationship is extensive. Knetter (1989) proposes a commonly used reduced form specification for estimating ERPT. He uses panel data with export prices denominated in the exporter's currency and indexed by country of destination and time. Knetter (1989) argues that export prices are affected by changes in the exchange rate through two channels: changes in marginal costs of production, and firms adjusting mark-ups to destination-sensitive elasticities of demand. He distinguishes between these two explanations of incomplete pass by exploiting data on the shipments of goods to multiple destinations. If firms use imported goods that are affected by exchange rate movements as inputs, and inputs represent a constant cost increase or decrease across all destinations for a product, the component of a price change due to marginal cost will be the same across destinations, whereas mark-ups are destination-specific.

A large body of empirical evidence supports incomplete pass-through of changes in exchange rates onto the local currency prices of goods. There are several theoretical explanations for incomplete pass-through. The most widely cited is the Krugman (1987) (and Dornbusch 1987) "pricing to market" model of firm's price setting behaviour in relation to changes in exchange rates: *"The phenomenon of foreign firms maintaining or even increasing their export prices to the US when the dollar rises may be described as pricing to market"* (Krugman 1987, p49). In a monopolistically competitive environment, firms adjust their mark-up depending on the elasticity of demand for their good in the destination market. For example, if firms are reluctant to lose market share, they will lower their mark-up when the exporter's exchange rate appreciates against the importing country. This behaviour is induced by changes in the exchange rate and is generally attributed to firms stabilising price changes in the buyer's currency.

Hummels and Skiba (2004) test for "pricing to market" as an alternative explanation to the Alchian-Allen hypothesis. They argue that the average FOB price would have to be "implausibly large" to explain the observed magnitude of the estimated elasticity of the coefficient on the distance term in the empirical estimation relating average FOB prices to transport costs. They note that within their framework, the effect of tariffs on trade prices for both the Alchian-Allen and PTM hypotheses reinforce each other, but the effect of transport costs on each hypothesis is opposing. Although Hummels and

Skiba do not empirically estimate the PTM relationship, they argue that the average coefficient found in the literature cannot explain their results, instead they argue that Alchian-Allen and PTM effects are likely both important in explaining the variation in FOB prices across destinations.

Studies estimating the ERPT relationship using micro data are limited and include Goldberg and Verboven (2005), Gopinath and Rigobon (2008), Goldberg and Hellerstein (2007), Fitzgerald and Haller (2008), and Berman et al (2009).[12] Fitzgerald and Haller (2008) use Irish plant level data to look at the impact of exchange rates on firms' pricing decisions. They exploit data on firms' prices for the same product sold in domestic and export markets, and data on firms' exporting the same product to different markets, in order to identify the effect of exchange rate driven demand and cost shocks on pricing decisions. Goldberg and Verboven (2005) study the price dispersion in the car market of EU member states over time. They estimate a hedonic pricing equation, utilising data on the attributes of each car. With annual time series data they find significant evidence of price discrimination across countries, which they then relate to changes in the bilateral exchange rates between countries. Gopinath and Rigobon (2008) firstly test whether significant foreign currency devaluations affect the probability of a goods' price change. They compare the probability of a price change in the period prior to and after currency devaluation. In general, they find no significant difference. They also estimate an ERPT equation with import prices indexed by the good, industry sector, and country of origin. They estimate the cumulative change in the exchange rate and import price since the last price change. This deals with problems of price stickiness being incorrectly associated with incomplete pass-through.

Gopinath and Rigobon (2008) use USD import prices and the bilateral exchange rate with the source country to estimate the ERPT relationship. They also estimate the degree of exchange rate pass through for US imports that are invoiced in USD vs. non-USD, finding a significant difference in the pass-through of exchange rate changes for each of these groups.

As far as we are aware, the only other attempt at estimating the impact of exchange rates on prices at the firm level is a recent working paper by Berman et al (2009). They index on firms to estimate the impact of exchange rates on export prices and quantity of goods exported. They index their prices on firm,

[12] Papers estimating the ERPT and pricing-to-market relationship using aggregate trade data are more prolific and include Bugamelli and Tedeschi 2008, Parsons and Sato 2006, Athukorala and Menon 1994, Gaulier, Lahrèche-Révil, and Méjean 2008, Mallick and Marques 2008, and Campa and Goldberg 2005.

destination market, and time. They also include a firm-specific measure of productivity to test whether firm responses to exchange rate changes differ across this dimension. However, Berman et al (2009) do not distinguish the currency of trade, and they estimate ERPT with the bilateral exchange rate of the country of destination. Given the Gopinath and Rigobon (2008) results, we expect knowledge of the currency of invoice (as in our study) to be an important factor to control for.

Goldberg and Knetter (1997), in their review of the literature on goods prices and exchange rates, note that dynamics complicate the study of PTM. Firstly, the currency in which trades are invoiced could bias the finding of PTM. If invoicing is in the buyer's currency and price adjustment is infrequent, this could lead to spurious findings of PTM. On the other hand if invoicing is in the exporters currency and price adjustment is infrequent this creates a bias against finding PTM. In addition, issues of permanent versus temporary changes in the exchange rate could also affect findings of PTM because exporters should respond differently to these changes (assuming identification of such a distinction is feasible). However, Goldberg and Knetter (1997) argue that conscious price discrimination appears to be pervasive and that price differentials appear to be persistent and not reflective of an underlying price convergence.

3 Data

3.1 The Longitudinal Business Database

The dataset used in this paper is indexed on firm, good, destination and currency of invoice. We start from daily Customs data linked to Statistics New Zealand's prototype Longitudinal Business Database (LBD) and then aggregate to a monthly trade frequency.[13] We justify this detailed indexing on the basis of observed dispersion in export unit values across and within firms. That is, we show that there is significant heterogeneity in unit values across firm-good-country relationships suggesting that pricing to market could be falsely identified from compositional change in the export destinations that firms trade to.

Products are defined using the highly detailed ten-digit Harmonised System

[13] Fabling and Sanderson (2008) document how we allocate trade data to manufacturing firms based on Statistics New Zealand's initial match to the LBD.

(HS10) and unit values are calculated as the free-on-board value (in either the invoicing currency or NZD) over the quantity exported:[14]

$$P^{FX,NZD}_{fcgxt} = \frac{\text{value}^{FX,NZD}_{fcgxt}}{\text{volume}_{fcgxt}} \tag{1}$$

where f, c, g, x, t index the firm, country, good, currency and month respectively, and the superscript denotes whether the FOB value is denominated in the currency of invoice (FX, which includes NZD-denominated contracts) or the NZD converted value.[15] Changes in unit values over time are log differences of levels divided by the number of months (M_t) between consecutive trades of the combination f,c,g,x, that is:

$$\Delta P^{FX,NZD}_{fcgxt} = \frac{1}{M_t}\left(\ln P^{FX,NZD}_{fcgx,t} - \ln P^{FX,NZD}_{fcgx,t-M_t}\right). \tag{2}$$

In this latter equation, we focus on the currency of invoice since we are primarily interested in whether New Zealand exporters are able to (or choose to) negotiate price changes in export contracts. Consideration of the effect of contract price in the foreign currency on the NZD-converted earnings of the exporter are considered when we look at exchange rate pass-through in Section 5.

The monthly data covers April 2004–December 2007, which is the period where we have comprehensive currency of invoice information.[16] Over this period we observe trade in 7,894 goods to 218 countries by 5,247 firms.[17] We have a total of 686,952 observations of P_{fcgxt}, and 513,864 observations of ΔP_{fcgxt} (there are 100,311 one-off trades and these are disproportionately invoiced in NZD). Table 1 shows the proportion of unit value level and change observations by currency of invoice. While a large proportion of trades are denominated in NZD, the majority of the (NZD) value of trade has the USD as the currency of invoice, making the role of currency fluctuation in the evolution of unit values a key consideration at the macroeconomic

[14] Quantities are measured in standard units that are time-invariant and good-specific (eg, kilograms, litres or counts). For a small proportion of trade, quantities are not defined – primarily because the span of goods in the ten-digit code is not thought to be homogeneous enough to be covered by a single unit of measurement. In such cases we use the shipment weight to derive a proxy unit value or, where this is not possible, drop these observations.

[15] Where the analysis the same across FX/NZD we drop the superscript and simply refer to P_{fcgxt} or P.

[16] April 2004 saw the introduction of mandatory electronic filing of exports shipments.

[17] Throughout the paper, firm-based counts are random-rounded to base three in compliance with Statistics New Zealand's confidentiality rules.

Table 1
Proportion of observations by currency of invoice

Currency (x)	Unweighted P_{fcgxt}	Unweighted ΔP_{fcgxt}	Trade-weighted P_{fcgxt}
NZD	0.491	0.453	0.175
USD	0.272	0.293	0.583
AUD	0.142	0.154	0.102
EUR	0.048	0.048	0.074
GBP	0.019	0.021	0.036
Other	0.028	0.031	0.030

level. That is, NZD-denominated trades are of lower average value than foreign-denominated trades. This may in part be because smaller firms are less capable or willing to enter trade relationships that involve currency risk of various kinds (see Fabling and Grimes 2008, and Fabling et al 2009 for evidence of this using the same Customs data used here).

The majority of firms (51.3 percent) only trade in one currency. Australia is our largest trading partner and also accounts for 29.9 percent of all observations. Within Australian trade, there is a roughly even split of observations between the currency of invoice being Australian Dollars (AUD) or NZD. A different picture is apparent for our second largest trading partner, the United States. While most US-destined trade is invoiced in USD (consistent with evidence from US importers), 80.9 percent of observations invoiced in USD are not destined for the US market, reflecting the role of the USD as an international currency of trade (Goldberg and Tille 2008; Krugman 1980). We select NZD and the four largest foreign currencies of invoice, USD, AUD, Euro (EUR), and Pound Sterling (GBP) for subsequent analysis.

3.2 Motivating the need for disaggregated unit values

Despite being widely used in research, a common critique of unit values is that they cannot ensure that the goods traded are homogeneous within product categories.[18] While we have made significant attempts to control for sources of heterogeneity when calculating unit values, we deliberately avoid referring to P_{fcgxt} as a price.

To explore the composition issue we construct various sub-populations and examine the coefficient of variation (ie, the standard deviation over the mean) of unit values in NZD, $c_\nu(P^{NZD})$. We look first at the variation across firms

[18] Silver (2007) explains in detail how the calculation of unit value-based price indices is affected by the composition of goods.

trading the same good – that is, a set of unit values that would be aggregated into a single product for an aggregate study – and consider the reduction in within-month variation that arises from further indexing on country and currency. We then look at within firm-good price dispersion across countries – a set of unit values that would, presumably, be averaged over should a firm be asked for a good-level export price. The presence of significant dispersion in unit values both across and within firms justifies indexing on firm, good, and country in our analysis of the evolution of export unit values. Finally, we question whether some of our good categories are sufficiently homogeneous by looking at Harmonised System descriptors that contain the phrase "not elsewhere classified (nec)". That analysis naturally leads into a broader discussion of measurement error.

In estimating $c_\nu(P_{gt}^{NZD})$ across firms trading the same good in a month, we restrict to goods where there are at least five firms trading in the month. Out of a total 143,680 monthly observations of goods traded, 12.8 percent satisfy this criteria. The median value of $c_\nu(P_{gt}^{NZD})$ is 0.939 across all countries and currencies. Among other things, product-level unit value dispersion will reflect firms discriminating across destinations, destination-dependent pricing that is common to all firms, any ability of firms to differentiate their products (which may be harder in goods with a lower value-added component[19]), and measurement error (discussed in the next subsection). Additionally controlling for the country of destination, so firms are all trading the same good to the same country in that month we have a total 14,001 unique observations, and the median deviation drops to 0.636.

Further restricting to goods being traded to the same country in the same currency, we have 10,974 unique observations with then median value of $c_\nu(P_{cgxt}^{NZD})$ being 0.553. This presents the most disaggregate level at which we can control for sources of heterogeneity. The reduction in variation at this level is relatively minor (compared to the prior step controlling for destination) mainly because most firms only trade goods to a country in a single currency. Aside from allowing us to interpret the impact of currency movements on unit values more clearly, an additional motivation for separating the currency of invoice is that firms trading to the same country in multiple currencies may be indicative of multiple buyers and, therefore, potentially reflect differing contract relationships.

To examine the within-firm dispersion of goods prices we restrict our dataset to firms trading in the same good in the same currency of invoice. Dropping

[19] The next version of this paper will follow up on this possibility by splitting goods into categories using the classification system of Rauch (1999).

Table 2
Relative Unit Value and destination characteristics

	All	$x = NZD$	$x \neq NZD$
Relative GDP per capita	0.0202***	0.0019	0.0310***
Relative distance	0.0635***	0.0618***	0.0722***
N	199,056	88,788	110,268
R^2	0.003	0.003	0.004

Counts random-rounded to base three for confidentiality reasons.
*** Significantly different from zero at the 1% level (robust standard errors).

the country index reduces our dataset to 471,483 observations of P. This reduction is small because firms trade most of their goods (82.3 percent) to a single country. A further 9.1 percent are firm-good observations are traded to two countries; and 8.6 percent are traded to three or more countries in a month. To produce meaningful statistics on within-firm dispersion we use this latter set of 40,566 observations (ie, firms that trade a good to at least three countries in any given month), finding the median coefficient of variation within firm across destination markets $c_\nu(P^{NZD}_{fgxt})$ is 0.326. Restricting to trade relationships where the currency of invoice is NZD (foreign), the median rises (falls) slightly to 0.348 (0.300).[20]

Since the presence of dispersion across destinations could suggest firms are discriminating on price across markets, we attempt to identify any systematic relationship between country characteristics and unit values.We do this by regressing the relative unit value on relative GDP per capita (proxying for income) and distance, bearing in mind that shipment values are measured before transport costs, but that differential trade costs may affect the composition of goods that firms send to destinations (see, eg, Fabling et al 2009). Relative values are derived by dividing through by the mean value at the firm, good, currency and month level.

Table 2 summarises regression coefficients for this equation estimated on the whole population and on the sub-population of NZD and foreign invoiced trades. Consistent with the empirical literature, we find positive and significant coefficients for both relative distance and GDP per capita. Hallak (2006) also finds a positive relationship between export unit values and the GDP per capita of the destination market. Extending the Linder (1961) hypothesis, Hallak suggests wealthier countries demand higher quality goods. In addition, a positive and statistically significant relationship between dis-

[20] Consistent with Goldberg and Tille (2008) who find that less differentiated goods are more likely to be traded in international currencies of trade (ie, “vehicle” currencies, primarily the USD).

tance and export unit values is consistent with estimation of Alchian-Allen effects in Hummels and Skiba (2004), and with QHFT trade models – if we are prepared to interpret higher unit values as reflecting higher quality products.

Both the across- and within-firm analyses above suggest the detailed level of observation will help eliminate changes in P caused by composition. However, we should still expect residual heterogeneity within goods that might only be eliminated by, say, observations of specific consistently measured goods (eg, bar code price studies such as Broda and Weinstein 2008).

Some suggestion of remaining composition issues can be found by looking at goods whose Harmonised System descriptor contains the phrase "not elsewhere classified (nec)". Within goods being traded, we observe larger dispersions for product categories that are described in this manner. On an unweighted basis, this categorisation is material, since roughly a quarter of observations of P are of this type. Controlling for country and currency, the median coefficient of variation for goods defined as nec is 0.934, compared to a median of 0.429 for non-nec goods suggesting that composition effects may be more of a problem in categories that are not so narrowly defined. Throughout the rest of the paper, we retain these observations on the maintained assumption that homogeneity within these categories is likely to be higher at the firm-level.

3.3 Other measurement issues

Before presenting empirical results, we discuss non-compositional measurement issues. These issues are particularly pertinent to situating our findings in the empirical literature where administrative trade data is not the source of price information. As our benchmark for comparison we use Gopinath and Rigobon (2008), who find significant stickiness in traded goods prices using *surveyed* micro-data from the United States. Whether survey prices reflect the actual price charged by firms more accurately than unit values is debatable. Self-reported price surveys and FOB unit value derived from Customs data are subject to many common critiques. For example, it is possible respondents/exporter's fill out forms incorrectly or forms are filled out inconsistently over time. In particular, firms may be reluctant to report all price changes because, eg, there is a cost to varying their response from last time, or price changes are "small" and therefore overlooked.

Survey design may exacerbate these latter biases towards finding greater price stickiness. For example, the survey data underlying Gopinath and Rigobon (2008) allows firms to report a fixed contract price in advance for multiple months. In the case of administrative data, at least, there is an ability to sanction firms for misreporting. Furthermore, administrative data generally collects much more and much finer detail than is possible through surveys. It is somewhat unclear what survey respondents will report when the same good is traded at multiple prices (potentially biasing stickiness results downwards). This problem is encountered less often when more detailed disaggregation is required (as per our discussion above), though the strength of the argument is conditional on respondents accessing data that is relevant to the more specific question rather than, say, applying "rules of thumb" at higher levels of aggregation.

In defence of the survey method, unit values could bias results towards finding little price stickiness since data for every trade is reported and any inconsistency in reporting FOB value or quantity of goods shipped could generate small fluctuations in unit values that are not actual price changes. Arguably, there is more room for measurement error when using FOB values and quantity to proxy for price, rather than direct price data since we have to perform a division (ie, value over quantity). Of course, this point assumes surveyed respondents reference a price directly.

Since we do not have direct surveyed prices of individual export goods in New Zealand, we cannot separate the impact of different data collection methods from differing market conditions. For an example of the latter, recall that the vast majority of US exporters contract in USD suggesting that, at a minimum, US firms are likely to be less exposed to fluctuations in export receipts due to currency movements than exporters in other jurisdictions (Gopinath and Rigobon 2008; Goldberg and Tille 2008). The fact that those firms are not exposed to as many currencies in trade may well also reflect an asymmetry in market power between US and other firms which could presumably flow through into price-setting behaviour.

One way to check for potential measurement error in ΔP^{FX} is to test for autocorrelation in unit values changes. We do this by regressing ΔP^{FX}_{fcgxt}, on its lagged value (ie, at $t - M_t$) yielding a statistically significant ($p = 0.000$) relationship with a coefficient of -0.39. The negative coefficient is consistent with both measurement error and/or some temporary shock(s) impacting on unit values. Separating the population on the median FOB New Zealand value, as a proxy for populations of large and small firms, we estimate the relationship again finding a coefficient of -0.41 for larger firms and -0.39 for smaller firms, suggesting that if the story is one of measurement error, it is not particularly more troublesome in smaller trade relationships.

In common with other types of export price data, we also have to consider the self-selection nature of our trade data. If a firm does not trade, we do not observe whether a product changes price. “Take it or leave it” offers of price variation by trading partners (perhaps driven by currency movements) could induce entry or exit by New Zealand exporters.[21] This analysis makes no adjustment for attrition and compares unit values across consecutive trading months.

One adjustment we do make when we consider price stickiness (ie, the same unit value persisting over time) is to allow for the possibility that rounding of reported Customs values has affected our measure of ΔP. In the next section we consider various threshold values at which we treat a unit price change as sticky.

Finally, in the LBD, t refers to the time the shipment clears Customs rather than the time when the trade contract was signed. Since this latter date is our ideal for analysing ERPT issues and there could be any number of months lag between contract signing and delivery, we potentially have a measurement issue with our right-hand side variable, the currency movement over time.[22]

3.4 Data summary

Overall, we have argued that controlling for a firm, good, destination, and currency is a substantial attempt at controlling for heterogeneity that could cause us to underestimate export unit value stickiness. Despite these controls P should be viewed as a proxy for a price and likely subject to some measurement error. With this in mind we focus on the dynamics of export unit value changes and the relationship between ΔP^{FX} and movements in the bilateral exchange rate with the currency of invoice.

4 Unit value stickiness

We begin our empirical analysis by estimating the “stickiness” of export unit values – the percentage of trades where P is observed to stay approximately

[21] Or, alternatively, fixed NZD price offers from NZ exporters could result in variable foreign demand.

[22] The next version of the paper will include lagged values of the exchange rate change to partially account for this issue.

Table 3
Proportion of sticky unit values

	Unweighted			Trade-weighted		
	ΔP^{FX}	ΔP^{FX}	ΔP^{NZD}	ΔP^{FX}	ΔP^{FX}	ΔP^{NZD}
Range	$x = NZD$	$x \neq NZD$	$x \neq NZD$	$x = NZD$	$x \neq NZD$	$x \neq NZD$
0	0.051	0.034	0.002	0.015	0.008	0.000
$[-0.001, 0.001]$	0.079	0.073	0.014	0.051	0.047	0.015
$[-0.005, 0.005]$	0.123	0.140	0.062	0.107	0.140	0.070
$[-0.010, 0.010]$	0.168	0.199	0.121	0.172	0.219	0.139

Underlying counts random-rounded to base three for confidentiality reasons.

Table 4
Summary statistics for ΔP^{FX} by currency of trade

Currency (x)	N	mean	median	st. dev.	$\mid \Delta P^{FX} \mid < 0.001$
NZD	232,974	0.002	0.000	0.583	0.079
USD	150,735	0.007	0.000	0.471	0.083
AUD	78,972	-0.002	0.000	0.573	0.054
EUR	24,762	0.000	0.000	0.442	0.069
GBP	10,728	-0.001	0.000	0.580	0.074

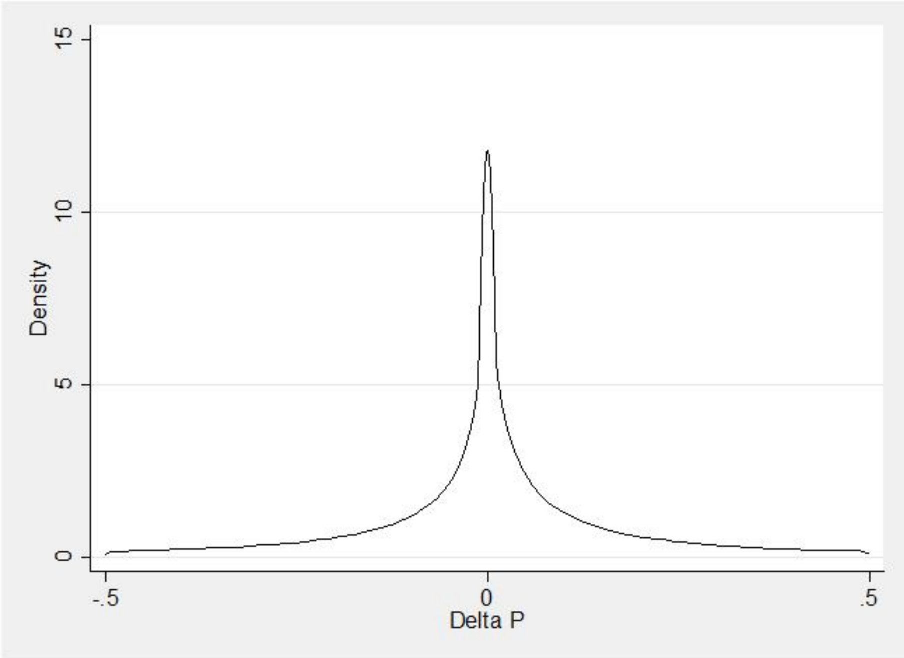
Counts random-rounded to base three for confidentiality reasons.

the same over time. Table 3 sets out the proportion of sticky unit values using different thresholds. Observed in the currency of invoice, the percentage of sticky unit values is roughly equal for NZD- and foreign-denominated trades, although slightly higher for NZD trade at low thresholds and slightly higher for foreign invoiced trades at higher thresholds (the first two columns of the table). The trade-weighted results suggest that smaller value trades are more likely to be sticky at low threshold levels. Foreshadowing the exchange rate pass through results in the following section, the NZD-converted unit value of foreign currency trade (columns 3 and 6 of table 3) are far less sticky than the invoiced currency value (columns 2 and 5).

Overall, most unit values change frequently. Figure 1 reinforces this point by plotting the distribution of ΔP^{FX}. Having said that, while this figure excludes observations in the tails,[23] it is clear that changes in unit values are clustered around zero. Table 4 reports summary statistics for ΔP^{FX} for the top five trading currencies and proportions of sticky values using a threshold value of 0.001. Consistent with the overall picture, changes in P^{FX} are centred on zero for every major currency of invoice.

[23] In compliance with Statistics NZ confidentiality requirements.

Figure 1
Distribution of ΔP^{FX}



5 Exchange rate pass-through

There are many reasons why firms might change prices. In this section we consider the possibility that exporters invoicing in a foreign currency could be motivated to smooth the NZD value of that income. Given that rationale for pricing behaviour, we would expect to see P^{FX} increase if the NZD appreciated against the currency of invoice. We would also expect successful smoothing of NZD-converted income to show up in measurable price stickiness in P^{NZD} where $x \neq NZD$. We have already seen from table 3 that this latter observation is not apparent, at least at low threshold values for defining stickiness. However, it is still possible that some of the variability NZD-converted income is smoothed by passing on some exchange rate variation into foreign unit values.

Our method for testing the strength of any ERPT relationship is simple – we regress ΔP^{FX} on the cumulative log change of the bilateral exchange rate between the currency of invoice and the NZD (we use the nominal exchange rate in units of foreign currency per New Zealand dollar, eg, $X_{USD,t} = 0.6$

Table 5
Exchange rate pass through estimation

	(1)	(2)	(3)	(4)
ΔFX_x	0.108		0.042	
p_0	(0.021)		(0.678)	
p_1	(0.000)		(0.000)	
$\Delta FX_x, M = 1$		0.092		
p_0		(0.086)		
p_1		(0.000)		
$\Delta FX_x, M > 1$		0.193		
p_0		(0.006)		
p_1		(0.000)		
$\Delta FX_x > 0$				0.131
p_0				(0.204)
p_1				(0.000)
$\Delta FX_x < 0$				0.027
p_0				(0.775)
p_1				(0.000)
Test: coef. equiv.		(0.255)		(0.462)
N	280,890	280,890	280,890	280,890
R^2	0.000	0.000	0.001	0.000

Robust p-values in brackets. Counts random-rounded to base 3 for confidentiality reasons. Columns 2 and 4 include unreported subgroup constants. Column 3 is implemented using Stata's AREG command.

means that one NZD buys 0.6 USD):

$$\Delta P^{FX}_{fcgxt} = \beta \Delta FX_{fcgxt} + \epsilon_{fcgxt}, \tag{3}$$

$$\Delta FX_{fcgxt} = \frac{1}{M_t} \left(\ln X_{x,t} - \ln X_{x,t-M_t} \right). \tag{4}$$

where M_t is defined as before. In this specification a positive coefficient on β less than one implies incomplete pass-through, but some ability of NZ exporters to pass currency risk to foreign buyers.

Tables 5 and 6 estimate the effect of ΔFX on ΔP^{FX} for the whole population of firms and by major foreign currency of invoice respectively. Focussing on table 5 first, column one shows the simple OLS estimate of β is 0.108. Roughly 11 percent of any exchange rate movement is carried through into subsequent contracted unit values. Two tests (reported p-values) are included and imply the rejection of no positive relationship between unit value changes and currency movements (the p_0 row, rejected at the 5 percent level), and rejection of complete pass-through (ie, that $\beta = 1$) at the 1 percent level. Subsequent specifications test the robustness of this result.

Firstly, in column two, we separate the population into observations of P^{FX} that occur over consecutive months and those that have at least a one month gap between trades (bearing in mind that both the dependent and independent variables have been normalised by the period between trades, M_t). We

Table 6
Exchange rate pass through by currency

	(1)	(2)
$\Delta FX_x, x = USD$	0.140	0.026
p_0	(0.014)	(0.819)
p_1	(0.000)	(0.000)
$\Delta FX_x, x = AUD$	0.037	-0.020
p_0	(0.768)	(0.903)
p_1	(0.000)	(0.000)
$\Delta FX_X, x = EUR$	-0.017	-0.163
p_0	(0.912)	(0.355)
p_1	(0.000)	(0.000)
$\Delta FX_x, x = GBP$	0.183	0.016
p_0	(0.536)	(0.958)
p_1	(0.006)	(0.002)
$\Delta FX_X, x = Other$	-0.069	-0.167
p_0	(0.669)	(0.349)
p_1	(0.000)	(0.000)
Test: coef. equiv.	(0.647)	(0.695)
N	280,890	280,890
R^2	0.000	0.000

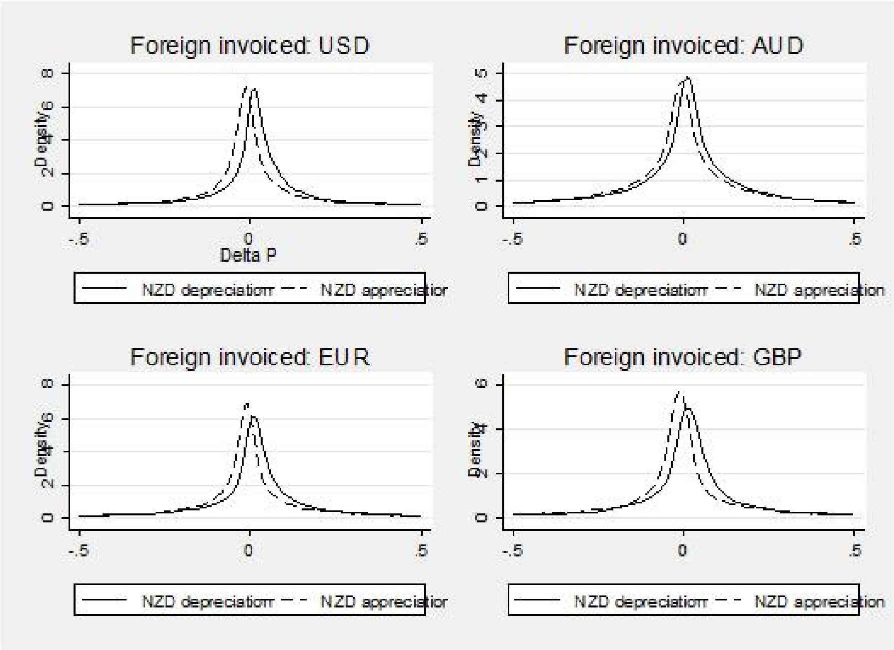
Robust p-values in brackets. Counts random-rounded to base 3 for confidentiality reasons. Regressions include unreported subgroup constants. Column 2 is implemented using Stata's AREG command.

make this split to test whether fixed price, multiple month contract durations might potentially explain a lack of pass-through. One implication of longer-term contracts would be an expectation that higher M trade has a higher β. Alternatively, if firms believe short-term currency fluctuations are largely temporary, then they may choose not to respond month-on-month to currency volatility, rather waiting for longer term deviations before renegotiating unit values. Consistent with both alternatives, point estimates of β for longer interval trade are higher – however, a test that the coefficients are different is rejected.

Column three returns to the basic specification but adds a t-M fixed effect,[24] which would account for any NZ-specific event that may shift all bilateral currencies in a particular direction and potentially affect costs for domestic producers (through, say, import prices). Such a confounding factor could lead to identification of a spurious relationship between ΔP and ΔFX. With fixed effects included, we cannot reject the possibility that there is no relationship between unit value movements and movements in the currency of

[24] That is, a fixed effect for every time (t) month-span (M) pair.

Figure 2
Distribution of ΔP^{NZ} by currency and periods of currency appreciation and depreciation



trade, though we still reject complete pass-through.[25]

In column four of table 5, we test for differences in ERPT when the NZD is appreciating or depreciating against the currency of invoice. We perform this test motivated by the possibility that NZ firms may have weak price-setting ability (relative to trading partners) so that bilateral currency movements are only passed on to unit values when that would raise the profits of the importer. A predominance of such trade relationships would imply a lower coefficient on ΔFX during appreciations. Alternatively, and yielding the same implications for coefficients, firms may strategically pass on exchange rate driven foreign prices declines (eg, to gain market share),[26] but be unwilling to raise prices during adverse currency movements say, because of implicit contracts with customers (as in Blinder 1991). The empirical results suggest point estimates of β are lower during appreciations of the NZD but,

[25] An alternative approach would be to introduce additional independent variables that might be thought to systematically affect ΔP^{FX} including the bilateral exchange rate with the country of trade, which may be important over longer time intervals (M). This approach is left to the next version of the paper.

[26] Or maintain prices during depreciations of the NZD to increase profits.

not significantly different across the two sub-populations.[27]

Finally, in table 6, we split across currencies of trade. Estimated coefficients are reported both without (column 1) and with t-M fixed effect (column 2). Once again we reject differences in sub-population pass-through coefficients and reject complete pass-through.

To summarise, we consistently find that exchange rate pass through is less than complete – we reject $\beta = 1$, at the 1 percent level, in every specification. Without risk mitigation strategies such as hedging currency exposure, the absence of substantial foreign price adjustment results in a substantially different picture of ΔP^{NZD} from that presented for ΔP^{FX}. This outcome is shown in Figure 2, which plots the distribution of the NZD-converted unit value (ie, P^{NZD}) split by whether the currency of invoice is appreciating (ie, NZ firms receiving lower profits, ceteris paribus) or depreciating.[28] For months where the bilateral exchange rate with the currency of trade depreciates, NZD converted unit values are positively skewed. For periods of depreciation, NZD unit value changes are negatively skewed. This is compared with figure 1 and the summary statistics presented in table 4 which clearly show distributions centred on zero – that is, a tendency for unit values to stay relatively stable, if not completely sticky, in the currency of trade.

6 Conclusion

We have documented the dispersion in export unit values across firms trading the same good, and within firms trading the same good, across destination markets. In particular, our results for firm-level price discrimination suggest distance and GDP per capita of the destination market play a significant role in explaining observed export unit values. Dispersion in product unit values both across and within firms motivates us to examine the evolution of export unit prices at the detailed firm-product-country-currency level.

Using this detailed measure of ΔP^{FX} we find that unit values of export goods tend to be reasonably flexible over time and that changes in unit values are similar across New Zealand Dollar (NZD)- and foreign currency-denominated contracts. However, NZD trades tend to be smaller and more likely to be one-off so that, on a trade-weighted basis, contracts written in foreign currencies

[27] Currency difference could explain why the point estimates are the wrong way around??

[28] This calculation ignores the available hedging data. Future work could usefully test whether NZD-converted values are less variable when hedging rates are taken into account.

are dominant. Focussing on the sub-population where $x \neq NZD$, we have examined the role that movements in the bilateral exchange rate between the currency of invoice and NZD play in determining unit value changes. Across a number of specifications, we reject the possibility that NZ firms negotiate the foreign (contracted) value of their goods in order to completely smooth the (realised) NZD value – that is, we reject complete exchange rate pass through. We observe two natural consequences flowing from incomplete pass-through. First, unit value stickiness is almost non-existent at the preferred (ie, 0.001) threshold level. Second, the NZD-converted income from foreign trades is impacted by currency appreciations and depreciations implying that short-run currency movements have implications for firms' bottom lines.

This last result is consistent with earlier research showing that firms trading to Australia actively manage exchange rate risk (Fabling and Grimes 2008). The next version of this paper will test whether such hedging practices result in greater stickiness in NZD-converted unit values, as well as addressing a number of methodological issues identified in the paper (such as controlling for the bilateral exchange rate with the country of trade, and accounting for the timing between contract and shipment dates).

References

Athukorala, P and J Menon (1994), "Pricing to market behaviour and exchange rate pass-through in Japanese exports," *Economic Journal*, 104(423), 271–281.

Baldwin, R and J Harrigan (2007), "Zeros, quality and space: Trade theory and trade evidence," *National Bureau of Economic Research, Working Papers*, 13214.

Baldwin, R and T Ito (2008), "Quality competition versus price competition goods: An empirical classification," *National Bureau of Economic Research, Working Papers*, 14305.

Berman, N, P Martin, and T Mayer (2009), "How do different firms react to exchange rate variations: Prices, quantity, and entry-exit," paper presented at 2009 American Economic Association meeting, San Francisco.

Betts, C and M Devereux (2000), "Exchange rate dynamics in a model of pricing-to-market," *Journal of International Economics*, 50(1), 215–244.

Blinder, A (1991), "Why are prices sticky? Preliminary results from an interview study," *AEA Papers and Proceedings*, 81(2), 89–100.

Broda, C and D Weinstein (2008), "Understanding international price differences using barcode data," *National Bureau of Economic Research, Working Papers*, 14017.

Bugamelli, M and R Tedeschi (2008), "Pricing-to-market and market structure," *Oxford Bulletin of Economics and Statistics*, 70(2), 155–180.

Campa, J and L Goldberg (2005), "Exchange rate pass-through into import prices," *The Review of Economics and Statistics*, 87(4), 679–690.

Co, C (2007), "Factors that account for the large variations in U.S. export prices," *Review of World Economics*, 143(3), 557–582.

Dornbusch, R (1987), "Exchange rates and prices," *American Economic Review*, 77(1), 93–106.

Fabling, R and A Grimes (2008), "Over the hedge? Exporters' optimal and selective hedging choices," *Reserve Bank of New Zealand, Discussion Papers*, DP2008/14.

Fabling, R and L Sanderson (2008), "Entrepreneurship and aggregate merchandise trade growth in New Zealand," paper presented at 11th McGill International Entrepreneurship Conference, Dunedin, New Zealand.

Fabling, R, L Sanderson, and D Taglioni (2009), "Exchange rate uncertainty and firms' trade," *Reserve Bank of New Zealand*, *Discussion Papers*, forthcoming.

Fitzgerald, D and S Haller (2008), "Exchange rates and producer prices: Evidence from micro-data," Stanford mimeo.

Fontagné, L, G Gaulier, and S Zignago (2008), "Specialization across varieties and North-South competition," *Economic Policy*, 23(1), 51–91.

Friberg, R and F Wilander (2008), "The currency denomination of exports – a questionnaire study," *Journal of International Economics*, 75(1), 54–69.

Gaulier, G, A Lahrèche-Révil, and I Méjean (2008), "Exchange-rate pass-through at the product level," *Canadian Journal of Economics*, 41(2), 425–449.

Goldberg, L and C Tille (2008), "Vehicle currency use in international trade," *Journal of International Economics*, 76, 177–192.

Goldberg, P and R Hellerstein (2007), "A framework for identifying the sources of local-currency price stability with an empirical application," *National Bureau of Economic Research*, *Working Paper*, 13183.

Goldberg, P and R Hellerstein (2008), "A structural approach to explaining incomplete exchange-rate pass-through and pricing-to-market," *American Economic Review*, 98(2), 423–29.

Goldberg, P and M Knetter (1997), "Goods prices and exchange rates: What have we learned?" *Journal of Economic Literature*, 35(3), 1243–1272.

Goldberg, P and F Verboven (2005), "Market integration and convergence to the law of one price: Evidence from the European car market," *Journal of International Economics*, 65(1), 49–73.

Gopinath, G and R Rigobon (2008), "Sticky borders," *The Quarterly Journal of Economics*, 123(2), 531–575.

Hallak, J and P Schott (2008), "Estimating cross-country differences in product quality," *National Bureau of Economic Research*, *Working Paper*, 13807.

Hallak, J C (2006), "Product quality and the direction of trade," *Journal of International Economics*, 68(1), 238–265.

Hummels, D and P Klenow (2005), "The variety and quality of a nation's exports," *American Economic Review*, 95(3), 704–723.

Hummels, D and A Skiba (2004), "Shipping the good apples out? An empirical confirmation of the Alchian-Allen conjecture," *Journal of Political Economy*, 112(6), 1384–1402.

Knetter, M (1989), "Price discrimination by U.S. and German exporters," *American Economic Review*, 79(1), 198–210.

Krugman, P (1980), "Vehicle currencies and the structure of international exchange," *Journal of Money, Credit and Banking*, 12(3), 513–526.

Krugman, P (1987), "Pricing to market when the exchange rate changes," in *Real-Financial Linkages among Open Economies*, eds S Arndt and J D Richardson, 49–70, The MIT Press, Cambridge, MA.

Linder, S (1961), *An Essay on Trade and Transformation*, Wiley.

Mallick, S and H Marques (2008), "Pass-through of exchange rate and tariffs into import prices of India: Currency depreciation versus import liberalization," *Review of International Economics*, 16(4), 765–782.

Melitz, M (2003), "The impact of trade on intra-industry reallocations and aggregate industry productivity," *Econometrica*, 71(6), 1695–1725.

Obstfeld, M and K Rogoff (1995), "Exchange rate dynamics redux," *Journal of Political Economy*, 103(3), 624–60.

Parsons, C and K Sato (2006), "Exchange rate pass-through and currency invoicing: Implications for monetary integration in East Asia," *The World Economy*, 29(12), 1759–1788.

Rauch, J (1999), "Networks versus markets in international trade," *Journal of International Economics*, 48, 7–35.

Schott, P (2004), "Across-product versus within-product specialization in international trade," *The Quarterly Journal of Economics*, 119(2), 646–677.

Silver, M (2007), "Do unit value export, import, and terms of trade indices represent or misrepresent price indices?" *International Monetary Fund*, *Working Paper*, 07/121.