AUSTRALIAN WOOL EXPORTS AND EXCHANGE RATE PASS-THROUGH: ASYMMETRIC RESPONSES AND MARKET SHARE

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1. INTRODUCTION

This study explores topics related to Australian wool exports and exchange rate pass-through (ERPT). It specifically analyzes the issue receiving the widest attention in the discipline: the relationship between the degree of ERPT and market share, using Australian data, when the asymmetric response of price to exchange rate fluctuation is considered. While the relationships between ERPT and market share, or ERPT and asymmetric response have been explored previously, the role of market share in the presence of asymmetric response has never been attempted.

The post-Bretton Woods era that allowed the free fluctuation of exchange rates provided the impetus for research on the effect of exchange rate shocks on commodity prices. This topic was explored more intensively in the 1980s as economies experienced an unprecedented fluctuation in real exchange rates accompanied by the appreciation (until 1985), and then the subsequent depreciation of the US dollar, the vehicle currency, in the same decade. While the first few years of the 1990s have been characterized as a period of stability in foreign exchange markets as Goldberg and Knetter (1997) point out, there were still some notably large fluctuations in various currency values. In the 1980s and 1990s, it was frequently observed that the price of commodities in an importing country did not fluctuate as expected or predicted by traditional models such as the law of one price. In other words, recent observations on the changes in commodity prices due to those in exchange rates were not consistent with the idea of absolute Purchasing Power Parity (PPP). In addition, they violated relative PPP as well, showing that the price gap between exporters and importers is not sustained when exchange rates fluctuate.

The frequent observation of incomplete pass-through (when changes in the exchange rate are not fully transferred to commodity prices), or perverse pass-through (when changes in the exchange rate influence commodity prices in unexpected directions), was in general, attributed by researchers to the intertemporal profit or market share maximization behavior of producers operating in imperfectly competitive markets. For example, Australian producers may respond to a depreciation of the Australian dollar
by partially decreasing their prices (in the foreign market) and also increasing their profit margins. Exchange rate pass-through to the importer’s price in this case is less than one. In other words, when the exporter’s exchange rate depreciates by 1 percent, its destination price decreases less than 1 percent, or the elasticity of the exchange rate pass-through is inelastic. On the other hand, in periods when the Australian dollar appreciates, it is frequently observed that Australian exporters increase prices but not to their full extent in order to maintain sales and defend their market share, but which in turn reduces their profit margins. Accordingly exchange rate pass-through to the importer’s price is again less than 1 (Gagnon & Knetter, 1995; Krugman, 1987; Tivig, 1996; Varangis and Duncan, 1993).

Tivig’s (1996) research on the perverse pass-through of exchange rates may be a seminal achievement in exploring seemingly idiosyncratic phenomena in the context of dynamic oligopoly competition. He theoretically proves that an exporter aiming to maximize profits over time may change destination prices different from the normal case when with changes in the exchange rate. For example, while it is expected that the destination price would increase when the destination’s currency depreciates, an exporter operating in an imperfect market may strategically decrease its destination price in the current period. While this strategic behavior is rigorously proved by Tivig (1996) and further developed by Gross and Schmitt (2000), it is in fact an extension of previous studies on incomplete pass-through such as Froot and Klemperer (1989). That is that the current perverse pass-through strategy is to take a large market share, and maximize intertemporal profit at the expense of a profit loss in the first.

Notwithstanding some unexpected outcomes such as perverse movements or the absence of pass-through for commodity prices, most studies that utilized disaggregated data (such as 4-digit country specific industry data) reported the existence of pass-through. However, the extent was partial and differentiated by periods and market structure, across regions and products (for example, Feenstra, 1989; Feenstra, Gagnon & Knetter, 1996; Gagnon & Knetter, 1995; Knetter, 1989, 1995; Marston, 1990; Martin & Rodriguez, 2004; Nagataki, 2002).
While intensive research has been carried out to find the existence, both theoretically and empirically, of incomplete or perverse pass-through, the possibility of an asymmetric response was theoretically dealt with by a few economists as early as the mid-1980s (for example, Foster & Baldwin, 1986). Nevertheless, it was not until the late 1990s that the empirical phase on the asymmetric response of price to exchange rate fluctuations attracted the interest of researchers. Literature on this subject is still rare limited to only a few empirical and theoretical papers. Webber (2000) argues that the theoretical literature offers three basic explanations for asymmetry: (i) marketing constraints, (ii) production technology switching, and (iii) market share objectives.

Foster and Baldwin (1986) believe that the asymmetry may come about because foreign exporters fix the ratio of sales to investment in a marketing capacity. When the importer’s currency appreciates against exporters, say by 1 percent, and if there is insufficient investment in marketing technology, the exporter will be unable to attract extra importers to purchase their product. In this case, the optimal action for the exporter may be to increase the export price by 1 percent, which leaves the importer’s price stable. Therefore, the import pass-through is zero. In contrast, if the importer’s currency depreciates, the increase in the import price will lead some importers to leave the market. This reduction in demand will cause a reduction in the market price, which will result in pass-through in the fluctuation of exchange rates to both the export and import price.

Production technology switching is suggested by Ware and Winter (1988) who assume that there exists a price-taking firm that exports to both a domestic and an export market. The firm purchases its inputs from overseas or domestically. When the exchange rate changes, the firm can alter where it gets its inputs from and the type of production technology it uses. When the domestic currency depreciates, the exporter will switch to domestic inputs (as foreign inputs are now more expensive) and technology. It will increase costs to some degree (as the foreign inputs were cheaper before depreciation), and accordingly increase the domestic (export) price. If this increase in the exporter’s price is the same ratio as the depreciation of the currency, the two effects are offset, and the import pass-through will be zero. During the domestic currency’s appreciation phase, the producer will switch to foreign inputs which lowers the cost, and consequently lowers
the domestic price. There is no guarantee that these depreciation and appreciation effects are symmetrical.

The third explanation for asymmetry was researched by Klemperer (1989) and Marston (1990), which is consistent with Krugman (1987) who considered “pricing-to-market” (PTM) behavior in imperfect markets. In this regard, the argument is in line with research conventionally developed in the field of ERPT. In imperfect markets, the degree to which the market price is higher than the marginal cost is called “mark-up.” This price mark-up plays the role of shock absorber, particularly when the producer’s aim is to capture gains in market share. When the exporter’s currency appreciates, if the exporter (producer) wants to maintain market share, they will reduce the price mark-up (and profits) and try to keep the destination price. In contrast, when the exporter’s currency depreciates, they can choose an optimal degree of pass through (decreasing the destination price) by absorbing some shocks with the mark-up, and transferring some shocks to the exporting price.

2. FRAMEWORK AND DATA

2.1. Aims and Significance of the Study

The purpose of this paper is to explore how much of the exchange rate shock is absorbed by the exporter and importer’s prices, taking into account that (i) the response of prices to exchange rate fluctuations may be different in cases of appreciation and depreciation, and (ii) market share matters.

The previous section reviewed recent developments in the field of ERPT studies, and discussed an asymmetric response of price to exchange rate fluctuation which attracted the interest of researchers. Nevertheless, only a few studies explored this issue as yet, for example, Coughlin and Polland (2000) and Webber (2000), where most found the existence of different price responses to both the appreciation and depreciation of currencies.
While previous research has investigated the extent of exporters’ market power in the world market, no study has yet analyzed the changes in destination prices within the rigorous PTM (pricing-to-market) framework, which emphasizes the joint roles of market structure and exchange rates in international pricing. This research aims to reveal how monopolistic exporters react differently (or similarly) to fluctuations in exchange rates against each of its major trading partners. It also takes into account the impact of the importer’s market power (i.e., how large a portion of the exporter’s total exports is taken by the importer), as well as the exporter’s market share (i.e., how large a portion of the importer’s market is taken by the exporter), as the importer’s market power may affect the response of exporters to exchange rate fluctuations.

This study further investigates the possibility of asymmetric responses. In other words, it will empirically test the existence of the asymmetry for each type of wool for each trade case, and discuss the implications.

In addition to the integration of asymmetry and market share, another contribution of this study can be found in the use of highly disaggregated data. Eight-digit wool data, defined by the World Trade Organisation (cf. Harmonized System Numbers), classify each type of wool in its stage of processing and quality. For example, 51012120 is scoured wool, degreased shorn but not carbonized, carded or combed, and its diameter ranges from 20µm to 23µm. Further benefits from the use of this data are provided in the following section.

This study also has strong policy implications. First, it is very important to understand the mechanism of the impact of exchange rate fluctuations to prices, which is related to various fields of economics such as international trade, international finance and industrial organization. Second, in a more macroeconomics aspect, this study is critical to understanding the effect of exchange rate changes on changes in the trade account. While it is commonly believed that depreciation of a currency will improve the trade account, this is not always true and depends on constellation of parameters and variables, such as the changes in prices due to exchange rate changes and the elasticity of demand. In this regard, it is dangerous to discuss the impacts of appreciation or
depreciation without a deep understanding of ERPT. Third, the analysis will contribute to understanding pricing strategies of an exporter with limited monopolistic power.

2.2. Data

This study uses Australian wool trade data for empirical analyses. There are four reasons to use this data. First is the reliability of data. The Department of Agriculture, Western Australia (DAWA), collated the relevant data in a very disaggregated level, classified by exporting ports and destinations. Second, once disaggregated to a reasonable level, wool in the same category is completely homogeneous. There is no more differentiation as can be found in manufacturing goods, hence, we minimize the level of noise coming from the differentiation of goods in the same category. Third, wool is a raw material and usually free from trade restrictions. While it is controversial how tariffs or non-tariff barriers affect ERPT, this characteristic of wool can exclude disturbances coming from trade barriers. Fourth, Australia is a major producer of wool, and its market share (and the share of importers) varies across destinations. This is helpful in investigating the relationship between ERPT and market share particularly with homogenous goods. Furthermore, the Australian dollar showed reasonable fluctuations with major currencies in the late 1990s and early 2000s, which is useful in analyzing the asymmetric response to exchange rate fluctuations.

The database “Australia’s Wool Export (AWX)” provided by DAWA records a total of 72 observations (monthly data for five financial years from July 1995 to June 2001) for the value and quantity of each type of wool exported and from each state to each destination. These monthly data were converted into quarterly data due to a large number of missing values.

The AWX database originally gives two variables for a variety of wool exported from each state to their destinations: The quantity of exports and their value for each period. The quantity is given in kilograms while the value is given in current Australian Dollars. The price of wool was computed in a straightforward fashion by dividing the value by the quantity, yielding to a new variable denominated in AUD/kg. According to
the data from DAWA, the three main ports for wool exports are Sydney, Melbourne and Fremantle.

As some variables remained with too many missing values, three types of Greasy wool and one Scoured wool were selected; the number of unobserved variables were too large for other kinds of wool. The Greasy raw wool were labeled as RAW 1, RAW 2 and RAW 3 respectively throughout the paper. For each quarter, a quantity weighted average price was computed. Table 1 provides some further information on the data.

Even after converting data by quarter, some variables still contain a large number of missing values. The series with a minimum of 21 observations (i.e. a maximum of three missing observations) out of 24 quarters were selected and missing observations were computed by extrapolation. This extrapolation allowed us to include keeping a wide range of importing countries, which will increase the quality of the system’s estimation.\(^1\)

The extrapolation was carried out as suggested by Dagenais (1975). He asserts that missing observations can be extrapolated without hurting the results of the original estimation. This is done by regressing the variable with unobserved values on independent variables, which are not included in the original equation but somehow related to the variable with missing observations. On a quarterly basis, prices from the different exporting ports are characterized by smoother fluctuations and a strong positive correlation. Therefore, it is possible to regress one series on another and to use the estimated relationship between the two series to infer the missing values. Melbourne has the greatest number of continuous time series (24 observations) and thus was used most of the time to conduct the extrapolation for the two other ports.

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\(^1\) Note, that the export of Scoured wool from Sydney to the United Kingdom presents an exception where a series with less than 21 observations is considered for extrapolation. Since the missing values for this particular series were well dispersed, it may be possible to conduct a sensible extrapolation and again necessitate adding some information when estimating the equation system described later.
Table 1. Types of Wool Used in the Study

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>51011110 (RAW 1)</td>
<td>Greasy shorn wool (incl. fleece-washed wool)</td>
<td>Not carded or combed, 19 µm and finer</td>
</tr>
<tr>
<td>51011120 (RAW 2)</td>
<td>Greasy shorn wool (incl. fleece-washed wool),</td>
<td>Not carded or combed, 20 µm to 23 µm</td>
</tr>
<tr>
<td>51011130 (RAW 3)</td>
<td>Greasy shorn wool (incl. fleece-washed wool),</td>
<td>Not carded or combed, 24 µm to 27 µm</td>
</tr>
<tr>
<td>51211130 (Scoured)</td>
<td>Scoured wool (Degreased shorn wool)</td>
<td>Not carbonized, carded or combed, 20 µm to 23 µm</td>
</tr>
</tbody>
</table>

3. ANALYSIS OF EXCHANGE RATE PASS-THROUGH

3.1 Introduction - The General Concept of Pricing to Market

Most of recent studies on ERPT or PTM have built their models based on Froot and Klemperer (1989) and Knetter (1986). This PTM model involves a firm, which produces and sells identical goods in multiple markets. The firm maximizes its profit by selling in \( n \) separate markets at different prices, \( p_1, \ldots, p_n \). The profit function of the firm is:

\[
\Pi(p_1, \ldots, p_n) = \sum_{j=1}^{n} \frac{p_j q_j(p_j)}{e_j} - C\left[\sum_{j=1}^{n} q_j(p_j)w\right],
\]

where \( p_j \) is the price in destination \( j \) in the destination’s currency; \( q_j \) is the corresponding quantity demanded, which is a function of the price in the importer’s currency, \( p_j \), with \( e_j \) the exchange rate (the value of the export-country’s currency in terms of the importer’s currency); and \( C(q, w) \) is the cost function, with \( q \) denoting total sales and \( w \) input prices. The first-order conditions result in the well-known
expression for the price in destination $j$, expressed as a fraction of the marginal cost and the elasticity of demand:

$$p_j = e_j \times MC \times \left[ \frac{\xi_j}{(\xi_j - 1)} \right], \tag{1}$$

where $\xi_j$ is the price elasticity of demand in destination $j$, and $[\xi_j/(\xi_j - 1)]$ is the mark-up. This first order condition shows that in imperfect markets, the price of a homogeneous commodity in each market depends on the market structure as represented by the value of the elasticity of demand. One implementation of this approach which has been widely used since its introduction, was conducted by Knetter (1989), who estimated:

$$\log p_{jt} = \theta_t + \lambda_j + \beta_j \log e_{jt} + \epsilon_{jt}, \tag{2}$$

where $p_{jt}$ is the price of exports to country $j$ (in terms of the exporter’s currency) measured at the export port; $\theta_t$ is a set of time effects; $\lambda_j$ is a set of destination-specific effects; $\beta_j$ is the exchange-rate elasticity; $e_{jt}$ is the exchange rate; and $\epsilon_{jt}$ is a disturbance. In a perfectly competitive market, prices are equalized across destinations, so that $\lambda_j = \beta_j = 0$ for all destinations, and only the time effects will be non-zero as they measure the common price in each period. However, if the market is not perfectly competitive, $\lambda_j$ and/or $\beta_j$ will not be zero.

While equation (2) shows a general framework to empirically test issues related to ERPT phenomena, it basically presumes that the extent of ERPT is symmetric to appreciation and depreciation. However, it was argued by some economists that there is no guarantee that ERPT is symmetric. The following section discusses how the model can be developed when the asymmetric response is taken into account.
3.2 The Asymmetric Response Model

The current exchange rate $e_t$ (in logarithmic values) can be decomposed into three parts as explained in Webber (2000):

$$e_t = e_0 + e_t^A + e_t^D$$

where $e_0$ is the initial value of the logarithm of the exchange rate series,

$$e_t^A \equiv \sum_{\tau=1}^{t} \lambda_\tau (e_\tau - e_{\tau-1}), \quad \lambda_\tau = 1 \text{ if } e_\tau \geq e_{\tau-1}$$

$$\lambda_\tau = 0 \text{ if } e_\tau < e_{\tau-1},$$

$$e_t^D \equiv \sum_{\tau=1}^{t} \lambda_\tau^* (e_\tau - e_{\tau-1}), \quad \lambda_\tau^* = 1 \text{ if } e_\tau < e_{\tau-1}$$

$$\lambda_\tau^* = 0 \text{ if } e_\tau \geq e_{\tau-1}.$$ 

Therefore, the variable $e_t^A$ represents the accumulated sum of the appreciation episodes, and $e_t^D$ the accumulated sum of the depreciation episodes where $e$ is defined as the value of importers currency in term of exporters currency. It is not necessary to include the depreciation force in the estimation, since an analysis using both $e_t$ and $e_t^A$ will allow us to form conclusions about the influence of depreciation, $e_t^D$.

The four variables, price ($P$), wage ($w$), exchange rate and exchange rate in appreciation episode, will be discussed soon. Considering the time-series process describing each of the variables in a set of four is assumed as embodied within the following general structure:

$$x_{kt} = m_{kt} + \nu_{kt}, \text{ and}$$

$$m_{kt} = \rho_k m_{kt-1} + \phi_k e_{kt}$$
for all variables $x_k$, where $\rho \in (-1, 1)$, $\varepsilon_{kt} \sim \text{IID}(0, \sigma_{\varepsilon_k}^2)$, $\nu_{kt} \sim \text{IID}(0, \sigma_{\nu_k}^2)$, $\forall k$, and $\phi_k$ are non-zero real numbers determining the potential long-run relations between the variables.

Then, variable $x_k$ can be expressed as

$$x_{kt} = \delta_{k0} + \phi_k \sum_{t=0}^{-1} \rho_k^t \varepsilon_{k,t-\tau} + \nu_{kt}, \quad (3)$$

where $\delta_{k0}$ are the initial values of the variables. As we have only 24 observations, we do not pay special attention to the co-integration relationship between the variables. Nevertheless, if we have a coefficient vector such as $\beta' = [\beta_1 \beta_2 \eta_1 \eta_2]$ which satisfies $\beta'\phi = 0$, for $\phi' = [\phi_p \phi_w \phi_e \phi_A]$, then, from (3), a (kind of single co-integral) relationship is given by

$$\beta' x_i = \beta' \delta_0 + \beta' \nu_i = z_i \quad (4)$$

where $\delta_0'$ is a vector of initial conditions and $\nu_i'$ is a vector of independent white noise disturbances.

From equation (4) and variables used in this study, a stochastic form of the export price vector normalized on export prices can be written in a general equation such as:

$$\ln p_i + \beta_0 + \beta_1 \ln w_i + \eta_1 \ln e_i + \eta_2 \ln e_i^4 = u_i \quad (5)$$

where $\beta_0 = -\beta'\delta_0$ and $u_i = \beta'\nu_i$. Consequently, the extent of appreciation export pass-through is $(\eta_1 + \eta_2)$ and the extent of depreciation pass-through is $\eta_1$. If it is found that

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2 This equation is what Webber (2000) used in his empirical study.
3 In other words, $(\eta_1 + \eta_2)$ and $\eta_1$ are % change in price due to a 1% appreciation and depreciation of the currency respectively.
\[ \eta_2 = 0, \] then the asymmetry hypothesis is not held, and we have symmetric ERPT, which is estimated as \( \eta_1 \). \(^4\)

### 3.3 Estimation and Discussion

Before the results are discussed, it will be helpful to investigate the structural relationship between the magnitude of the elasticity of export ERPT and that of import ERPT, as considerable previous research concentrates on the latter. In this study, due to the availability of data, the export price is used. The conversion of export ERPT to conventional import ERPT is summarized in Table 2.

<table>
<thead>
<tr>
<th>Magnitude of Export ERPT Elasticity</th>
<th>Interpretation to Import Pass-Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 &lt; \eta</td>
<td>Excessive</td>
</tr>
<tr>
<td></td>
<td>The import price moves in the expected direction but the effect is excessive.</td>
</tr>
<tr>
<td>\eta = 0</td>
<td>Complete</td>
</tr>
<tr>
<td></td>
<td>The import price moves in the expected direction, and all of the exchange rate shock is absorbed by the import price.</td>
</tr>
<tr>
<td>-1 &lt; \eta &lt; 0</td>
<td>Incomplete</td>
</tr>
<tr>
<td></td>
<td>The import price moves in the expected direction, and the exporter and importer share the exchange rate shock.</td>
</tr>
<tr>
<td>\eta = -1</td>
<td>No Pass-Through</td>
</tr>
<tr>
<td></td>
<td>The import price does not change.</td>
</tr>
<tr>
<td>\eta &lt; -1</td>
<td>Perverse</td>
</tr>
<tr>
<td></td>
<td>The import price moves in an unexpected direction.</td>
</tr>
</tbody>
</table>

\(^4\) While the equation is used to test and find asymmetric pass-through, it can be also used to test for other issues related to prices in international markets, such as PPP. For more information, see Webber (2000).
It was hypothesized in previous models that ERPT elasticities are a function of market share, particularly a quadratic function as suggested by Feenstra, Gagnon and Knetter (1996). Unfortunately, the small number of observations used in this study does not allow using market share directly into the model when asymmetry is hypothesized. At present, it appears to be the only resolution to estimate ERPT elasticity directly from the model without using market share as regressors. Then for RAW 3 and Scoured wool, as we have 35 and 36 cases each, the elasticity is regressed on the exporter and importer’s market share. This method cannot be applied to RAW 1 and RAW 3 as they have nine cases only, from three ports to each of their destinations. The results of the estimating equation (5) are rearranged and summarized in Table 3. All coefficients (ERPT elasticities) reported in the table should be interpreted referring to Table 2.

Table 3 indicates that asymmetry is revealed for 39 cases out of 83 pairs of [port-destination] for 4 types of wool, where for 32 cases, depreciation pass-through is found to be larger than appreciation pass-through. Several studies have examined the price response of the under appreciation and depreciation of traded goods, but the results were mixed and the direction of the asymmetry was unclear, as Pollard and Couglin (2003) concluded. For example, Mann (1986) reports that ERPT into the US was greater when the dollar appreciated (or the exporter’s currency depreciated) than when it depreciated (or the exporter’s currency appreciated), which is consistent with the findings in this study. However, Kadiyali (1997) and Goldberg (1995) point out that the price of the photographic film and automobile imports in the US were more affected by a depreciation of the dollar (or appreciation of the exporter’s currency). The pattern of the price movement is also controversial in the field of industrial organization. For example, while Blinder et al (1998) conclude that there was essentially no evidence for the

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5 As we have two exchange rate variables (e and e'), by using a quadratic function for ERPT elasticity, we have to estimate 12 coefficients, which is a half of the total observation for each trade case. In addition, it is well accepted in empirical research on ERPT to estimate ERPT elasticities without market share.
6 Depreciation pass-through usually occurs when the destination price decreases and while the opposite is the case for appreciation pass-through.
common belief that prices adjust more rapidly upward than downward, Peltzman (2000) still argues that prices tend to rise faster than they fall. The case of wool exports used in this study reports that generally, a downward price adjustment in destination is more widely observed.

### Table 3. ERPT Elasticities for Appreciation and Depreciation

| Importers | Raw 1 (Greasy 51011110) | Raw 2 (Greasy 51011120) |
|------------|--------------------------|--------------------------|  |
|            | Exporters                | Sydney                   | Melbourne               | Fremantle   |  |
 China       | 0.00 | 0.00 | 0.00 | 0.00 | 0.73 | 1.44 |  |
 Italy       | 0.00 | 0.00 | -0.29 | 0.98 | 2.18 | 2.18 |  |
 France      | 0.00 | 0.00 | -1.48 | -1.48 | 0.00 | 0.00 |  |
China       | -1.71 | 0.00 | 0.00 | 0.00 | -0.85 | 0.00 |  |
Czech       | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |  |
France      | -0.69 | 0.00 | -0.71 | 0.00 | 0.00 | 0.00 |  |
Germany     | -0.47 | 0.53 | -0.36 | 0.30 | 0.00 | 0.00 |  |
India       | -2.41 | -2.41 | 0.00 | 0.00 | 0.00 | 0.00 |  |
Italy       | 0.00 | 0.00 | -0.65 | 0.00 | 0.00 | 0.00 |  |
Japan       | 4.86 | 2.03 | 0.00 | 0.00 | - | - |  |
Spain       | 0.00 | 0.00 | -0.99 | -0.99 | -2.19 | 0.09 |  |
Turkey      | -0.10 | -0.10 | 7.25 | 0.00 | 5.47 | 0.00 |  |
Taiwan | -0.83 | -0.83 | -1.09 | -1.09 | 0.00 | 0.00  
United Kingdom | -0.55 | -0.55 | -0.48 | 0.00 | 0.00 | 0.00  
United States | -1.80 | -1.80 | 0.55 | -1.22 | -0.96 | -0.96  

**Raw 3 (Greasy 51011130)**

|         |       |       |       |       | 0.00 | 0.00  
China     | -2.39 | 0.00 | 0.00 | 0.00 | -3.40 | 0.00  
India     | -3.31 | -3.31 | -3.43 | -1.72 | -2.01 | -2.01  
Spain     | 0.00 | 0.00 | -1.04 | 0.93 | -0.96 | 0.00  

**Scoured (51012120)**

|         |       |       |       |       | 0.00 | 0.00  
China     | -1.46 | -1.46 | - | - | - | -  
Germany   | - | - | -1.53 | 0.83 | -0.95 | 0.00  
India     | -1.92 | -1.92 | -2.91 | -1.94 | 0.00 | 0.00  
Italy     | 0.00 | 0.00 | -1.93 | 0.54 | 0.00 | -0.80  
Japan     | 0.00 | 0.00 | -0.68 | 0.49 | 1.13 | 1.13  
Korea     | 0.00 | 0.00 | -0.01 | 0.53 | 1.22 | 1.22  
Malaysia  | 0.11 | -1.84 | 0.00 | 0.00 | - | -  
Spain     | - | - | -0.81 | -0.81 | -0.75 | 1.03  
Thailand  | 0.18 | 0.94 | 0.01 | 0.78 | 0.11 | 1.44  
Taiwan    | 0.00 | 0.00 | -4.03 | -5.39 | - | -  
Turkey    | - | - | -0.25 | -5.39 | - | -  
United Kingdom | -3.35 | 0.00 | -1.81 | 1.08 | -3.18 | 0.00  
United States | - | - | -4.84 | 0.00 | -4.73 | 0.00  

NOTE: Insignificant coefficients are reported as zero.
In this study, while ERPT for appreciation is larger than ERPT for depreciation in only seven cases, the elasticities are extremely irregular in all of these seven cases. Figure 1 indicates that the relationship between the two types of ERPT elasticity for each trade case with symmetric responses is on the 45-degree line. It is noteworthy that the three exceptional cases are Australia’s exports to Turkey, which might indicate an intrinsic data problem for Turkey. These three cases are in the extreme southeast area of the scatter diagram. While it is not clear why Australia’s ERPT to Turkey shows such an irregularity, it should be reminded that Turkey has experienced an extremely insecure monetary system and exchange rate markets during the period investigated in this study. ERPT is frequently observed as being irregular when exchange rates change dramatically in a short period.

![Figure 1. Scatter Diagram of ERPTs – for all wools](image)

**Figure 1. Scatter Diagram of ERPTs – for all wools**

NOTE: Small triangles are the elasticities for Turkey.
The second interesting finding is that, among these eight exceptions, four cases are for RAW 2 and four for Scoured wool, the cases for RAW 2 generally lie in northeast of those of Scoured wools. In other words, exports of RAW2 show relatively large ERPT appreciation and depreciation, implying that the response in RAW 2’s export price is relatively more excessive when the exchange rate changes. While there is may be some relation between this irregularity of ERPT and exports of certain kinds of wool, this matter is beyond the scope of this study. Third, for most of these eight cases, the import market share is very low. In contrast, the market share for exporters is either medium or large. This will be investigated in detail in the following section.

In the case of appreciation, positive ERPT is discovered in a total of 8 cases, where 5 are from these 8 exceptions and 3 cases are from 32 “expected” cases. As already discussed, a positive ERPT appreciation implies an excessive market response. The exchange rate shock is magnified and transferred to the importer. It would not be a coincidence that all of the five cases from the eight exceptional trade cases have very low import market share, as the low level would imply a very low level of negotiation power.

Figure 2 rearranges the scatter diagram of the elasticities for the entire sample as shown in Figure 1, to illustrate the ERPT distribution for each trade case. For each ERPT, ERPT elasticities can be categorized into three groups: Excessive ERPT (0 < \(\eta\)), normal ERPT (-1 \(\leq\) \(\eta\) \(\leq\) 0) and perverse ERPT (\(\eta\) < -1). Therefore, the combination of appreciating and depreciating ERPT produces nine groups of responses. For example, Area I in Figure 2 indicates where the export price shows an excessive response to fluctuations in the exchange rate, and results in magnified price changes at destination.\(^7\) Seven trade cases out of 83 are included in this area. In Area II, appreciation ERPT is excessive but depreciation ERPT is normal. Only two cases are in this area, and both are exports to Turkey. Appreciation ERPT is unreasonably large, and depreciation ERPT is zero. Area III lists excessive appreciation ERPT and perverse depreciation ERPT. This case shows that regardless of the direction of exchange rate fluctuations, the price of wool at destination always increases.

\(^7\) Area I is where \(\eta_A > 0\) and \(\eta_D < 0\), which is exactly the same as the North-East area in Figure1. Area II is where \(\eta_A > 0\) and \(-1 \leq \eta_D \leq 0\), which is the Middle-East area in Figure 1, and so forth.
Area IV contains only one trade case, exports of Scoured wool from Melbourne to Turkey. Appreciation ERPT is normal, however, depreciation ERPT is perverse to a large extent, implying that in case of a depreciation of the Australian dollar against the Turkish lira, Australia’s export price of Scoured wool to Turkey increases in large proportions. Area V includes trade cases of perverse responses for both appreciation and depreciation. A total of 11 cases lie in this area, meaning that the destination price increases when the exporter’s currency depreciates and vice-versa. For ten cases, depreciation pass-through is larger than appreciation pass-through. The only exception is scoured wool exports from Melbourne to Taiwan, which shows a large size for the two ERPTs. Area VI is where appreciation ERPT is perverse and depreciation ERPT is normal. Therefore, the

<table>
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**Figure 2. Distributions of ERPTs**
destination price decreases whenever the exchange rate fluctuates, regardless of whether it appreciated or depreciated. For all seven trade cases in this area, depreciation pass-through is zero, meaning that a depreciation of the Australian dollar does not affect Australia’s export price. In contrast, appreciation pass-through ranges widely, from –1 to –5. Trade cases included in Area VII show a perverse response to appreciation and an excessive response to depreciation. When the Australian dollar appreciates, its export price decreases which leads to a decrease in the destination price. A depreciation of the Australian dollar results in an excessive response in the destination price. This area has 5 trade cases. Area VIII collects seven trade cases, for which appreciation ERPT is normal, but depreciation ERPT is excessive. Appreciation ERPT is zero for two of them, meaning that Australian exporters absorb all exchange rate shocks. All depreciation ERPT's lie in between zero and one, or very close to one. Area IX has a group of trade cases where the two ERPT’s range between –1 and 0. In both cases of appreciation and depreciation, the exporter and importer absorb parts of the exchange rate shock. This is what the ERPT is conventionally believed to be. This area pertains to 41 trade cases, which is roughly half of the total trade cases examined in this study.8

Figure 3 summarizes the frequency of the three possible ERPTs. It is clear that while most export prices show normal ERPT, [Excessive-Excessive] and [Perverse-Perverse] combinations show generally higher frequencies than mixed combinations. When depreciation ERPT is perverse to a destination, it is highly likely that appreciation ERPT is also perverse.

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8 The degree of ERPT by ports is also categorized but not listed in this paper, as it is not the major concern of this study.
Figure 3. Summary of the Frequency of ERPT

Note: P, N and E stand for Perverse, Normal and Excessive, respectively. A and D in brackets represent appreciation and depreciation.

3.4 Asymmetry and Market Powers Revisited

Most studies focusing on the impact of market share to ERPT concern the influence of monopolistic market power on pricing. While this study pursues the effects of market share or power on ERPT, it has at least two distinctively different characteristics from previous studies. First, this study investigates the impact of the importer and exporter’s power to ERPT. The buyer with a larger market share is expected to have power in negotiating prices, as witnessed in the case of monopsony, which is an extreme case of concentration in purchasing power. Second, the importance of market share has never been explored in conjunction with an asymmetric response to exchange rates. All of the
studies that consider market share are based and built on the assumption of symmetric responses to appreciation and depreciation. Recent studies, including this study, revealed that asymmetric responses are very frequently observed, which implies that the use of the results based on the assumption of symmetric responses may provide incorrect information. This study examines this important but under-researched issue, by integrating the significance of market power into an asymmetry model.

The most ideal method to explore the effects of market share in an asymmetry model would be to include the coefficient of the (log) exchange rate as a function of the exporter and importer’s market share. It is conventional in studies in this field that the ERPT function is expanded to the quadratic function as suggested by Feenstra, Gagnon and Knetter (1996). However, as we have only 24 observations, this method is at risk of losing too large a portion of available observations. This is especially so as two more terms – linear and quadratic - with regard to the importer’s market share should be included. In consequence, the appreciation and depreciation elasticities are first computed as shown in the previous section, and then these elasticities are regressed on the two kinds of market share. As RAW 1 and RAW 3 have only nine cases of wool exports, the regression of ERPT elasticity on market share is carried out for only two kinds of wool, RAW 2 and Scoured wool.

If the import share is larger, the importer is expected to exercise their market power, as a monopsonist does. Suppose that the prevailing price is what the importer, with a certain degree of market power, accepts as an optimal price, given the exchange rate. When the exporter’s currency appreciates, an importing country, say F, experiences an increase in the price of its currency unless ERPT is perverse or nil. Therefore, if importing country F has market power, it will try to stabilize the price it pays in its currency. If the importer’s market power is successfully practised, and it can maintain an unchanged price of wool in its own currency, then export ERPT must be – 1, and no import ERPT will be observed. In other words, the export price decreases (or increases) to a degree to completely offset the effects of appreciation (or depreciation) of the importer’s currency, and the (import) price in F remains the same. If the importer’s power exists but is not sufficiently large enough to fully offset the effect an appreciation of the
importer’s currency (or depreciation of the exporter’s currency), then incomplete pass-through \((-1 < \eta < 0)\) will be observed. Or, if the importer’s market power is far stronger, it may be the case that the importing country forces exporters to further decrease the export price so that the import price is even lower in F’s currency. This is the case of perverse pass-through, with \(\eta < -1\).

In contrast, when the exporter’s currency depreciates, Country F, with a large import market share will attempt to exploit all the benefits from depreciation of the exporter’s currency, by paying the lowest possible amount in its currency. In an extreme case, the export price is unchanged and F’s importing price in its currency decreases in proportion to the depreciation of the exporter’s currency. Therefore, complete pass-through will be observed. If F’s market share is negligible, the exporter will increase their export price while leaving F’s importing price unchanged in F’s currency, thus maximizing profit in terms of the exporter’s currency. Therefore, no ERPT at destination will be observed.

Tables 4 and 5 summarize the results of regressing ERPT elasticities for appreciation and depreciation on different functional forms of market share, labelled as columns (1) to (7). While no estimation is found to be meaningful for Scoured wool (which could be predicted from the frequent irregularities of the results shown in the previous section), some interesting findings are revealed from the estimation for RAW2. For both appreciation and depreciation, as shown in columns (1), (2) and (7), ERPT is significantly explained by quadratic and linear terms exporters’ market share, where the quadratic term is negative. These results are very robust with the inclusion of importers’ market share, and the maximum is reached when the market share is about 0.46 to 0.48. While this result is different from previous studies, for example, by Feenstra, Gagnon and Knetter (1996), where a positive quadratic relationship is found, a close look at the data used in this study reveals that this result is not inconsistent.\(^9\) It is very rare that a port’s

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\(^9\) Nevertheless, while ERPT increases from the beginning in this study, Feenstra, Gagnon and Knetter (1996) find that it starts to increase after the market share is sufficiently large, at a level of at least 0.3.
market share is larger than 50% for any kind of wool.\textsuperscript{10} In other words, although fitting using a quadratic function turns out to be significant, virtually relevant market share ranges from 0% to about 50% in the most cases, and for this range ERPT elasticity increases as market share increases. Fitting using a linear function shows a positive relationship between market share and ERPT elasticity, supporting this argument (as shown in column (3)), although its significance is slightly out of 10% in case of depreciation. In contrast, the quadratic term of the importer’s market share has a positive coefficient, which has its minimum value at about 0.25. When a linear function is fitted together with a port’s market share, the importer’s market share has a significant and negative coefficient (as shown in columns (6) and (7)). As the importer’s market share rarely exceeds 25%, the results of the fitting of the importer’s market share using a quadratic function are not inconsistent. The results reported in Tables 4 and 5 can be summarized in two parts.

(i) The larger the exporter’s market share, the larger appreciation ERPT tends to be.

This result implies that, when the exporter’s currency appreciates, it decreases its export price to the area where it has a larger market share. More of a burden of the exchange rate shock is transferred to the importer. However, this result applies only to RAW 3 and is not found for Scoured wool.

(ii) The larger the importer’s market share for exports, the smaller appreciation ERPT tends to be.

This result implies that, when the buyer takes a large share of the exporter’s products, exporters decrease their export price to that importer more when the

\textsuperscript{10} There are some exceptions such as Fremantle’s exports of scoured wool to Germany. Nevertheless, these represent only a small portion of the set of observations.
### Table 4. ERPT and Market Share with Asymmetric Responses – RAW 2

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**Depreciation**

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Least Squares with Newey-West HAC Standard Errors & Covariance
S and IS stand for export share and import share.
Standard error given below the coefficients.
***, **, *: Significant at 1%, 5%, 10% Level of Significance respectively
### TABLE 5. ERPT AND MARKET SHARE WITH ASYMMETRIC RESPONSES – SCOURRED

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<td>-</td>
<td>-20.71</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(34.63)</td>
<td></td>
<td></td>
<td>(34.70)</td>
<td></td>
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</tbody>
</table>

Least Squares with Newey-West HAC Standard Errors & Covariance

S and IS stand for export share and import share.
Standard error given below the coefficients.
19 January 2006

***, **, *: Significant at 1%, 5%, 10% Level of Significance respectively

the exporter’s currency appreciates. Therefore, the price paid by the importer in their currency is not substantially affected, in spite of the appreciation compared to importers with a smaller market share. Exporters should also bear the decrease in price in their currency.

For depreciation, only the quadratic term for the exporter’s share turns out to be significant at a 5% level of significance while that of the importer’s share is not. Maximum ERPT is achieved when market share is about 41%, which is surprisingly consistent with in the case of appreciation. The buyer’s market share turns out to be significant for column (5) and (6), however, the fitness of the model is lower than (1) and (7). For (1) and (7), the buyer’s market share is not significant in the case of depreciation, while the exporter’s market share is important. When the exporter’s currency depreciates, exporters can increase their export price without affecting (increasing) the destination price. The findings from (1) and (7), combined with the market share range of Australian ports explain that exporters can increase their export price by larger extent when their market share increases. Therefore, buyers cannot enjoy the decrease in price due to the depreciation of Australian dollar.

3.5 Does a Lagged Exchange Rate Matter?

While some studies exclusively consider current exchange rates (e.g., Aw, 1993; Gagnon and Knetter, 1995; Salvador, 2003), the lagged effects of exchange rate shocks on the price of a commodity have been the center of interest in the field of international economics, as this issue is particularly related to the exploration of the distinction between dynamic adjustment to temporary and permanent exchange rate changes. While Tcha and Sjaastad (1998) investigated the lagged effects of different exchange rates on the steel price in the US using a model developed from theoretical pursuit, the most general approach is to use co-integration and vector autoregressions (VAR) to analyze the
dynamics, as did Gross and Schmitt (2000), Hung, Kim and Ohno (1993), Tcha and Kim (2002) and Varangis and Duncan (1993) among many others. Froot and Klemperer (1989) find that the fall in the import price (US dollars) after a temporary appreciation is less than that after a permanent appreciation. They also argue that purely temporary exchange rate changes lead to an unusually high degree of pricing-to-market.

While the analysis of the dynamic effects of exchange rate changes is useful, the data used in this study has only 24 observations, not enough to draw out any useful and reliable results. As evident from previous studies using impulse responses, when quarterly data is used, the exchange rate shock does not last longer than three to four quarters. This study attempts to find the lagged effects using a simple regression method where the equation to be estimated included exchange rates up to two lags. Unfortunately, the results did not present any interesting or meaningful findings, and consequently are not reported in this paper.

4. SUMMARY AND IMPLICATIONS

This study examines ERPT with an asymmetric response and both import and export market share, using wool trade data. Altogether, 83 trade relationships are investigated using 24 quarterly observations that cover the period from 1995 to 2001. The major contributions of this study include the analysis of ERPT considering both symmetric and asymmetric response cases, comparison of ERPT across different major destinations, and investigation of the effects of the market share of importers and exporters. Major implications from this study can be briefly summarized as follows.

First, what must be taken into account is that the responses (both in price and quantity demanded) to changes in the exchange rate are considerably different across goods, and even for homogenous goods across countries. For instance, symmetric responses are found from 44 cases and asymmetric cases are found from 39 cases, out of 83 total cases. Among the 44 cases with symmetric responses, 27 are found to be cases of complete pass-through with 17 cases incomplete. For 39 asymmetric cases, ERPT for
depreciation is greater than that for appreciation which totals 32 cases. These results indicate that asymmetric responses may be as common as symmetric responses, where in the real world both cases exist together. In addition, in the case of depreciation, the export price changes more than in the case of appreciation in general, and as a result the destination price changes less. Second, policymakers have to enhance their understanding of the pricing strategies of firms, and domestic firms have to improve their understanding of the pricing strategies of foreign competitors. For example, in this study, the cases of excessive or perverse pass-through are found more frequently than reported in previous studies. Out of 166 cases (in appreciation and depreciation cases for 83 trade relationships), perverse cases are reported on 37 occasions while excessive cases are reported in 30 instances. This finding points out that the strategic behavior of firms or an unexpected response to exchange rate fluctuations takes place more frequently than commonly expected or at particularly disaggregated levels.

Third, when the model considers asymmetric responses of the export price to an appreciation and depreciation (of the exporter’s currency), the estimation provides somewhat different results. For 39 out of 83 trade cases, the export price was found to have responded to appreciation and depreciation in different fashions, although the normal response was the dominating phenomenon with 99 cases or about 60% of 166 cases. Consequently, the argument based on a symmetric response should not be applied.

Fourth, an asymmetry approach with market share shows that the exporter’s market share affects export ERPT for RAW 2, when the exporter’s currency appreciates and depreciates: in contrast, the importer’s market share affects export ERPT for RAW 2 only when the dollar appreciates. Their influences were not found to be significant for Scoured wool. Therefore, regardless whether Australian wool exporters implicitly or explicitly collude or behave independently, it was statistically suggested that they practise market power in adjusting their export price of RAW 2 by responding to changes in exchange rates change. More specifically, the larger the exporter’s market share, and the smaller the importer’s market share (for RAW 2), the greater the likelihood of an increase in export ERPT. In other words, exporters decrease their (exporting) prices less in response to an appreciation of their currency, or increase their (exporting) prices more in
response to a depreciation of their currency, when trading with countries where they take a large market share. In comparison, for RAW 2 when an exporter’s currency appreciates, large-scale purchasers of the commodity attempt to maintain stable export and import prices.

Fifth, when the exchange rate fluctuates dramatically, ERPT elasticity is found to be unreliable, as was observed in the case for Turkey. While the data used in this study is of very high quality, it is still possible that some observations are not accurate owing to the aforementioned reasons. This lack of precision seems to be a function of the volatile quantity data and therefore requires further investigation.
REFERENCES


**DATA SOURCES**

*Bilateral Exchange Rate Data for the period 1995-2001* are collected from:

International Financial Statistics of the International Monetary Fund

Financial Statistics of the Federal Reserve Board

*Wage Rate Data for the period 1995-2001* are collected from:

Australian Bureau of Statistics: (6302.0) “Average Weekly Earnings”

*Wool Trade Data for the period 1995-2001* are provided by:

Department of Agriculture Western Australia