The Relationship between U.S. Antidumping Enforcement and Exchange Rate Movements Revisited

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and

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Abstract

This paper develops a real options model of export with imperfect exchange rate pass-through to investigate the relationship between exchange rate movements and dumping activity. It is found that exchange rate level as well as its trend and volatility has an asymmetric effect on dumping occurrence, which depends on the long-run level of exchange rate. Specifically, when the value of an importing country’s currency is low, its appreciation or expected appreciation will cause the dumping activity to rise, whereas when the value of the currency is high, this relationship might be reversed. Similarly, while the magnitude of exchange rate pass-through and dumping occurrence are positively related when the value of an importing country’s currency is high enough, whereas their relationship might become negative when the value of the currency is low enough. Furthermore, the exchange rate volatility and dumping occurrence will be positively related only if the value of an importing country’s currency is extremely low or extremely high. Industry-level data on anti-dumping filings of the United States covering the period 1980-2006 are used to test the validity of our theoretical model. Our empirical results are generally consistent with the prediction of our theory.

Keywords: Dumping, exchange rate pass-through, real options

JEL Classification: F13, F31, G13

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I. Introduction

Antidumping (AD) policy recently has become a prevalent instrument around the world. According to World Trade Organization (WTO), there are 3,220 AD filings by its member countries between 1995 and 2008. Among those filing countries, India was the most active one and had 564 AD filings in total. The United States and European Union were also very active in adopting AD policy. They had 418 and 391 AD filings, respectively.\(^1\) Dumping on the international market has been regarded as an unfair trade by some experts or government officials, and antidumping rules of the World Trade Organization (WTO) allows a protectionist response whenever a foreign product “like” to a domestic one is dumped on the domestic market and causes injurious impact on domestic producers. However, many economists argue that dumping behavior can be justified as a rational response of exports in many circumstances,\(^2\) and anti-dumping measures have frequently been used as a protectionist policy for a country’s declining industries.

One distinct feature of dumping activity is that it fluctuates considerably over time, which suggests that there are some economy-wide factors determining this activity. Some recent studies, hence, investigate the relationship between dumping occurrence and macroeconomic factors. Particularly, the impact of exchange rate

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\(^1\) See the WTO website: http://www.wto.org/english/tratop_e/adp_e/adp_e.htm#statistics.
movements on antidumping filings has been a focus of recent studies because of the sharp changes in exchanges rates of many countries. \(^3\) However, theoretical studies in this regard are rather limited. \(^4\) In addition, the empirical evidence about the effect of exchange rate on AD is still mixed. For instance, Feinberg (1989), Niels and Francois (2006) find that an appreciation of importing country’s currency deters the dumping activity while Stallings (1993), Leidy (1997), Knetter and Prusa (2003), Irwin (2005), Feinberg (2005), Sadni Jallab et al. (2006) indicate that an appreciation of importing country’s currency stimulate the dumping activity.

One of the limitations in most studies in the literature is that the impact of exchange rate pass-through is ignored. Exchange rate pass-through is closely related to the probability of dumping occurrence, since dumping occurrence is based on dumping margin as well as industry injury. The relationship between exchange rate pass-through and the probability of dumping occurrence is ambiguous in priori. For instance, a higher exchange rate pass-through refers to the situation when an appreciation (depreciation) in the currency of an importing country brings about a higher decrease (increase) in its import price. On the one hand, a higher exchange rate pass-through implies a lower dumping margin and thus diminishes the probability of

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3 See Blonigen and Prusa (2003) for a comprehensive review of earlier theoretical and empirical work.
4 Recently, Moraga-Gonzalez and Viaene (2005) develop a simple model of vertical-industry trade to examine the incentives of oligopolistic exporting firms to undertake dumping. Besides, Aggarwal (2004) employs a panel data of 99 countries to examine how macro factors influence the use of antidumping in developed and developing countries. However, theoretical and empirical studies in this respect are still very limited, and existing empirical evidence is mixed.
dumping occurrence. On the other hand, the appreciation and its resultant higher
decrease in the export price will cause a larger negative impact on the domestic firms
in the importing country, thus raise the probability of dumping occurrence.

Many recent empirical studies illustrate that the exchange rate pass-through
varies among countries and industries; see, for instance, Dornbusch (1987), Froot and
and Gonzalez Minguez (2006), Campa and Goldberg (2005), Pollard and Coughlin
(2006). Given the fact that AD filings have concentrated on a few industries, such as
chemicals and steel industries, it is also interesting to examine whether or not it has
something to do with the extent of exchange rate pass-through across industries.

Following Chen and Lin (2007), this paper investigates the impact of exchange
rate movements on dumping occurrence both theoretically and empirically. We first
extend the real options model of Dixit (1989) to analyze the probability of dumping
occurrence under exchange rate uncertainty. In contrast to Chen and Lin (2007), the
impact of exchange rate pass-through is incorporated into the model. The numbers of
antidumping filing from 1980 to 2006 in the United States by industry are then used to
test the validity of our theoretical results. We find that the effects of exchange rate
level, its trend, and its volatility on dumping occurrence seem to be asymmetric,
depending on the long-run level of exchange rate. The empirical evidence is
consistent with the theoretical prediction.

The remainder of this paper proceeds as follows. Section 2 extends the real options model of Dixit (1989) to the setting of imperfect competition with incomplete exchange rate pass-through. Section 3 presents our comparative static analysis of the model. Based on the theoretical framework, an empirical model is developed and our estimation method is discussed in Section 4. Section 5 presents empirical results, and the final section concludes.

2. Theoretical Model

In order to investigate how the extent of exchange rate pass-through affects the identification of dumping behavior, this paper incorporate incomplete exchange rate pass-through into the real option model of Dixit (1989). Assume that that a domestic firm exports to a foreign market with profits in each period, $\pi$, as follows:

$$\pi = (p_f \cdot R - c)q_f - F,$$  \hspace{1cm} (1)

where $p_f$ is foreign price in terms of foreign currency and $q_f$ is quantity sold in the market; $c$ represents a constant marginal cost; $R$ is exchange rate expressed as units of domestic currency per unit of foreign currency; $F$ denotes fixed costs incurred each period.

We assume that exchange rate follows a stochastic process of exogenously geometric Brownian motion:

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5 The subscript $t$ is omitted for simplicity.
\[ \frac{dR}{R} = \mu \cdot dt + \sigma \cdot dz \]  \hspace{1cm} (2)

where \( \mu \) is the growth rate of exchange rate and \( \sigma \) is its standard deviation, \( t \) denotes time, and \( z \) is a Wiener process.

To maximize the firm’s profits from its export, its optimal export price \( p_x \) (in terms of the currency of the exporter’s home country) can be shown as follows:

\[ p_x = c \left( \frac{\phi}{\phi-1} \right) \]  \hspace{1cm} (3)

where \( \phi \) is the absolute value of the price elasticity of export demand. It is clear from Eq. (3) that the optimal export price depends on marginal cost as well as the price elasticity of export demand.

Let \( m kp \) denote the markup of export price over marginal cost, and thus \( m kp = p_x / c = \left( \frac{\phi}{\phi-1} \right) \). According to Dornbusch (1987) and Campa and Goldberg (2005), a change in exchange rate might affect a firm’s price competitiveness in a foreign market and thus influence its optimal price level. Therefore, \( m kp \) is assumed to be determined by exchange rate level and some industrial characteristics, and hence it can be written as

\[ m kp = X \cdot R^{-\eta} \]  \hspace{1cm} (4)

where \( X \) denotes industrial characteristics that influence \( m kp \), \( \eta \) is the elasticity of export price with respect to exchange rate. Dornbusch (1987) illustrates that the elasticity of export price with respect to exchange rate is dependent on the characteristics of the export products or markets, such as product differentiation, market structure and cost conditions.

Since a profit-maximizing firm will not set its price below marginal cost, hence we assume that \( m kp \geq 1 \). Consequently, the export price in terms of foreign currency
$p_f (= p_x / R)$ can be written as follows:

$$p_f = X \cdot R^{-\eta} \cdot c \cdot R^{-1} = \Omega \cdot R^{-\eta} = \Omega \cdot R^{-\varepsilon} \quad \text{(5)}$$

where $\Omega = X \cdot c$ and $\varepsilon = (1 + \eta)$ is the elasticity of import price with respect to exchange rate. The definition of exchange rate pass-through is the percentage changes of import price over the percentage changes of exchange rate, and thus $\varepsilon$ denotes the magnitude of exchange rate pass-through. The extent of exchange rate pass-through is classified into three possible cases in this paper: When $\varepsilon = 1$ it is referred to as the case of full pass-through, when $\varepsilon = 0$ it is referred to as the case of null pass-through, and when $0 < \varepsilon < 1$ it is referred to as the case of partial pass-through.\(^6\) The profit function of the firm can now be written as follows:

$$\pi = \left( \Omega R^{-\varepsilon} \cdot R - c \right) q_f - F = \left( \Omega R^{1-\varepsilon} - c \right) q_f - F \quad \text{(6)}$$

If the firm faces an uncertain exchange rate, it has to determine if it will keep on exporting each period. In other words, the firm faces a dynamic programming program as follows:

$$V(R) = \max \left\{ -K, \pi + \frac{1}{1 + \Delta t \rho} E[V(R') | R] \right\} \quad \text{(7)}$$

where $V$ is the optimal expected value of the firm, $K$ denotes the costs the firm incurs when it decides to exit the Foreign market,\(^7\) $R'$ represents the exchange rate level in the next period, $\rho$ is subjective discount rate of the firm, $\Delta t$ is time interval. The first term in the parenthesis on the right hand side, $(-K)$, represents the expected value of the firm if it exits from foreign market; the second term, $(\pi (\pi + (1 + \Delta t \rho)^{-1} E[V(R') | R])$, denotes the expected value of the firm if it decides to keep on exporting to the foreign market.

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\(^6\) We rule out the case when $\varepsilon > 1$.

\(^7\) If $K < 0$, it implies that there remain certain residual values when the firm exits the export market.
Since an appreciation of foreign currency will increase the firm’s profits from the Foreign market, according to Dixit and Pindyck (1994), there is an exchange rate threshold $R^*_E$ such that, when $R < R^*_E$, the expected value of the firm will be larger if it chooses to exit the Foreign market. Hence, the firm’s optimal decision is to stop exporting. To simply the following analysis, we assume that the exporting firm has already faced capacity constraint so that its quantity of output is fixed. We further assume that the firm’s capacity is 1. Using value-matching and smooth-pasting conditions, the value of $R^*_E$ can be derived as follows:

$$R^*_E = \left( \frac{c + F}{\rho} - K \right)^{\frac{\alpha}{1+\alpha}} \frac{\rho - (1 - \varepsilon) \left( \mu - \frac{1}{2} \varepsilon \sigma^2 \right)}{\Omega} \frac{\gamma^{(1-\varepsilon)}}{(1-\varepsilon)}$$

(8)

where $\alpha = \frac{[(\mu - 0.5\sigma^2) + \sqrt{(\mu - 0.5\sigma^2)^2 + 2\sigma^2 \rho}]}{\sigma^2} > 0$. To ensure the convergence of the discounted value of the firm, we assume that $\rho - (1 - \varepsilon) \left( \mu - \frac{1}{2} \varepsilon \sigma^2 \right) > 0$. In addition, in order to let the firm have a positive probability to exit the Foreign market, we assume that $c + F - \rho K > 0$.

3. Comparative Statics

Dumping probability

Dumping margin ($DM$) is defined as the difference between a firm’s export price and the “normal value” of its product. If $DM > 0$, it is determined that the firm is undertaking dumping activity. In addition, if it is found that the firm’s dumping has caused material injury on the domestic firms producing the like product in the importing country, the firm might be charged an antidumping duty as high as the

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8 See Dixit (1989: 626) *
dumping margin. Given the fact that the United States frequently uses cost data to construct the normal value of an import product, the average cost of the exporting firm is used as a measure of the normal value in this paper. Therefore, based on our previous discussion, dumping margin of a firm can be written as:

\[ DM = c + F - p_f R = c + F - \Omega R^{1-\varepsilon}. \]  

If \( \varepsilon \) is smaller than 1, we obtain another exchange rate threshold \( R^*_D = (p_d / \Omega)^{\varepsilon(1-\varepsilon)} \), which implies that when \( R < R^*_D \), the firm is undertaking dumping activity.

Note that if \( R < R^*_E \), then the firm will exit the market, and thus no dumping activity will occur. It suggests that dumping activity occurs only if \( R^*_E < R < R^*_D \).

Since exchange rate \( R \) follows a geometric Brownian Motion process, the firm’s dumping probability can be expressed as:

\[
\Pr(R^*_E < R < R^*_D) = N(m_D) - N(m_E) = f \left( R^*_E (\sigma, \mu, \varepsilon, \rho, K, c, F, \Omega), R^*_D (\varepsilon, c, F, \Omega), \sigma, \mu, \ln R_0, T \right)
\]

where \( m_D = \frac{\ln R^*_D - E \ln R}{\sigma \sqrt{T}} \); \( m_E = \frac{\ln R^*_E - E \ln R}{\sigma \sqrt{T}} \); \( N(.) \) is a cumulated standard Normal distribution.

According to Equation (10), the probability of dumping will be influenced through two possible channels - namely, the threshold effect (TE) and distribution effect (DE). Here, TE is attributed to the changes in \( R^*_D \) or \( R^*_E \) whereas DE is attributed to the changes in the distribution of exchange rate. From Equation (10), it is clear that all variables considered in this paper might affect the probability of

\[ \text{In general, } R^*_E \text{ is larger than } R^*_D; \text{ otherwise, a firm facing economic losses will choose to exit instead of dumping on the export market.} \]
dumping occurrence through $TE$. However, among those variables, only $\sigma$ and $\mu$ might affect the probability of dumping occurrence through $DE$ as well. The relationship between several exchange rate variables and dumping probability will be examined respectively as follows.

**Exchange rate volatility and dumping probability**

The total effect of $\sigma$ on dumping probability can be decomposed as follows:

$$
\frac{df(\cdot)}{d\sigma} = \frac{\partial f(\cdot)}{\partial R_E^*} \cdot \frac{\partial R_E^*}{\partial \sigma} + \frac{\partial f(\cdot)}{\partial \sigma} \cdot \frac{\partial \sigma}{dE},
$$

(L1)

**Lemma 1** The distribution effect of $\sigma$ is positive if $\bar{R}_D^* > \bar{R}_E^* > \bar{R} + \sigma \cdot \omega_H$ or $\bar{R} + \sigma \cdot \omega_L > \bar{R}_D^* > \bar{R}_E^*$, whereas this effect is negative if $\bar{R} + \sigma \cdot \omega_H > \bar{R}_D^* > \bar{R}_E^* > \bar{R} + \sigma \cdot \omega_L$, where

$$
\bar{R} = E\ln R, \quad \bar{R}_D = \ln R_D^*, \quad \bar{R}_E = \ln R_E^*, \quad \omega_H = \frac{1}{2}(\sigma T + \sqrt{4T + T^2\sigma^2}) > 0, \text{ and} \quad \\
\omega_L = \frac{1}{2}(\sigma T - \sqrt{4T + T^2\sigma^2}) < 0.
$$

**Proof.** See Chen and Lin (2007).

**Proposition 1** Exchange rate volatility, $\sigma$, is positively related to the probability of dumping occurrence if $\bar{R}_D^* > \bar{R}_E^* > \bar{R} + \sigma \cdot \omega_H$ or $\bar{R} + \sigma \cdot \omega_L > \bar{R}_D^* > \bar{R}_E^*$.

**Proof.** If $0 < \varepsilon < 1$, from Equations (8) and (10), the threshold effect of exchange rate volatility can be derived as follows:

$$
\frac{\partial f(\cdot)}{\partial R_E^*} \cdot \frac{\partial R_E^*}{\partial \sigma} = e^{-\frac{m^2}{2\sigma^2}} \cdot \frac{-\phi_1}{\sqrt{2\pi T} \phi_2 \phi_3 \sqrt{2\rho \sigma^2 + (\mu - 0.5\sigma^2)^2}}.
$$
where $\phi_2 = \mu + 0.5\sigma^2 + \sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2} - \varepsilon\sigma^2 > 0$

$$\phi_3 = \rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2) > 0$$

$$\phi_1 = \varepsilon\phi_2\sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2} - (\phi_2 + \varepsilon\sigma^2)\phi_3$$

Since

$$\frac{\partial \phi_1}{\partial \varepsilon} = \sigma^2\left[2(\rho - \mu) + \varepsilon(\mu + 0.5\sigma^2 - \sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2})\right],$$

thus

$$\frac{\partial \phi_1}{\partial \varepsilon} > 0 \text{ if } \varepsilon < \varepsilon^*$$

$$\frac{\partial \phi_1}{\partial \varepsilon} = 0 \text{ if } \varepsilon = \varepsilon^*$$

$$\frac{\partial \phi_1}{\partial \varepsilon} < 0 \text{ if } \varepsilon > \varepsilon^*$$

where $\varepsilon^* = \frac{2(\rho - \mu)}{-\mu - 0.5\sigma^2 + \sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2}} > 0$.

Further, since $\phi_1\big|_{\varepsilon = 0} = -(\rho - \mu)\phi_2 < 0$, $\phi_1\big|_{\varepsilon = \varepsilon^*} = 0$, and $\frac{\partial^2 \phi_1}{\partial \varepsilon^2} = \frac{2(\rho - \mu)}{-\varepsilon^*} < 0$, we have $\phi_1 \leq 0$, thus $\frac{\partial f(\cdot)}{\partial R^*_E} \cdot \frac{\partial R^*_E}{\partial \sigma} > 0$. In addition, according to Lemma 1, the distribution effect of $\sigma$ is also positive under these conditions. Hence, from Equation (11) we have $df(\cdot)/d\sigma > 0$.

The economic intuition behind this proposition is as follows. The exchange rate volatility influences the probability of dumping occurrence through its effect on the threshold of exit and the distribution of $R$ simultaneously. The economic intuition of $TE$ is that the exit is like a put option whose value increases if the underlying uncertainty increases. Hence, the exporting firm has more incentive to wait until it gets extra information from the market as the uncertainty rises. Therefore, the exiting threshold $R^*_E$ will be lower as $\sigma$ rises. In other words, the firm will keep exporting at

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10 See Chen et al. (2006: 284)
a very low exchange rate level if the exchange rate volatility is high enough, and thus the probability of dumping occurrence will be higher.

However, if the exchange rate pass-through is greater than zero, higher exchange rate volatility will depress the discounted present value of the exporting firm’s profits and hence increase its probability to exit the market. While these two effects are opposite and their net effect might be ambiguous, our proof of this proposition indicates that the latter effect is smaller than former one so that the net effect of exchange rate volatility on the threshold effect is positive.

As for the distribution effect of $\sigma$, it is ambiguous, as shown in Lemma 1. It depends on the logarithmic values of exiting threshold ($\bar{R}_E^*$) and dumping threshold ($\bar{R}_D^*$), and the expectation of logarithmic exchange rate ($\bar{R}$). If the level of $\bar{R}$ is low enough ($\bar{R}_D^* > \bar{R}_E^* > \bar{R} + \sigma \cdot \omega$), or high enough ($\bar{R} + \sigma \cdot \omega > \bar{R}_D^* > \bar{R}_E^*$), $DE$ will be positive; otherwise, it will be negative. In other words, this proposition suggests that if $\bar{R}_E^*$ and $\bar{R}_D^*$ are close to $\bar{R}$, then the exchange rate volatility tends to reduce the probability of dumping occurrence. In contrast, if $\bar{R}_E^*$ and $\bar{R}_D^*$ are far away from $\bar{R}$, then the exchange rate volatility might increase the probability of dumping occurrence. Consequently, the effect of exchange rate volatility on dumping seems to be asymmetric.

The logic behind the above result is as follows: An increase in exchange rate volatility will increase the probability of extreme values in the exchange rate to occur and lower the probability of the exchange rate to be around its mean as well.
Therefore, an increase in volatility will lower the probability of dumping occurrence when the interval of dumping occurrence is around the mean of the distribution of exchange rate, whereas it will increase the probability of dumping occurrence when the interval of dumping occurrence locates on either tail of the distribution of the exchange rate, which implies that it is far away from its mean.

Exchange rate trend and dumping probability

The total effect of \( \mu \) on dumping probability can be decomposed as follows:

\[
\frac{df(\cdot)}{d\mu} = \frac{\partial f(\cdot)}{\partial R_E^*} \cdot \frac{\partial R_E^*}{\partial \mu} \cdot \frac{\partial \mu}{\partial E_x} + \frac{\partial f(\cdot)}{\partial \mu} \frac{\partial \mu}{\partial E_x} \tag{12}
\]

Lemma 2 The distribution effect of \( \mu \) is positive if \( R_D^* > R_E^* > \bar{R} \), and negative if \( \bar{R} > R_D^* > R_E^* \).


Proposition 2 Exchange rate trend \( \mu \) is positively related to the probability of dumping occurrence if \( R_D^* > R_E^* > \bar{R} \).

Proof. If \( 0 < \varepsilon < 1 \), it can be shown that the threshold effect of \( \mu \) is positive:

\[
\frac{\partial f(\cdot)}{\partial R_E^*} \cdot \frac{\partial R_E^*}{\partial \mu} \cdot \frac{\partial \mu}{\partial E_x} = \frac{e^{-\frac{1}{2}m^2}}{\sigma \sqrt{2\pi T}} \left( 1 + \alpha - \varepsilon \right) \left( \rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2) \right) \sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2} > 0
\]

where \( \Phi = \rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2) - (1 + \alpha - \varepsilon)\sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2} < 0. \)

\[^{11}\text{See appendix for the proof of } \Phi < 0.\]
distribution effect of $\mu$ is positive when $\overline{R}_D > \overline{R}_e > \bar{R}$ (Lemma 2). Hence, from Equation (12) we have $df(\cdot)/d\mu > 0$.

Similar to exchange rate volatility, exchange rate trend $\mu$ also affects the probability of dumping occurrence through two channels: threshold effect and distribution effect. As for the threshold effect, since $\mu$ represents the expected future exchange rate level, an increase in $\mu$ will increase the expected profit flows. Hence, it lowers the incentive of exiting the foreign market and lowers the exiting threshold, thus increasing the probability of dumping occurrence.

As regards the distribution effect, it is ambiguous as Lemma 2 shows. However, it will be positive if $\overline{R}_D > \overline{R}_e > \bar{R}$. Thus, the exchange rate trend might increase the probability of dumping occurrence if the thresholds are greater than the expected exchange rate level $\bar{R}$. It is because an increase in $\mu$ raises the mean of exchange rate in addition to increasing the probability of the exchange rate level whose value is greater than its mean. Consequently, the relationship between exchange rate trend and the probability of dumping occurrence is positive if $\overline{R}_D > \overline{R}_e > \bar{R}$. Furthermore, Lemma 2 shows that the distribution effect of $\mu$ is negative if $\bar{R} > \overline{R}_D > \overline{R}_e$. It indicates that an increase in $\mu$ might dampen the dumping activity when the expected exchange rate is high enough. Therefore, there also exists asymmetry in the effect of exchange rate trend on dumping activity.
Proposition 3  The initial level of the logarithmic exchange rate, \( \ln R_0 \), is positively related to the probability of dumping occurrence if \( \bar{R}_D > \bar{R}_L > \bar{R} \) and is negatively related to the probability of dumping occurrence if \( \bar{R} > \bar{R}_D > \bar{R}_L \).

Proof: Since \( E \ln R = \ln R_0 + \mu T - 0.5 \sigma^2 T \), thus differentiating (10) with respect to \( \ln R_0 \) yields:

\[
\frac{\partial f (\cdot)}{\partial \ln R_0} = \frac{1}{\sigma \sqrt{2\pi T}} \left[ e^{-\frac{1}{2} \left( \frac{\ln R_0 - \mu T}{\sigma} \right)^2} - e^{-\frac{1}{2} \left( \frac{\ln R_0 - \mu T}{\sigma} \right)^2} \right],
\]

According to Lemma 2, \( \frac{\partial f (\cdot)}{\partial \ln R_0} > 0 \) if \( \bar{R}_D > \bar{R}_L > \bar{R} \) and \( \frac{\partial f (\cdot)}{\partial \ln R_0} < 0 \) if \( \bar{R} > \bar{R}_D > \bar{R}_L \). ■

This proposition shows that an appreciation of foreign currency tends to increase the probability of dumping occurrence if the current exchange rate level is below the dumping region, but tends to lower it if the current exchange rate level is above the dumping region. Thus, there also exists asymmetry in the effect of exchange rate level on dumping activity. The rationale behind this proposition is similar as Proposition 2. It is because an increase in \( \ln R_0 \) also raises the mean of exchange rate.

Exchange rate pass-through and dumping probability

Proposition 4  The relationship between exchange rate pass-through and dumping probability is ambiguous. If \( R \geq 1 \), and \( R > \bar{R}_D > \bar{R}_L + \Lambda_1 \), exchange rate pass-through and dumping probability are positively related. However, if...
$\bar{R}_E^* + \Lambda > \bar{R}_D^* > \bar{R}_E^* > \bar{R}$, then exchange rate pass-through and dumping probability are negatively related.

**Proof.** Differentiating (10) with respect to $\varepsilon$, we have

$$\frac{\partial f(\cdot)}{\partial \varepsilon} = \frac{1}{\sigma \sqrt{2\pi T}} \frac{1}{1 - \varepsilon} \left[ e^{-\frac{1}{2} \varepsilon^2} \bar{R}_D^* - e^{-\frac{1}{2} \varepsilon^2} \left( \bar{R}_E^* + \Lambda \right) \right]$$

where

$$\Lambda = \frac{\Psi}{\left( \rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2) \right) (1 + \alpha - \varepsilon)} > 0$$

$$\Psi = \left( \mu + (0.5 - \varepsilon)\sigma^2 \right) (1 + \alpha - \varepsilon) + \left( \rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2) \right) > 0 \quad 12$$

Hence, from Lemma 2, it can be shown that if $\bar{R} > \bar{R}_D^* > \bar{R}_E^* + \Lambda$, then $\partial f(\cdot)/\partial \varepsilon > 0$ and if $\bar{R}_E^* + \Lambda > \bar{R}_D^* > \bar{R}_E^* > \bar{R}$, then $\partial f(\cdot)/\partial \varepsilon < 0$.

The economic intuition behind this proposition is as follows. Exchange rate pass-through affects dumping probability only via threshold effect. Without considering other factors in the Equation (4), $mkp \geq 1$ implies that $R \geq 1$. If $R \geq 1$, an increase in exchange rate pass-through ($\varepsilon$) will cause the pricing of the exporting firms less responsive to the exchange rate movements, thereby raising the dumping probability. However, given our assumption that the capacity is fully utilized so that the quantity is fixed, partial pass-through will cause a decrease in the profits of the exporting firm. As a result, the probability of exit of the firm will increase and hence reduce its dumping probability. In other words, an increase in exchange rate pass-through ($\varepsilon$) will cause both dumping threshold and exit threshold to rise. Since the rise in these two thresholds have opposing effects on dumping probability, the net effect will depend on relative magnitude of these two effects. If the expected

12 See appendix for the proof of $\Psi > 0$.

13 Note that $R \geq 1$ implies $R_D^* > R_E^* \geq 1$; otherwise, there are no firms undertaking dumping activity on the export market.
exchange rate level is higher than dumping interval and the dumping threshold and exit threshold are not close, the dumping threshold will dominate exit threshold so that exchange rate pas-through are positively related, and vice versa.

4. Empirical model and methodology

From our theoretical framework, it is clear that the relationship between the exchange rate and dumping occurrence is not determinate, depending on the expected level of the exchange rate. In order to test the validity of Propositions 1 and 4, we will divide the level of exchange rate into three regions: high, medium, and low. Similarly, in order to test the validity of Propositions 2 and 3, the level of the exchange rates of the importing country is divided into two areas: one is a strong currency area (SCA), and the other is a weak currency area (WCA).

Based on our theoretical results, our empirical model is specified as follows:

\[
DUMP_{it} = \beta_0 + \beta_1 REER_{it} + \beta_2 \mu_i + \beta_3 \sigma_i + \beta_4 PT_i + \beta_5 REER_{it} \times D_1_i + \beta_6 \mu_i \times D_1_i + \beta_7 \sigma_i \times D_2_i + \beta_8 PT_i \times D_3_i + \beta_9 GDP_i + \beta_{10} D85_i + \beta_{11} CHM_i + \beta_{12} METAL_i + \beta_{13} TIME_i + e_{it}
\]  

(13)

where \(DUMP_i\) denotes the number of dumping filings, and \(i = 1,2,3\). Here, subscript \(t\) refers to time, \(\beta_j\) \((j = 0,1,\ldots,8)\) are parameters, and \(e_{it}\)’s are disturbance terms.

The definition of the independent variables in (13) and their expected signs (summarized in Table 1) are explained as follows:

\(REER_{it-1}\): the 2-year moving average of real effective exchange rates of the currency
of the U.S. from time \( t-2 \) to \( t-1 \), whose expected sign is indeterminate. However, according to Proposition 3, the expected sign of this variable is negative in Strong Currency Area.

\( \mu_t, \sigma_t \): the trend and volatility of the real effective exchange rates, respectively. The expected signs of these variables are ambiguous, also depending on the level of exchange rates. According to Proposition 2, the expected sign of exchange rate trend is positive in WCA and ambiguous in SCA. Moreover, Proposition 1 predicts that the expected sign of exchange rate volatility is positive when the exchange rate level is high or low enough, otherwise, it is ambiguous.

To measure the trend and volatility of the real effective exchange rate, \( \mu_t \) and \( \sigma_t \) are defined respectively as a modified average and a modified standard deviation of the monthly changes in the log of the real effective exchange rate over the past 24 months; that is:

\[
\sigma_t = \frac{1}{\sqrt{\Delta}} \left[ \frac{1}{T-1} \sum_{j=1}^{T} \left( r_{t-j+1} - \frac{1}{T} \sum_{j=1}^{T} r_{t-j+1} \right)^2 \right]^\frac{1}{2}, \quad \mu_t = \frac{1}{T \cdot \Delta} \sum_{j=1}^{T} r_{t-j+1} + \frac{\sigma_t^2}{2},
\]

where \( r_j = \log R_j - \log R_{j-1}; \quad T = 24; \quad \Delta \) is the space time interval, equal to \( 1/T. \)

\( PT_i \): the magnitude of exchange rate pass-through in industry \( i \) expressed as percentage.

\( D_1 \): a dummy variable, whose value is 1 for the strong U.S. dollar period, 1981-1986, and 0 for other periods including 1978-80 and 1987-2006. The division of exchange rate level into SCA and WCA areas is determined by the

real effective exchange rates of the U.S. dollar. During the period 1978-2006, as shown in Table 2, the average value of the index within SCA is 129.41 with a minimum 116.61 over the period 1981-1986. In contrast, the value of the index is lower than 107 within WCA with an average of 93.93. Therefore, the former period is referred to as a strong U.S. dollar period and the latter is referred to as a weak U.S. dollar period.

\[ D_2 : \text{a dummy variable to denote unusually high or low exchange rate regions, respectively. Following the Proposition 1 and the data we use, two thresholds are defined as follows:} \]

\[ RH_t = \bar{R}_t + \sigma_t \cdot \omega_{H,t}, \quad \text{and} \quad RL_t = \bar{R}_t + \sigma_t \cdot \omega_{L,t}. \]

These two variables are shown in Figure 4. Proposition 1 indicates that exchange rate volatility, \( \sigma \), is positively related to the probability of dumping occurrence if \( \bar{R}_{H}^* > \bar{R}_{E}^* > RH \) or \( RL > \bar{R}_{H}^* > \bar{R}_{E}^* \), which is most likely to happen either when RH is very small or when RL is very large. Therefore, \( D_2 \) is assumed to be 1 for the highest five years of RL (high exchange rate region) and the lowest five years of RH (low exchange rate region); and 0, otherwise. The top five years of RL consist of 1982-1986 and the lowest five years of RH consist of 1992, and 1994-1997.

\[ D_3 : \text{a dummy variable to denote unusually low exchange rate region. According to Proposition 4, PT is negatively related to the probability of dumping occurrence, therefore, } D_3 \text{ is assumed to be 1 for the lowest five years of RH (1992, and 1994-1997); and 0, otherwise.} \]

\[ GDP_{t-3} : \text{the 3-year moving average of real GDP growth rates from time } t-3 \text{ to } t-1, \]
whose expected sign is negative. The rationale is as follows: If the importing country, the United States, experiences an expansion, then an exporter would likely raise its export price, therefore reducing the likelihood of dumping. In a recession, in contrast, the exporter would likely reduce its price in the host market to retain market share, thus increasing the likelihood of dumping.\textsuperscript{15}

\begin{align*}
D85 &: \text{a dummy variable to denote changes in antidumping laws in 1984, whose value over the period of 1985-2006 is 1; 0, otherwise. The U.S. amended its The Trade and Tariff Act in 1984. This amendment stipulates that ITC take into account imports of all sources, including those from non-dumping firms, when determining industry injury. It would make the determination of industry injury more likely to be positive.}\textsuperscript{16} \\
CHM &: \text{a dummy variable to denote chemical industry, whose value is 1 if the subject industry is chemical industry; 0, otherwise.}
\METAL &: \text{a dummy variable to denote metal industry, whose value is 1 if the subject industry is metal industry; 0, otherwise.}
\TIME &: \text{a dummy variable to denote linear time trend.}\textsuperscript{17}
\end{align*}

Since the number of filings is a non-negative count number, negative binomial (NB) or Poisson regression are widely used under this circumstance. As shown in Table 2,

\textsuperscript{15} See Feinberg (2005: 613-614).
\textsuperscript{17} Most empirical studies use the time trend to control for time-related variables. See, for instance, Sadni Jallab et al. (2006), and Feinberg (1989,2005).
however, the variance of the dependent variable considerably exceeds its mean, which is not consistent with the assumption of Poisson regression, Hence, NB regression is used in our estimation.\textsuperscript{18} In addition, given that industry-level panel data is employed in this paper, we adopt Negative Binomial Regression Random-Effect Model (NBREM) for estimation.\textsuperscript{19}

\section*{5. Data and empirical results}

\textbf{Data}

Given the fact that the U.S. has been a heavy user of an AD policy, we use the U.S. as the sample county in this study. The dependent variable is the annual cases of AD filings in the U.S. covering the period 1980-2006. The data are compiled from “Import Injury Investigations Case Statistics” released by the International Trade Commission of the U.S. The cases in the database are classified into 15 SIC industries, among them, the other industry is excluded from our sample due to the difficult in collecting related data regarding this industry. The average annual cases per year are 2.89 (see Table 2). The distribution of AD filings among industries is illustrated in Table 3. There are 1,110 cases in total over the period 1980-2006, in which the primary metal industry and chemical industry have largest AD cases. They have 560 cases and 142 cases, respectively.

The estimates of exchange rate pass-through for industries in the U.S. are shown in Table 4. Previous studies on industry-level exchange rate pass-through are limited.

\textsuperscript{18} See Cameron and Trivedi (1998).
The estimates from two previous studies are used in this paper: Yang (1997) and Pollard and Coughlin (2006). Yang (1997) employs monthly data over 1980-1991 to determine the short-run estimates of exchange rate pass-through range from 8.97% to 62.13% with an average 31.43%, while the long-run estimates of exchange rate pass-through range from 8.12% to 88.43% with an average 41.95%. Pollard and Coughlin (2006) estimate exchange rate pass-through for 29 manufacturing industries in the U.S. with quarterly data covering 1978-2000. Their results reveal that the values of exchange rate pass-through range from 17.2% to 58.6% with an average of 34.3%. Except for few industries, such as electronic and electric industry, there are no significant differences between the estimates from these two studies. Campa and Goldberg (2005) also obtain similar estimates of the exchange rate pass-through in the U.S.

The data sources are as follows: GDP is compiled from the database of International Financial Statistics of the International Monetary Fund. Descriptive statistics of these variables are reported in Table 2.

**Empirical results**

Our empirical results are presented in Table 5. The first column in Table 5 is our benchmark model in which the estimation does not consider the asymmetric effects of exchange rate variables on the dumping occurrence. Columns 2-4 incorporate dummies variable into the empirical model to test the existence of asymmetric effects. In addition, different estimates of exchange rate pass-through are also used to check the robustness of our empirical results.

In our benchmark model, only the coefficient of $\sigma$ is not statistically significant. The positive sign of the coefficient of REER and $\mu$ implies that an appreciation the U.S. currency or an expected appreciation in the U.S. currency tends to stimulate
dumping activity, which is consistent with most previous studies. In addition, the positive sign of the coefficient of PT suggests that the higher the exchange rate pass-through in an industry is, the more likely the dumping occurs in that industry.

The estimation in Column 2 tries to identify the asymmetric effects of exchange rate variables. The interactive term of exchange rate and $D_1$, $\text{REER} \times D_1$, has a negative coefficient which is significant at 10% level. It implies that, compared with the weak currency area, the appreciation of the importing country is less likely to stimulate the dumping activities within the strong currency area. In contrast, the coefficient of REER is significantly positive, and the total effect is also positive ($\beta_1 + \beta_2 > 0$). These results suggest an appreciation of the U.S. currency tends to stimulate dumping activity except for the period of strong U.S. dollar. They are consistent with our theory. They can also account for the mixed results in the relationship of exchange rate and dumping occurrence in the previous empirical studies about the case of the U.S.

Regarding the exchange rate trend, while the coefficient of $\mu$ is positive and significant at 1% level, the coefficient of $\mu \times D_1$ is negative but not statistically significant. This result provides weak support for the asymmetric effect demonstrated in Proposition 2. In other words, an expected appreciation of an importing country’s currency will stimulate the dumping filings if the exchange rate level is low enough, while it might deter the dumping activities if its level is high enough.

As for exchange rate volatility, while the coefficient of $\sigma$ is insignificantly negative, the coefficient of $\sigma \times D_2$ is positive and significant at 1% level. These results
suggest that when level of exchange rate is unusually high or unusually low, an increase in exchange rate uncertainty tends to stimulate dumping activity, which is also consistent with our theory.

Regarding the effects of exchange rate pass-through, while the coefficient of PT is significantly positive at 1% level, the coefficient of PT×D₃ is significantly negative at 5% level. These results suggest that exchange rate pass-through and dumping occurrence are positively related within strong currency area and negatively related within weak currency area, which are also consistent with the prediction of our theoretical model.

Columns 3 and 4 report the estimation results with two different estimates of exchange rate pass-through. These results are very similar to those reported in Column 2, which suggests that our empirical results are not very sensitive the estimates of exchange rate pass-through.

Regarding other control variables, the industry dummies have positive and significant coefficients, which indicate that the firms in chemical and metal industries have relatively higher propensity to file for antidumping investigation. The coefficient of GDP growth rate is negative and not very significant. In addition, the coefficient of D₈₅ is significantly positive, indicating the change in the antidumping laws of the U.S. in 1984 have enhanced antidumping filings significantly. Finally, the significant and negative coefficient of time trend suggests that the intensity of enforcement of antidumping policy in the U.S. has been declined over time during the past decades.

6 Conclusion

Antidumping measures have become the most important instruments in the trade
policy around the world. One of the distinct features of AD filings is their sharp fluctuation over time, which is attributed to some macroeconomic factors in general, and exchange rates in particular. This paper investigates the relationship between exchange rate movements and dumping activity both theoretically and empirically. A real options model of export under imperfect exchange rate pass-through is developed. It is found that exchange rate level as well as its trend and volatility has an asymmetric effect on dumping occurrence, which depends on the long-run level of exchange rate. Industry-level data on anti-dumping filings of the United States covering the period 1980-2006 are used to test the validity of our theoretical model. Our empirical results are generally consistent with the prediction of our theory.

Specifically, it is shown in this paper that when the value of an importing country’s currency is low, its appreciation or expected appreciation will cause the dumping activity to rise, whereas when the value of the currency is high, this relationship might be reversed. These findings could shed light on the mixed results regarding the relationship between exchange rates and AD filings in previous empirical studies.

Similarly, the magnitude of exchange rate pass-through and dumping occurrence is positively related when the value of an importing country’s currency is high enough, whereas their relationship might become negative when the value of the currency is low enough. Furthermore, the exchange rate volatility and dumping occurrence will be positively related only if the value of an importing country’s currency is extremely low or extremely high. These results suggest that it is essential to take into account the asymmetric effects when investigating the relationship between exchange rate movements and AD activity.
References


World Economy, 28, 651-668.


Appendix

Proof of $\Phi < 0$

$$\Phi = \rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2) - (1 + \alpha - \varepsilon)\sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2}.$$  

Since

$$\Phi_{\rho=0} = \begin{cases}  
-\frac{2}{\sigma^2}(\mu - 0.5\varepsilon\sigma^2)^2 < 0 & \text{if } \mu - 0.5\varepsilon\sigma^2 > 0 \\
-\frac{1}{2}(1-\varepsilon)^2\sigma^2 < 0 & \text{if } \mu - 0.5\varepsilon\sigma^2 < 0 
\end{cases}$$

and $0 < \rho$, if $\frac{\partial \Phi}{\partial \rho} < 0$, we have $\Phi < 0$.

$$\frac{\partial \Phi}{\partial \rho} = -\frac{\mu - 0.5\sigma^2 + \varepsilon\sigma^2 - \sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2}}{\sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2}}. \quad (A1)$$

Since $\mu$ is the growth rate of exchange rate, thus $\mu > -1$. If $\frac{\partial \Phi}{\partial \rho}_{\mu=-1} < 0$, and $\frac{\partial^2 \Phi}{\partial \mu \partial \rho} < 0$, then $\frac{\partial \Phi}{\partial \rho} < 0$. From (A1) we have

$$\frac{\partial^2 \Phi}{\partial \mu \partial \rho} = \frac{-\sigma^2\left(4\rho - 2(1 - \varepsilon)(\mu - 0.5\sigma^2)\right)}{2\left[2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2\right]^{3/2}}.$$  

Because convergence condition implies that $\rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2) > 0$, thus $\frac{\partial^2 \Phi}{\partial \mu \partial \rho} < 0$.

$$\frac{\partial \Phi}{\partial \rho}_{\mu=-1} = \frac{1 + (\varepsilon - 0.5)\sigma^2 - \sqrt{2\rho\sigma^2 + (1 + 0.5\sigma^2)^2}}{\sqrt{2\rho\sigma^2 + (1 + 0.5\sigma^2)^2}}.$$  

Given $0 < \varepsilon < 1$, $1 + (\varepsilon - 0.5)\sigma^2 \leq 1 + 0.5\sigma^2 < \sqrt{2\rho\sigma^2 + (1 + 0.5\sigma^2)^2}$. Hence,

$\frac{\partial \Phi}{\partial \rho}_{\mu=-1} < 0$. Therefore, we have $\Phi < 0$. ■
Proof of $\Psi_1 > 0$

$$\Psi_1 = \left(\mu + (0.5 - \varepsilon)\sigma^2\right)(1 + \alpha - \varepsilon) + \left(\rho - (1 - \varepsilon)(\mu - 0.5\varepsilon\sigma^2)\right) > 0$$

Since

$$\frac{\partial \Psi_1}{\partial \varepsilon} = \varepsilon\sigma^2 - \left(\mu + 0.5\sigma^2 + \sqrt{2\rho\sigma^2 + (\mu - 0.5\sigma^2)^2}\right),$$

We have

$$\frac{\partial \Psi_1}{\partial \varepsilon} \begin{cases} > 0 & \text{if } \varepsilon > \varepsilon^{**} \\ = 0 & \text{if } \varepsilon = \varepsilon^{**} \\ < 0 & \text{if } \varepsilon < \varepsilon^{**} \end{cases}$$

where $\varepsilon^{**} = 1 + \alpha > 1$. In addition, since $\Psi_1|_{\varepsilon=\varepsilon^{**}} = 0$ and $\frac{\partial^2 \Psi_1}{\partial \varepsilon^2} = \sigma^2 > 0$, hence, we have $\Psi_1 \geq 0$.\[\blacksquare]
Table 1 The expected signs of exchange rate variables

<table>
<thead>
<tr>
<th>Condition</th>
<th>$R$</th>
<th>$\mu$</th>
<th>$\sigma$</th>
<th>$\varepsilon$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{R}_D &gt; \bar{R}_E &gt; \bar{R} + \sigma \cdot \omega_h$</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>$\bar{R}_D &gt; \bar{R} &gt; \bar{R}_E^*$</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>$\bar{R}_D &gt; \bar{R}_E &gt; \bar{R}$</td>
<td>+</td>
<td>+</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>$\bar{R}_D &gt; \bar{R} &gt; \bar{R}_E^*$</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>$\bar{R} &gt; \bar{R}_D &gt; \bar{R}_E^*$</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>$\bar{R} + \sigma \cdot \omega_h &gt; \bar{R}_D &gt; \bar{R}_E^*$</td>
<td>-</td>
<td>?</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1  exchange rate thresholds :  RH and RL

Table 2 Descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The number of AD initiation</td>
<td>2.89</td>
<td>0.00</td>
<td>70.00</td>
<td>7.78</td>
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<tr>
<td>Real effective exchange rate (REER)</td>
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<td></td>
</tr>
<tr>
<td>Strong currency area (1981-1986)</td>
<td>129.41</td>
<td>116.61</td>
<td>143.24</td>
<td>10.51</td>
</tr>
<tr>
<td>Average real GDP growth rate (%)</td>
<td>3.12</td>
<td>-1.08</td>
<td>5.45</td>
<td>1.25</td>
</tr>
</tbody>
</table>
### Table 3: The cases of AD filings by industry in the U.S.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture and Processed food</td>
<td>14</td>
<td>16</td>
<td>13</td>
<td>17</td>
<td>24</td>
<td>84</td>
</tr>
<tr>
<td>Mining and Non-ferrous metal</td>
<td>7</td>
<td>19</td>
<td>16</td>
<td>4</td>
<td>22</td>
<td>68</td>
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<tr>
<td>Chemical products</td>
<td>31</td>
<td>30</td>
<td>33</td>
<td>10</td>
<td>38</td>
<td>142</td>
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<tr>
<td>Plastic products</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>11</td>
<td>22</td>
<td>46</td>
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<tr>
<td>Leather products</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Wood and wooden products</td>
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<td>0</td>
<td>12</td>
<td>0</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Paper and paper products</td>
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<td>2</td>
<td>11</td>
<td>0</td>
<td>5</td>
<td>18</td>
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<td>Textiles</td>
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<td>6</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>19</td>
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<tr>
<td>Apparels</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Metal</td>
<td>110</td>
<td>113</td>
<td>135</td>
<td>79</td>
<td>123</td>
<td>560</td>
</tr>
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<td>Machinery</td>
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<td>27</td>
<td>20</td>
<td>3</td>
<td>1</td>
<td>63</td>
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<tr>
<td>Electricity and electronic</td>
<td>8</td>
<td>18</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>43</td>
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<td>equipments</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Transportation equipments</td>
<td>13</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>23</td>
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<tr>
<td>Precision instruments</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>205</td>
<td>248</td>
<td>270</td>
<td>137</td>
<td>249</td>
<td>1,109</td>
</tr>
</tbody>
</table>

### Table 4: Estimated Exchange Rate Pass-through by Industry in the U.S.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Processed food</td>
<td>18.75</td>
<td>24.85</td>
<td>23.3</td>
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<tr>
<td>Non-ferrous metal products</td>
<td>62.13</td>
<td>88.43</td>
<td>35.9</td>
</tr>
<tr>
<td>Chemical products</td>
<td>37.54</td>
<td>53.12</td>
<td>40.6</td>
</tr>
<tr>
<td>Plastic products</td>
<td>42.85</td>
<td>53.18</td>
<td>19.2</td>
</tr>
<tr>
<td>Leather products</td>
<td>28.45</td>
<td>31.44</td>
<td>27.9</td>
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<td>Wood and wooden products</td>
<td>8.97</td>
<td>8.12</td>
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<tr>
<td>Paper and paper products</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Textiles</td>
<td>20.91</td>
<td>31.24</td>
<td>24.9</td>
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<td>Apparels</td>
<td>10.99</td>
<td>10.68</td>
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<tr>
<td>Metal</td>
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<td>21.23</td>
<td>20.3</td>
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<tr>
<td>Machinery</td>
<td>56.35</td>
<td>75.59</td>
<td>63.9</td>
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<tr>
<td>Electricity and electronic equipments</td>
<td>29.3</td>
<td>39.14</td>
<td>86.1</td>
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<td>Transportation equipments</td>
<td>21.44</td>
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<td>35.8</td>
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<tr>
<td>Precision instruments</td>
<td>54.7</td>
<td>72.56</td>
<td>67.8</td>
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<tr>
<td>Average</td>
<td>31.43</td>
<td>41.95</td>
<td>36.01</td>
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Table 5 Empirical Results of the Determinants of AD Filings in the U.S.

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Magnitude of exchange rate pass-through</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
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<tbody>
<tr>
<td></td>
<td>Yang (1997): Short run</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept ($\beta_0$)</td>
<td>-3.1521 $^a$</td>
<td>-3.0760 $^b$</td>
<td>-3.2375 $^b$</td>
<td>-2.9357 $^c$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-3.39)</td>
<td>(-2.03)</td>
<td>(-2.16)</td>
<td>(-1.82)</td>
<td></td>
</tr>
<tr>
<td>REER ($\beta_1$)</td>
<td>0.0155 $^b$</td>
<td>0.0203 $^b$</td>
<td>0.0206 $^b$</td>
<td>0.0199 $^b$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.15)</td>
<td>(2.22)</td>
<td>(2.27)</td>
<td>(2.13)</td>
<td></td>
</tr>
<tr>
<td>$\mu$ ($\beta_2$)</td>
<td>1.4750 $^b$</td>
<td>2.0036 $^a$</td>
<td>2.0383 $^a$</td>
<td>1.9902 $^b$</td>
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<tr>
<td></td>
<td>(2.40)</td>
<td>(2.58)</td>
<td>(2.63)</td>
<td>(2.49)</td>
<td></td>
</tr>
<tr>
<td>$\sigma$ ($\beta_3$)</td>
<td>-0.6985</td>
<td>-4.2995</td>
<td>-3.4556</td>
<td>-3.9250</td>
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<tr>
<td></td>
<td>(-0.08)</td>
<td>(-0.41)</td>
<td>(-0.33)</td>
<td>(-0.35)</td>
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<tr>
<td>PT ($\beta_4$)</td>
<td>0.0177 $^a$</td>
<td>0.0203 $^a$</td>
<td>0.0161 $^a$</td>
<td>0.0140 $^b$</td>
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</tr>
<tr>
<td></td>
<td>(3.85)</td>
<td>(4.38)</td>
<td>(4.96)</td>
<td>(2.32)</td>
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</tr>
<tr>
<td>REER×D1 ($\beta_5$)</td>
<td>-0.0074 $^c$</td>
<td>-0.0075 $^c$</td>
<td>-0.0070 $^c$</td>
<td>-0.0070 $^c$</td>
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<tr>
<td></td>
<td>(-1.87)</td>
<td>(-1.91)</td>
<td>(-1.78)</td>
<td>(-1.78)</td>
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<tr>
<td>$\mu$×D1 ($\beta_6$)</td>
<td>-0.9975</td>
<td>-0.9874</td>
<td>-0.9308</td>
<td>-0.9308</td>
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<tr>
<td></td>
<td>(-0.73)</td>
<td>(-0.72)</td>
<td>(-0.67)</td>
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<tr>
<td>$\sigma$×D2 ($\beta_7$)</td>
<td>5.5448 $^a$</td>
<td>5.4965 $^a$</td>
<td>5.2195 $^b$</td>
<td>5.2195 $^b$</td>
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<tr>
<td></td>
<td>(2.57)</td>
<td>(2.56)</td>
<td>(2.29)</td>
<td>(2.29)</td>
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</tr>
<tr>
<td>PT×D3 ($\beta_8$)</td>
<td>-0.0232 $^b$</td>
<td>-0.0163 $^b$</td>
<td>-0.0183 $^c$</td>
<td>-0.0183 $^c$</td>
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<tr>
<td></td>
<td>(-2.34)</td>
<td>(-2.31)</td>
<td>(-1.82)</td>
<td>(-1.82)</td>
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<tr>
<td>GDP ($\beta_9$)</td>
<td>-0.1652 $^c$</td>
<td>-0.1209</td>
<td>-0.1198</td>
<td>-0.1184</td>
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<tr>
<td></td>
<td>(-1.86)</td>
<td>(-1.30)</td>
<td>(-1.29)</td>
<td>(-1.27)</td>
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</tr>
<tr>
<td>D85 ($\beta_{10}$)</td>
<td>1.1099 $^a$</td>
<td>0.8180 $^b$</td>
<td>0.8199 $^b$</td>
<td>0.8227 $^b$</td>
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<tr>
<td></td>
<td>(2.80)</td>
<td>(2.09)</td>
<td>(2.10)</td>
<td>(2.07)</td>
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<tr>
<td>CHM ($\beta_{11}$)</td>
<td>1.3500 $^a$</td>
<td>1.3859 $^a$</td>
<td>1.3386 $^a$</td>
<td>1.5000 $^a$</td>
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<tr>
<td></td>
<td>(7.12)</td>
<td>(7.42)</td>
<td>(7.17)</td>
<td>(7.92)</td>
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<tr>
<td>METAL ($\beta_{12}$)</td>
<td>2.8589 $^a$</td>
<td>2.9313 $^a$</td>
<td>2.9641 $^a$</td>
<td>2.7460 $^a$</td>
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<tr>
<td></td>
<td>(16.00)</td>
<td>(16.53)</td>
<td>(16.78)</td>
<td>(16.40)</td>
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</tr>
<tr>
<td>TIME ($\beta_{13}$)</td>
<td>-0.0400 $^b$</td>
<td>-0.0429 $^a$</td>
<td>-0.0428 $^a$</td>
<td>-0.0437 $^a$</td>
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<tr>
<td></td>
<td>(-2.43)</td>
<td>(-2.58)</td>
<td>(-2.57)</td>
<td>(-2.60)</td>
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</tr>
</tbody>
</table>

Wald $\chi^2$: 311.7 $^a$ 349.3 $^a$ 350.1 $^a$ 351.4 $^a$

Notes: The z-statistics are in parentheses; superscripts a, b and c denote that the test statistics are significant at the 1%, 5% and 10% levels, respectively.