


1998

Exchange rate and market power in import price

Jeong-Yun Seo
Iowa State University

Follow this and additional works at: <https://lib.dr.iastate.edu/rtd>

 Part of the [Agricultural Economics Commons](#), [Finance Commons](#), and the [Finance and Financial Management Commons](#)

Recommended Citation

Seo, Jeong-Yun, "Exchange rate and market power in import price " (1998). *Retrospective Theses and Dissertations*. 12523.
<https://lib.dr.iastate.edu/rtd/12523>

This Dissertation is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

Exchange rate and market power in import price

By

Jeong-Yun Seo

**A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY**

Major: Economics

Major Professor: Arne Hallam

Iowa State University

Ames, Iowa

1998

UMI Number: 9911639

UMI Microform 9911639
Copyright 1999, by UMI Company. All rights reserved.

**This microform edition is protected against unauthorized
copying under Title 17, United States Code.**

UMI
300 North Zeeb Road
Ann Arbor, MI 48103

Graduate College
Iowa State University

This is to certify the Doctoral dissertation of

Jeong-Yun Seo

has met the thesis requirements of Iowa State University

Signature was redacted for privacy.

Major Professor

Signature was redacted for privacy.

~~For the Major Program~~

Signature was redacted for privacy.

For the Graduate College

DEDICATION

To the sweat-heart who loved the spring of 1992.

TABLE OF CONTENTS

	Page
GENERAL INTRODUCTION	1
Dissertation Organization	1
Overview	1
CHAPTER 1. IMPORT DIVERSIFICATION AND CURRENCY HEDGING	4
ABSTRACT	4
I. INTRODUCTION	4
II. DECISION MODEL	7
III. INTERPRETATIONS	14
III.1. Diversification and Hedging Effects	14
III.2. Comparative Statistics	17
IV. CONCLUDING REMARKS	20
REFERENCES	21
FOOTNOTES	23
APPENDICES	25
CHAPTER 2. DEMAND DIVERSIFICATION UNDER UNCERTAINTY AND MARKET POWER: APPLICATION TO THE CHINESE WHEAT IMPORT MARKET	31
ABSTRACT	31
I. INTRODUCTION	31
II. THEORETICAL MODEL	35
II.1. Expected Price vs. Risk	35
II.2. Supplier's Market Power vs. Risk	37

II.2.1.	monopolistic market power	37
II.2.2.	systematic risk	40
III.	EMPIRICAL APPLICATION: WHEAT IMPORTS in CHINA	46
III.1.	Backgrounds and Statement of Problems	46
III.2.	Empirical Methods and Results	50
IV.	CONCLUSION	59
	REFERENCES	60
	FOOTNOTES	62
	APPENDICES	65
CHAPTER 3.	PRICE INTERACTIONS IN EXCHANGE RATE PASS-THROUGH	75
	ABSTRACT	75
I.	INTRODUCTION	75
II.	AN OLIGOPOLY MODEL FOR PASS-THROUGH ANALYSIS	78
II.1.	An Extended Dixit-Stiglitz Model	78
II.2.	Pass-Through Analysis	81
III.	EMPIRICAL EXAMPLE	85
IV.	CONCLUDING REMARKS	97
	REFERENCES	98
	FOOTNOTES	100
	APPENDICES	102
	GENERAL CONCLUSION	109

GENERAL INTRODUCTION

Dissertation Organization

This dissertation consists of three papers in the area of international market analysis, as listed in chapter 1, 2, and 3. Each paper has its own issue and application, but the main theme behind these papers is to figure out the interactions of international firms' real decisions with respect to changes in financial variables or structure attributing to the firms' behaviors. Chapter 1, the first paper, deals with the interaction between real diversification and currency hedging, under the dual uncertainty sources of exchange rate and price itself. The second paper, Chapter 2, is about another risk-diversification model, developed within the framework of the capital-asset-price-model (CAPM). The third paper, Chapter 3, approaches the issue of 'incomplete passthrough' of exchange rate in terms of the competitive pressure faced by foreign oligopoly, and shows how the firm's price leadership affects exchange rate pass-through. Following the third chapter is a general review of conclusions.

Overview

The first paper relates the real decision with the role of hedging tool(s) for currency risk. Given the importance of stabilizing the fluctuation in exchange rates, most of previous hedging literature have examined the positive role of hedging to the real decision, either imports or exports, under currency uncertainty. The main issue of this article focuses on the interactions between two risk managing strategies, diversification and currency hedging, especially on the production or total import level. Existence of hedging tools would be beneficial for a decision-maker: transferring the associated risk directly to the market speculators, and thus would affect real decisions positively.

Import diversification should be considered a realistic approach since there are many instances when firms import one of their inputs, which might be a homogeneous product or products within the same group, from multiple suppliers of different nationalities. However, there are no relevant hedging instruments for product price variation except diversification. The major objective of this paper is to show that the effectiveness of engaging in futures market depends on the degree that the relevant exchange rates are correlated or affected by

the market-wide systematic risk. The paper offers several interesting findings driven from the model.

Chapter 2 provides one way to apply the portfolio approach similar to the CAPM to the real decision of demand diversification, and uses the approach in an application in international trade. Further, the paper is especially designed to justify the diversification behavior of a risk-averse buyer of products, which are not necessarily homogenous, under price uncertainty. It first theoretically examines the relationships among the key variables of the model, such as the expected price, the systematic risk of price, and also the monopolistic market power of the suppliers in the market.

The major testable implications drawn are as follows; first, the monopolistic market power of a supplier positively affects the systematic risk of the price, and thus adversely affects the negative relationship between the expected price and its risk, similar to the CAPM. Secondly, the systematic price risk relative to the optimal market portfolio can be decomposed into the net risk measure and a residual term due to the market power. Based on these implications, the Chinese wheat import market is empirically examined to justify its diversification behavior over the sample period. The results generally shows that the portfolio approach, while controlling the monopolistic power effect, shall be an useful methodology in explaining potential conflicts between the buyer's risk diversification efforts and the suppliers' market power.

The last paper of the dissertation, Chapter 3, relates the topic of exchange rate pass-through - which refers to the partial response of import prices to nominal exchange rates- to the industrial structure of an exporting firm, especially to the barometric price leadership in the industry. Recent study of the subject have drawn heavily on models of industrial organization and focused on the impact of market structure on the foreign firm's behavior. In particular, existing literature emphasizes the convexity of demand schedules in explaining pricing adjustments following exchange rate changes. To find the nature of the convexity, current literature has concerned on the specific industry structure, such as degree of competition, product substitutability, market quantity shares, or the degree of destination-specific production.

The purpose of this paper is two-fold. First, based on an adapted Dixit-Stiglitz model, it theoretically draws testable implications on the subject. The model shows how pass-through is affected by barometric price leadership: pass-through tends to be greater for a firm that the market perceives its price changes to be exogenous to the market price (p^*), followed by the firm of p^* -leader, than that of p^* -taker. Overall, pass-through is negatively affected by the firm's markup factors attributing the degree of competitive pressure faced by the firm; e.g., in addition to the price interactions, pass-through is negatively related to the relative price to p^* , and positively related to the degree of product substitutability.

Second, this paper offers an empirical example, focusing on price interactions, of import beer pricing behavior in the US during 1979 to 1988, where the sample period is known as two distinctive and prolonged eras of US dollar appreciation and depreciation. As a diagnostic step, we first performed a VAR analysis to figure out the barometric leadership. Because there are open debates over the stability of pass-through level, the Kalman Filter methodology is used to investigate potential structural changes in parameters, and thus to capture dynamics of pass-through, as well as of other elasticities. Coefficients are generally estimated in the way predicted in the theoretical section, and are mostly stable over the sample period, thus supporting our model.

CHAPTER 1. IMPORT DIVERSIFICATION AND CURRENCY HEDGING

A paper prepared to be submitted to the Journal of Futures Market

Jeong-Yun Seo

ABSTRACT

This paper examines interactions between diversification strategy and currency hedging when a competitive & risk-averse importing agent chooses optimal import quantities and hedging levels under price uncertainty. Exchange rate and input price are the dual uncertainty sources of stochastic import prices. The resulting total import level under both schemes depends significantly on the degree of correlation among relevant currencies, because it is the existence of currency hedging that determines the covariance effect of portfolio variance. Both real and hedging decisions must be made within the portfolio framework (i.e., they are non-separable), and any change in the degree of closeness in stochastic price movements always affects the diversification incentive of the firm.

I. INTRODUCTION

Firms involved in international trade are subject to fluctuations in exchange rates as well as price uncertainty itself. Many of the internationally traded commodities do not have derivative markets as means to stabilize fluctuations in associated prices, but the major currencies are traded both in futures and forwards markets. Previous literature (e.g., Wolf: 1995) stresses benefits of engaging in currency futures contracts. The existence of derivative markets, unless the subjective speculation in futures markets is significantly downward biased towards a reduction in an agent's expected return, reduces the risk that the firm faces, and leads to a higher production or trade level as the firm's ex-ante welfare level increases. This study theoretically investigates a risk-averse international firm's production, import diversification, and hedging decisions under import price uncertainty, where price itself and exchange rate provide the joint sources of uncertainty. Thus, in addition to hedging the relevant currency variations through futures contracts, this study includes

another feasible and realistic strategy, the use of diversified channels for importing homogeneous products from multiple countries.

A group of countries such as Spain, Taiwan, Korea, Israel and others are recently considering or have started the introduction of financial futures markets, like index futures and foreign currency futures, to allow hedging. The problem of managing the risk outside home country is important to many countries, especially when the foreign trade sector is a significant component of the country's economy (e.g., Dornbusch: 1987). Given the importance of stabilizing the fluctuation in exchange rates, most of previous hedging literature have examined the positive role of hedging to the real decision, either imports or exports, under currency uncertainty. The major focus of the literature is to figure out the degree of risk reduction and the degree of appropriate use of hedging tool(s) (i.e., optimal hedge ratio). Examining the separation property between real and hedging decisions is critical since it deals with the degree of risk reduction in the firm's profit by participating in an appropriate hedging device, which in turn affects the real decisions.

Neglecting the basis risk, the complete separation will be in general achieved if there exists direct hedging tool(s) for the corresponding risk exposed (See Kawai and Zilcha: 1986 for the full double hedging theorem), even in the multi-period framework (Donoso: 1995). Non-separation, on the other hand, will result with existence of basis risk (for instance, Paroush and Wolf: 1992), or with an indirect or cross hedging device (Broll et al.: 1995; Broll and Wahl: 1996). Regardless of the degree of separation, the real decisions are positively affected by the inclusion of the hedging tool(s) in a significant manner, as the risk level reduces, given the reasonable speculation values in the futures market(s).

The main issue of this article is on the interactions between two risk managing strategies, diversification and currency hedging, especially on the production or total import level. Existence of hedging tools would be beneficial for a decision-maker by transferring the associated risk directly to the market speculators, thereby affecting real decisions positively. None of the previous papers has, however, considered the possibility of engaging in hedging devices involving multiple export or import channels. Diversification is another way to reduce the total variance of the end-of-period profit by eliminating, at least parts of, unsystematic risk. It should be also considered as a realistic approach since there are many

instances when firms import one of their inputs that might be a homogeneous product or products within the same group, from multiple suppliers of different nationalities. However, there are no relevant hedging instruments for the product price variation except diversification. To cite a few examples, we may think of steel imports for auto industry, memory chips for computer industry, or coal imports for energy industry (Wolak and Kolstad: 1991). Note that engaging in cross-hedging, if available, could yield another problem of inaccurate estimation, or specifically a serious basis risk, if the commodity used for the hedging is not a very close-substitute (Eaker and Grant: 1987).

The findings of this article show that the introduction of currency hedging tool doesn't eliminate the firm's incentive to diversify, given the different role of two strategies in the total risk reduction. The separation of real and hedging decisions would not be achieved without direct hedging tool(s) for all exposed risk source(s) (e.g., Kerkvliet and Moffett: 1991). Non-separation is also the case of this article even under unbiased futures structure and without basis risk as long as real diversification is involved. Due to the interaction between two strategies, the resulting total imports of a firm (or an industry) can be substantially different, depending on the relevant exchange rates structure of the product suppliers. If the stochastic movements of suppliers' currencies are little (highly) correlated, then the total real effect by introducing financial hedging tools will be small (large). It has been shown that the availability of hedging does not necessarily induce a higher trade level than under the diversification strategy alone, unless the import purchase is made by a single currency (e.g., US dollars). These different outcomes occur since the hedging either increases or reduces the covariance effect (i.e., 'bowing' property or the convexity to the expected return axis) of portfolio variance in the efficient frontier.

Import prices are the only uncertainty¹ that a risk-averse international firm faces, but there are dual stochastic price sources, input price itself and exchange rate, in the model. Following Wolf, the sources are assumed to be independent with each other in the multiplicative form. Thus the model doesn't consider any potential price discrimination of suppliers through exchange rate movements (e.g., 'pricing-to-market', Krugman: 1986). In other words, this paper is limited to the context of homogeneous input imports, and thus a single output, to focus on the combined effects of diversification of imports and the currency

hedging. Import diversification is our case, but the findings of this article should be applicable to an exporting firm, since the importer's decision problem is basically the same as the exporter's once the agent's profits have been redefined in the marketing firm's model.

The findings of this article are briefly summarized in section IV, the concluding remarks. Section II introduces the basic theoretical model of this article, and draws several implications, denoted as R1 to R5, on the decisions of the import diversification and hedging levels from optimal conditions. Most of these observations are quite different from those of Wolf's as well as other papers dealing with the case of non-diversification. The observations also indicate that a caution must be given in analyzing the interactive effects due to 'diversification and the use of currency futures markets' to a firm within the framework of the optimal portfolio of decisions. The next section (III) shows some generalized findings of this article by comparing the total import level of the firm under several possibilities (section III.1), and the effects of model parameters in imports and hedging ratio (section III.2). The underlying cause in section III.1 stems from the observations of section II, which show the possible conflict between the diversification effect (i.e., a lower variance of return due to correlation in importing prices) and currency hedging effect. Lastly, section III.2 is an analysis of comparative statistics for only two exporters to examine sensitivities of these decisions with respect to changes in model parameters. Doing so, the purpose of the section is to visualize the impact of changes in the closeness of stochastic price movements on diversification incentive of an agent and on the optimal hedge ratio.

II. DECISION MODEL

Suppose a risk-averse processing firm that produces and sells a certain product in the domestic market and imports one of its major inputs from abroad under price uncertainty. The firm's objective is to maximize its expected utility of profit denominated in domestic currency. Import prices are the only stochastic variables that the firm faces, but there are a couple of sources of uncertainty in each importing price, which is input price itself and the exchange rate. The dual sources are assumed to be independent with each other in a multiplicative form, following Wolf. If there exists a suppliers' monopolistic market power,

mainly due to product differentiation, then we may observe incomplete pass-through of exchange rates (Krugman) which obscures the independence assumption. As long as the market power is minimal to the importer, however, factors affecting changes in exchange rates are presumably different from factors affecting changes in the input price.

The firm has accesses to currency futures markets, but has no second hedging markets available for the commodity price to be imported. Instead, the firm has channels available for the import from several suppliers of that major or material input, in which inputs from these countries are assumed to be homogeneous. Diversification cost, such as agency cost, might not be totally negligible in reality, but it would be an issue outside the scope of this paper. Currency futures markets exist for all of the exporters' currencies, so the basic model structure in this theoretical section deals with the opportunity set of involving both strategies in a full level. This multiple hedging assumption will be released in section III.1 to deal with other possibilities for diversification. They include cases of using the single currency (e.g., US\$) for the input purchase, which is equivalent to the case of importing from suppliers in a single country. If only a single or a limited number of currency futures markets, then the cross-hedging can be also used to hedge against stochastic exchange rates of exporting prices, given transferability of some or even majority of systematic exchange rate risk among developed markets (Ziobrowski: 1995).

Each import price is denominated in the home (import) country's currency and is assumed to be expressed as $\tilde{w}_j = \tilde{g}_j \tilde{r}_j$, for the country j for any $j=1, \dots, n$. \tilde{g}_j indicates the realized input price and \tilde{r}_j is the real exchange rate between these two countries. Since this is a partial equilibrium model of a single importing commodity, the stochastic process of any exchange rate is assumed to be unrelated to that of any input price (\tilde{g}_j), for j from one through n , as noted earlier. In other words, \tilde{r}_i is expectation- and variance-independent of \tilde{g}_j , for all $i, j=1, \dots, n$. This specification of prices visualizes each source of uncertain price and makes it feasible to use currency futures markets to hedge against one of risky sources of these import prices.

The firm makes purchasing decisions of that input based on an one-period planning horizon perspective, such as an annual planning. Purchases can be made via either spot markets or forward contracts that do not fix the price in advance, such as formula contracts,

depending on market characteristics. At the beginning of an one-period planning period, before the price is realized, demand and hedging decisions must be made simultaneously in order to acquire the uncertain terminal wealth at the end of the horizon, provided that the firm does not engage in the trade business of ‘purchase and resale’ of the products. The firm is a price taker in input markets in the probability sense. In other words, the firm is not large enough to affect its subjective probability distribution in those prices. Since the model is restricted only to the case of input uncertainty to focus on the diversification decisions as well as hedging effects, we are basically assuming that the firm has a prior knowledge on its output market structure, including technological relations and the degree of output market power, with certainty.

The agent’s attitude towards risk can be described by a twice-differentiable Von Neumann-Morgenstern utility function $U(\pi)$ where $U' > 0$, $U'' < 0$. It is assumed that the agent or producer has a negative exponential utility function, expressed as $EU(\pi) = -e^{-\lambda\pi}$, where λ is a Arrow-Pratt coefficient of absolute risk aversion, defined as $-U''/U'$. This utility function, as a result, imposes the constant absolute risk aversion over all feasible range of wealth. Furthermore, the specification of mean-variance is used to investigate this optimality analysis for risky pricing situations in the presence of the opportunity of import diversification. The mean-variance model, as is well known, is consistent with the model of expected utility, when utility is quadratic, wealth is normally distributed, and/or choices involve a single random variable or linear combinations of random variables (Meyer: 1987).

Given these assumptions, the terminal wealth, or the cash flow, at the end of each period, without time subscriptions, is expressed as

$$(1) \quad \begin{aligned} \tilde{\pi} &= NR(X; Z) - \sum \tilde{w}_j x_j + \sum (\tilde{r}_{f(j)} - r_{f(j)}) c_j \\ &= NR(X; Z) - \sum \tilde{g}_j \tilde{r}_j x_j + \sum (\tilde{r}_j - r_{f(j)}) c_j. \end{aligned}$$

NR is the short-run revenue of output sales net of production costs, and is the function of the total import level (X) given Z, where X is the total import levels, as the sum of each import of homogeneous products. Z is a vector of non-risky and long-run inputs and x_j is the import of

the stochastic input from the j -th country, for $j=1, \dots, n$. It is also assumed that $NR' > 0$, $NR'' < 0$ with respect to X , given a positive but declining marginal productivity.

The corresponding revenue from manipulations in currency futures contracts will be $\sum (\tilde{r}_{f(j)} - r_{f(j)}) \cdot c_j$, where $r_{f(j)}$ and $\tilde{r}_{f(j)}$ are the current and the end-of-period rate, respectively, for a unit currency futures contract and c_j is the quantity contracted. Since basis risk, which is the difference between \tilde{r}_f and \bar{r} , is insignificant in financial futures, it is not considered in this paper and $\tilde{r}_{f(j)}$ is replaced by \bar{r}_j (e.g., Eaker and Grant). Under the certainty of return, a diversification scheme is economically feasible only if outputs/inputs are non-homogeneous and their mixture yields a higher return or utility (assuming a homothetic function of return), based upon the production and demand structure of, for example, the case of economics of scope or the third price discrimination over distinguished markets.

Under these set-ups, we obtain optimal input and hedging decisions by solving the following problem of maximizing the expected utility (V) of the firm, with respect to the mixture of suppliers and hedging levels, x_i 's and c_i 's for any i of one through n , where

$$V \equiv E_{w_i, s} (U(\pi)) \equiv \bar{\pi} - \lambda / 2 \cdot \text{var } \pi,$$

subject to the quantity constraints of (a) $X = \sum x_i$, and (b) $x_i \geq 0$, for all $i=1, \dots, n$. The agent, or a marketing firm, who handles the whole process from production to sales of the output, should solve the corresponding first order conditions simultaneously to get the optimal choices, x_1, \dots, x_n , and thus X , the total import level, as well as c_i 's at a given decision time.

Notations for the equations in this section are defined as follows:

the notation ' E ' denotes the agent's subjective expectation operator,

λ measures Arrow-Pratt absolute risk aversion,

the notation ' $'$ ' is the transpose of a vector or a matrix,

\mathbf{x}^* is $n \times 1$ vector of optimal quantities of each supplier,

$\mathbf{MNR}(X;Z)$ is $n \times 1$ column vector of marginal net revenues, whose elements are the same for all x_i 's since all imports are perceived to be homogeneous,

$\bar{\mathbf{w}}$, or $\bar{\mathbf{r}}' \cdot \bar{\mathbf{g}}$, is $n \times 1$ column vector of expected importing prices,

$\bar{\mathbf{r}}$ and \mathbf{r}_f are $n \times 1$ column vectors of the expected exchange rates and current futures rates

respectively,

\bar{g}_I and \bar{r}_I are nxn diagonal matrices of expected export prices and expected currency rates respectively, where non-diagonal elements of the matrices are zeros,

\bar{m} is nx1 expected margin defined as $\text{MNR}(X;Z) - \bar{w}$,

Σ_{ww} is nxn variance-covariance matrix of importing prices, and

Σ_{rr} and Σ_{gg} are variance-covariance matrices of exchange rates and export(input) prices respectively.

The variance of the end of period wealth can be expressed as

$$(2) \quad \text{var}\pi = \mathbf{x}' \Sigma_{ww} \mathbf{x} + \mathbf{c}' \Sigma_{rr} \mathbf{c} - 2\mathbf{c}' \Sigma_{wr} \mathbf{x} \\ = \mathbf{x}' (\bar{g}_I \Sigma_{rr} \bar{g}_I + \bar{r}_I \Sigma_{gg} \bar{r}_I + \Sigma_{rr} \Sigma_{gg}) \mathbf{x} + \mathbf{c}' \Sigma_{rr} \mathbf{c} - 2\mathbf{c}' \Sigma_{rr} \bar{g}_I \mathbf{x}$$

Note that Σ_{ww} is factored into covariance matrices of \mathbf{r} and \mathbf{g} , the two stochastic components of \mathbf{w} , as $\bar{g}_I \Sigma_{rr} \bar{g}_I + \bar{r}_I \Sigma_{gg} \bar{r}_I + \Sigma_{rr} \Sigma_{gg}$. Based on the work by Bohenstedt and Goldberger (1969), this derivation was possible due to the assumption that any r_i , the exchange rate component of the import price, is expectation- and variance- independent of any g_j , the country j -specific input price of w_j . Furthermore, the assumption of multivariate normality of r_i , r_j , and g_k , for any i, j , or k for 1 through n will lead to the exact covariance matrix² of $\mathbf{c}' \Sigma_{wr} \mathbf{x}$ as $\mathbf{c}' \Sigma_{rr} \bar{g}_I \mathbf{x}$.

Combining first order conditions associated with optimal input decisions and hedging decisions will result in the following optimality conditions, in vector-matrices forms,

$$(3) \quad \text{MNR}(X^*; Z)' - \bar{w}' + (\bar{r} - \mathbf{r}_I)' \bar{g}_I - \lambda \cdot [\mathbf{x}' \Sigma_{ww} - \mathbf{x}' \bar{g}_I \Sigma_{rr} \bar{g}_I] = \mathbf{0}' ,$$

assuming the non-negative constraints are satisfied. This implies that, if optimal x_i^* for any i turns out to be negative in an empirical exercise, by the complementary slackness condition, the x_i^* is zero as the shadow price of the constraint becomes a positive value. The term $\mathbf{x}' [\Sigma_{ww} - \bar{g}_I \Sigma_{rr} \bar{g}_I] \mathbf{x}$ in equation (3) stands for the portfolio variance. Further, the second order conditions are easily met if the utility function is concave (Ingersoll) and if the MV-

specification ensures the concavity. Optimal currency hedging levels and quantities of imports can be expressed as

$$(4) \quad \mathbf{c}^* = \Sigma_{rr}^{-1} \cdot \frac{(\bar{\mathbf{r}} - \mathbf{r}_f)}{\lambda} + \bar{\mathbf{g}}_I \cdot \mathbf{x}^* = \frac{1}{\lambda} [\Sigma_{rr}^{-1} + (\Sigma_{rr} \Sigma_{zz} + \bar{\mathbf{r}}_I \Sigma_{zz} \bar{\mathbf{r}}_I)^{-1} \bar{\mathbf{g}}_I] \cdot (\bar{\mathbf{r}} - \mathbf{r}_f) \\ + \frac{1}{\lambda} \bar{\mathbf{g}}_I [\Sigma_{rr} \Sigma_{zz} + \bar{\mathbf{r}}_I \Sigma_{zz} \bar{\mathbf{r}}_I]^{-1} \cdot \bar{\mathbf{m}}(X^*; Z, \bar{\mathbf{w}})$$

$$(5) \quad \mathbf{x}^* = \frac{1}{\lambda} [\Sigma_{rr} \Sigma_{zz} + \bar{\mathbf{r}}_I \Sigma_{zz} \bar{\mathbf{r}}_I]^{-1} \cdot [\bar{\mathbf{m}} + \bar{\mathbf{g}}_I \cdot (\bar{\mathbf{r}} - \mathbf{r}_f)] .$$

The close observations on these equations yield the following five results of R1 to R5 of the effects on the mixture of input suppliers by the inclusion of futures markets as additional hedging tools, and also about the hedging levels:

- R1. If input prices are perceived to be non-stochastic, the remaining uncertainty source which is the exchange rate risk can be completely hedged away by engaging in futures contracts.
- R2. Given the availability of diversification, ‘non-separation’ holds even under unbiased rates and without basis risk.
- R3. The optimal currency hedging removes total variability of the import prices that the firm faces by the amount of $\bar{g}_k \bar{g}_i \text{cov}(r_k, r_i)$, for any k and i , in each element of the variance-covariance matrix of import prices.
- R4. Unlike the case of Wolf, the non-diversification scheme with a single currency futures market, an upward (downward) bias in a currency does not necessarily lead to a higher (lower) hedging level of that currency.
- R5. Despite the ambiguity on speculation levels, diversification strategy does not change the relationship of the minimum-variance hedge ratio, the long position, in each market as long as exchanges rates are independent of input prices.

For result 1, if input prices(\tilde{g}) are fixed at the decision time, the term Σ_{ww} will disappear in the portfolio variance in equation (3) via engaging in optimal currency hedging. From the optimal condition, in this case, the agent has no incentive to diversify away unless products are non-homogeneous. Since the exchange rate uncertainty is directly hedged through the currency futures, the optimal X^* is equal to a certain x_i^* that yields the highest return of $MNR(x_i^*) - r_{f(i)}\bar{g}_i$ among the products available, regardless of the speculation level. However, as long as the input prices are perceived to be stochastic to the decision-maker, it is rational to involve in the diversification strategy in the real side, and most of the shares should not be zero in reality, unless some prices are significantly above the market price (Wolak and Kostad).

The examination of non-separation between hedging and import or production decisions (result 2) ensures the validity of involving diversification; i.e., if the separation is feasible, the agent will choose the x_i in a way mentioned above. In his 1995 paper, Wolf shows that, in the presence of multiplicative forms of two or more variables, the separation property does not hold and these two decisions are not independent to each other. The implicit optimal solutions in equations (4) and (5) clearly display this result, even under the most simplified model assumption of the unbiased futures rates without basis risk. This in turn implies that the interactive effects due to diversification and the use of currency futures markets to a firm should be examined in caution within the framework of the optimal portfolio decisions of a firm.

Most importantly, result 3 exhibits the underlying cause of changes in the mixture of suppliers (\mathbf{x}) by engaging in futures contracts. This indicates the reduction of own-variance of prices by $\bar{g}_i^2 \sigma_{r(i)}^2$ and the covariance term by $\bar{g}_k \bar{g}_i \text{cov}(r_k, r_i)$ for any $i \neq k$, but the direction of changes in the covariance terms is ambiguous if some off-diagonal elements of the matrix happen to be negative. This in turn draws an ambiguity in the changes in the portfolio variance, $\mathbf{x}'[\Sigma_{ww} - \bar{g}_f \Sigma_{rr} \bar{g}_f] \mathbf{x}$. The next subsection (III.1) focuses on the real effect of the total import level (X^*), and the following R4 and R5 summarize the relevant issues in terms of optimal hedging levels or ratios. The right-hand-side of equation (4) is the sum of the speculative term and the minimum variance hedging level. The diversification effect is

directly reflected in the speculative part and indirectly reflected in the set of hedging levels (c^*) through x^* .

III. INTERPRETATIONS

III.1. Diversification and Hedging Effects

To examine the effects of diversification and introduction of currency futures markets on the level of total import or production, three propositions are shown in this subsection, and some comments about the implications on these findings are presented at the end of this subsection.

Proposition 1. Let X^d and X^* be the total import level under diversification only and under the basic model of the previous section respectively. If all off-diagonal elements of Σ_π are positive, then $X^d < X^*$, unless the firm faces an extreme contango in current futures rates. But the relationship does not necessarily hold if some³ exchange rates exhibit negative correlation, even under the unbiasedness of currency futures.

proof. Appendix 1.1

Proposition 2. If all input purchases are made in a single currency (e.g., US \$), then the total import level (say X^s) is always higher than X^d , unless the firm faces an extreme contango in futures rates.

proof. Appendix 1.2

Proposition 3. Let the currency futures markets to be unbiased and X^c to be the total imports under a single (cross) currency hedging scheme with diversification. Under positive correlation of exchange rates with the currency used for the cross hedging, and of input prices, we have the following relationships that (a) $X^d < X^c < X^*$, and also (b) $x_i^* < x_i^c$, where x_i^c is the imports from supplier i and its currency used for the cross hedging.

proof. Appendix 1.3

Previous studies (e.g., Broll: 1996; Wolf: 1995) draw a common implication that production of a competitive firm increases with an introduction of unbiased futures market(s) which directly eliminates the associated risk in the return to some degree. Propositions 1 and 3, however, show that the statement is not necessarily guaranteed for a firm of our model, if some of the currencies are negatively correlated. That is because of the compensation of advantages of participating currency futures, which is the removal of the terms of exchange rate variance, $\bar{g}_1 \sum_r \bar{g}_1$, over the reduction of benefits from the optimal (or Markowitz) portfolio (e.g., a lower variance of profit contributed by imperfect correlation in prices).

The above in turn implies that the total import effect of introducing currency futures contracts depends on how the relevant exchange rates are correlated. In other words, if exchange rates are negatively (positively) correlated, then the introduction of currency futures contracts reduces (increases) the 'bowing' property or convexity to expected return axis of portfolio variance by removing the negative (positive) correlation terms. As a consequence, the effect of introducing currency futures is not as apparent as in the case of non-diversification in increasing the total import, thus production, level. We should note that the degree of exchange rate correlation indicates the degree of transferability of the systematic risk among the relative currencies. Our findings thus imply the potential deviation in real effects among firms or industries, depending on the group of associated trading partners, via the introduction of currency futures; i.e., the total imports can be significantly increased ($X^* \gg X^d$) or be even smaller ($X^* < X^d$) in an extreme.

In a rough manner, this can be illustrated graphically in the efficient frontier as shown in Graph 1 of Appendix 2. The utility level increases in any case by the inclusion of direct hedging tools, exchange rate futures, as the opportunity set increases or moves leftward. But, the frontier, denoted as F^* in the graph, can be either less or more bowed than the frontier under diversification alone (F_d). As a result of the 'less (more) convexity', we may end up with a lower (significantly higher) total import level.

If only a single currency is what matters to the importer, then the introduction of currency futures market will result in a higher production level than X^d , which is the import

(production) under the diversification scheme alone, according to Proposition 2. It is a realistic possibility in many commodities, considering the increased currency power of US dollars in the international trade. It also refers to the case of importing from several suppliers from a single country. We cannot generally draw the conclusion as to which total import level is greater between the cases of proposition 1 and 2 without more information.

Proposition 3 further shows that the optimal total import level will be also increased than that under diversification strategy alone by making an appropriate cross hedging of a single or a limited number of currency futures when its (their) currency rate(s) is positively related to other exporting countries'. Previous studies have introduced cross-hedging or imperfect hedging as means to reduce parts of the risk that firms face in absence of a direct hedging tool to reduce the source of risk (Eaker and Grant; Broll and Wahl on indirect hedging; and Bowden (1995) on a natural hedging). In these articles, the level of the corresponding trade decisions are determined to be somewhere between the levels under non-use of hedging and under direct hedging given a non-extreme speculation value. This is also true in this paper under the above restriction of exchange rate structure. The resulting import level of Proposition 3 is less than X^* , which is from the basic model of using both strategies due to its largest opportunity set.

But another finding of this study is that the import from the supplier i is greater than that under X^* case, if currency i is used for the single cross hedging. Ex ante utility is of course higher under multiple-portfolio hedging, but a cross hedging using single or a limited number of currencies could be more beneficial to the financial manager of the importing firm in special cases. It is more simple to use under complicated restrictions, for instance, if a greater amount of total imports from a specific supplier is implicitly preferred over the total quantity, or if the manager is subject to various trading restrictions such as short-selling constraints of futures trading or less-than unitary ratio of hedging contracts (Glen and Jorion: 1993). It can also be more economical in terms of low transaction costs, or if the estimates of the expectation on the import price are not quite dependable, given the transferability of a major portion of systematic exchange rate risk among developed countries (Ziobrowski: 1995).

III.2. Comparative Statistics

Finding out generalized parameter effects on the decision variables may be impossible within the portfolio framework without a prior knowledge on the realized variables. To get an insightful idea in a simple way, however, a comparative statistics analysis is performed for the case of only two exporting countries, as shown in Table 1, with positively correlated input prices ($\sigma_{g(1,2)}$) for some cases, which is a reasonable assumption for any commodity. Also, unbiased futures prices are postulated throughout the comparative statistics analysis to concentrate on diversification and production decisions under non-extreme values of exchange rates. In this model, if the marginal net revenue is constant over all ranges of total input demanded (X), then X^* will increase considerably since the diversification provides not only a reduction in the volatility of return but also an increase in the expected return over a certain range⁴ of x vector. The plausible and realistic economic assumption, however, will be a diminishing marginal net revenue, as we assumed, mainly due to a diminishing return to scale of production. Unlike the case of constant MNR, optimal shares will not be independent of the total import level X^* since the expected marginal return in equation (5) varies with the level of X^* chosen.

As expected, an increase in the i -th expected import price (via either \bar{r}_i or \bar{g}_i) or decrease in the expected margin results in a decrease in their own import levels (x_i). However, there is a positive effect in cross imports (x_j , for $j \neq i$), given the perfect substitutability of products. The individual real effects are also clear with respect to changes in $\sigma_{r(i)}^2$ and $\sigma_{g(i)}^2$; i.e., increases in variability of import prices will certainly cause a lower own import (x_i^*) and a higher cross import (x_j^*). On the other hand, the total production effect (X^*) as a sum of x_1^* and x_2^* is in general ambiguous. For instance, X^* due to changes in $\sigma_{g(i)}^2$ will decrease if $\sigma_{r(12)} > 0$, and the values of model parameters are in a reasonable range; i.e., $|\Psi_{ii}| > |\Psi_{ij}|$ for $i \neq j$ and $i, j=1, 2$. Ψ_{ij} is the partial derivative of the first-order-condition of x_i with respect to x_j , and the second-order conditions require a negative Ψ_{ii} for $i, j=1, 2$, and $\Psi_{11}\Psi_{22} - \Psi_{21}\Psi_{12} > 0$. If however $\sigma_{r(12)}$ is negative, the direction of changes in X^* becomes ambiguous, as

$$\text{sign}(\partial X^* / \partial \sigma_{g(i)}^2) = \text{sign}((\Psi_{jj} - \Psi_{ji})(\sigma_{r(i)}^2 + \bar{r}_i^2) + (\Psi_{ii} - \Psi_{ij})\sigma_{r(j)}).$$

This ambiguity in the total effect is due to the role of diversification in reducing the total variance ($\text{var}(\pi)$) of profit. For a negative $\sigma_{r(12)}$, the diversification effect is relatively

Table 1. Comparative statistics of import decisions^{1,2}

Variable \ parameter	\bar{w}_1	\bar{w}_2	$\sigma_{g(1)}^2$	$\sigma_{g(2)}^2$	$\sigma_{g(1,2)}$	$\sigma_{r(1)}^2$	$\sigma_{r(2)}^2$	$\sigma_{r(1,2)}$	λ
Import from supplier 1 (x_1)	-	+	-	+	?	-	+	?	-
Import from supplier 2 (x_2)	+	-	+	-	?	+	-	?	-
Total imports ³ (X)	-	-	a	a	a	b	b	c	-

1. Under the assumption of unbiased futures price in exchange rate, the sign of changes in hedging levels (c_i 's), for $i=1, \dots, n$, is simply determined by the sign ($\partial x_i / \partial p$) where p is any model parameter.
2. For a, b, c, the results are ambiguous generally because of the trade off between expected income effect in (higher) $E\pi$ and diversification in (lower) $\text{var}(\pi)$.
3. a: If $\sigma_{r(ij)} > 0$, and $|\Psi_{ii}| > |\Psi_{ij}|$ for $i \neq j$ and $i, j=1, 2$, then X^* decreases, otherwise ambiguous.
b: As $\sigma_{r(i)}^2$ increases, X^* decreases if $|\Psi_{ii}| > |\Psi_{ij}|$ for $i=1, 2$ where $i \neq j$.
c: X^* decreases if $\sigma_{r(ij)} > 0$, and $|\Psi_{ii}| > |\Psi_{ij}|$ for $i \neq j$ and $i, j=1, 2$.

If $\sigma_{r(ij)} < 0$, and $|\Psi_{ii}| > |\Psi_{ij}|$ for $i \neq j$ and $i, j=1, 2$, then X^* decreases as $|\sigma_{r(12)}|$ increases.

large, and thus an increase in $\sigma_{g(i)}^2$ may result in a lower $\text{var}(\pi)$ and a higher total import level at the expense of a lower expected margin. If the covariance ($\sigma_{g(12)}, \sigma_{r(12)}$) are positive, then the changes in x_i 's with respect to $\sigma_{g(i)}^2$ becomes less sensitive to the diversification effect. This generally induces a higher $\text{var}(\pi)$ than the case of negative covariance, and the increased uncertainty induces a lower total production. Similar results of own and cross effects apply to the case of an increase in $\sigma_{r(i)}^2$, $i=1, 2$, such as, assuming a positive $\sigma_{g(12)}$, the negative effect on own imports, but positive effect in cross imports. The total effect in this case is still ambiguous, but is likely to be negative if $|\Psi_{ii}| > |\Psi_{ij}|$ regardless of the sign of $\sigma_{r(12)}$, given the reduced structure of $\text{var}(\pi)$ through the currency hedging.

In terms of an increase in covariance terms ($\sigma_{g(12)}, \sigma_{r(12)}$), the intuition is clear despite ambiguity in signs of changes in x_1^* and x_2^* , as the closer the stochastic movement in import prices, the less incentive the firm to diversify importing channels and thus a lower total import. In the reasonable range of parameter values (i.e., $|\Psi_{ii}| > |\Psi_{ij}|$ for $i \neq j$ and

$i, j=1, 2$), if both $(\sigma_{r(12)})$ and $\sigma_{g(12)}$ are positive values, then the total import X^* will decrease, as the benefit of the diversification decreases due to an increase in the total $\text{var}(\pi)$. The sign of $\partial X^*/\partial \sigma_{g(12)}$ becomes ambiguous, but the change is less sensitive than the case of positive $\sigma_{r(12)}$ under the same condition. Also, $\partial X^*/\partial |\sigma_{r(12)}|$ is strictly positive for the absolute value of $\sigma_{r(12)}$ when $\sigma_{r(12)}$ is negative in the given condition. Total imports of the input will again decrease in general as import prices become more positively correlated with each other.

Unbiased futures rates are one of the underlying assumptions of this comparative statistics, and thus the analysis is limited to the minimum-variance hedge ratio as mentioned in the note 1 below the table. One meaningful examination under biased futures markets would be the changes in optimal hedge ratio with respect to the increase in price correlation, possibly due to an increase in tacit collusion or informational efficiency. Assuming that the sign of $\partial x_i/\partial \sigma_{g(1,2)}$ is negative at the optimum; i.e., the individual import level decreases as import prices become more correlated, the optimal hedge ratio in each currency futures market will diverge from the minimum-variance hedge ratio, as input prices become more positively correlated ($+\sigma_{g(1,2)}$). The divergence occurs regardless of the direction of subjective expectations in speculative terms. No such divergence would occur, of course, if the firm's expectation is unbiased. For a country $i=1, 2$, the change in hedge ratio with respect to changes in $\sigma_{g(1,2)}$ can be directly obtained from equation (4), as

$$(6) \quad \partial c_i / x_i / \partial \sigma_{g(1,2)} = (\bar{g}_i x_i - c_i) \cdot \frac{1}{x_i^2} \cdot \frac{\partial x_i}{\partial \sigma_{g(1,2)}} .$$

If a under hedge (i.e., a short futures position or a partial long hedge) is optimal (i.e., $\bar{g}_i x_i - c_i > 0$), then the hedge ratio in the market i will decrease as the correlation in input prices increases, as can be seen from the equation. If on the other hand an over hedge (long speculation) turns out to be optimal in market i , the hedge ratio will increase with an increase in the correlation. This case is illustrated in Graph 2 of Appendix 2.

The economic reasoning for these changes in hedge ratios is as follows. Since a decrease in x_i for all i is due to the decrease in benefits of diversification effect (a lower systematic risk of returns), the expected return effect become relatively more significant to the firm as the positive $\sigma_{g(1,2)}$ increases. This increased sensitivity to the expected return

induces a higher weight on the speculation revenue from the manipulation of futures contracts. Such a result of divergence, however, is a limited case because of an ambiguity in changes in individual imports as $\sigma_{g(12)}$ changes. The change in hedge ratio in each market i become rather ambiguous in general, especially if the correlation in exchange rates is negative, or the value of $\sigma_{r(12)}$ varies with $\sigma_{g(12)}$. In sum, the bottom line in the analysis of currency hedging, under the biased futures market structure, is the divergence of hedge ratio in a market i from the minimum-variance hedge ratio ($c_i/x_i = E(g_i)$) if x_i decreases as a result of an increase in the closeness of stochastic movements in input prices, in which the firm relies on diversification as a means to reduce the risk.

IV. CONCLUDING REMARKS

Firms involved in international trade are subject to fluctuations in exchange rates as well as price uncertainty itself. This study, under import price uncertainty, extends the analysis of previous hedging literature by including another feasible scheme, the diversification of importing channels of homogeneous products to multiple suppliers. The dual sources of uncertainties, input price itself and exchange rate, in import prices take multiplicative form and the firm is able to use currency futures contracts for all relevant currencies in our basic model. Close observations on the optimal conditions give us several results on the use of currency hedging in diversified strategies. The results related to real decisions (R1, R2, R3) provide the justification for the use of both strategies given their different roles in portfolio risk reduction. The hedging decisions (R4, R5) on the other hand are related to the real portfolio in the speculation, but not in the pure hedging, part.

In section III.1, it is shown that the effect of introducing unbiased currency futures markets to all relevant exporters' exchange rates (or to a limited number of currencies for a cross-hedging) depends on the degree that the relevant exchange rates are correlated. If they are all positively correlated (or if exchange rates are positively correlated with the currencies used for the case of cross hedging), then the resulting total import will be significantly increased. Otherwise, the changes in imports and thus production will become less significant, and may be even decreased in an extreme. Due to changes in the 'covariance effect' of portfolio variance, the implication is that there is an apparent positive

effect on real decision in the introduction of currency hedging tools for a firm or an industry involving trade with developed economic communities, such as in Western countries, where exchange rates are co-integrated in a high degree. The real effects, however, becomes less apparent for the industry when it involves trade with less developed financial markets, whose currency fluctuations are less affected by the market-wide systematic risk.

This article investigates mainly the effects of introducing currency hedging to a firm which diversifies imports of its material (or major) inputs into multiple suppliers under the import price uncertainty. The market power of suppliers is not considered, and this article deals only with the competitive and risk-averse importing agent. If market power is present because of a collusive behavior of suppliers, then we expect increased input prices, and thus lower total imports. We also expect an increased closeness of the stochastic movements in input prices, since the sources of fluctuations are likely to be economic-wide shocks under collusion. Thus, the findings of this paper indicates that (a) the benefits of risk reduction due to diversification will be reduced, (b) the role of currency hedging will become in general more significant in risk reduction, and (c) the optimal hedge ratio on currency futures markets tends to diverge from the minimum-variance hedge ratio under biased rates. On the other hand, if the existence of suppliers' power in an import market is due to heterogeneity of inputs, then the degree of exchange rate pass-through matters in the analysis; i.e., exchange rates and input prices are not independent with each other. In this incidence, we expect a less closeness of import price fluctuations and, roughly, the reversed results of the above case. The results, however, also depend on many other industry- or firm-specific factors such as output market structure of an importing firm.

REFERENCES

- Basak, Suleyman, 1996, An Intertemporal Model of International Capital Market Segmentation, Jr. *Financial and Quantitative Analysis*, 31: 2: 161-187.
- Blair, Roger D., 1974, Random Input Prices and the Theory of the Firm, *Economic Inquiry*, 214-225.
- Bohenstedt, G. W., and Goldberger, A. S., 1969, On the Exact Covariance of Products of Random Variables, Jr. *American Statistical Association*, 64: 1439-1442.

- Bowen, Roger J., 1995, Production Organization and Risk Control When Market Instruments Are Available, *Management Science*, 41: 6: 1073-1082.
- Broll, Udo and Wahl, Jack E., 1996, Imperfect Hedging and Export Production, *Southern Economic Journal*, 62: 667-674.
- Broll, Udo, Wahl, Jack E., and Zilcha, Itzhak, 1995, Indirect Hedging of Exchange Rate Risk, *Jr. International Money and Finance*, Oct.: 667-678.
- Donoso, Guillermo, 1995, Exporting and Hedging Decisions With a Forward Currency Market: The Multi-period Case, *Jr. Futures Markets*, 15: 1: 1-11.
- Dornbusch, R., 1987, Exchange Rates and Prices, *American Economic Review*, 77: 93-106
- Eaker, Mark R., and Grant, Dwight M., 1987, Cross-Hedging Foreign Currency Risk, *Jr. International Money and Finance*, March: 85-105.
- Glen, Jack and Jorion, Philippe, 1993, Currency Hedging for International Portfolios, *Jr. Finance*, Dec.: 1865-1886.
- Ingersoll, Jonathan E., 1987, Theory of Financial Decision Making, Rowman and Littlefield Inc., Savage, MD.
- Kawai, Masachiro and Zilcha, Itzhak, 1986, International Trade with Forward-Futures Markets Under Exchange Rate and Price Uncertainty, *Jr. International Economics*, Feb.: 83-98.
- Kerkvliet, Joe and Moffett, Michael H., 1991, The Hedging of an Uncertain Future Foreign Currency Cash Flow, *Jr. Financial and Quantitative Analysis*, 26: 4: 565-578.
- Krugman, Paul, 1986, Pricing to Market When Exchange Rate Changes, in S. W. Arndt and J. D. Richardson (eds.), Real-Financial Linkages Among Open Economics, 1987, The MIT Press, Cambridge, MA.
- Meyer, J., 1987, Two-Moment Decision Models and Expected Utility Maximization," *American Economic Review*, 77: 421-430.
- Paroush, J. and Wolf, Avner, 1992, The Derived Demand with Hedging Cost Uncertainty in Futures Markets, *The Economic Journal*, 102: 831-844.
- Scherer, F. M. and Ross, David, 1991, Industrial Market Structure and Economic Performance, 3rd ed., Houghton Mifflin Company, Boston, MA.

- Sheldon, Ian, 1995, Contracting, Imperfect Information and the Food System, Paper presented at conference on "Public Policy in Foreign and Domestic Market Development," organized by the Food and Agricultural Marketing Consortium, Jan.12-13, Orlando, FL.
- Wolak, F. A. and Kolstad C. D., 1991, A Model of Homogeneous Input Demand Under Price Uncertainty, *American Economic Review*, 81: 3: 514-38.
- Wolf, Avner, 1995, Import and Hedging Uncertainty in International Trade, *Jr. Futures Markets*, 15: 2: 101-110.
- Zilcha, Itzhak and Broll, Udo, 1992, Optimal Hedge by Firms with Multiple Sources of Risky Revenues, *Economics Letters*, Aug.: 473-77.
- Ziobrowski, B. J. and Ziobrowski Alan, 1995, Exchange Rate Risk and Internationally Diversified Portfolios, *Jr. International Money and Finance*, 14: 1: 65-81.

FOOTNOTES

1. For the paper dealing with output price uncertainty, with known input prices and production process, the implicit justification for (only) output price uncertainty is on the existence of time-lag between production decision and actual production and sales of output. On the other hand, for a rationale of the case of stochastic input price, one might first imagine a firm taking orders for future delivery of its product at a fixed price. Once committed to producing the specific output quantities, actual input prices, especially material input costs, are not known in advance until the inputs are purchased. Most competitive bidding contracts generally fall into this class of problem (Blair: 1974).

Another case is that, in developing contracts, importers/exporters want to stabilize the import quantity levels, but one of them or both parties have no incentive to lock in the price. Formula contracts, or any quantity-fixing forward contracts, for instance, in crude oil trade or food processing industries, are examples for this case, which allows a room for different price expectations. The problem of imperfect information, due to the moral hazard and the adverse selection the principle faces, provides the reasoning for this type of contracts. For instance, Sheldon(1995)'s paper examines that, while contracts between farmers and food processors can offer agents some degree of insurance from risk, full insurance cannot be offered because of the need to provide incentive at the margin for agents to exert efforts.

2. To show derivations of the first and the third terms of the right-hand-side of equation (2),

a) let x , y , and z be jointly distributed random variables and $\Delta i = i - E_i$ for $i = x, y, z$. In terms of the $n \times n$ covariance matrix Σ_{wr} , $\text{cov}(xy, z) = E_x \cdot \text{cov}(y, z) + E_y \cdot \text{cov}(x, z) + E(\Delta x)(\Delta y)(\Delta z)$, which implies that, for any i and j , $\text{cov}(w_i, r_j) = \text{cov}(g_i r_i, r_j) = E g_i \text{cov}(r_i, r_j) + E r_i \text{cov}(g_i, r_j) + E(\Delta g_i \Delta r_i \Delta r_j)$. $\text{Cov}(g_i, r_j)$ is equal to zero by the model assumption and, if g_i, r_i , and r_j for any i, j , are distributed as the multivariate normal, the third expectation term vanishes into zero. This result can be summarized in the form of matrix as $\Sigma_{wr} = \Sigma_{\pi} E(g_i)$.

b) Σ_{ww} can be factored into covariance matrices of r and g , based on the same assumptions. For any $\text{cov}(w_i, w_j) = \text{cov}(g_i r_i, g_j r_j)$, each term is approximated as $E g_i \text{cov}(r_i, w_j) + E r_i \text{cov}(g_i, w_j) + E(\Delta g_i \Delta g_j)(\Delta r_i \Delta r_j)$. $\text{Cov}(r_i, w_j)$ is reduced into the expression of $E g_j \text{cov}(r_i, r_j)$, and also $\text{cov}(g_i, w_j)$ into $E r_j \text{cov}(g_i, g_j)$. $E(\Delta g_i \Delta g_j)(\Delta r_i \Delta r_j)$ is equal to $\text{cov}(g_i, g_j) \text{cov}(r_i, r_j) + \text{cov}((\Delta g_i \Delta g_j), (\Delta r_i \Delta r_j))$ by the definition of a covariance, and, since the stochastic movement of any r is assumed to be independent of any g in this paper, the last term, $\text{cov}((\Delta g_i \Delta g_j), (\Delta r_i \Delta r_j))$, turns out to be zero, and thus we draw the above result in matrices. Or, note that exact covariance matrices of Σ_{ww} can be easily derived by the formula that, if x is expectation- and variance-independent of y , then $\text{var}(xy) = (E_x)^2 \text{var}_y + (E_y)^2 \text{var}_x + \text{var}_x \cdot \text{var}_y$. Applying the same step to the matrix operations, since r_i is independent of g_i , the same equation can be readily obtained (See Bohenstedt and Goldberger for a detail).

3. The word 'some' is mathematically unclear unless the functional form of $NR(X)$ and specific parameter values are known. However, the logic behind the term refers to the level that affects the expected utility of agent significantly due to loss in diversification benefits versus gain from manipulations in futures markets.

4. Without the consideration of futures markets, the range indicates that optimal solutions satisfy the following. Given a non-negative expected return from using only the least expected inexpensive imports, we obtain the following relationship $(X^d - X^n) = (\bar{w}' \cdot \mathbf{x}^* - \bar{w}_k X^n) / MNR$, where X^d and X^n denote the optimal total imports from diversification and non-diversification cases, respectively, as defined before, and \bar{w}_k is the lowest expected import price among n prices.

APPENDICES

1. Proofs of Propositions

1. proof of Proposition 1

(a) Let c_{ki} be the k -th row and i -th column element of the reduced form of variance-covariance matrix of the random profit in equation (5). Note that the initial variance is reduced by $\bar{g}_i \sum_r \bar{g}_i$ after being adjusted by optimal hedging positions in equation (4) for all relevant currency futures markets. The first order condition for an input x_i , after adjusted with optimal futures positions, is

$$(7) \quad \bar{m}_i(X^*) + \bar{g}_i \cdot (\bar{r}_i - r_{f(i)}) = \lambda \cdot \sum_{k=1}^n x_k^* c_{ki}$$

$$= \lambda \cdot \left[(\sigma_{w(i)}^2 - \sigma_{r(i)}^2 \bar{g}_i^2) x_i^* + \sum_{k \neq i} (\sigma_{w(k,i)} - \sigma_{r(k,i)} \bar{g}_k \bar{g}_i) x_k^* \right].$$

The expected margin (\bar{m}_i) is a function of the total import level X^* . If exchange rates, as well as input prices, are positively correlated, then any c_{ki} is less than its corresponding element of the matrix without the hedging tool by the amount of $\bar{g}_k \bar{g}_i \cdot \text{cov}(r_k, r_i)$.

For a positively biased or unbiased futures rate, let's assume $X^d = X^*$. Then, compared with the case without currency futures, the left-hand-side of equation (7) is higher (if backwardation) or the same (if unbiased), but the right-hand-side becomes lower due to a lower value of each c_{ki} , unless $\sum x_k^*$ in equation (7) increases enough to compensate the decrease in variance terms. This however contradicts the assumption of $X^d = X^*$. The similar analogy applies to the case if $X^d > X^*$, which also leads to the contradiction.

Therefore X^* should be greater than X^d , under a declining function of \bar{m}_i and positively correlated exchange rates, unless the firm faces highly downward biased futures structure.

On the other hand, if some of exchange rates in terms of the importing country's currency and/or input prices are negatively correlated, then we cannot draw any general result on the direction of changes of the right-hand-side of equation (7). This is because of an ambiguity of changes in $(\sigma_{w(k,i)} - \bar{g}_k \bar{g}_i \cdot \text{cov}(r_k, r_i))$ for all k, i , and thus $\sum (c_{ki} x_k^*)$, compared with that under the following equation (7'). The equation is the optimal condition for the diversification strategy alone with respect to x_i :

$$(7') \quad \bar{m}_i(X^d) = \lambda(\sigma_{w(i)}^2 x_i^d + \sum_{k=i}^{k=1, \dots, n} \sigma_{w(k,i)} x_k^d).$$

Therefore the change in X^* is also unclear, even under unbiased futures. That is basically because of the conflict between the diversification effect (the reduction in total variance of wealth significantly contributed by negatively correlated sources of import prices) and the currency hedging effect (a reduction of total variance by the amount of $\bar{g}_1 \sum_r \bar{g}_1$ given non-existence of basis risk). The optimal position thus will be determined based on specific values of model parameters on the current information set, such as time series components of prices, and the output market structure of production relationships and the firm's monopolistic market power in the industry. The following shows an example for a higher X^d than the level of X^* .

(b) Consider only 2 suppliers as an illustrative example. First, if the firm uses both strategies, then, from the conditions of optimal imports in equation (5), we can derive the following by subtracting the optimal conditions for x_2 from the condition for x_1 ,

$$(7.1) \quad \begin{aligned} \frac{1}{\lambda}(\bar{w}_2 - \bar{w}_1) &= x_1^*(\sigma_{w(1)}^2 - \sigma_{w(1,2)}) - x_2^*(\sigma_{w(2)}^2 - \sigma_{w(1,2)}) \\ &\quad - x_1^*(\sigma_{r(1)}^2 \bar{g}_1^2 - \sigma_{r(1,2)} \bar{g}_1 \bar{g}_2) + x_2^*(\sigma_{r(2)}^2 \bar{g}_2^2 - \sigma_{r(1,2)} \bar{g}_1 \bar{g}_2) \\ &\equiv x_1^* a - x_2^* b - x_1^* c + x_2^* d . \end{aligned}$$

Secondly, if the firm only involves in the diversification strategy, then,

$$(7.2) \quad \frac{1}{\lambda}(\bar{w}_2 - \bar{w}_1) = x_1^d a - x_2^d b ,$$

where $\sigma_{w(1)}^2 = \sigma_{r(1)}^2 \bar{g}_1^2 + \sigma_{g(1)}^2 \bar{r}_1^2 + \sigma_{r(1)}^2 \sigma_{g(1)}^2$, $\sigma_{w(1,2)} = \sigma_{r(1,2)} \bar{g}_1 \bar{g}_2 + \sigma_{g(1,2)} \bar{r}_1 \bar{r}_2 + \sigma_{r(1,2)} \sigma_{g(1,2)}$, and similarly for $\sigma_{w(2)}^2$. The equations can be rearranged as respectively

$$(7.3) \quad x_1^* a = (\bar{w}_2 - \bar{w}_1) + x_2^* (b - d) + x_1^* c , \text{ and}$$

$$(7.4) \quad x_1^d a = (\bar{w}_2 - \bar{w}_1) + x_2^d b .$$

Assume that x_1^* and x_1^d are the same and also $x_1^* = x_2^*$. Then, $(b+c-d) \cdot x_2^*$ should equal to $b x_2^d$ to hold the equality between the right-hand-side of equations (7.3) and (7.4), which indicates that we may have $x_2^d > x_2^*$, and thus $X^d > X^*$, if $c > d$. To have this condition, $c > d$, we must observe the negative correlation in exchange rates (and possibly between input prices), and $\bar{g}_1^2 \sigma_{r(1)}^2 > \bar{g}_2^2 \sigma_{r(2)}^2$. Also, it should be noted that taking the similar analogy for the positive correlation is not valid since it violates the first-order conditions, as shown in the proof early. //

2. proof of Proposition 2

In this case, the first-order condition for \mathbf{x} after adjusting with optimal futures positions can be written as

$$(3') \quad \bar{\mathbf{m}}(X^*; Z, \bar{\mathbf{w}}) + (\bar{r} - r_f) \mathbf{i}' \bar{\mathbf{g}}_f - \lambda \mathbf{x}' \left[\Sigma_{ww} - \sigma_r^2 \bar{\mathbf{g}}_f' \bar{\mathbf{g}}_f \right] = \mathbf{0}' \quad ,$$

where \mathbf{i} is the $n \times 1$ vector of 1's, and $\Sigma_{ww} = \sigma_r^2 \bar{\mathbf{g}}_f' \bar{\mathbf{g}}_f + (\bar{r}^2 + \sigma_r^2) \Sigma_{gg}$. Since all elements of Σ_{ww} are positive values, all elements in the variance term of the blank [] in equation (3') are smaller than the corresponding element of Σ_{ww} . Unless $(\bar{r} - r_f)$ is extremely negative value, X^s is always greater than X^d (This can be easily seen by applying the same logic of equation (7) in the proof of Proposition 1. //

3. proof of Proposition

Since the main logic behind a cross hedging or any imperfect hedging is transferability of the systematic exchange rate risk among exporting countries (Broll et al.: 1995), we'll postulate the use of a single currency futures (say, country 1) for the purpose of cross hedging of multiple exchange rate risk. The stochastic return to the firm at the end of a period is

$$\bar{\pi} = NR(X) - \bar{\mathbf{w}}' \cdot \mathbf{x} + (\bar{r}_1 - r_{f(1)}) \cdot c_1, \text{ and the variance of the return is}$$

$$\text{var } \pi = \mathbf{x}' \Sigma_{ww} \mathbf{x} + \sigma_{r(1)}^2 \cdot c_1^2 - 2c_1 \Sigma_{1w} \mathbf{x} ,$$

where Σ_{1w} (Σ_{1r}) is the $n \times 1$ covariance column vector between import prices (exchange rates) and country 1's currency rate, and $\bar{g}_1^2 \sigma_{r(1)}^2$ and $\bar{g}_1 \bar{g}_k \sigma_{r(1,k)}$ are the first and the k -th element of Σ_{1w} .

After solving for the first order conditions under the assumption of unbiased futures price, the component of $\bar{g}_1 \Sigma_{rr} \bar{g}_1$ in the variance of profit in equation (2) is reduced by $\Sigma_{1w} \Sigma_{1w}' / \sigma_{r(1)}^2$, and thus $\bar{g}_1 \Sigma_{rr} \bar{g}_1$ becomes

$$(8.1) \quad \bar{g}_1 \cdot (\Sigma_{rr} - (\Sigma_{1r} \Sigma_{1r}' / \sigma_{r(1)}^2)) \cdot \bar{g}_1$$

$$= \bar{g}_1 \cdot \begin{bmatrix} 0 & 0 & \dots & 0 \\ 0 & \sigma_{r(2)}^2 - (\sigma_{r(1,2)}^2 / \sigma_{r(1)}^2) \dots \sigma_{r(2,3)} - (\sigma_{r(1,2)} \sigma_{r(1,3)} / \sigma_{r(1)}^2) \\ \cdot \\ \cdot \\ 0 & \sigma_{r(2,3)} - (\sigma_{r(1,2)} \sigma_{r(1,3)} / \sigma_{r(1)}^2) \dots \sigma_{r(n)}^2 - (\sigma_{r(1,n)}^2 / \sigma_{r(1)}^2) \end{bmatrix} \cdot \bar{g}_1 .$$

This yields the following relationship for any i , at the optimum, as

$$(8.2) \quad \bar{m}_i(X^c) = \lambda \cdot \left[x_1^c c_{i1} + \sum_{k=2}^n x_k^c d_{ik} \right] ,$$

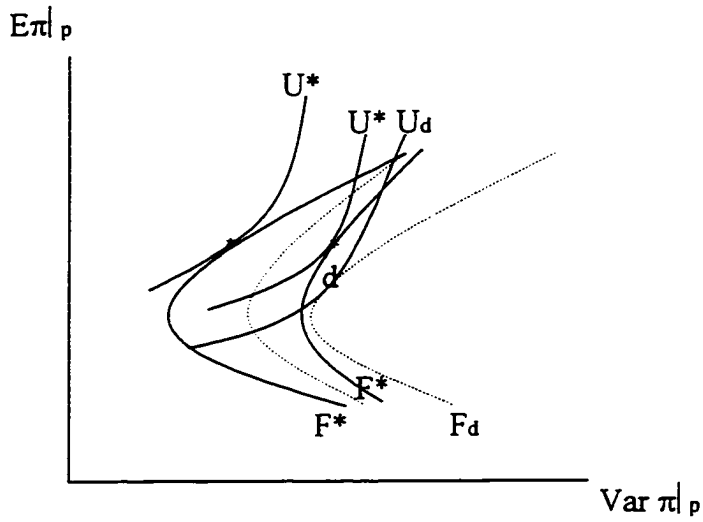
where c_{i1} is the i -th row and the 1-st column element, or its symmetric element, of the reduced variance in equation (5), as defined in Proposition 1. Also, d_{ik} is the corresponding element of $\Sigma_{ww} - \Sigma_{1w} \Sigma_{1w}' / \sigma_{r(1)}^2$, the reduced form of the total variance under the single cross hedging, where specific values for the reduction are expressed in equation (8.1). Given a positive $\sigma_{g(i,k)}$ for all i, k , which is a reasonable assumption in reality, if all exchange rates are positively correlated with the currency 1, then X^c is greater than X^d . That's because of lower values of each c_{i1} and d_{ik} , than the corresponding term under diversification only, following the method in the proof of Proposition 1. The similar analogy can be applied to the relationship of $X^c < X^*$, since, for each d_{ik} , $d_{ik} < c_{ik}$. If some exchange rates are

negatively correlated to the currency 1, then the relationship between d_{ik} and c_{ik} for all i and k ($i \neq k$: off-diagonal elements) is not clear, and thus the value of $|X^* - X^c|$ is ambiguous as mentioned in the proof of Proposition 1.

To show $x_1^* < x_1^c$, first note that $\bar{m}_i(X^*) < \bar{m}_i(X^c)$ for any i at the equilibrium, given a declining function of the expected margin and the relationship of $X^c < X^*$. If $x_1^* = x_1^c$, then, compared with equations (7) and (8.2), $x_1^c c_{i1} = x_1^* c_{i1}$, and $\sum_{k=2}^n x_k^c$ must be greater than $\sum_{k=2}^n x_k^*$ enough to compensate the reduction in d_{ik} , for all $k(>1)$ and i , and the higher value of $\bar{m}_i(X^c)$ in equation (8.2). This contradicts the first result of $X^c < X^*$. If $x_1^* > x_1^c$, then $x_1^c c_{i1} < x_1^* c_{i1}$, and $\sum_{k=2}^n x_k^c$ must be even greater than the case of $X^c < X^*$ enough to compensate the value of $(x_1^* - x_1^c)$. This increase in $\sum_{k=2}^n x_k^c$ can be seen more clearly if we consider equation (8.2) with respect to x_1 , since $c_{i1} > c_{ik}$ for any $k(>1)$. Therefore, $x_1^* < x_1^c$ to have a proper balance. //

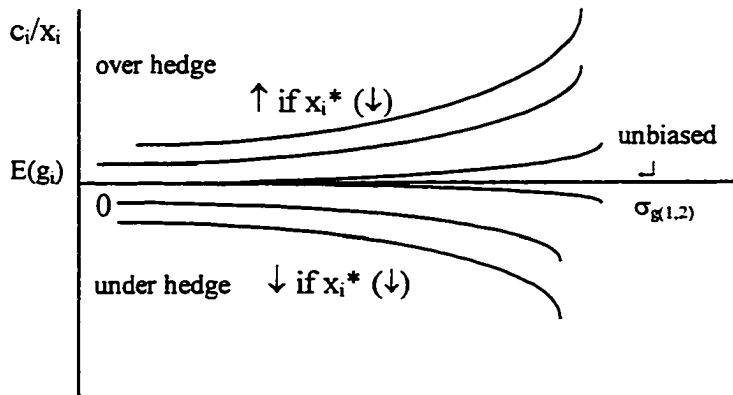
2. Graphs

1. In the graph, U_d refers to the indifference curve of the importer under diversification scheme alone, U^* is the curve under both schemes, and F_d and F^* correspond to the EV frontiers respectively in each regime. As for engaging in currency futures, the efficient frontier will shift leftward from that under diversification alone (F_d) to F^* , which is either less or more convex to $E\pi|_p$ -axis of portfolio. Thus, the improvements in the expected utility level from 'd' to '*' might be either small or significantly large.



Graph 1. EV frontier

2. Assuming a constant $\partial x_i / \partial \sigma_{g(1,2)}$, for each $i=1,2$, optimal hedge ratio(s) will diverge from the unbiased, or pure, hedge ratio, as shown below. Even if we have a non-constant $\partial^2 x_i / \partial \sigma_{g(1,2)}^2$, the deviation will be achieved as $\sigma_{g(1,2)}$ increases.



Graph 2. Hedge ratio(s) under biased futures.

CHAPTER 2. DEMAND DIVERSIFICATION UNDER UNCERTAINTY AND MARKET POWER: APPLICATION TO THE CHINESE WHEAT IMPORT MARKET

A paper prepared to be submitted to the Journal of Business and Economics

Jeong-Yun Seo

ABSTRACT

This paper justifies theoretically and empirically the diversification behavior of an importing firm when it chooses the mixture of potentially differentiated products of its major input under the price uncertainty. The paper investigates an equilibrium relationship among three key explanatory variables, which are the expected price, the systematic risk of price, and monopolistic market power of the suppliers in the market. The theoretical section shows that there exists a conflict between the risk-diversification effect and the agent's preference over certain products when the importer chooses the vector of optimal quantity shares. The later effect may disturb or even dominate the former, which can be represented in an equilibrium relationship similar to the framework of the CAPM. As an empirical application, the Chinese wheat import market is examined and analyzed to answer the questions raised from the basic statistics.

I. INTRODUCTION

There are many instances in which firms purchase a group of products from various sellers who charge different prices. In the international trade, for instance, some suppliers may have consistently higher prices than their competitors' during considerable time periods, yet still supply significant portions of total imports. This situation seems to violate the criterion of expected cost minimization for input choice. Wolak and Kostad (WK), in their 1991 AER paper on input demand diversification, show one way to choose the mixture of risky input suppliers, and how to quantify the relative risk characteristics of input prices in a framework similar to that used to assess the relative risk of securities in the capital-asset-pricing model (CAPM). Based on their work, this paper is designed to justify the diversification behavior of a buyer, an importing firm or a trader, of heterogeneous products

under price uncertainty by examining the relationships among the expected price, the systematic risk of price, and also the monopolistic market power of the suppliers in the market.

The CAPM asserts that securities will be priced in equilibrium to yield an expected return that is a linear function of the systematic or non-diversifiable risk. In order to apply the same idea to real market analysis under price uncertainty, prior knowledge of the vector of optimal shares is required so that one can build the value of the market portfolio. The decision on quantity shares comes from the micro-economic framework of solving the importer's optimization problem under uncertainty. To find the mixture of optimal shares depending only on the time-series components of each import price, WK show that the optimization problem can be decomposed into a two-stage process, like the cost-minimization problem. In the first stage, an optimal portfolio of suppliers is chosen to yield a given total amount of imports in each period time. To justify the portfolio of suppliers in an effort of risk management, they empirically examine the negative and linear relationship between the expected price and the measure of risk in Japanese steam coal imports market.

Optimization by focusing only on the first step is known to be consistent with the expected utility maximization problem under price uncertainty and a non-stochastic production function (Pope and Chavas). The monetary value of the composition of these optimal shares determines the value of a market portfolio as a benchmark with which compares the market value of each supplying price in terms of its systematic price risk. The advantage of adopting systematic price risk, instead of conditional risk, is apparent in the sense that the measure reflects the agent's efforts to diversify away the uncertainty he faces, conditional on the total import or production level, and thus informs us of the hedging role of products imported. Despite their robust modification of the financial asset equilibrium idea in studying real asset allocation such as an import portfolio, the paper by WK is limited to the assumption of 'homogeneous' products imported. In other words, their model attempts to justify the importer's incentive to diversify away the associated price risk purely within the context of a price-based portfolio.

In reality, products imported are only homogeneous in a very limited way. WK's model concerns the buyer's problem of 'input cost' minimization under price uncertainty in

deriving the optimal portfolio, and will not be consistent with the pricing behavior, if products appear to be distinguished by their product varieties. The existence of horizontal differentiation depends on a diversity of preferences or end-of-user purposes and is exploited within the economic context of imperfect substitution/ monopolistic competition (Scherer: 1990). A negative relationship, similar to CAPM, will not strictly hold under market imperfections. For instance, products of imperfect substitutes may lead the importer to consider the market power associated with certain varieties of products over their price or price risk, or if there is any collusive behavior among suppliers. Under non-homogeneity, increased import shares of certain products may even increase the profit of the importer over the increased input, or import, cost.

To allow for heterogeneity of imports, we first need to redefine the value of the optimal portfolio, and thus the measure of risk, by taking into account supplier-specific influences on the observed equilibrium price. Given the lack of a well-defined model of the determinants of the relative risk measure adopted in WK's study, it is difficult to determine how much of the import price variation is explained by the risk measure and how much is attributable to the existence of monopolistic market power by the suppliers in the import diversification analysis. A number of papers have investigated the relationship between a firm's market power and the systematic, or non-diversifiable, risk of the firm's rate of return on securities as explained by the Sarpe-Lintner CAPM (Subrahmanyam et al.: 1980; Chen et al.: 1986; Peyser: 1994; and Sun: 1993). These papers appear to have exclusively focused on the effects of a monopoly's market power, its capital-labor ratio, and the wage rate (Sun), on its own systematic risk. They find a negative relation between the market power and risk, using various definitions of the market power, for instance, the market value to book ratio, Tobin's q , or Cournot duopoly power, etc.

The objective of this study is to examine, theoretically and empirically, the relationship of the degree of monopolistic power of the seller and the measure of relative price risk. This will provide an additional explanation of the observed prices and the choice-vector of import demands by the buyer, besides the time-series components of stochastic prices. The theoretical framework overall follows that of Chen et al. However, because this paper deals with the import diversification instead of the rate of return in security markets, the market

specific price risk (β_i^*) relative to the optimal import value (W^*) will be the appropriate measure of relative risk instead the systematic risk (β_i) in the CAPM.

Section II first briefly explains the structure of WK's model to yield a negative and linear relationship between the expected price and its relative risk over all suppliers, given the homogeneity of products. A direct theoretical linkage is drawn between the monopolistic power of the supplier and the measure of relative risk, where both are driven from the equilibrium concept and from both buyer's and suppliers' optimality conditions. Implications drawn in Section II, when the assumption of homogeneity is relaxed, are as follows:

1. The monopolistic market power of a supplier positively affects the relative risk of the price, and thus adversely affects the negative relationship shown by WK.
2. The systematic price risk (β_i^*) relative to the optimal market portfolio can be orthogonally decomposed into the net risk measure and a residual term due to the market power (Equation 10).
3. A positive relationship between relative risk and the covariance between the expected price and the rate of return on the market portfolio is obtained.

The main clarification of WK's work is on the possible conflicts between two effects. In other words, if monopolistic market power of suppliers is present, then this power will increase the expected dollar price of risk (Section II.2.2), and thus positively affect β_i^* . This is basically because the importer does not choose the vector of quantity shares based on the criterion of the cost-minimization under uncertainty given the heterogeneous returns on the revenue by products purchased. Thus, the existence of market power in excess of zero may disturb or even dominate the negative and linear relationship between expected price and β_i^* . The later effect is only one considered by WK as a result of the risk-diversification effort of the buyer. The degree of significance of this power in a demand analysis is an empirical issue, but the theoretical section of this paper shows one way to extend the framework of WK, based on their concept of the relative risk measure (β_i^*). Section III examines the Chinese wheat import market as an empirical application.

II. THEOREICAL MODEL

II.1. Expected Price vs. Risk

This subsection briefly explains the structure of WK's model, which demonstrates one method of constructing the concept of systematic risk relative to the value of the optimal market portfolio in a real asset allocation model (e.g., import diversification) similar to the CAPM. This concept of risk will be used as an analytic tool in section II.2. Time subscripts are not marked throughout the section for a notational simplicity. Since the market portfolio is unobservable (and a proxy, such as S&P500 in security markets, is also unavailable), WK build the value of the optimal market portfolio in an import market within the context of a 'price-based' portfolio from the perspective of the importer. For this purpose, consider a firm whose expected utility is defined as $U(E, V)$ with $U_1 > 0$ and $U_2 < 0$, and E and V are the expected profit and variance of the profit, respectively. The firm purchases a set of homogeneous products from the several suppliers of total amount for the purpose of trading or production of outputs.

The purchase prices (\tilde{w}_i) available from all n suppliers, which are the only stochastic variable to the buyer of products, are unknown at the time the quantities or quantity shares of products are chosen. The uncertainty is resolved at the end of a certain time period. This uncertainty is due to the existence of time-lag in production and sales. The buyer's optimization problem is equivalent to the 2-stage process, whereby first an optimization portfolio is chosen to yield a given total import level (Q). Then in the second stage, the proper balance is struck among outputs, non-risky inputs and the total amount of the risky input (Q). Because we are only interested in the choice of the portfolio of suppliers of the risky input, the focus is on the first stage. The optimal portfolio is based only on the import price, since the revenue side for the buyer needs not be considered with the homogeneous-product assumption. The value of the portfolio, denoted as $\tilde{W}_0 (= \sum s_i^0 \tilde{w}_i)$, is then defined as the sum of prices (\tilde{w}_i) weighted by optimal quantity shares (s_i^0).

In the above model of import diversification, WK (pp. 532-535) show that we may derive an equilibrium relationship similar to the CAPM between the expected price (W_j) and the measure of risk (β_i^0) of any supplier i 's price relative to the value of optimal portfolio (\tilde{W}_0). The set of optimal portfolio (s_j^0 's, for all $j = 1, \dots, n$) is analogous to the market

portfolio and β_i° is analogous to the market-specific measure of risk on the rate of return to a security i in the CAPM. Copeland and Weston (1988) and Black (1993) show the derivation of the market security line of a minimum-variance zero-beta portfolio. Based on the same logic, the relationship in the real asset (e.g., import) allocation model is expressed as follows:

$$(1) \quad W_i = E(\tilde{w}_i) + (E(\tilde{W}_o) - E(\tilde{w}_i)) \beta_i^\circ.$$

W_i ($\equiv E(\tilde{w}_i)$) is the expected import price (in other words, the expected monetary value of buying one unit of the product i (q_i)), and $E(\tilde{w}_i)$ is the expected value that the importer would be willing to pay for a riskless product (q_z) which in turn yields the lowest expected return to the buyer. $E(\tilde{W}_o)$ is the expected value of the optimal portfolio, and, the magnitude of risk is defined as

$$\beta_i^\circ = \frac{\text{cov}(\tilde{W}_o, \tilde{w}_i)}{\text{var}(\tilde{W}_o)}.$$

Equation (1) is exactly parallel to the CAPM except that (a) $E(\tilde{w}_i)$ has replaced the rate of return on the risk-free asset and (b) the measure (β_i°) of risk for each \tilde{w}_i , in the context of real asset allocation, is based upon the relative value of the market portfolio \tilde{W}_o instead of the market rate of return. The difference between Equation (1) and the CAPM formula for the minimum-variance zero-beta portfolio is that \tilde{w}_i is not the rate of return of firm i 's securities as in the Sharpe-Lintner CAPM, but the cost of purchasing q_i to the buyer in this model of diversification. The market price of risk, $E(\tilde{W}_o) - E(\tilde{w}_i)$, is negative because the expected value ($E(\tilde{w}_i)$) of q_z is higher than any other combination of q_j 's for all j . This occurs because the purchasing firm is willing to pay more for an input with a less risky price. Thus, W_i has a negative linear relation with β_i° and has the highest value at $E(\tilde{w}_i)$ in which risk premium ($\equiv (E(\tilde{w}_i) - E(\tilde{W}_o)) / E(\tilde{W}_o)$) needs not be paid and $\beta_i^\circ = 0$, as suggested by Equation (1).

The measure (β_i°) of each price risk relative to \tilde{W}_o is derived from the purely price-based portfolio of the investor, and thus the products purchased must be considered to be homogeneous. This negative relation, due to the importer's incentive to diversify away the

risk, however will not strictly hold for some products purchased, if there is any collusive behavior among suppliers. Also, if products are imperfect substitutes, then the importer may consider more the monopolistic power of certain varieties of products over their price risk in his decision-making. To allow for the heterogeneity of imports, we first need to redefine the value of the optimal portfolio, and the measure of risk as a consequence, by taking into account the suppliers' impact on the observed equilibrium price. WK's model concerns only the buyer's perspective of 'input cost' minimization under price uncertainty in deriving the optimal portfolio, and this will no longer be consistent with pricing behavior due to the heterogeneous returns of products purchased.

II.2. Supplier's Market Power vs. Risk

II.2.1. Monopolistic Market Power

Given the shortcomings of the price-only-based analysis, re-define the optimal value of the market portfolio as \tilde{W}^* ($\equiv \sum s_i^* \tilde{w}_i$). \underline{s}^* , or a set of s_i^* 's for $i=1, \dots, n$, stands for the optimal mixture of quantity shares with the non-homogeneity of products, and it must be different from \underline{s}^o , the optimal set of shares for the homogeneous products, due to different returns from each product in the importer's revenue. This specification of optimal shares yields the corresponding market specific risk

$$\beta_i^* (= \frac{\text{cov}(\tilde{W}^*, \tilde{w}_i)}{\text{var}(\tilde{W}^*)}) \text{ relative to } \tilde{W}^*.$$

A specific derivation of the set of s_i^* 's is not feasible, unless the output/input market structure of the importing firm is known. The specific structure is not necessary however in this stage of analytic study, since \tilde{W}^* is a hypothesized value similar to the market rate of return in the CAPM¹. The objective of this theoretical section is to model a measure of market power (u_i) of the supplier i to have some degree of linkage to β_i^* , by examining first the relationship between u_i and the systematic risk or non-diversifiable risk (say β_i) of the supplier.

Because the vectors of prices and β_i^* 's are the equilibrium values in the real market, we may derive the systematic risk of the import price as a function of the supplier's market power within the context of the supplying firm's optimality conditions. The analytic part generally follows the basic model of Sun (1993) and Chen et al. (1986) at this section, and is combined with the β_i^* in Section II.2.2 to modify the model to represent the analysis of demand diversification. For this purpose, assume that a shareholder wealth-maximizing, price-setting firm, or supplier, operates for a single period after which it is dissolved at zero salvage value. There are no taxes, or bankruptcy, or agent costs, and Modigliani-Miller capital structure applies. The firm produces a single product and the firm's factor demand does not affect the stochastic distribution of the price. Money capital is raised in a financial market characterized by Sharpe-Lintner equilibrium. A constant marginal cost and average cost function are assumed for simplicity, since the focus is on the output price (or input price for an importing firm) itself, in which several suppliers compete in a single market in this import diversification model.

Among the suppliers, we consider an arbitrary supplier i , in the market, producing product q_i and facing the following stochastic revenue function²,

$$(2) \quad \tilde{w}_i q_i = (1 + \tilde{\varepsilon}_i) W_i q_i(\underline{W}, I) \quad .$$

$q_i(\underline{W}, I)$ is the conditional demand for the commodity i (from supplier i) by importing firm, $\tilde{\varepsilon}_i$ is a stochastic component of the firm i 's output price (\tilde{w}_i) and is independent of the quantity sold (q_i) with $E(\tilde{\varepsilon}_i) = 0$. Outputs of each supplier are possibly non-homogeneous or imperfect substitutes within the same group of the commodity, and thus the monopolistic power may be exercised. The notation ' $\underline{\quad}$ ' indicates an $n \times 1$ vector of the variable, W_i is expected price of product i in terms of the buyer's currency, and I represents the total expenditure on all products. A single variety for each supplier is assumed, and suppliers treat the prices of the other suppliers as fixed; i.e., they are Bertrand maximizers.

A linear technology is assumed, calling for capital (K_i) and labor inputs (L_i). In other words, capital is exhausted in the production process and its cost is assumed to be $(1+r)$ with the constant production relation as $K_i = b_i q_i$, and also $L_i = a_i q_i$. Then, the technology results

in a constant marginal and average short-run cost(c_i), where $a_i+(1+r)b_i \equiv c_i$, in each time period. Since the CAPM requires a single-period decision framework, we accordingly assume that the firm's assets and production potential are exhausted completely within one period. According to the valuation formula provided by the Sharpe-Lintner CAPM, the market value (V_i) of the supplier i is the present value of the net cash flow. The corresponding cash flow ($\tilde{\pi}_i$), net of capital depreciation, and market value are given respectively by

$$(3) \quad \tilde{\pi}_i = (1 + \tilde{e}_i) \cdot W_i \cdot q_i - c_i q_i, \text{ and}$$

$$(4) \quad V_i = [E(\tilde{\pi}_i) - \lambda \cdot \text{cov}(\tilde{\pi}_i, \tilde{R}_m)] / (1+r),$$

where λ is the market price of risk, r is the risk-free rate of interest, \tilde{R}_m is the stochastic rate of return on the capital market portfolio, and $\sigma_{i,m}$ is the covariance of \tilde{e}_i with the rate of return on the market portfolio.

V_i can be modified in the following way to derive the optimality conditions of the supplying firm. Let ψ_i be the certainty equivalent of $(1+\tilde{e}_i)$, given by $\psi_i = E(1+\tilde{e}_i) - \lambda\sigma_{i,m} = 1 - \lambda\sigma_{i,m}$. The certainty equivalent price is then $(E(\tilde{w}_i) - \lambda\sigma_{w(i),m}) = (E(1+\tilde{e}_i) - \lambda\sigma_{i,m})W_i = \psi_i W_i$, where $\sigma_{w(i),m}$ is the covariance³ between \tilde{w}_i and \tilde{R}_m . Using these terms, $E\pi_i$ becomes $(W_i - c_i)q_i$, and the $\text{cov}(\tilde{\pi}_i, \tilde{R}_m)$ is expressed as $\sigma_{w(i),m} q_i = W_i\sigma_{i,m} q_i$. Equation (4) thus can be simplified as

$$(5) \quad V_i = (\psi_i W_i - c_i) \cdot q_i / (1+r).$$

Since the objective of the supplying firm is to maximize the shareholders' wealth with product heterogeneity, the problem is to choose W_i to maximize Equation (5), its own present market value net of investment(or capital depreciation). Then the first order condition for optimization yields the following

$$\Psi_i W_i \cdot \left(1 + \frac{\partial q_i}{\partial W_i} \frac{W}{q_i}\right) - c_i \frac{\partial q_i}{\partial W_i} \frac{W_i}{q_i} = 0 ,$$

where $\Psi_i W_i$ is the certainty equivalent price. Define $\left[-\frac{W_i}{\partial W_i} \frac{\partial q_i}{q_i}\right]^{-1}$ to be u_i , the reciprocal of the positive elasticity of own demand (q_i) with respect to the expected price (W_i). The condition is then written, in a simpler form, as

$$(6) \quad \Psi_i W_i = \frac{c_i}{1 - u_i} .$$

Since \bar{w}_i is the stochastic price in the decision time and W_i is its expected value, the term u_i indicates the market power of the supplier i in the industry in risk-discounted expectation form with product varieties. In other words, u_i is the certainty equivalent spread between price and marginal cost as a proportion of price ($u_i = \frac{\Psi_i W_i - c_i}{\Psi_i W_i}$). If products are homogeneous and the market is characterized by the perfectly competitive environment, this spread should not exist and u_i would be zero. Otherwise, the variable is related to monopolistic market power of the supplier and is in general less than 1. Without uncertainty (i.e., $\Psi_i = 1$), this is at the level of a single firm Lerner-index (also frequently defined as $\frac{1}{1 - u_i}$), which is widely used in the literature as a measure of the monopolistic power of a firm (Chakravarty, pp. 53).

II.2.2. Systematic Risk

The main concern of this paper is the relationship between β_i^* and the supplier's monopolistic market power (u_i). WK deal with the case of non-existence of market power, given that products are perfect substitutes with one another. From their mean-variance specification of the importer's utility with product non-homogeneity, the expected vector of quantity shares is equal to the optimal vector of quantity shares (s^0) based on the first two

moments of the series of stochastic prices, conditional on the total import level (Q) and the degree of risk aversion (λ). That is,

$$E(s) = f(\underline{W}, \text{var} \underline{w} \mid (Q, \lambda)) = \underline{s}^{\circ} .$$

In a real asset allocation model, the importer can be thought as an investor in a financial security market, and a higher import price decreases the return of its cash flow. The expected value and the risk of the actual market portfolio of import shares is a tangency point to the efficient frontier of $((\underline{W}, \text{var} \underline{w}) \mid \lambda)$ given a certain utility level (say U_0). And the riskless level of the expected price can be obtained once we get the tangency line (See WK, pp. 532-4). Using \underline{s}° , the construction of β_i° as a relative price risk measure is feasible, and the use of the measure is analogous to the systematic risk, β_i , of the CAPM, as presented in Equation (1).

However, if the monopolistic market power of the supplier i (u_i) is present to be non-zero, then the time-series components of prices are no longer the only factors in deriving optimal shares or quantities of the importer. The vector of expected observed shares (\underline{s}^*) now has the following implicit functional form

$$E(s) = f(\underline{w}, \underline{u}(\underline{w}, \underline{z}) \mid \lambda) = \underline{s}^* ,$$

where \underline{z} represents model parameters of the importer's utility (U), other than the first two moments of price, such as importer's production or transaction costs, and the effect of product substitutability on the importer's revenue.

β_i^* still represents the systematic price risk of \tilde{w}_i relative to \tilde{W}^* by its definition. But, the vector of the expected prices (\underline{W}) is no longer a parameter to the importer but is treated as a function related to $(\underline{u}, \underline{z})$. Thus, the relationship between β_i^* and u_i , as well as z_i , may disturb the negative and linear relationship of Equation (1) between β_i^* and W_i . The common tangency line between the efficient frontiers of $((\underline{W}, \text{var} \underline{w}) \mid \lambda)$ and a certain utility level (U_0) is unlikely to be obtained given the different frontiers for each supplier, which in turn obscures the common constant and negative slope coefficient of Equation (1) in the

cross-sectional analysis. This indicates that caution must be given in applying the modified CAPM equation of WK to empirical data, if there is any suspicion over the homogeneity of the products within a market.

In conjunction with Section II.2.1, the systematic risk of a firm can be represented as a function of the principal microeconomic determinants of the firm's operation, especially, the firm's certainty equivalent market power u_i , in the following way. According to the CAPM, the systematic risk (β_i), or so called as the beta coefficient, of the rate of return on the security of the firm i is measured by the relationship between the rate of return (\tilde{R}_i) on the firm's securities and the rate of return (\tilde{R}_m) on the capital market portfolio. For an explicit form of β_i , similar to the previous literature (e.g., Subrahmanyam et al.), define

$$\tilde{R}_i = \frac{\tilde{\pi}_i}{V_i} - 1, \text{ and } \tilde{R}_m = \frac{\tilde{\pi}_m}{V_m} - 1, \text{ where } \tilde{\pi}_m = \sum_i \tilde{\pi}_i \text{ and } V_m = \sum_i V_i.$$

Financial market participants are interested in the market value of suppliers, V_i (and also, $\tilde{\pi}_i$ and \tilde{R}_m) for all $i=1, \dots, n$, while the importer's concern is on the suppliers' market prices in his demand diversification problem. In the equilibrium analysis of an import, or any demand, diversification, the capital market rate of return (\tilde{R}_m) can be restated with \tilde{W}^* ($\equiv \sum_i \tilde{w}_i \cdot s_i^*$), the monetary value of an importer's optimal demand portfolio as follows. Given the industry (or the import market in this paper)-specific portion of the CAPM market, we may express the CAPM market rate of return (\tilde{R}_m) as an expectation- and variance-independent fraction (say \tilde{f}_p) of the rate of return of the industry (say \tilde{R}_{mp}):

$$\tilde{R}_m = \tilde{R}_{mp} \cdot \tilde{f}_p, \text{ where } \tilde{R}_{mp} \equiv \frac{\tilde{\pi}_{mp}}{V_{mp}} - 1.$$

Note that, by the independence assumption, the rate of return on aggregate securities in the import market (\tilde{R}_{mp}) is defined within the market of n suppliers. Furthermore, the optimal weighting of $\tilde{\pi}_i$ in the specific-market is determined by the investor (i.e., the importer) in the real market. We then have, by aggregating $\tilde{\pi}_i$ over all suppliers for $\tilde{\pi}_{mp}$,

$$(7) \quad \tilde{R}_{mp} = \frac{\sum(\tilde{w}_j - c_j)q_j^*}{V_{mp}} - 1 = \frac{Q \cdot (\tilde{W}^* - \sum c_j s_j^*)}{V_{mp}} - 1,$$

where Q is the total optimal import demand at the time-period, and V_{mp} is expressed as

$$\frac{1}{1+r} Q \cdot M^* \text{ from Equation (5), where } M^* \text{ is } \sum_i (\psi_i W_i - c_i) s_i^*.$$

Under this set-up, we may relate β_i (\equiv the systematic risk of the rate of return on the security i relative to market portfolio) to β_i^* (\equiv supplier i 's price risk relative to \tilde{W}^* ($\equiv \sum_i \tilde{w}_i \cdot s_i^*$)) via simple manipulations. By the CAPM definitions of β_i and \tilde{R}_i , β_i is given by

$$(8) \quad \beta_i \equiv \frac{\text{cov}(R_i, R_m)}{\sigma_m^2} = \frac{\text{cov}(\pi_i, R_m)}{\sigma_m^2 V_i} = \frac{W_i q_i^* \sigma_{i,m}}{\sigma_m^2 V_i}.$$

On the other hand, the independence assumption of \tilde{R}_{mp} from \tilde{R}_m yields

$$\beta_i = \frac{\tilde{f}_p \cdot \text{cov}(R_i, R_{mp})}{\tilde{f}_p^2 \cdot \text{var} R_{mp}}, \text{ following the covariance analysis provided by Bohenstedt and}$$

Goldberger (1969). Based on the definitions of \tilde{R}_i and β_i^* , and the relationships for \tilde{R}_{mp} (Equation (7)) and V_i (Equation (5)), we then obtain

$$(9) \quad \beta_i = \left(\frac{1}{\tilde{f}_p} \cdot \frac{q_i^*}{V_i} \right) \cdot \frac{\text{cov}(w_i, R_{mp})}{\text{var}(R_{mp})} = \frac{q_i^*}{\tilde{f}_p V_i} \cdot \frac{V_{mp}}{Q^2} \cdot \frac{\text{cov}(w_i, W^*)}{\text{var} W^*}$$

$$= \frac{V_{mp} q_i^*}{\tilde{f}_p Q V_i} \cdot \beta_i^* = \frac{\sum_j (\psi_j W_j - c_j) s_j^*}{\tilde{f}_p (\psi_i W_i - c_i)} \cdot \beta_i^* \equiv \frac{M^*}{\tilde{f}_p m_i} \cdot \beta_i^*.$$

where \tilde{f}_p indicates the expected \tilde{f}_p , σ_m^2 is the variance of \tilde{R}_m , and $\frac{M^*}{m_i}$ is a supplier-specific value around one.

In sum, without perfect knowledge of the import market structure, the derivation of \underline{s}^* is not feasible. From the supplier's perspective, however, it is possible to draw a functional form of \underline{W} , to which Section II.2.1 is devoted. Note that the supplier's optimality condition (Equation (6)) is based on the equilibrium model assumption that supplier's revenue function (Equation (2)) directly reflects the importer's preference over that product. Now, we may express the explicit form of β_i^* , by combining Equation (8) and (9), with some model parameters that affect the equilibrium relationship of demand diversification as

$$(10) \quad \beta_i^* = \frac{\text{cov}(w_i, \underline{W}^*)}{\text{var}\underline{W}^*} = \left[\frac{c_i \sigma_{i,m} \bar{f}_p (1+r)}{\psi_i \sigma_m^2 M^*} \right] \cdot \left[\frac{1}{1-u_i} \right],$$

or simply, $\beta_i^* \equiv \beta_i^n \cdot \frac{1}{1-u_i}$.

Equation (10) summarizes one way of analyzing the equilibrium relationship between key determinants of β_i^* in the import market under price uncertainty, when the assumption of product homogeneity is released. The value of u_i is generally less than 1, as mentioned below Equation (6). Equation (10) shows that β_i^* is positively related to u_i (or $\frac{1}{1-u_i}$), the supplier i 's monopolistic power in the certainty equivalent form, under the normal condition of positive $\sigma_{i,m}$. In an extreme, β_i^* is a monotonically increasing function of $\frac{1}{1-u_i}$, if the demand shock (\bar{e}_i in Equation (2)) happens to be a common economy-wide source of uncertainty, and if we have the same marginal production costs (c_i) over all suppliers. Note that by virtue of using the CAPM as the description of the security market equilibrium, we are assuming that the firm is in the competitive position in the capital market. The positive relationship arises because the existence of u_i in excess of zero generates a higher expected price per unit of (the suppliers' capital-market) risk, implied by $\sigma_{i,m}$, and not from any noncompetitive access to the capital market (Chen, pp. 70)⁴.

Also, β_i^* is positively related to $\sigma_{i,m}$, the covariance of the stochastic demand term with the rate of return on the market portfolio, which is supposed to be positive in general.

This says, the relative risk of price is higher if its stochastic movement is highly correlated with the capital market movement of the rate of return. Since $\sigma_{(e(i), W^*)}$, or the covariance term between $(\tilde{e}_{i,t}, \tilde{W}_t^*)$, is the positive fraction of $\sigma_{i,m}$ (expressed as $\sigma_{i,m} \approx \frac{\tilde{f}_p(1+r)}{M^*} \cdot \sigma_{(e(i), W^*)}$ in our model), an increased value of $\sigma_{(e(i), W^*)}$ indicates a lower diversification effect or existence of higher risk premium of the product imported in the CAPM context. Thus, a high value of $\sigma_{(e(i), W^*)}$ generally indicates that imports of such products do not induce a good hedge (i.e., a lower risk of portfolio) against the market price variation. However, the implication is more complicated than this, since $\sigma_{(e(i), W^*)}$ is also positively associated with actual price (\tilde{w}_i), partially due to existence of the market power, and/or the high quantity share (s_i) of the product i .

Equation (10) also shows that we may express net risk measure (β_i^n) relative to \tilde{W}^* as a fraction of β_i^* . This simple orthogonal decomposition visualizes how much of the import price variation is explained by the risk measure given \tilde{W}^* and how much is directly attributable to the existence of the monopolistic market power of the suppliers in the import diversification analysis. Derivation of a pure risk measure, independent of u_i , is not feasible, since u_i itself indirectly affects \tilde{W}^* , but the β_i^n refers to the net systematic risk term of β_i^* , conditional on observed \tilde{W}^* . Under the existence of market power in a normal sense (i.e., $0 < u_i < 1$), we observe the positive departure of β_i^* from β_i^n , and the spread increases in correspondence to the increased u_i . That is, if products are the perfect substitutes with each other, or if the certainty equivalent market power virtually does not exist (i.e., $u_i \leq 0$), then the resulting β_i^* in general becomes less than that with the market power at the equilibrium.

In sum, this section shows how price risk is related to the suppliers' market power. It thus provide one the theoretical foundation to justify a relevant empirical research, for instance, our example of the Chinese wheat import diversification, studied in the following section. The key point here is again the supplier's power positively affects the measure of β_i^* , and thus disturbs the CAPM-type negative equilibrium relationship between β_i^* and the expected price (W_i). The degree of significance of the market power in a demand analysis is

an empirical issue. But this theoretical section examines one way to extend the framework of WK, which entirely depends on the issue of importer's risk diversification, based on their concept of the systematic risk measure (β_i^*) relative to the value of the market portfolio.

III. EMPIRICAL APPLICATION: WHEAT IMPORTS IN CHINA

III.1. Background and Statement of Problems

This paper analyzes the Chinese wheat import market, using the model developed in this paper to test its empirical applicability. China is one of the world's largest wheat producers, and, at the same time, is a major importer in the world wheat market. In the marketing year of 1994/95, China imported 10,056 thousand metric tons of wheat, accounting for 10.8 % of the world wheat trade. The China National Cereal, Oils, and Foodstuffs Import/Export Corporation (CEROILS) is the sole state trading agency which determines the optimal combination of suppliers in Chinese wheat imports. The total import quantity Q is decided by another government agency, MOFERT, an upstream institute, to fill the gap between domestic demand and supply, and CEROILS then chooses the set of suppliers given Q .

According to the agency, the factors that affect the decision of the mixture of suppliers include, most importantly, price paid for the imported wheat, and also product quality, as a close second, measured by things such as quarantine objects, live insects, dockage and protein level. Governmental relationship is another important factor considered by the CEROILS, but China in general prefers to maintain flexibility not being restricted by any long-term bilateral trade agreement (Crook et al.:1993). Wheat is purchased through three mechanisms: long-term (LT) contracts, short-term (ST) contracts, and spot-market purchase. China's wheat imports are basically planned on an annual basis, and revised in the medium term to fill the unexpected gap between demand and supply. The tendency to engage in LT contracts, more than 2 years or so, is in general declining (USDA, China: Agriculture and Trade Report), and there is room to re-negotiate the price of LT agreements based upon current market conditions.

There exists the time lag of 1-6 months, even in cash purchases, between when wheat is purchased and when it is shipped. Typically the sales activity, more than actual shipments,

affects commodity prices, and the lags are also different by types of wheat (Turner and Ruppel: 1993). Thus, as pointed out by WK, there are inherent risk sources in actual import prices, due to the lead/lag structure in any form of purchase: fluctuations in exchange rates and transportation costs, and demurrage costs associated with the availability of loading the cargo immediately upon the arrival at port. Stochastic quality can be another source of import price variation. The dockage level of the US product, for instance, ranges between .4 - .8% in general compared to .2 - .3% of Canadian and Australian wheat. The high dockage reduces milling yields and thus raises the price paid on a millable material basis. And it also raises the cleaning and fumigation cost for the government agency because of the existence of live insects and Johnston grass seed. These inconsistent qualities provide the importing agency another stochastic source for the price re-negotiation after the delivery via either deduction from the gross weight or penalties specified in contracts (Crook et al.).

Wheat types are imperfect substitutes with one another within the same commodity group. Thus, it is natural to consider the monopolistic market power of suppliers, as well as the time-series components of stochastic price in the analysis of a model of diversification⁵. These market conditions make the wheat import market a challenging empirical application of the theoretical model. There are many theories on modeling oligopoly pricing. This paper postulates Bertrand play for the suppliers, and thus any non-competitive pricing behavior is simply expressed as u_i (or $1/(1 - u_i)$). Also, our model of the Chinese wheat import market is based on the Armington assumption, which differentiates wheat by country of origin (Larue and Lapan: 1992). There are some criticisms against the Armington assumption, but it avoids the complexity raised from the case of multi-class wheat export by a single country (e.g., US), given the shortcomings of specific data available. Thus the price an importer is willing to pay for a unit of wheat also depends on exporter reputation, which should be reflected in the measure of u_i .

Data on monthly wheat import prices for China, measured in the Chinese currency unit, yuan, and annual import quantities from major exporters are obtained from several sources such as World Wheat Statistics, and USDA: China: Agriculture and Trade Report. Over the last two decades or so, China imported four classes of wheat: durum, hard spring, hard winter, and soft wheat. Since durum wheat accounted for less than one percent in most

marketing years, only the other three classes are considered in this paper. Import prices are measured in yuan per metric ton, and are deflated by the consumer-price-index of China. Figure 1 exhibits actual price series for three major suppliers (which account for almost 90% of the total supply) of Canada, US, and Australia. Further, Table 1 summarizes mean and standard deviations of import prices and quantity shares for all five suppliers.

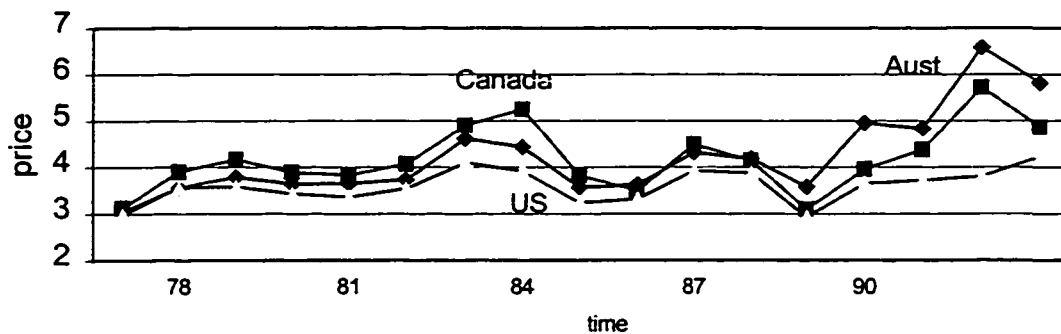


Figure 1. Actual price-series for three major suppliers

The first column of the table shows the mean and standard deviation of wheat import prices for China during the seventeen years (1978:7-95:6), while the second column shows the first two moments of quantity shares for the same period. The last column in the table exhibits the mean of the quality-adjusted prices in the sense of ad hoc premium margin. In this case, ten dollars are subtracted from the Canadian and Australian prices, which is the approximate monetary value, according to the survey by Crook et al., that CEROILS officials consider as the premium margin between the US and these two suppliers, due to their equally superior quality. Also, five dollars are added to the price of low quality EEC and Argentina products. The importing agent, CEROIL, believes that wheat quality, including its tender, clearly reflects the price that the agent is willing to pay for the specific products (See Appendix 1 for more description of the data).

As exhibited in the table, China imported wheat simultaneously from several major exporters who charge different prices. There were instances in the data when the price from

Table 1. Summary statistics for prices and quantity shares (1978:7-1995:6)
(Standard errors in parentheses)

Suppliers	Mean (import price)	Mean Quantity Share(%)	Mean of import price - quality-adjusted
Argentina	3.7 (.474)	5.5 (.044)	3.813
Australia	4.23 (.916)	19.8 (.144)	4.013
Canada	4.18 (.7)	37.2 (.103)	3.954
EC	3.34 (.489)	5.2 (.054)	3.462
USA	3.6 (.365)	32.8 (.173)	3.599

Source: World Grain Statistics and USDA: China: Agriculture and Trade Report, Situation and Outlook Series.

one exporter was consistently above other exporters' for an extended period of time, yet China continued to import highly priced wheat. This appears to violate the criterion of expected cost minimization. An attempt to explain this observation suggests, following WK's logic, that China may tradeoff the level of import cost against its variability in the decision of allocating total imports across available exporters in each decision time period. That is, by importing from a variety of exporters, China is diversifying away some of the price risk associated with satisfying demand from the single exporter with the least level of expected price. Another explanation of course involves the quality issue where Chinese shows a higher preference for certain types of products. As noted, this paper's objective is to figure out interactions between two explanations, based on the idea that the unstable mixtures of suppliers are associated with the combined effects of the price fluctuations and product preference.

Overall, the observations from Table 1 call into questions against the expected cost minimization model of input choice. Specifically, the import prices of the Canadian and Australian wheat are above all those of other suppliers even after the quality premium of \$10 relative to the US is applied. These prices are the most volatile among the price time series, yet the two countries supply the average of 37% and 20% respectively. A second observation is that the US price is consistently low with the least price variability among

other suppliers during the sample period, but the average quantity share of the US is less than that of Canadian and most importantly is the most unstable. Even though our major concern is on the three major suppliers (which account for almost 90% of the total supply), the final observation is that export share of the US is about three times larger than that of EC and Argentina combined, even if these two suppliers are able to charge about the same low price as US with a relatively low price variability in the market.

III.2. Empirical Methods and Results.

This section is developed to justify import diversification behavior, by answering these questions raised from Table 1, mostly based on the estimation of the net price risk measure (β_i^n) relative to \tilde{W}_i^* , and the measure of certainty equivalent monopolistic market power of suppliers (u_i). As an initial step, our basic methodology for estimating the time-conditional expected import prices for the five suppliers is based on a vector autoregression (VAR) framework representation of a number of variables, which constitute a rather large subset of full information set that is available to market participants. The non-structural VAR approach is widely accepted in a short-run forecasting and has the desirable property, in examining the interrelationships among a set of economic variables, that all variables of price series are treated symmetrically, so that we rely neither on any incredible identification restrictions nor on the issue of stationary of VAR variables in a significant manner (Doan: 1992). Details of the estimation are reported⁶ in Appendix 2.

Given the series of expected import prices, the next step is to obtain estimates of other key variables, such as β_i^* and u_i for all five suppliers. \tilde{W}_i^* is defined as the sum of optimal quantity share ($s_{i,t}^*$) multiplied by actual price ($\tilde{w}_{i,t}$) over the five suppliers at any time t , but the actual shares ($s_{i,t}^a$) are used instead as proxies for $s_{i,t}^*$. That's because, the optimal derivation is not feasible or even undesirable, without sufficient knowledge on the revenue and cost structure of the Chinese wheat industry. Also note that the quantity data is available only on the annual basis. Thus, we need to convert the frequency of actual and expected price data series from monthly into annually by averaging the 12-month periods. Given the estimates $E_t \tilde{w}_{i,t+1} (\equiv W_{i,t})$ and $E_t \tilde{W}_{i,t+1}^* (= \sum_i W_{i,t} \cdot s_{i,t+1}^a)$, where E_t stands for the time- t conditional expectation, we have once more conduct VAR estimations in a similar manner to

get the series of $\{\beta_{i,t}^*\}$. Since the time-dependent series is defined as $\{\text{cov}(\tilde{w}_{i,t}, \tilde{W}_t^*) / \text{var}(\tilde{W}_t^*)\}$, this procedure is to derive the numerator, $E_t[(\tilde{w}_{i,t+1} - W_{i,t})(\tilde{W}_{t+1}^* - E_t \tilde{W}_{t+1}^*)]$, as well as the denominator, $E_t[(\tilde{W}_{t+1}^* - E_t \tilde{W}_{t+1}^*)^2]$, of the series for all 5 suppliers (Appendix 3 shows details of the estimation).

For the preliminary diagnostics, Table 2 reports the following relationship, in each supplier's time-series analysis:

- (1) the correlation between $W_{i,t}$ (expected price) and $\beta_{i,t}^*$,
- (2) the covariance between $\tilde{e}_{i,t}$, the stochastic component of actual price, and \tilde{W}_t^* ,
- (3) the correlation between $W_{i,t}$ and the value of the market portfolio (\tilde{W}_t^*).

Further, for the purpose of cross-sectional comparisons, Figure 2 plots the average value of $\beta_{i,t}^*$ versus the expected import price ($W_{i,t}$) of the 5 suppliers over the latest 16 years. For these comparisons, since $\beta_{i,t}^*$ is determined independent of the total import level (Q_t) at any time t , price series are normalized by their annual sum to eliminate time effects of the quantity.

From the table, the results in general support the implications of the theoretical section. In the time series, all normalized expected prices are negatively correlated with their own risk measure. This of course indicates the existence of trade-off between the expected return, via a lower import price, and the risk, regardless of the level of market power of each supplier. In other words, expected prices become lower (higher) to compensate for their increased

Table 2. Relationships between key variables (in time-series).

	Argentina	Australia	Canada	EC	US
1. corr ($W_{i,t+1}$, $\beta_{i,t}^*$)	-.073	-.487	-.085	-.462	-.135
2. cov ($\tilde{e}_{i,t}$, \tilde{W}_t^*) *10 ³	-.289	.065	.198	-1.956	.219
3. corr ($W_{i,t+1}$, \tilde{W}_t^*)	-.494	-.089	.829	-.339	.012
4. $W_{i,t+1}$ (=E _t $\tilde{w}_{i,t+1}$)	.974	1.106	1.096	.879	.945
5. $\beta_{i,t}^*$.021	1.068	.959	.042	.899

Note: $\text{var}(\tilde{W}_t^*) = 2.1(*10^3)$. $W_{i,t+1}$ and $\beta_{i,t}^*$ are the sample means (1979-94).

(decreased) systematic risk of price relative to the value of market portfolio. The table also shows apparent positive $\text{cov}(\tilde{e}_{i,t}, \tilde{W}_t^*)$, covariance between $\tilde{e}_{i,t}$ and \tilde{W}_t^* , for the three major suppliers of Canada, US, and Australia, which account for almost 90% of total supply.

According to our theoretical model, a positive $\text{cov}(\tilde{e}_{i,t}, \tilde{W}_t^*)$, as a proxy of $\sigma_{i,m}$, is associated with the existence of market power and/or the significant market share of supplier i in the market. Due to the positive relationship between $\text{cov}(\tilde{e}_{i,t}, \tilde{W}_t^*)$ and β_i^* , the high covariance also implies high values of β_i^* 's for the suppliers.

As predicted, the estimated β_i^* for the three suppliers are highest among the group, but the underlying cause for the value of β_i^* for each supplier is not clear without further examinations. That is, the high β_i^* can be due to either market power or significant market share of suppliers, or both. Positive correlation of $(W_{i,t}, \tilde{W}_t^*)$ for Canada and US is also observed in the time-series. As mentioned in footnote 4, a higher level of market power may induce the higher correlation. The estimated market power (Table 3.b) shows the highest estimated market power for Canada, which exhibits a considerably higher correlation at .829 in Table 2. In sum, the relative risk (β_i^*) does affect the determination of expected price, as exhibited in the negative correlation of $(W_{i,t+1}, \beta_{i,t}^*)$ in the price time-series of all suppliers. However, for our purpose of analyzing the hedging role of products imported, similar to the CAPM, suspicions over the values of β_i^* as a true risk measure, are unavoidable as examined in the diagnosis, as well as Figure 2 below.

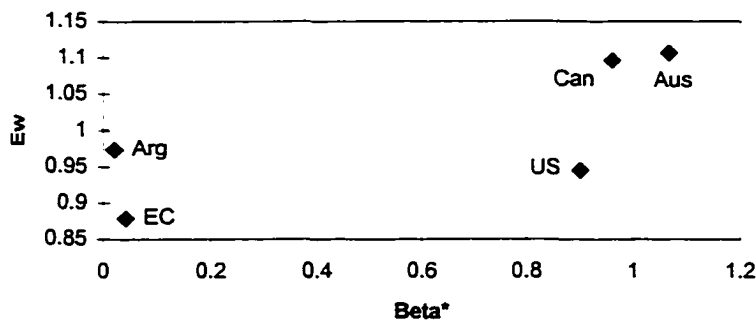


Figure 2. Average Expected Price (W_i) vs. Beta (β_i^*)

Figure 2 plots the sample mean of normalized W_i (expected price) and β_i^* for the purpose of a cross-sectional comparison. Unlike the time-series result, Figure 2 does not exhibit a negative cross-sectional relationship, as in Equation (1), between average values of two variables, W_i and β_i^* . A positive relationship among suppliers rather seems to appear in this scattered graph, and this contrasts to the theoretical and empirical result of WK in their application to the Japanese steam coal import market. These examinations may indicate that other factors, such as the monopolistic market power of the suppliers, and/or its relationship with β_i^* , are critical in analyzing the cross-sectional behavior of Chinese wheat import diversification.

To examine the effects of the monopolistic market power, the following system of conditional demand functions, $q_i(W, I)$ in Equation (2), is estimated. The econometric functional form estimated is:

$$(12) \quad \log q_{i,t} = a_{0i} + a_{1i} \log q_{i,t-1} + a_{2i} \log W_{i,t} + (1 - a_{2i}) \log W_{i,t}^{-1} + a_{3i} \log(q_{i,t}^{-1}) + a_{4i} \text{trend} + h_{i,t}; \quad i = 1, \dots, 5.$$

$q_{i,t-1}$ refers to the one-period lagged quantity demanded, $W_{i,t}^{-1}$ is the average normalized expected price of non-other than $W_{i,t}$, $q_{i,t}^{-1}$ is the total quantity imported net of $q_{i,t}$ and $h_{i,t}$ is the i.i.d regression error. Equation (12) represents a set of demand equations for products within the same category. And, the equation says that $\log(q_{i,t})$ series has been growing (or declining) because it has a trend, but would be stationary after detrending (i.e., $|a_{1i}| < 1$). Since the explanatory variables are different in each 5 equations with relatively small data set, and considering the high contemporaneous correlation in price series, the seemingly unrelated regression has been run to increase the estimation efficiency. The results of parameter estimates and standard errors in parenthesis are reported in Table 3.a, and the estimated market powers (u_i) are in Table 3.b.

Results show that the trend stationary specification is an appropriate one including the first-order lagged dependent variable as a regressor; i.e., $|a_{1i}| < 1$, for $i=1, \dots, 5$, and a_{4i} is non-zero at statistically significant levels for most equations. The estimation of parameters is not affected whether 'time' is included among the explanatory variables, or whether the variables

are detrended before the regression (Johnston and DiNardo, pp. 81; Pindyck and Rubinfeld, pp. 460). The monopolistic market power(u_i) is obtained from the regression. For the short-run(or impact) estimates, $u_{i(SR)}$ is measured, as defined in the theoretical section, as the reciprocal of demand elasticity, $-(\partial \log(q_{i,t})/\partial \log(W_i))^{-1} = -(1/a_{2i})$. The long-run (or dynamic) market power, $u_{i(LR)}$, which is our concern, is measured as $-[a_{2i}/(1-a_{1i})]^{-1}$. This is because, the detrended series of $\log(q_{i,t})$ is the stationary process at AR(1), the series, $\{\log(q_{i,t}) - a_{4i} \cdot \text{time}\}$, is supposed to have the same value at time t and $t-1$ in the long-run. The estimates of a_{3i} (or $qn_{i(LR)}$ for a sufficiently large t) represent the cross-market demand effects, which account for the response of $q_{i,t}$ due to changes in total quantity net of $q_{i,t}$. The direct use of total expenditure, as a proxy of income level, as a regressor is avoided due to the multi-collinearity problem between explanatory variables, and the effect of changes in income or total quantity demand should be reflected in the equation via estimates of trend and $\log(q_{i,t-1})$ coefficients.

In our empirical example, the analysis is limited to only 5 Armington-type suppliers, and also to relatively small data set due to the annual quantity data used. Based on these outcomes, however, we may justify the behavior of Chinese wheat import diversification, especially, by answering those specific questions mentioned in the last part of Section III.1. From Equation (10), once we achieve estimates for W_i and β_i^* , we are able to derive an estimate for the net risk measure(β_i^n) relative to \tilde{W}^* , as a fraction of β_i^* , to visualize how much of the import price variation is explained by the risk measure and how much is attributable to the direct effect of the monopolistic market power of the suppliers. Table 4 summarizes the average values of $1/(1-u_i)$, expected prices, β_i^* , and β_i^n . The result shows that the net systematic risk(β_i^n) of some suppliers (especially, Canada and US) is quite different from β_i^* in a significant manner; i.e., $\beta_{(Canada)}^*$ is the second largest at .959 contrary to $\beta_{(Canada)}^n = .426$, which is the median value in the whole group, and $\beta_{(US)}^n$ is largest, contrary to $\beta_{(US)}^*$, which is much less than $\beta_{(Australia)}^*$.

Even though the intercept term ($E(\tilde{w}_z)$) of Equation (1) is not a major concern of this paper, we derive a time-series of risk premium at time t (RP) and the plots are exhibited in Figure 3. Following Wolak and Kolstad(WK), RP_t is defined as $(E(\tilde{w}_{z,t}) - E(\tilde{W}_{o,t}))/E(\tilde{W}_{o,t})$, where $E(\tilde{W}_{o,t})$ and $E(\tilde{w}_{z,t})$ are expected value for the optimal

Table 3. Conditional Demand Estimation

(*, **, statistically significant at 90% and 95% confidence level)

a. SUR estimation of Equation (12) for the annual data 1978:7-95:6 :

$\log q_i \backslash \text{RHS}$	$a_{0i}(\text{constant})$	$a_{1i}(\log q_{i,t-1})$	$a_{2i}(\log W_i)$	$A_{3i}(\log q_i^{-1})$	$a_{4i}(\text{trend})$
Argentina	-9.79(10.2)	-.36(.25)*	-13.4(6.5)**	2.54(1.4)**	-.31(.1)**
Australia	12.8(1.63)**	.36(.15)**	-4.24(1.4)**	-1.06(.2)**	.04(.03)
Canada	8.24(2.15)**	-.17(.17)	-2.11(.98)**	.21(.19)	.001(.01)
EC	-29.4(10.0)**	.04(.22)	-2.04(5.09)	4.21(1.2)**	.19(.09)**
US	5.08(8.95)	.46(.19)**	8.06(8.52)	-.11(1.18)	.06(.11)

b. Estimated market power (u_i) and quantity response elasticity (qn_i)

	$u_{i(LR)}^1$	$u_{i(SR)}$	$qn_{i(LR)}^2$
Argentina	.102	.075	1.865
Australia	.151	.235	-1.652
Canada	.556	.474	.176
EC	.471	.49	4.372
US	-.067	-.124	-.199

1. $[1/(1-u_{i(LR)})]$ is an alternative measure of power, rather than u_i , and the magnitudes are ranked in the order of $0.937(\text{US}) < 1.113(\text{Arg.}) < 1.178(\text{Aust.}) < 1.892(\text{EC}) < 2.25(\text{Can.})$.

2. qn_i refers to the changes in q_i with respect to the change in q_i^{-1} in percentage term, and $qn_{i(SR)}$ is simply a_{3i} .

risky portfolio and for the riskless portfolio, respectively, as introduced in Equation (1). In other words, the value of RP_i is the negative of the ratio of market price of risk,

$E(\tilde{W}_{o,t}) - E(\tilde{w}_{z,t})$, over the expected market price for the risky portfolio. The series of RP_i in this paper is measured in a rough manner after adjusting market power effects in observed and forecasted prices, based on our estimates of W_i and market power(u_i). Also note that

Table 4. Summary of estimation results

	Argentina	Australia	Canada	EEC	US
$1/(1-u_i)$	1.112	1.178 (3)	2.25 (1)	1.892	0.937 (5)
$W_i (=E_t \tilde{w}_{i,t+1})$	3.703	4.23 (1)	4.182 (2)	3.346	3.599 (4)
β_i^*	.021	1.068 (1)	.959 (2)	.043	.899 (3)
β_i^a	.019	.907 (2)	.426 (3)	.022	.959 (1)

Note: These are average values over the relevant time: 79.7-94.6.

Normalized W_i values reported in Table 2.

Parentheses: the magnitude order of the corresponding variable for the three major suppliers.

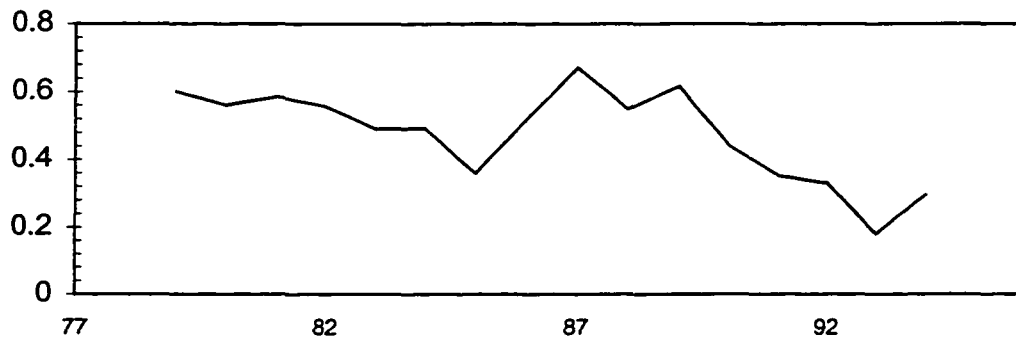


Figure 3. Risk premium (RP)

optimal mixture of quantity shares, as well as prices, in these portfolios differ from the set of s_i^* in \tilde{W}_t^* . Thus for the derivation of $E(\tilde{W}_{o,t})$ and $E(\tilde{w}_{z,t})$, the market power term is first adjusted in W_{it} series, and then the corresponding optimal quantity shares for the five suppliers, given the adjusted prices, are calculated in a way similar to WK⁷.

Insufficient credibility on the estimated values of RP_t is unavoidable, since the values are based on derived outcomes from the previous regressions; i.e., the plots of RP_t in the figure are only approximated values. But one implication from the analysis is that, the

importing agency appears willing to pay around 47.5 percent, in average of the sample period, above the power-adjusted market price for a supply of wheat having no risk. Also, a weak trend of decreasing risk premium is observed in the figure, especially after the late 1980s. This is consistent with the view that, as the importance of quality attributes increases in the Chinese market as reported by Crook et al., the average premium China is willing to pay for wheat with no price risk should decrease.

Mostly based on the results of Table 4, we now may answer the questions raised early about the Chinese wheat import behavior in the following way:

(1) Recall that one of the questions is on Canada's behavior: the highest price and price variance, closely next to Australia, but the most stable quantity share among the major three suppliers (during 1978-95), as summarized in Section III.1. For Canada, the strong market power seems to be the key explanation why its products maintain sizable market shares in the Chinese wheat import market despite their high first two moments of actual price. Results show that Canada exercises the most supplying power in a significant way in the Chinese wheat market. As mentioned, the effect of market power of Canadian products can be also captured from the results in Table 2, the time-series relationships between key factors of this model. Furthermore, within the group of three major suppliers of Canada, US, and Australia, the lowest β_i^n value of Canada in a considerable manner indicates that consistent imports of Canadian products provide the importer a good hedge against market price variation. Thus, the importer takes advantages in risk control and in his preference over Canadian products by maintaining sizable and stable shares of the products.

Estimation results show that Australian data generally mimics the Canadian, or the US, in a less considerable manner: i.e., the second largest $u_{i(LR)}$ (and also $u_{i(SR)}$), and the second lowest β_i^n among the major suppliers. One thing to note is the negative response ($a_{3(Aust.)}$ or $q_{(Aust.)}$) of Australian wheat demand with respect to changes in $q_{(Aust.)}^{-1}$, which is highly significant and negative in contrast to the rest of suppliers, and this reflects the independence of the demand from the rest of market demands. This may reflect the substitute aspect of Australian wheat for the other products due to its southern geographical location, based on the revision of the Chinese importing agency's annual importing plan to fulfill the unexpected gap between domestic supply and demand. On the other hand, this negative

response, with the highest constant term, may correspond to the gradual decrease of Australian share over time (e.g., 20.5% during 1978-85 to 14.3% after 1985) and, thus, the share far below that of US in average. Despite its geographical niche (and perhaps its superior quality), Australian wheat suppliers appear to increase their price way too high over time (See Figure 1) enough to lose the significant market occupancy.

(2) Three aspects are noticeable from the review of US data. First, the US stands on the lowest point over all suppliers in terms of its magnitude of $u_{i(SR)}$ and $u_{i(LR)}$. Secondly, the US has the highest net systematic price risk (β_i^n), and, finally, exhibits the considerable negative sensitivity (qn_i) toward the increase in $q^1_{(US)}$, total market demand net of US (i.e., the estimated value of $qn_{(US:LR)} = -1.119 < 1.865$ (Argentina), $.176$ (Canada)). Overall, it seems like that the US products are not a primary choice within the group of major suppliers. The observations imply that, (a) its monopolistic market power is the lowest among the entire group, (b) imports from the US do not help stabilizing the market price risk despite its low price and the least price variability among the whole suppliers, and (c) its demand is negatively subject to the expansion of overall market demand at the given time. The third observation indicates that the substitute role, rather than a primary choice, of the US product, without having the geographical advantage like Australia. All of these results appear to be proper sources explaining the reason why US share is less than that of Canadian in average and most importantly is very unstable over time. These factors, especially (a) and (b), must be compensated for in terms of a low expected supply price in order for China to have significant market demands for the US wheat.

(3) Even though the focus of this analysis is mostly on the three major suppliers, the final question raised early was the significantly higher US share over the combination of shares of EEC and Argentina despite about the same low price and price variability. These three suppliers are the group that charges the lowest prices and lowest estimated market power among the suppliers in the Chinese wheat market. Given the above observations on the US estimates, the key answer for the question appears to be on the general fact that the US is one of the largest wheat producer and exporters in the world with a variety of product classes. Note that the estimated price effect ($a_{2(US)}$) on demands is statistically negligible for the US, and the values of ($a_{3(US)}$, $qn_{(US)}$) are negative and statistically insignificant unlike the

other two suppliers, despite being a major supplier. These examinations give us the idea that wheat import from the US is generally treated as the best ‘residual’ (or ‘substitute’) in terms of its large quantity available and product varieties from the viewpoint of Chinese importing agency. In other words, once some base amount of wheat is purchased from the non-US sources (especially, Canada), CEROILS then appears to allocate a share of all additional purchases of several classes to the US, as mentioned in the report by Crook et al. (1993).

IV. CONCLUSION

WK in their 1991 AER paper demonstrate one way to justify the behavior of import diversification by examining a negative relationship between expected import price (W_i) and systematic price risk (β_i^*) relative to the optimal market portfolio. This relationship across prices is parallel to the idea of the security line of the CAPM, reflecting the importer’s incentive to diversify away systematic price risk. This article attempts to extend their framework by examining the supplier-side influence on the equilibrium price, since WK’s approach is limited only to the importer’s perspective assuming ‘homogeneity’ of products imported. In the theoretical section of this paper, equilibrium relationships among these key explanatory variables, W_i , β_i^* , and the monopolistic market power (u_i), necessary to the analysis, are derived by allowing the supplier’s optimality conditions within the modified framework of the CAPM.

The main argument is, if the monopolistic market power of suppliers is present in the importing agent’s decision-making, then u_i positively affects β_i^* . The underlying cause for the positive relationship is the increased expected dollar price of risk given the different effect on the importer’s revenue for each product. The existence of differentiated products thus disturbs the negative and linear relationship, which reflects the systematic risk-diversification effect of the importer, between W_i and β_i^* . And this paper further exhibits an orthogonal decomposition of β_i^* into the net price risk (β_i^n) relative to \tilde{W}^* and the market power term to visualize how much of the import price variation is explained by the risk measure and how much is attributable to the direct effect of the monopolistic market power of the suppliers.

As an empirical application in the international trade, the Chinese wheat import market is analyzed in Section III. Observations from the basic statistics of Table 1 provide us some specific questions against the criterion of expected cost minimization, for instance, the most unstable shares of the US over the sample time-period despite its lowest average price and price variability among the suppliers. VAR analysis is adopted to acquire the time-conditional expectations of each import price series $\{W_i\}$, and the series of $\{\beta_i^*\}$ given the estimates of $\{W_i\}$. Empirical relationships between the key factors are examined in the last part of Section III.2, and the specific questions raised are answered to justify the diversifying behavior of Chinese wheat import. The results certainly confirm the theoretical framework that the monopolistic market power should be a critical factor, in its way of affecting W_i and β_i^* , being considered in a demand analysis of non-homogeneous products. In sum, unless the market power of all suppliers is virtually negligible, the analysis purely based on the 'price-based portfolio' may mislead us in conducting an empirical study of real asset allocation model (e.g., import diversification).

REFERENCES

- Abbot, Phillip C., Matterson, Paul, and Reca, Alejandro, 1993, Imperfect Competition and Exchange Rate Pass-Through in the Food Processing Sector, *American Jr. Agricultural Economics*, 75: 1226-1230.
- Appelbaum, E., 1982, Estimation of The Degree of Oligopoly Power, *Jr. Econometrics*, 19: 287-299.
- Armington, P., 1969, A Theory of Demand for Products Distinguished by Place of Production, *IMF Staff Paper*, 16: March: 159-176.
- Black, Fischer, 1993, Beta and Return, *Jr. Portfolio Management*, 20: Fall: 8-18.
- Blair, Roger D., 1974, Random Input Prices and the Theory of the Firm, *Economic Inquiry*, 214-225.
- Bohenstedt, G. W. and Goldberger, A. S., 1969, On the Exact Covariance of Products of Random Variables, *Jr. American Statistical Association*, 64: 1439-1442.

- Chakravarty, Satya R., 1995, Issues in Industrial Economics, Avebury, Ashgate Publishing Co., Brookfield, VM.
- Chen, K., Cheng, D., and Hite, G., 1986, Systematic Risk and Market Power: An Application of Tobin's q , *Quarterly Review of Economics and Business*, 26: 3: 58-72.
- Copeland, Thomas E. and Weston, J. Fred, 1988, Financial Theory and Corporate Policy, Addison-Wesley, Boston, MA.
- Crook, F., Lin, W. and Colby, H., 1993, Determinants of Wheat Import Demand: China. USDA, Economic Research Service.
- Dixit, A. K. and Stiglitz, J. E., 1979, Monopolistic Competition and Optimum Product Diversity, *American Economic Review*, 67: 297-308.
- Doan, Thomas, 1992, RATS User's Manual, Estima, Evanston, IL.
- Enders, Walter, 1995, Applied Econometric Time Series, John Wiley and Sons, INC., NY, NY.
- Gregory, Allen and Watt, David, 1995, Sources of Variation in International Real Interest Rate, *Canadian Jr. Economics*, Spring: 120-40.
- Helpman, E. and Krugman, P. R., 1989, Trade Policy and Market Structure, The MIT Press, Cambridge, MA.
- Jagannathan, R. and McGrattan, E., 1995, The CAPM debate, *Federal Reserve Bank of Minneapolis Quarterly Review*, Fall: 2-17.
- Johnston, J. and DiNardo, J., 1997, Econometric Methods, 4th ed., McGraw-Hill Co., NY, NY.
- Karp, Larry S. and Perloff, Jeffrey M., 1993, A Dynamic Model of Oligopoly in the Coffee Export Market, *American Jr. Agricultural Economics*, 75: 448-457.
- Larue, B. and Lapan, H., 1992, Market Structure, Quality and World Wheat Market, *Canadian Jr. Agricultural Economics*, 40: 311-328.
- Leahy, John V. and Whited Toni, 1996, The Effect of Uncertainty on Investment: Some Stylized Facts, *Jr. Money, Credit, and Banking*, 28: 1: 64-83.
- Li, Zhong, 1992, China's Wheat Import Decisions: Testing a Risk-Diversification Model, Unpublished Master's Thesis, University of Nebraska, Lincoln.

- Mills, Terence C., 1993, The Econometric Modeling of Financial Time Series, Cambridge University Press, Cambridge, MA.
- Peysner, Paul S., 1994, Beta, Market Power and Wage Rate Uncertainty, Jr. *Industrial Economics*, 2: 217-226.
- Pick, Daniel H. and Carter, Collin A., 1994, Pricing to Market with Transactions Dominated in a Common Currency, *American Jr. Agricultural Economics*, 76: 55-60.
- Scherer, F. M. and Ross, David, 1991, Industrial Market Structure and Economic Performance, 3rd ed., Houghton Mifflin Company, Boston, MA.
- Subrahmanyam, M. and Thomadakis, S., 1980, Systematic Risk and the Theory of the Firm, *Quarterly Jr. Economics*, 437-451.
- Sun, Liming, 1993, Market Power, Wage Rate, and Systematic Risk: A Homogeneous Production Function Approach, *Jr. Economics and Business*, 45: 99-108.
- Turner, Stephanie and Ruppel, Fred, 1993, Time Lag Between Export Purchases and Export Shipments of Wheat, by Class, *Wheat S&O/WS-303*, Sep.: 19-22.
- U.S. Department of Agriculture, Economic Research Service, China: Agriculture and Trade Report, various issues, 1980-95.
- Wolak, F. A. and Kolstad C. D., 1991, A Model of Homogeneous Input Demand Under Price Uncertainty, *American Economic Review*, 81: 3: 514-38.

FOOTNOTES

1. In the empirical application, we replace the set of s_i^* 's with the actual shares observed without having serious difficulty, since this CAPM type analysis is basically about the equilibrium relations for both importer's and suppliers'.
2. For the paper dealing with output price uncertainty, with known input prices and production process, the implicit justification for (only) output price uncertainty is on the existence of time-lag between production decision and actual production and sales of output. On the other hand, for a rationale for the case of stochastic input price, one might imagine a firm taking orders for future delivery of its product at a fixed price. Once committed to producing the specific output quantities, actual input prices, especially material input costs,

are not known in advance until the inputs are purchased. Most competitive bidding contracts generally fall into this class of problem (Blair: 1974).

3. Note that in the normal case we would expect firms to have positive systematic risk so with $\sigma_{i,m} > 0$ the certainty equivalent term would be less than one. Consequently, uncertain revenue is valued at less than its expected value due to the discount for systematic risk (Chen, pp. 60).

4. To examine a positive relationship between u_i and β_i^* in a more intuitive way, consider only two suppliers. \tilde{W}^* is the sum of $s_1^* \tilde{w}_1$ and $s_2^* \tilde{w}_2$ or $(1 - s_1^*) \tilde{w}_2$, where s_1^* and s_2^* are the optimal shares for the supplier 1 and 2 with stochastic prices \tilde{w}_1 and \tilde{w}_2 . For the supplier 1 with higher market power, an increase in \tilde{w}_1 will lead to the higher increase in \tilde{W}^* than the case with a lower or without market power. That's because of (1) the direct effect (i.e., W_1 is higher with market power), and (2) the indirect effect (i.e., the decrease in s_1^* is smaller (and so is the increase in s_2^*)). Note that β_i^* is independent of the level of Q , and that s_1^* is less sensitive to the price changes, given q_1 's monopolistic effect in the market of Q . In other words, the changes in $(\tilde{w}_1 - \tilde{W}^*)$ is lower with more market power than the changes without or small degree of market power. Thus, given $\text{var}(\tilde{W}^*)$, $\text{cov}(\tilde{w}_1, \tilde{W}^*)$ becomes larger with market power due to the close stochastic movements in $\text{var}(\tilde{W}^*)$ and $\text{cov}(\tilde{w}_1, \tilde{W}^*)$, and β_i^* , $\text{cov}(\tilde{w}_1, \tilde{W}^*)/\text{var}(\tilde{W}^*)$, becomes larger toward one.

5. The measure of u_i is estimated from an econometric model of systems of demand equations in our empirical application (Section III.2). But in the future research, u_i might be driven by qualitative analysis (for instance, hedonic price functions), which would be the direct way to address the problem of heterogeneous product qualities. Alternatively, we may be able to acquire a relative measure of quality from a survey for time-dependent preferences over products, which might be even more accurate, since trades in agricultural products are significantly subject to the non-economic reasoning, such as trade embargo.

6. For the possible cointegration between series of prices, Dickey-Fuller and Augmented Dickey-Fuller tests are first performed under various specification of the model to infer the number of unit roots (if any) in each of the variable. Tests show that price series of Canada, Argentina, and Australia are $I(1)$ process while those of EC and US are stationary in $I(0)$ process. This failure of cointegration in the first-stage can be also acknowledged

from the VAR analysis in the sense of existence of (1) the high contemporaneous correlation among variables, and (2) the tendency to lead (i.e., Granger-cause) the market price by some price series (e.g., US). - See Appendix 2 for a detail.

7. The first set of optimal shares in $E(\tilde{W}_{o,t})$ correspond to the solutions of solving the problem of maximizing the agent's expected utility of profit, while restricting the ex-ante utility to the mean-variance (MV) specification and assuming non-existence of suppliers' monopolistic market power (Equation (8) and (10) in WK). The second optimal mixture of shares in $E(\tilde{w}_{z,t})$ indicates the portfolio of suppliers, which has no market risk, given the risky prices. To compute this portfolio, WK solve for the minimum-variance weighted-average price subject to the constraint that its covariance with $\tilde{W}_{o,t}$ is zero. The solution is shown in Equation (25) in WK. The calculation of these two types of optimal shares in this paper is strictly based on their equations (Equation (8) and (25)), while assuming, instead of estimating, the risk coefficient (λ) to be .75 (Black: 1993). For the detail of derivation of the shares, consider WK's 1991 paper, and for the empirical procedure of this paper, consider Appendix 4.

APPENDICES

1. Import Price Data

The import price quoted in this article includes both transportation costs and average exchange rates because the importing agency should be interested in importing prices. The U.S. has started an export-aid program, so called as Export Enhancement Program (EEP), to reduce its wheat export price to China since the early beginning of 1987, and these arrangements of price were made in the set of US price data. Thus the US export price data is the average of the three classes (reported in World Wheat Statistics) adjusted by the EEP bonus rate, which is calculated as the ratio of unitary export value (reported in the series of Wheat Situation and Outlook) over the average price. The EC uses the common market restitution program to cut off the price of agricultural exports to specific countries, and these prices net of export refunds can be directly obtained from the WWS. Canada operates the central wheat board that functions as a monopoly outside normal market channels, and, with this agency, is able to utilize its positions to guarantee special quality characteristics and/or lower prices. Specific data for the price-cutting program in Canada is not however available to the public. As a result, it's a common method to apply the same rate of EEP of the US, to Canadian, as well as Australian, price set, which is done in this paper.

2. Estimation of Expected Price in a VAR

For the estimation of expected price, consider the following system of equations:

$$(a) \quad w_{i,t} = c_i + \sum_{j=1}^p a_{ij} w_{i,t-j} + \sum_{j=1}^p a_{isj} w_{s,t-j} + e_{i,t}, \text{ for } i=1, \dots, 5 ;$$

$w_{i,t}$ = the actual Chinese wheat import price from the i -th supplier at time t ,

c_i = the 1×15 vectors containing a constant, 11 seasonal (monthly) dummy variables, a time trend, and two level dummies to account for the Chinese currency (yen) depreciation (1994:1) and the subsidy program (1987:7),

p = the number of lags for the endogenous variables,

a_{ikj} = coefficient for the k -th endogenous variable (i.e. w_k) with j -th lags for the dependent variable $w_{i,t}$.

$e_{i,t}$ = independently and identically distributed disturbance terms, while $E(e_{i,t}, e_{j,t})$ for all i, j , is not necessarily zero.

The issue of whether the variables in a VAR need to be stationary exists. Doan(1992), for instance, recommended against differencing or the use of a deterministic time trend. The trend dummy is included however in this estimation since the detrending yields the best diagnostics. Also, the monthly dummies are initially included given the data on the monthly basis. The coefficient estimates are of particular interest in a VAR. If, for example, all coefficients of a_{ikj} , for all $j=1, \dots, p$, are zero, then the knowledge of the w_k series does not reduce the forecast error variance of w_i series. Formally speaking, $\{w_k\}$ does not Granger cause $\{w_i\}$, and, unless there is a contemporaneous response of $\{w_k\}$ to $\{w_i\}$, the $\{w_i\}$ series evolves independently of $\{w_k\}$. If, instead, any of the coefficients in these polynomials differ from zero, there are interactions between the two series.

Each equation is estimated using the lag lengths of 12, 6, and 3 months. Because each equation has identical right-hand-side variables, ordinary least square (OLS) is an efficient estimation technique. Using χ^2 -tests, it appears that the length of 12 is the most appropriate choice. In addition to that, alternative test criterion to determine the appropriate length and/or the seasonality are the multivariate generalization of the Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBIC: Enders, pp. 315), and the criterion is to choose the model with the lowest value of these statistics. Table A.1 shows that AIC is the lowest in the model of 12 lags without the seasonal dummies but SBIC draws the preference over the model of same lags with dummies. Among them, since we fail to reject the null of the model without seasonal dummies at 1% significance level with χ^2 -tests, we decided to choose model (4) in the table.

Although the objective of the VAR analysis in this section is to acquire the time-conditional expectations of each price series, we obtained the variance decomposition, using the orthogonalized innovations obtained from a Choleski decomposition to ascertain the importance of the interactions between the 5 price series. Variance decomposition are presented in Table A.2 for two orderings; that based on the relative shares of suppliers (I : Can., US, Aust., Arg., EEC) in average, and an ordering based on the relative average price

(II: Aust., Can., Arg., US, EEC), for the 24-month forecasting horizons. The forecast error variance decomposition tells us the proportions of the movements in a sequence due to its own shocks versus shocks due to the other variables. Given the high contemporaneous correlation (for example, the correlation between $e_{Arg,t}$ and $e_{Aust,t}$ is 0.474), the order of the variables in the factorizations have significant influences on the results.

Granger-causality tests are also performed for all incidences and are reported in the parenthesis of Table A.2. An interesting hypothesis to examine is whether the price movements in Canada, as a share leader in average, or Australia, as a price leader, have a tendency to lead (i.e., Granger-cause) movements in the other markets. The tests indicate, however, that both are not the case and conclude in favor of the restricted model of these two variables for most of the equations. Nonetheless, certain features do stand out from these outcomes, combined with the analysis of the impulse response functions, which show the response of each variable to a unit innovation in the others. The price movements of the US and EEC, rather, Granger causes other suppliers' price, as seen from the tests, in which it may also be visualized in the impulse response functions due to the high effects of their innovations, especially the US, to own and to the others. Australia seems to be the most active to/from international influences in the sense that it is affected by the feedback from the US and EEC, but also has fairly high percentage of the variance decomposition to most cases in both orderings. Argentina, and perhaps Canada, on the other hand, appears to act as a

Table A.1. Tests for lag-length and seasonal dummies
(** reject the null of restricted model at 5% significance level)

Model\test-stat.	AIC	SBIC	χ^2 -tests (alternative to model(1))
(1) 12-lag length	2.156	-5.934	
(2) 6-lag length	3.499	-7.030	363.04**
(3) 3-lag length	3.976	-7.773	197.59**
(4) 12-lag w/o seasonal dummies	2.088	-6.897	60.77

Table A.2. Forecast error variance decomposition (24-month) and Granger-causality tests (F-statistics) in the parenthesis (** reject the null of restricted model at 5% significance level)

LHS\RHS variables	Argentina .. ordering(I / II)	Australia (I / II)	Canada (I / II)	EEC (I / II)	US (I / II)
Argentina	24.1 / 22.2 (25.41**)	24.8 / 32.7 # (1.36)	22.4 / 7.4 # (0.49)	20.2 / 20.2 (9.85**)	8.7 / 17.5 (2.34**)
Australia	7.5 / 4.6 (2.77**)	38.0 / 46.8 (35.74**)	26.7 / 5.1 # (1.66)	17.4 / 17.4 (16.54**)	10.4 / 26.1 (3.29**)
Canada	3.2 / 2.0 (2.94**)	18.8 / 42.7 (1.10)	48.4 / 14.5 (29.91**)	12.1 / 12.1 (10.91**)	17.5 / 28.6 (2.98**)
EEC	17.1 / 16.2 # (1.17)	18.1 / 27.6 # (1.56)	20.3 / 9.4 # (1.50)	36.0 / 36.0 (3.48**)	8.5 / 10.8 (2.29**)
US	11.5 / 9.7 (2.75**)	21.5 / 39.0 # (1.59)	35.4 / 11.2 # (0.60)	18.4 / 18.4 (11.89**)	13.3 / 21.7 (15.27**)

follower, reacting innovations in other price, rather than its own innovations having an influence on the others (Enders; Mills).

Since the interrelationship of price movements is not the major concern for the VAR analysis here, combined with outcomes of Table A.2, we re-estimated Equation (a) while restricting all the coefficients of the variables marked as (#) in the table to get the time-conditional expectations of each price series. Note that the re-estimation is necessary since the forecasts from an unrestricted VAR are known to suffer from over-parameterization. The estimation of seemingly unrelated regression (SUR) would be the appropriate choice, given the non-identical structure of the right-hand-side variables. Finally, the fitted values for each price equation are assumed to be the expected import price series and are used for the later estimation purpose.

3. Brief Description on Estimation of $\beta_{i,t}^*$

Time t -conditional series of $\beta_{i,t}^*$ is defined as $\{E_t[N_{i,t}] / E_t[(D_{t-1})^2]\}$ for all $i = 1, \dots, 5$ suppliers, where $N_{i,t}$ and $(D_{t-1})^2$ indicate $[(\tilde{w}_{i,t-1} - W_{i,t})(\tilde{W}^*_{t-1} - E_t\tilde{W}^*_{t-1})]$ and $[(\tilde{W}^*_{t-1} - E_t\tilde{W}^*_{t-1})^2]$, respectively. Since we have already obtained series of $N_{i,t}$ and $(D_{t-1})^2$ from the estimation of expected prices (i.e., $W_{i,t}$ for $i=1, \dots, 5$), the next step is to derive the time-dependent expectation of these series. To do so, two separated vector auto-regressions, say V_I and V_{II} , without any restriction, of order one are run: one for five $N_{i,t}$ series and the other for the six series of $[(D_{t-1})^2]$ and $[(\tilde{w}_{i,t-1} - W_{i,t})^2]$ for 5 suppliers. Formally, these two systems of equations we will estimate are expressed as, $lhs_{i,t} = c_i + \sum_{j=1}^m a_{ij} rhs_{j,t-1} + r_{i,t}$. For the regression V_I , i is $1, \dots, 5$, and $m=5$, and, for V_{II} , $i=1, \dots, 6$ and $m=6$. And, lhs and rhs variables are numerators and denominator(s) of $\beta_{i,t}^*$ as defined above, while c_i = the 1×2 vector containing a constant and time trend, a_{ij} = coefficient for the j -th endogenous variable (i.e. rhs_j) with first lag for the dependent variable $lhs_{i,t}$, $r_{i,t}$ = independently and identically distributed disturbance terms, while $E(e_{i,t}, e_{j,t})$ for all i, j , is not necessarily zero.

Limited number of 17 annual observations restricts the VAR analysis to be order one. The denominator of $\beta_{i,t}^*$ is the common value for the series, but the series of $[(\tilde{w}_{i,t-1} - W_{i,t})^2]$ for 5 suppliers are included in the second VAR to increase the estimation efficiency. For each regression, 'forecast error variance decompositions (4-year forecasting horizon)' and Granger-Causality tests are reported in Table B.1.1 and Table B.1.2. Based on these results, the seemingly unrelated regression (SUR) is run, and the results are also reported below in Table B.2.1 and Table B.2.2 for each regression. Note that the re-estimation is necessary due to over-parameterization of the unrestricted VAR, and that the fitted values are used to estimate $\beta_{i,t}^*$ -series for the five suppliers.

4. Risk Premium

Derivation of the series is based on previous estimates of market power-adjusted prices.

As mentioned, the first set of optimal shares in $E(\tilde{W}_{o,t})$ corresponds to the solutions of solving the problem of maximizing the agent's expected utility in a MV specification. The only difference between WK's equations (8 or 10) and this paper is that, risk coefficient (λ) is assumed to be .75, following Black (1993), instead of restricting $\lambda_t Q_t$ being a constant over

Table B.1.1. Forecast error variance decomposition (4-year horizon) for the numerators (V_N): sample period (1978-1994) (* statistically significant at 90 or a higher percent confidence level)

LHS\RHS	N1	N2	N3	N4	N5
N1	92.2 (-.22)	1.0 (.42)	3.5 (-.5)	3.0(-1.05)	.27 (.17)
N2	19.3(-1.29)	48.8(.95)	25.2(.52)	5.1(-2.3*)	1.57(-.58)
N3	26.6(-1.63)	24.1(.36)	44.3(.74)	4.35(-1.9*)	.74(-.34)
N4	17.1 (-.72)	17.2(1.8*)	47.9(-.26)	15.3(-1.95*)	2.59(-.73)
N5	15.0 (-.63)	53.9(-.14)	10.4(.82)	2.3(-.59)	18.3(-.38)

Note: The numbers 1 through 5 indicate Argentina, Australia, Canada, EC, US, respectively. Parentheses report Granger-Causality Statistics (t-value under order one). Further, $N(i) = [(\tilde{w}_{i,t+1} - W_{i,t})(\tilde{W}^*_{t+1} - E_t \tilde{W}^*_{t+1})]$.

Table B.1.2. Forecast error variance decomposition (4-year horizon) for denominator (V_D)

LHS\RHS	D1	D2	D3	D4	D5	Dm
D1	97.6	.48	.33	.01	1.08	.47
D2	7.59	60.6	23.9(1.8*)	2.21(1.7*)	3.39	2.3
D3	49.6(-2.9*)	10.9	32.7	4.13(-2.9*)	1.58	1.05
D4	4.15	24.4(8.3*)	32.8	25.7(2.0*)	1.06	12(-4.3*)
D5	8.36	25.5	9.5	5.26	51.1	.32
Dm	24.4	34.1	28.8(2.2*)	1.9	3.4	7.3

Note: $D(i) = [(\tilde{w}_{i,t+1} - W_{i,t})^2]$ and $Dm = [(\tilde{W}^*_{t+1} - E_t \tilde{W}^*_{t+1})^2]$. Parentheses report only statistically significant Granger-Causality statistics.

Table B.2.1. SUR estimation for numerator of β_i *
 (Yr86 is a dummy variable due to the low market share for US in 1986)
 (*, **, statistically significance at 90 and 95 % confidence level)

LHS\RHS	N1	N2	N3	N4	N5
Constant	.0024	.0035**	.0043**	-.0042*	.0031**
Trend	-.002	-.002**	-.002**		-.0012*
Yr86					.0018*
N1(-1)	-.129	-.201**	-.286**	-.252	
N2(-1)		-.136	-.186	3.15**	-.393**
N3(-1)			.353*	-.491	
N4(-1)	-.074	.297*	-.062	-.434*	
N5(-1)					.287

Table B.2.2. SUR estimation for denominator of β_i *

LHS\RHS	D1	D2	D3	D4	D5	Dm
Constant	.0098**	.0026**	.011**	-.017**	.003**	.0032**
Trend	-.0006*	-.00008	-.0006**		-.00007	-.00014*
Yr86					.0015	
D1(-1)	-.148		-.395**			-.095*
D2(-1)	-.202	.095		19.01**	-.142	-.133
D3(-1)		.153*	.265*	3.436*		.315**
D4(-1)		-.0081*	-.039**	.293**		
D5(-1)					-.152	
Dm(-1)				-13.46**		

time as in WK, where Q_t is the total quantity demanded. The second optimal mixture of shares in $E(\tilde{w}_{s,t})$ indicate the portfolio of suppliers, which has no market risk, given the risky prices. For the derivation of shares, this paper strictly follows Equation (25) of WK. These optimal shares are reported in Table C.1 and C.2, respectively.

To do so, however, we additionally need the variance-covariance matrix of power-adjusted prices. The matrix is simply measured as the residual covariance matrix by conducting a seemingly unrelated regression for the following system of equations:

$$[W_{a^*(i,t)} / \tilde{w}_{a^*(i,t+1)} - 1] = \text{constant}_{(i)} + e_{(i,t)} \quad \text{for } i=1, \dots, 5,$$

where $W_{a^*(i,t)}$ and $\tilde{w}_{a^*(i,t+1)}$ denote power-adjusted expected and actual prices, and $e_{i,t}$ is an error term. The results show highly insignificant constant terms, being close to zero, for all 5 equations and the corresponding matrix is

$$\begin{bmatrix} 1.91 & & & & \\ -.11 & .99 & & & \\ .29 & 1.16 & 1.76 & & \\ -2.8 & -4.40 & -.35 & 26.5 & \\ -.02 & 1.44 & 1.75 & -7.0 & 2.37 \end{bmatrix} .$$

Table C.1. Set of optimal shares in $E(\tilde{W}_{o,t})$: sample period (1979-94)

OS1	OS2	OS3	OS4	OS5
0.00000	0.00000	0.90691	0.093087	0.00000
0.00000	0.00000	0.87719	0.12281	0.00000
0.00000	0.00000	0.88135	0.11865	0.00000
0.00000	0.00000	0.87561	0.12439	0.00000
0.00000	0.00000	0.89402	0.10598	0.00000
0.00000	0.00000	0.89730	0.10270	0.00000
0.00000	0.00000	0.89342	0.10658	0.00000
0.00000	0.00000	0.89274	0.10726	0.00000
0.00000	0.00000	0.87646	0.12354	0.00000
0.01120	0.00000	0.85600	0.13280	0.00000
0.00000	0.00000	0.88173	0.11827	0.00000
0.00000	0.00000	0.75844	0.099189	0.14237
0.00000	0.00000	0.64717	0.10338	0.24945
0.00000	0.00000	0.69244	0.089811	0.21775
0.00000	0.00000	0.50717	0.079537	0.41330
0.00000	0.00000	0.63160	0.093286	0.27511

OS(i) is the estimated optimal share for supplier i.

Table C.2. Set of optimal shares in $E(\tilde{w}_{z,i})$

zs1	zs2	zs3	zs4	zs5
0.21738	0.21714	0.21891	0.16081	0.18576
0.21786	0.21937	0.21567	0.16062	0.18648
0.21779	0.21924	0.21623	0.16064	0.18610
0.21771	0.22070	0.21587	0.16054	0.18518
0.21738	0.21866	0.21753	0.16072	0.18571
0.21712	0.21895	0.21882	0.16071	0.18439
0.21709	0.21935	0.21855	0.16068	0.18433
0.21725	0.21925	0.21832	0.16067	0.18451
0.21765	0.22087	0.21598	0.16054	0.18497
0.21785	0.22204	0.21439	0.16044	0.18527
0.21754	0.22027	0.21647	0.16059	0.18513
0.21710	0.22017	0.21885	0.16062	0.18327
0.21718	0.22289	0.21757	0.16042	0.18194
0.21692	0.21909	0.22027	0.16071	0.18302
0.21665	0.21751	0.22209	0.16083	0.18292
0.21695	0.22058	0.21953	0.16060	0.18235

zs(i) is optimal share for supplier i.

CHAPTER 3. PRICE INTERACTIONS IN EXCHANGE RATE PASS-THROUGH

A paper prepared to be submitted to the Journal of Business and Economics

Jeong-Yun Seo

ABSTRACT

Recent study of the pass-through has drawn heavily on models of industrial organization and emphasized the convexity of demand schedules of the foreign firm. As an illustration of the market structure, this study theoretically relates the issue of pass-through directly to the oligopoly price conduct, or interactions between a supplier's price and the market price. While focusing on the degree of competitive pressure faced by foreign firms, it also examines an empirical example of import beer pricing in the US. Given the open debate on the stability of the level of pass-through, the Kalman filter estimation is adapted in the empirical application.

I. INTRODUCTION

The underlying rationale for any price interaction model is that a firm's pricing decision matters to the market price because of its potential influence on the rival's actions. From a realist's point of view, price interactions or barometric price leadership can be inevitable consequences in most industries. This study theoretically relates the degree of oligopoly conduct in the market price, as well as other factors attributing to the firm's market performance, to the issue of incomplete pass-through of exchange rate and cost shocks. It also provides an empirical example of import beer pricing in the US. Pass-through analysis determines the relationship between exchange rate movements and the adjustments of traded goods. This study argues that a foreign firm's decision on the level of pass-through is significantly affected by its price interaction with the market price, in a barometric sense, and pass-through analysis is overall adversely related to the measure of the competitive pressure faced by the foreign supplier.

Many articles on international trade have recently examined the problem of imperfect price competition, in particular, on oligopoly pricing that is induced by exchange rate

movements. The issue of 'incomplete exchange rate pass-through' refers to the partial response of import prices to nominal exchange rates, and 'pricing-to-market' refers to destination-specific price adjustments by monopolistically competitive exporters. Exchange rate fluctuations are usually perceived as cost shocks for a foreign firm producing in its home country and selling in its export market. When the exchange rate changes, the import price responses in the range of the complete pass-through, as the firm chooses to pass the cost shock fully into its selling prices, to no pass-through, as the firm absorbs the shock fully into its markup. The partial pass-through refers to some of the above combination¹.

Recent study of the pass-through has drawn heavily on models of industrial organization, based on the convexity property of demand schedules, and focused on the role of market structure as well as product differentiation. Factors stressed to explain the market structure include the degree of competition, product substitutability, adjustment costs, or market quantity shares. In Dornbusch(1987)'s model of Cournot competition between foreign and domestic sellers, for instance, the effect of a dollar appreciation on the dollar price of a tradable good becomes higher the more competitive the industry and the larger the total import share². Current literature also suggests that the degree of pass-through varies across industries in explaining pricing adjustments following exchange rate changes. Incomplete pass-through occurs if demand becomes more elastic as price increases (e.g., Feenstra: 1989; Marston: 1990). However, measuring pass-through, solely depending on the convexity, possesses a number of problems: there is no information relevant to the timing of price responses and to the market structure lying behind the different responses of suppliers (Mennon: 1995).

Some PTM studies are exclusively concerned with the specific structure of firm's output market, rather than with the convexity itself. Feenstra et al. (1996), for example, considered the magnitude of market quantity shares of exporters in pass-through phenomenon and found a weak non-linear relationship in US automobile import market between the two variables. Gron and Swenson (1996) contributed to the literature by estimating the coefficient while controlling for some degree of local (or destination) production, which may vary by destinations and influence the inferences drawn regarding pricing behavior. A recent paper by Yang (1997) suggests that, based on an adapted Dixit-

Stiglitz model, pass-through is larger the more differentiated (or less substitutable) the products in an industry, and the smaller the elasticity of marginal cost with respect to output. Some theoretical papers, on the other hand, heavily depend on the game aspect of the players' strategic interactions in examining the dynamic nature of imperfect competition in the determination of pass-through level (e.g., Meckl: 1996; Pick and Carter: 1994).

Pass-through analysis in this paper focuses on the interactions between market and importing prices. This paper is organized as follows. In section II, some testable implications are drawn about pass-through related to the market structure: pass-through is overall adversely determined by the firm's markup level or its factors attributing to the firm's competitive pressure in the industry. From the perspective of the foreign firm's price interactions with the market price (say p^*), pass-through tends to be greater for a firm whose price is decided as being exogenous to p^* , followed by the firm of leading p^* , than that of taking p^* . In addition to the price conjecture, pass-through is also negatively related to the firm's relative price to p^* , and positively related to the degree of product substitutability.

Second, this paper offers an empirical example of pricing behavior of imported beer in the US from 1979 to 1988, focusing on the price interactions. The sample period was known as two distinctive eras of US dollar appreciation and depreciation, and each era had persisted for prolonged time-periods. Existence of such time-lags is often required for exporters to have the incentive for price discrimination or destination-specific price adjustment (Levin: 1994). The beer exporters are supposed to have some degree of monopolistic market power, due to product differentiation, while exhibiting fair degrees of fluctuations in their market shares. As a diagnostic step, a VAR analysis is first performed to figure out the price interactions. Because there are open debates over the stability of pass-through level in a time-varying manner, a Kalman Filter methodology is used to investigate potential structural changes in parameters, and thus to capture the dynamics of price adjustments to changes in exchange rate, as well as other related components. Estimation results show that beer prices of German and Dutch exporters exhibit considerable exogeneity to the US market price, while Canadian beer price strictly follows p^* . Coefficients are generally estimated in the way predicted in the theoretical section supporting

our model, and are mostly stable over the sample period. Section III describes the empirical application in a detail.

II. AN OLIGOPOLY MODEL FOR PASS-THROUGH ANALYSIS

II.1 An Extended Dixit-Stiglitz Model

The purpose of this analysis is to investigate the relationship between exchange rate pass-through and oligopoly price leadership. The basic model assumption is that domestic and foreign firms are competing in the domestic market, say within the US, with differentiated products that belong to a well-defined industry category. The theoretical framework follows the extended Dixit-Stiglitz model introduced by Dornbusch(1987) to capture the strategic interactions in the industry as perceived by the individual price-setting firm. The major theoretical difference is that this paper provides specific solutions to the model of pass-through in section II.2, which offers some implications for empirical testing relevant to foreign suppliers' price interactions with the market price (p^*). This article also relates the firm's markup level to the degree of its competitive pressure in the market, while Dornbusch focuses on the number of domestic and foreign firms which are identical in each group as an indicator of market competitiveness.

The profit of a foreign supplier i , without time-subscripts, can be expressed as

$$(1) \quad \pi_i(p_i, p^{-i}; I, z) = p_i \cdot q_i(\underline{p}; I) - r_i \cdot C_i(q_i; z) ,$$

where \underline{p} is the vector of all prices (p_i, p^{-i}), p_i is the price charged by supplier i in the domestic market, measured in US dollars, p^{-i} is a vector of prices charged by all other firms. q_i is the quantity demand schedule faced by firm i , which is a function of all prices(\underline{p}) and the income level(I). z refers to a vector of long-run input costs, and the short-run cost is assumed to follow a Leontiff process with respect to q_i , so that its marginal and average cost are the same at a constant level (c_i), where c_i is denoted in its own currency (say Deutsche Mark: DM). r_i stands for the nominal exchange rate measured as buyer's currency per unit of exporter's currency (e.g., dollars/DM).

For a single-period game between price-setting players who produce homogeneous products, the Nash strategy leads to the famous Bertrand paradox of no pure profits earned, or no market power being exercised. The paradox occurs because of the incentive for each player to offer a lower price in order to secure a certain market share for their products. In the case of differentiated products within the same group, the optimal strategy chosen in this game by Bertrand competitors is to price at the following, treating the prices of the other players as being fixed at the decision time-period:

$$p_i = r_i c_i \cdot \frac{\varepsilon_i}{\varepsilon_i - 1}; \quad \varepsilon_i, -\frac{\partial q_i}{\partial p_i} \cdot \frac{p_i}{q_i}, \text{ is the (positive) elasticity of demand; } \frac{\varepsilon_i}{\varepsilon_i - 1} \text{ indicates the}$$

associated markup of the exchange rate-adjusted price over the short-run marginal cost.

If we define ε_i to be $1/(1-\rho)$, where ρ is the degree of product substitutability in the industry in the range of $(0, 1)$, then the optimal relationship becomes $p_i = r_i c_i / \rho$. The markup for the representative firm increases as ρ decreases in a less substitutable way. This condition is used in most previous PTM literature for their econometric model (e.g., Feenstra et al.: 1996; Gagnon: 1994). The strategy, however, restricts the potential price interactions between players; i.e., each imperfectly competitive firm assumes it is sufficiently small so that its own price changes leave the industry price unchanged.

The point of any price interaction model is that commitments or changes in a price matter to the market price because of their influence on the rival's actions. To incorporate pricing interactions in players' decision-makings, the first-order-condition for a profit-maximizing supplier should be written as

$$(2) \quad q_i + (p_i - r_i \cdot c_i) \cdot \left(\frac{\partial q_i}{\partial p_i} + \sum_{j \neq i} \frac{\partial q_i}{\partial p_j} \cdot \frac{\partial p_j}{\partial p_i} \right) = 0, \quad i \neq j, \quad i, j = 1, \dots, n.$$

There have been numerous studies on the issue of price interaction. From a realist's point of view, price interactions are not simply a *modus operandi* designed to circumvent strategic pricing conduct: they can, instead, be an inevitable consequence in many industries (e.g., Deneckere and Kovenock: 1992; Rotemberg and Saloner: 1990).

To relate the oligopoly pricing conduct directly to the issue of the incomplete pass-through of exchange rates, we need an explicit expression for the blanked term in the optimal condition Eq. 2. Given the difficulty of identifying individual responses for all other players, we may adapt the extended Dixit-Stiglitz model introduced by Dornbusch in the following way. The original Dixit-Stiglitz (1977) model, where product substitutability determines demand elasticity, postulates Chamberlinian imperfect competition and hence each supplier assumes that he does not affect industry price. Dornbusch however extended the model so that the same structure of differentiated products can easily be adapted to introduce the strategic interaction by way of a conjectural variation. His model assumes a number of identical domestic firms and a number of identical foreign firms to measure the degree of competitiveness in the market, but this paper generalizes the model into that of n number of heterogeneous suppliers.

The initial Dixit-Stiglitz model postulates that a representative consumer's preference consists of a number of subutility functions that have the property of homogeneous functional separability so that a two-stage maximization procedure is consistent. Each sub-utility function resembles the model with differentiated products belonging to the same industry (or product category) as arguments. We focus hereafter on one such industry. For the industry, the total demand (Q) is expressed as $Q = (\sum q_i^\rho)^{1/\rho}$; $0 < \rho < 1$. The consumer's budget constraint for consuming products in this industry is $p^* \cdot Q = \sum p_i q_i$, where p^* is the utility-based market price index for commodity Q . Maximization of the utility subject to the budget constraint yields the demand for each individual brand, as well as the specific form for p^* , as follows:

$$(3) \quad q_i = Q \cdot \left(\frac{p^*}{p_i} \right)^g \quad ; \quad g = 1/(1-\rho), \quad g > 1$$

$$(4) \quad p^* = \left(\sum p_i^h \right)^{1/h} \quad ; \quad h = -\rho/(1-\rho) : \quad h \in (-\infty, 0).$$

Our interest in this paper is on the responses of prices, the inverse demands, to cost shocks such as exchange rate fluctuations. Eq. 3 is the demand curve faced by an

imperfectly competitive firm, with the relative price of its product p_i/p^* as the determinant. The extended model assumes that an individual firm's price decision may affect the industry price in a certain level, and that the firm responds to changes in p^* . The response is measured by a given conjecture term. Maximization of the profit function subject to Eqs. 3 and 4 thus yields a simplified expression for Eq. 2 as

$$(5) \quad p_i = r_i \cdot c_i \cdot A_i; \quad A_i = \frac{\varepsilon_i'}{\varepsilon_i' - 1}; \quad \varepsilon_i' = g \cdot (1 - \theta_i); \quad \theta_i \equiv \frac{dp^*}{dp_i} \cdot \frac{p_i}{p^*}.$$

ε_i' is the total demand elasticity related to the blanked term in Eq. 2, and the demand curve faced by an individual foreign firm is then no longer proportional to a constant markup over unit cost. Its markup (A_i) is a function of ρ and the conjectural variation θ_i , which captures the strategic interaction between firms as perceived by the individual price-setting firm. Note that assuming a given conjecture rather than deriving it from a dynamic game-theoretic framework is obviously a shortcut. Nor is there any concern here with a single conjectural variation in the industry level; i.e., θ_i is a firm-specific parameter and is a function of dp^*/dp_i and p_i/p^* for any $i = 1, \dots, n$.

II.2. Pass-Through Analysis

Based on Eq. 5, we are now able to determine the effect of a change in the exchange rate on the import price. Differentiating the equation yields the following

$$(6) \quad \frac{\partial \ln p_i}{\partial \ln r_i} = \left[1 + \left(\frac{1}{g \cdot (1 - \theta_i) - 1} \right) \cdot \left(\frac{\partial \ln \varepsilon_i'}{\partial \ln p_i} \right) \right]^{-1}$$

$$= \left[1 + \left(\frac{1}{g \cdot (1 - \theta_i) - 1} \cdot \frac{\theta_i}{1 - \theta_i} \right) \cdot \left(-\frac{d \ln \theta_i}{d \ln p_i} \right) \right]^{-1} \equiv \eta_i.$$

This expression shall be defined as the 'pass-through' elasticity (η_i) of the exchange rate, which must be positive from the second-order conditions of profit-maximization (Feenstra et

al). The equation shows that pass-through depends on factors consisting of the firm's markup as well as the partial derivative $\left(\frac{\partial \ln \varepsilon'_i}{\partial \ln p_i}\right)$, the percentage change in total demand elasticity (ε'_i) with respect to changes in the logarithm of p_i . Further, an incomplete pass-through must be observed if the sign of $\left(\frac{d \ln \theta_i}{d \ln p_i}\right)$ is negative. Eq. 6.1 is another way of expressing the pass-through, following Marston (1990). If demand in the importing region exhibits constant price elasticity, complete pass-through must be observed. However, if the demand elasticity (ε'_i) increases as the importing country's currency depreciates, there will be less than complete pass-through from the equation

$$(6.1) \quad \eta_i = 1 - \frac{1}{g(1-\theta_i)-1} \cdot \left(\frac{\partial \ln \varepsilon'_i}{\partial \ln r_i}\right).$$

We may draw a number of meaningful implications from Eq. 6 and 6.1 under reasonable restriction(s) regarding pass-through. The magnitude of pass-through η_i is a function of three parameters in this model: degree of conjecture dp^*/dp_i , relative price ratio to the market price p_i/p^* , and degree of substitution among the variants ρ . Holding $-\left(\frac{d \ln \theta_i}{d \ln p_i}\right)$ to be a positive constant³, Eq. 6 will yield the following relationship:

$$(7) \quad \frac{\partial \eta_i}{\partial \left(\frac{dp^*}{dp_i}\right)} < 0, \quad \frac{\partial \eta_i}{\partial \left(\frac{p_i}{p^*}\right)} < 0, \quad \frac{\partial \eta_i}{\partial \rho} > 0.$$

Eq. 7 overall indicates that pass-through is negatively affected by the degree of foreign firm's competitive pressure in the industry. Prices are strategic or choice variables, and dp^*/dp_i indicates the firm i's industry-wise price conjecture, given the price ratio p_i/p^* . The implication due to changes in $\theta_i (= (dp^*/dp_i)(p_i/p^*))$ is related to the firm's market

price interaction. As will be explained later, what happens then is that pass-through elasticity tends to be lower for a taker of market price (p^*) than the leader of p^* . The level of η_i is also higher than that of p^* -taker, if the supplier's pricing is perceived to be exogenous to p^* in the market. For a firm with a low p_i/p^* (or a small markup level), its η_i level tends to be larger as it faces less competitive pressure. An increased level of ρ also decreases the industry markup, forcing the individual firm to increase η_i , being close to one, and this is the most popular result of previous literature based on elasticity approach (For a detailed review, see Menon).

The conjecture term, or its elasticity θ_i , points out whether, as p_i increases, the market or remaining rivals cooperate to a certain degree in raising price (if the i -th firm is a p^* -leader), or do not cooperate at all and compete for the firm's whole market share (if a strict p^* -taker), or respond only a little to changes in p_i (if exogenous-to- p^*). Generally speaking, changes in p_i should be positively related to reactions in $\sum_{j \neq i} p_j$ because they are strategic complements to each other; i.e., the assumption of non-decreasing return to scale in each firm's profit function ensures the positive slope of reaction functions as well as Bertrand equilibrium (Shapiro: 1989). To relate θ_i to a mark-up approach, because pricing decisions are interdependent, we may represent each firm's pricing policy in terms of a price reaction function: $p_i = r_i c_i \cdot A_i(p_i / p^*, \sigma_i, \rho)$, where $\sigma_i (= (dp_i / dp^*) \cdot (p^* / p_i))$ is the markup factor (A_i) is the conjectural variation that measures the firm's response to changes in p^* in elasticity term. The two terms are positively related to each other, assuming $\sigma_i = d \ln p_j / d \ln p^*$ for all j other than the i -th supplier, as follows⁴:

$$(7.1) \quad 0 < \theta_i \approx \left(\sigma_i + (1 - \sigma_i) \cdot \left(\frac{p^*}{p_i} \right)^h \right)^{-1} = \left(1 + (1 - \sigma_i) \cdot \sum_{j \neq i} \left(\frac{p_j}{p_i} \right)^h \right)^{-1} < 1.$$

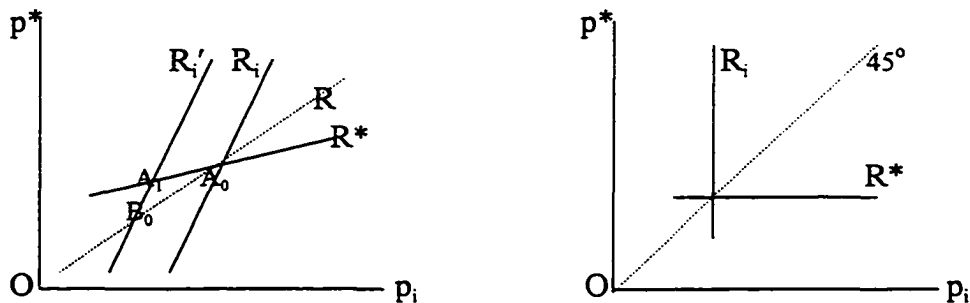
Hooper and Mann (1979) specified the markup factor A_i in Eq. 5 as $[p^* / (r_i c_i)]^{\alpha_i} \cdot (CU_i)^{\beta_i}$, which can be used as an illustration for the implication of conjectural variation. α_i and β_i are constant terms in (0,1) range; α_i indicates the degree of competitive pressure faced by the foreign firm, which is conceptually equivalent to σ_i in Eq. 7.1, and CU_i

is the capacity utilization level of the firm as a measure of demand pressure on the output. The pricing equation Eq. 5 then becomes, after taking logarithm,

$$(8) \ln p_i = (1 - \alpha_i) \ln r_i + \alpha_i \ln p^* + (1 - \alpha_i) \ln c_i + \beta_i \ln CU_i .$$

This specification shows that the pass-through will be zero for a firm which is strictly following the market price, since α_i becomes one. Holding CU_i unchanged, the p^* -taker sets the price equal to the p^* and changes in exchange rate and production cost have no effect. This means that the firm fully absorbs the shock in the exchange rate or foreign costs into its markup. At the opposite extreme, full level of η_i will be observed with a negligible competitive pressure in terms of p^* . This indicates that the firm's pricing decision is insensitive or separable to p^* , and its markup is left unchanged. A moderate p^* -leader will pass-through at the level between two types and, finally, if the firm is the sole monopoly in the market, its pass-through will resemble that of p^* -taker because the firm is simply the market price setter.

In correspondence to the specification of Eq. 8, Figure 1.1 roughly shows the impact of dollar appreciation for a moderate p^* -leader using pricing reaction functions. The schedules R_i and R^* denote reaction functions of the i -th foreign supplier and of the market, and A_0 is the initial equilibrium. An appreciation (i.e., a decrease in r_i) will shift the foreign



1. p^* -leader

2. Two extremes in price leadership

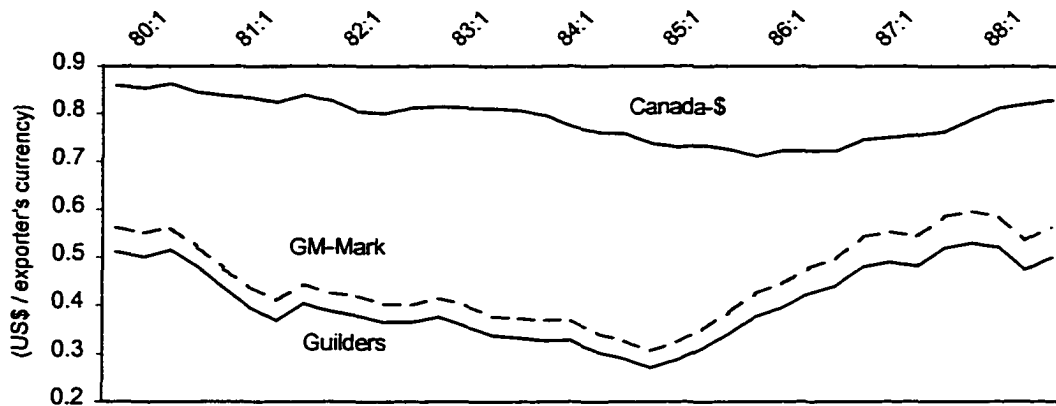
Figure 1. Reaction functions

supplier's reaction function up and to the left, and given the initial relative prices (i.e., along the OR-ray), OB_0/OA_0 represents the percentage appreciation. The new equilibrium will be somewhere on A_1B_0 , depending on the response of p^* due to appreciation. In Figure 1.2, the strict p^* -taker at one extreme will set the price along the relative price ray, which will be a 45 degree-ray if products are homogenous, while absorbing cost shocks completely into its markup (A_i) to maintain its relative price ratio to the given p^* . A firm behaving perfectly exogenous to p^* , on the other extreme, perceives σ_i to be zero and dp^*/dp_i to be close-to-zero, and thus, its pricing reaction is independent to changes in p^* , implying the complete pass-through⁵.

III. EMPIRICAL EXAMPLE

The objective of this empirical application is to test the validity of the implications drawn in our theoretical section, focusing especially on the price interactions. Armington-type suppliers are adopted, and the data used are quarterly observations from 1979 to 1988 in three beer-exporting countries such as Canada, Germany, and Netherlands, to the US. The sample period is known as two distinctive periods of US\$ appreciation, or strong US dollars, during the early 80s and depreciation during the late 80s. The import price data⁶ are unit values in US dollars. Exchange rate data are nominal rates and marginal cost data are proxied by 'wholesale price index' from International Financial Statistics. The changes in nominal exchange rates for the three suppliers are shown in Graph 1, indicating the strongest US\$ against Deutsche-Mark or Dutch-Guilders at around the second quarter of 1985 and against Canadian-dollar at 1986:1. Further, Table 1 below reports the summary statistics of import and market prices, and suppliers' market quantity shares.

Unit costs have increased in a fairly stable manner for all three major foreign suppliers throughout the whole sample period. For the market quantity shares, German exporters have managed only 10 % of the total foreign supply, but firmly maintained the level for the 10 sample years at the highest average price. Dutch exporters also have charged high prices, closely behind the German, with the highest market shares among foreign suppliers who have seen a slight decline from high-40 (first half of the sample) to low-40 % (second half). Consumption on Canadian beers has on the other hand slightly increased from

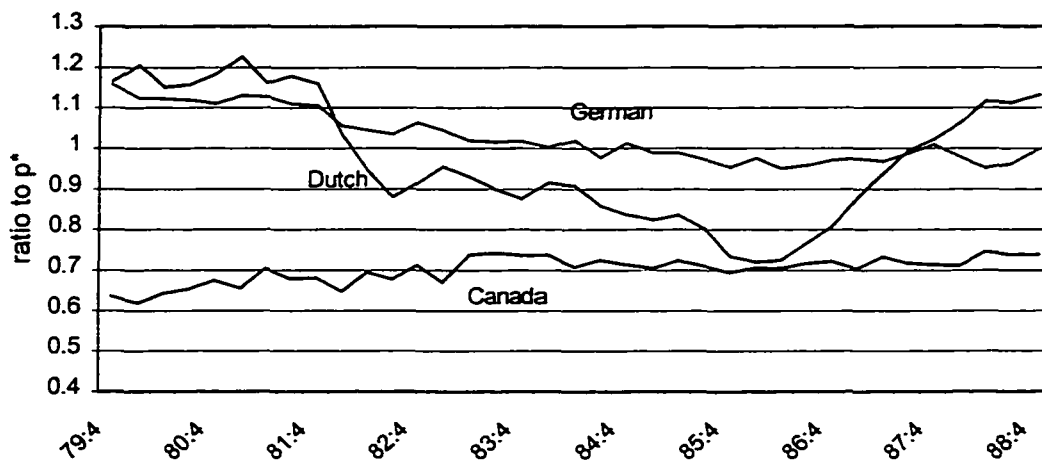


Graph 1. Nominal exchange rates

Table 1. Summary statistics of US beer import market
(average values and standard deviations in parentheses)

	Canada	German	Netherlands
Import Price (p_i)	2.39 (.401)	3.87 (.537)	3.66 (.389)
Import Price-a ¹	1.49 (.057)	2.23 (.205)	2.12 (.364)
p_i / p^{*2}	.697 (.035)	1.04 (.07)	.987 (.157)
Quantity Share ³	.313 (.049)	.102 (.016)	.448 (.057)
Unit Cost ⁴	1.07 (.112)	1.74 (.115)	1.81 (.138)

1. Import Price-a denotes the import price adjusted by the US consumer price index.
2. Because we use the indexed data for average market price (p^*), the initial $p^*(1979:1)$ is set equal to the initial mean of import price. The mean and standard deviation in parentheses of p^* and P^*-a are 3.074 (.362) and 2.142 (.058) respectively.
3. Quantity shares over total import quantity
4. Since marginal cost data is proxied by the 'wholesale price index', the initial observation (1979:1) is set to .5 of p_i/r_i of the same time period so that initial markup ratio is .5.



Graph 2. Import price changes relative to market price (p_i / p^*)

around-30 to mid-30 % during the same time periods. To visualize relative price changes of foreign suppliers, Graph 2 plots the ratio of export price (p_i) to the US market price (p^*) over the sample period. A rough look at the graph gives us an idea that, unlike other suppliers, the relative export price of Dutch beer appears to follow fluctuations of exchange rates, implying a potentially very high pass-through of exchange rate as well as cost shocks. As a diagnostic step, we use the VAR methodology to figure out the price interactions between foreign suppliers' prices as well as market price (p^*). The non-structural VAR approach has the desirable property, in examining the interrelationship among a set of economic variables, that all variable price series are treated symmetrically, so that we rely neither on any incredible identification. From the results of the estimation, Canadian beer exporters appear to be a strict follower to p^* as well as to their own past price shocks. Two European prices, however, appear to be separated to p^* in some degree, even though they turn out to be non-exogenous to the whole price system. The analysis also gives one an idea that the beer price in the US market overall is insignificantly related to prices of import beer. Details of the estimation and more discussions are reported in Appendix 2.

For the estimation model, optimal price p_i depends on exchange rate(r_i), marginal cost(c_i), all other prices(p^{-i}), and income level(I) from the first-order condition Eq. 5:

$$p_i = p_i(r_i, c_i, p^i, I) .$$

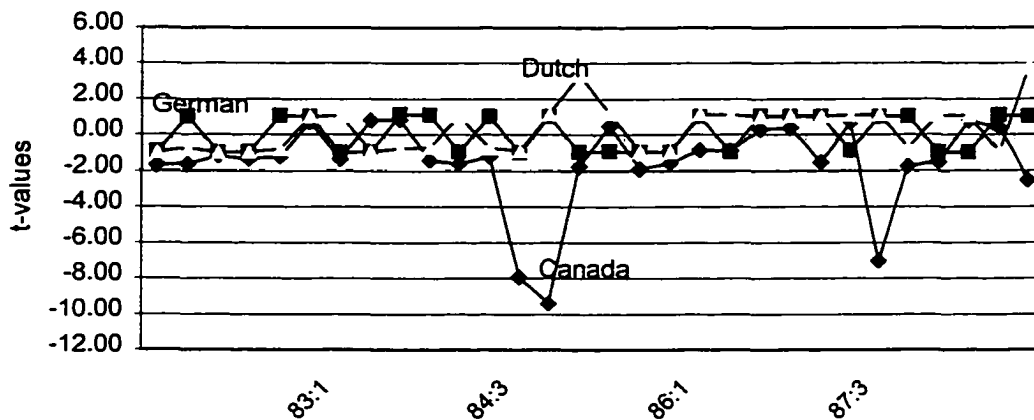
The theoretical model that we have specified however is restrictive in that it imposes the same pass-through rate of exchange rate and foreign cost. Many literatures also employed restricted versions, even with a cross-estimate restriction for competitors' prices with respect to pass-through (e.g., Gagnon and Knetter: 1994; Feenstra et al.). Exchange rates tend to be more fluctuating over time than production cost or the domestic market price. Firms may be more willing to absorb changes in exchange rates (under the expectation of transitory changes) into their profit margins than to absorb changes in costs or the competitors' price. In the empirical model, we thus estimate the most relaxed version of the model without imposing any cross-coefficient restriction among the three key explanatory variables of r_i , c_i , and p^i .

We also find that, with very few exceptions, most variables involved do contain unit roots and, as a result, the first-difference series (denoted as Δ) for all variables are used in this estimation. With time subscripts, the system of equations we estimate, for each supplier, is:

$$(9) \quad \Delta p_{i,t} = \theta_{0i,t} + \theta_{1i,t} \cdot \Delta l_{i,t} + \theta_{2i,t} \cdot \Delta l_{c_{i,t}} + \theta_{3i,t} \cdot \Delta l_{p^*_{i,t}} + \theta_{4i,t} \cdot \Delta l_{I_{i,t}} + \theta_{5i,t} \cdot \Delta p_{i,t-1} .$$

The notation “ l ” denotes the logarithm of the corresponding variable. The coefficients $\theta_{1i,t}$ and $\theta_{2i,t}$ are the pass-through elasticity and price-to-unit cost elasticity respectively in Eq. 6 and 6.1, which we expect to be in the range of $[0,1]$, and $\theta_{3i,t}$ indicates price elasticity to market price. For the total income level or capacity utilization, we instead use quantity demanded (say $q_{i,t}$) as a proxy. Due to delivery and sales process, there exist certain time-lags for exchange rate pass-through, or price adjustment to cost shocks; the lags usually take less than a half year (Menon). For this reason, some studies adapted weighted sum of current and past series for r_{it} (e.g., Kim: 1990). The weighting scheme is however avoided in this paper due to the possible multi-collinearity problem. We instead include the one-period lagged dependent variable $\Delta p_{i,t-1}$ to capture the time-lag effect. $\theta_{0i,t}$ is an intercept term that captures differences in price changes between suppliers, and perhaps over time periods, that are not explained by the regressors of our model.

There are open debates over the responses in pass-through elasticity (η_i) with respect to changes in r_i (as well as c_i and p^*) in a time-varying manner. To capture potential dynamics, Graph 3 plots test statistics for the recursive residual tests via ordinary least square (OLS) estimations for Eq. 9 to see whether parameters are consistent throughout the whole sample period. The outcomes of the OLS regressions are reported in Table A.1 of Appendix 1. The test statistics follow the student t-distribution: being higher than 2 or so, they indicate that corresponding recursive residuals lie outside the standard error bands, which in turn are suggestive of parameter inconstancy⁷. As shown in the graph, suspicions over the constancy are unavoidable in some pricing equations, especially for Canada. Test values for German prices on the other hand show the most fair levels of stability over the sample period.



Graph 3. Test for parameter inconstancy

(suggestive of parameter inconstancy for t-statistics greater than 1.7 at 95% confidence level)

For a time-varying parameter regression, the Kalman Filter is a highly useful method for investigating structural changes in parameters or constructing forecasts based only on historical data. The estimation method is a recursive or an updating method that bases the regression estimates for each time period on previous period's estimates plus the information for the current time period. With the initial conditions Eq. 10.3 on parameters, this class of models consists of two parts: the transition equation Eq. 10.1, which describes the evolution

of a set of state variables, and the measurement equation Eq. 10.2, which describes how the data actually observed is generated from the state variables. Once a model is in state space form, a backward recursion, known as smoothing, enables optimal estimators of the state vector to be calculated at all points in time using the full sample.

In the present study, we suppose that the import price $p_{i,t}$ for all three suppliers is generated by the following system of three equations of Eq. 9:

$$(10.1) \quad y_t = \bar{X}_t' \alpha_t + u_t, \quad u_t \sim \text{NID}(0, \sigma^2 H)$$

$$(10.2) \quad \alpha_t = \alpha_{t-1} + v_t, \quad v_t \sim \text{NID}(0, \sigma^2 Q)$$

$$(10.3) \quad \alpha_0 \sim N(a_0, \sigma^2 P_0) .$$

y_t is the $3 \times n$ vector of $\Delta p_{i,t}$ for $i=1, \dots, 3$, n is the number of observations, X_t is the $3 \times 3n$ matrix of the regressors in Eq. 9, where m is the number of regressors in the measurement equation, which is 3 in our example. α_t is 3×1 vector of coefficients to be estimated, and we suppose that it follows a multivariate random walk with no drift, as in Eq. 10.2. Eq. 10.3 is about the initial parameter condition. And, $\sigma^2 Q$ is the stationary variance-covariance matrix of the innovation v_t in the transition equation, which is mutually and serially uncorrelated with the innovation u_t in the measurement equation.

The system, Eqs. 10.1-10.3, is called as the multivariate random-walk parameter model, and it takes the form of a state-space model (See Ch. 7, Harvey: 1981). The model differs from the auto-regressive scheme in that the parameters are allowed to vary over time. Because the process is non-stationary, α_t has no fixed mean and so the model is able to accommodate fairly fundamental changes in structure, including radical changes in the underlying relationship. Among the applicable algorithms for the space-state form, the Kalman-filter approach provides a convenient means in estimating the trajectory of α_t . It however requires an important step to find or determine the system matrices necessary for the estimation, such as a_0 , the vector of prior coefficient, and variance-covariance matrices P_0 ,

H-, and Q-matrix. The following procedures, similar to Kim (1990), are adapted in this paper for the appropriate values.

For the vector of α_0 , since the transition equation is not stationary, the initial conditions are not given as part of the model specification: they are simply estimated from the first k (which is 6) observations in this paper, similar to the OLS recursion. To find Q-matrix, prior information could be used as in Cooley and Prescott (1973). Without it, Harvey (1981) proposed the maximum likelihood estimation. But the suggested method involves estimation of 18^2 elements in the matrix even in this simple model. Some papers, such as Wolff (1987) and Kim, suggest that the Q-matrix is approximated by a certain fixed proportion (say μ) of the variance-covariance matrix (say VC_1) of the OLS estimation in different ways. There is, however, no clear theoretical justification either for an appropriate value of μ or for the procedure of letting Q to be proportional to the matrix. In this paper, the Q-matrix is alternatively obtained using the variance-covariance matrix from the recursive least squares. Recursive estimation is an appealing procedure with time series data, since this gives a unique ordering of the data in visualizing parameter changes. Doing it this way, it still embodies the assumption, as captured in VC_1 , that parameter variation tends to reflect uncertainty and correlation in parameter estimates.

Also, the recursion can be regarded as a special case of the Kalman filter. That is because the associated transition equation is simply a special case of the system (e.g., $\alpha_t = \alpha_{t-1}$, where $Q=0$). From the recursive outcomes, the expectation $E_{t-1}(\hat{\alpha}_t - \hat{\alpha}_{t-1})$ will be zero-vector, and its variance of the random walk process shall be approximated to $\sigma^2 Q$. To take care of the contemporaneous correlation among coefficients, we run the seemingly unrelated regression (SUR) for the 18 series of $\{\hat{\alpha}_{j,t} - \hat{\alpha}_{j,t-1}\}$ for $j=1, \dots, 18$ with constant terms, which are supposed to be zero, and the 18×18 variance-covariance matrix (say VC_2) is used as a proxy for $\sigma^2 Q$ in Eq. 10.2. σ^2 in the system will be estimated by running the Kalman-filter because we don't have prior information on σ^2 ; the trace of the variance-covariance matrix (say $\hat{\sigma}^2$) of the SUR estimation of Eq. 9 is, however, applied to Q-matrix as a proxy for σ^2 ; i.e., $Q = (1/\hat{\sigma}^2) \cdot VC_2$. And finally, for $\sigma^2 H$ -matrix of the measurement equation, we use the 3×3 residual variance-covariance matrix of the SUR estimation of Eq. 9 to capture the

Table 2. Kalman-Filter Estimation (81:1-88:4)
 (*, **, statistically significant at 95, 99% confidence level)

Parameters	<u>Dependent Variables</u>		
	Δ/p_1	Δ/p_2	Δ/p_3
θ_0	4.88E-03	4.74E-03	2.94E-03
θ_1	0.097	0.098 *	0.193 *
θ_2	0.392	0.963 **	0.43
θ_3	1.21 *	-0.394	-0.198
θ_4	0.036	0.027 *	-9.2E-03
θ_5	-0.547 **	-0.182	0.483 **

Note: Variance of recursive residuals is .00274 and parameter estimates are of the average observations.

contemporaneous correlation in the three pricing equations. The correlation between dependent variables $\Delta/p_{i,t}$ is also reported in Figure A3.b in Appendix 2.

The regression outcomes are summarized in Table 2 for the Kalman Filter estimation, while the parameter estimates are of the average observations. We completely list the trajectories of 6 smoothed coefficients in the three pricing equations of the system in Table A.2 of Appendix 1. As predicted from the recursive residual tests, coefficients for Canadian pricing equation are somewhat unstable over the sample period. Otherwise, most trajectories overall appear to be fairly stable, without notion of dramatic changes. One may catch this idea on the stability from the VAR analysis described in Appendix 2, in which Canadian prices are supposed to be highly subject to fluctuations in the market price p^* . Table 3 shows the average statistics of all long-run elasticities, which are obtained after adjusting the lagged coefficient terms of dependent variables. For instance, pass-through elasticity (η_{LRI}) is derived as $\theta_{1i}/(1-\theta_{5i})$. The average short-run elasticities are simply the coefficient trajectories estimated. Graph 4 plots the long-run elasticities for all three major foreign suppliers on the sample time horizon.

Table 3. Summary of long-run elasticity
(Standard deviations in parentheses)

Variables	Canada	German	Netherlands
Exchange Rate ¹	.061 (.145)	.083 (.01)	.374 (.012)
Cost	.252 (.088)	.815 (.014)	.835 (.033)
Market Price (p*)	.783 (.006)	-.332 (.021)	-.383 (.031)
Quantity	.023 (.013)	.023 (.001)	-.018 (.004)
$r_i + c_i^2$.157 (.116)	.449 (.003)	.605 (.015)

1. Long-run pass-through elasticity of exchange rate.
2. Pass-through elasticity under the restriction of same responses of price to exchange rate and to production cost shocks.

The statistical significance reported in Table 2 overall coincides with the result of the VAR analysis. In the VAR, Canadian beer exporters are analyzed to follow the market price strictly, while their US market markups absorb fluctuations in nominal exchange rates and production costs. The tables of the estimation also show that, among the big three exporters, only Canadian suppliers exhibit considerable degree of sensitivity toward changes in p^* and insensitivity to r_i and c_i . On the other hand, the market price has even negative effect which is statistically insignificant, on import prices from Dutch and German suppliers, potentially suggesting the separated demand for these products. The European suppliers are, however, quite responsive to fluctuations in exchange rate and cost in their pricing decision, indicating their ability to maintain the markup to be stable in fair levels in the US beer market. Finally, the coefficients on the quantity term are small and statistically insignificant in most pricing equations.

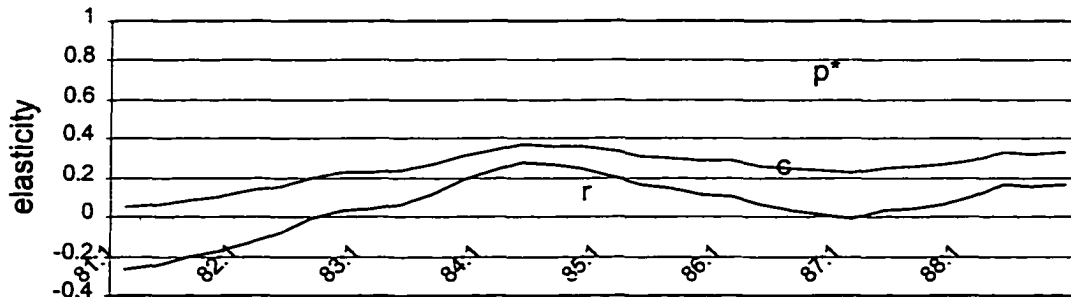
From Table 2, the coefficients estimated suggest that the short-run effect of a 100 percent appreciation (depreciation) of the US dollar is to decrease (raise) import price to 9.7(Canada), 9.8(German), and 19(Dutch) percent. With respect to costs, the price changes are 39(Canada), 96(German), and 43(Dutch) percent. The long-run elasticities, reported in

Table 3, are obtained after adjusting lagged effects of dependent variables. Note that the long-run effects are greater (smaller) for Dutch (Canada and German) in absolute term. For Canada and German, this implies decreased sensitivity to changes in r_i and c_i , and decreased p^* -taking behavior in the longer term: Dutch on the other hand exhibits short-run price rigidity in the market and slowly adjusts to shocks in the longer period. From Table 3, the results on pass-through suggest that the long-run effect of a 100 percent appreciation of the US dollar is to decrease import prices 6.1 (for Canadian products) to 37.4 (for Dutch products) percent, suggesting substantially less than full pass-through. Price elasticity with respect to unit cost changes is, however, much greater than pass-through (η_{LRi}) for all suppliers (e.g., 25% for Canada to 84% for Dutch).

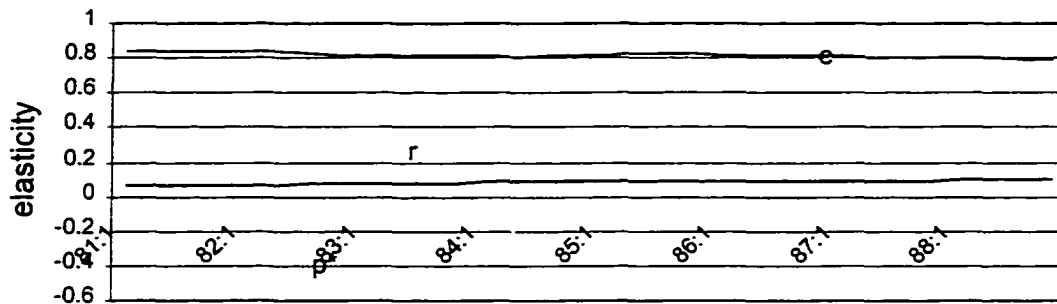
Exporters, then, seem to perceive changes in costs to be more permanent in effect than exchange rate fluctuations (e.g., Yang; Hooper and Mann). Some previous literature (e.g., Gagnon and Knetter) restrict the model to have the same coefficients with respect to r_i and c_i . But these unequal responses require one to distinguish the two types of shocks in pricing decisions and show the possible importance of the issue on how the market perceives changes in stochastic exchange rates; that is, the permanent versus transitory effects. In sum, Dutch exporters exhibit the highest elasticity of pass-through, followed by German and Canada, while the two European exporters transfer very high percent of their cost shock (82-84%) to the price. The levels of these elasticities therefore are higher for exporters being exogenous-to- p^* behavior, thus supporting the theoretical implication on the price interactions.

The stable shape of the time-series in Graph 4 in general suggests the stability of pass-through (e.g., Kim) in our example. That is, we observe little fluctuations for the two European exporters, but a little tendency of increased pass-through to r_i and c_i as prolonged depreciation of US dollar has squeezed markup level in the mid- to late-80s. Canadian estimates show no fluctuations to p^* at all, again implying its high and significant dependency on p^* in its price determination. Although statistically insignificant, Canadian prices show somewhat unstable responses to changes in r_i and c_i . The underlying cause is not clear, but we noticed that trajectories of θ_{01} reported in Appendix 1 have fluctuated in the

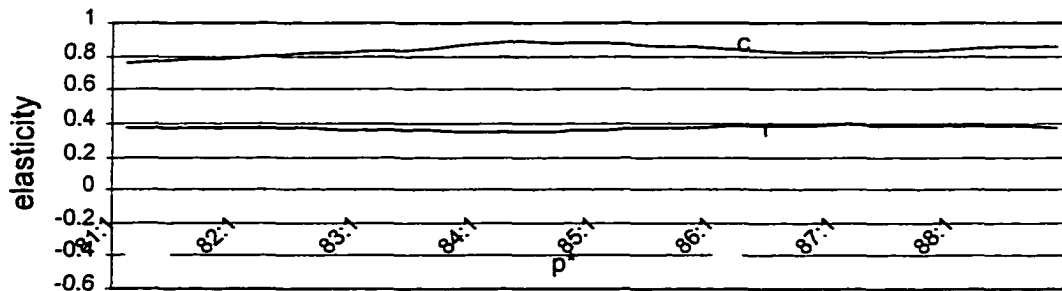
Canada



German



Netherlands



Graph 4. Long-run elasticity for three major exporters (81:1-88:4)
 (r , c , p^* denote the price elasticity with respect to r_i , c_i , p^* respectively)

opposite way to the elasticities. In other words, an increase in the constant term θ_{01} of Eq. 9 implies that the offer price responds less to its level as explained by the model regressors, or that the supplier is willing to price higher than the level decided by the market conditioned by explanatory variables. It is presumably natural to exhibit the time-varying constant term for Canadian suppliers, who have taken most fluctuations in markup with the least pass-through of exchange rates and cost shocks.

It should be admitted that the stability of pass-through shall be an open question, heavily depending on industries and market conditions. During the dollar depreciation, import prices may respond more strongly if the decline in the dollar takes place against a background of profit margins that are being squeezed significantly by, for example, a strong rebound in prices of oil and other materials (Hooper and Mann). Further, the strong rebound in pass-through may also happen if foreign suppliers, without facing severe domestic competition, strengthen their collusive level to maintain the squeeze in a small level. These possibilities should be uncommon in our example of the US beer industry, where foreign supplies do not lead or considerably affect the market price overall.

Applying Hooper and Mann's specification of markup, the degree of each supplier's competitive pressure is measured as $\frac{\ln A_i - b_i}{\ln A_i + \log(p^* / p_i)}$, where A_i is the markup and b_i stands for $\beta_i \cdot \ln CU_i$ in the range of $(-1,0)$, as in Eq. 8. This is a restricted version in the sense that it forces the same elasticity, say η_i^* , to r_i and c_i , and $1-\eta_i^*$ to p^* . However, following the specification, the competitive pressure in our example, for Canada, German, and Dutch exporters is estimated respectively as .823, .257, and .133 in the long-run in average. This again implies that Dutch, closely followed by German, exporters have acted as if they were mostly exogenous-to- p^* with least competitive pressure in the market. Finally, the result of smaller $\eta_{(\text{German})}$ than $\eta_{(\text{Dutch})}$ is possibly due to the higher competitive pressure measured in this manner, which is also implied by higher relative price (p_i/p^*). Furthermore, the high pass-through of Dutch might be a reason for its gradual loss of the US market share over the sample period.

IV. CONCLUDING REMARKS

The analysis of pass-through determines the likely effects on import prices of shocks in exchange rates. Recent study of the pass-through have drawn heavily on models of industrial organization and focused on the impact of market structure on the foreign firm's behavior. Besides emphasizing the convexity of demand schedules, existing literature also suggests that the degree of pass-through varies across industries, and that the variation relates to market structure such as market competition level, degree of product differentiation, adjustment costs, or market quantity shares. In a similar attempt, this study relates the degree of oligopoly conduct on price interaction, or interactions among suppliers, directly to the issue of incomplete 'pass-through'. While focusing on the degree of competitive pressure faced by the suppliers, this paper also shows one way to apply the implications to our empirical example of the import beer pricing in the US. It should be admitted that abundant examples, rather than just the beer import market, would provide more solid verification for the implications. But the results of our empirical example relatively correspond well to the theoretical implications, and the empirical methodology used in this paper should be easily applicable to other industry- or firm-level analysis.

Another restriction of this paper is that, following most pass-through literature, this study is a partial equilibrium model. We have defined pass-through as a partial derivative that reflects the willingness of foreign firms to adjust their price, and thus profit margins, to offset changes in exchange rates. For a future research, a more general model might take into account other less direct effects of exchange rates on the import price, through their effects of other factors determining pricing decisions. For instance, a depreciation of the dollar lowers the US purchasing power over the product (hence depressing foreign capacity utilization), or lowers foreign costs, via a reduction in input costs from the US or in imported material input costs. This thereby implies that the total pass-through may be less than indicated by the partial derivative analyzed. Alternatively, the impact of depreciation on the US market price level could work in the opposite direction, to increase total pass-through, and thus could lead to biased estimates of the pass-through.

REFERENCES

- Athukorala, P. and Menon, Jayant, 1994, Pricing to Market Behavior and Exchange Rate Pass-Through in Japanese Exports, *Economic Journal*, 104: 271-281.
- Bagwell, Kyle and Stager, Robert W., 1997, Collusion over the Business Cycle, *Rand Jr. Economics*, 28: 1: 82-106.
- Cooley, T. and Prescott, 1973, Systematic Variation Models Varying Parameter Regression: A Theory and Some Applications, *Annals of Economic and Social Measurement*, 2: 463-473.
- Deneckere, Raymond and Kovenock, Dan, 1992, Price Leadership, *Review of Economic Studies*, 59: 143-162.
- Dixit, A. K., and Stiglitz, J. E., 1977, Monopolistic Competition and Optimum Product Diversity, *American Economic Review*, 67: 297-308.
- Dornbusch, R., 1987, Exchange Rates and Prices, *American Economic Review*, 77: 93-106.
- Dueker, Michael C, 1997, Markov Switching in GARCH Processes and Mean-Reverting Stock-Market Volatility, *Jr. Business and Economics*, 15: 1: 26-34.
- Ellison, Glenn, 1994, Theories of Cartel Stability and the Joint Executive Committee, *Rand Jr. Economics*, 25: 1: 37-57.
- Feenstra, R. C., Gagnon, J. E., and Knetter, M., 1996, Market Share and Exchange-Rate Pass-Through in World Automobile Trade, *Jr. International Economics*, 40: 187-207.
- Feenstra, R. C., 1989, Symmetric Pass-Through of Tariffs and Exchange Rates under Imperfect Competition: An Empirical Test, *Jr. International Economics*, 27: 25-45.
- Feinberg, R. M., 1991, The Choice of Exchange-rate Index and Domestic Price Pass-through, *Jr. Industrial Economics*, 39: 409-420.
- Froot, K. A. and Klemperer, P. D., 1989, Exchange-Rate Pass-Through when Market Share Matter, *American Economic Review*, 79: 637-654.
- Gagnon, J. E. and Knetter, M., 1994, Pricing-to-Market in International Trade: Evidence from Panel Data on Automobiles, *Jr. International Money and Finance*, 14: 289-310.
- Gron, A. and Swenson, D. L., 1996, Incomplete Exchange-Rate Pass-Through and Imperfect Competition: The Effect of Local Production, *American Economic Review*, 86: 2: 71-76.

- Haltiwanger, J. and Harrington, J. E., 1991, The Impact of Cyclical Demand Movements on Collusive Behavior, *Rand Jr. Economics*, 22: 1: 89-106.
- Helpman, Elhana, 1984, Increasing Returns, Imperfect Markets, and Trade Theory, in R. W. Jones and P. B. Kene (ed.), Handbook of International Economics, vol. I, 325-365, Elsevier Science Publishers, NY, NY.
- Harvey, Andrew C., 1993(1981), Time Series Models, 2nd(1st) ed., The MIT Press, Cambridge, MA.
- Hooper, Peter and Mann, Catherine, 1989, Exchange Rate Pass-Through in the 1980s: The Case of US Imports of Manufactures, *Brookings Papers on Economic Activity*, 1: 297-329.
- Johnston, J., and DiNardo, J., 1997, Econometric Methods, 4th ed., McGraw-Hill Co., NY, NY.
- Katics, Michelle and Peterson, Bruce C., 1994, The Effect of Rising Import Competition on Market Power: A Panel Data Study of US Manufacturing, *Jr. Industrial Economics*, 277-286.
- Kim, Yoonbai, 1990, Exchange Rates and Import Prices in the US: A Varying-Parameter Estimation of Exchange rate Pass-Through, *Jr. Business and Economic Statistics*, 8: 3: 305-315.
- _____, 1991, External Adjustments and Exchange Rate Flexibility: Some Evidence from US Data, *Review of Economics and Statistics*, 176-181
- Kirman, A. and Philips, L., 1996, Exchange-rate Pass-through and Market Structure, *Jr. Economics*, 64: 2: 129-154.
- Knetter, M., 1989, Price Discrimination by US and German Exporters, *American Economic Review*, 79: 27-36.
- _____, 1993, International Comparison of Pricing-to-Market Behavior, *American Economic Review*, 83: 473-486.
- Koontz, S., Garcia, P., and Hudson, M. A., 1993, Meatpacker Conduct in Fed Cattle Pricing: An Investigation of Oligopsony Power, *American Jr. Agricultural Economics*, 75: 537-548.
- Levin, Jay H., 1994, On Sluggish Output Adjustment and Exchange Rate Dynamics, *Jr. International Money and Finance*, 13: 447-458.

- Marston, R. C., 1990, Pricing to Market in Japanese Manufacturing, Jr. *International Economics*, 29: 217-236.
- Meckl, J., 1996, Market Power of Firms and Exchange-Rate Fluctuations, Jr. *Economics*, 63: 1: 57-77.
- Menon, Jayant, 1995, Exchange Rate Pass-Through, Jr. *Economic Surveys*, 9: 197-231.
- Pick, D. H. and Carter, C., 1994, Pricing to Market with Transactions Denominated in a Common Currency, *American Jr. Agricultural Economics*, 76: 55-60.
- Rotemberg, Julio J. and Saloner Garth, 1990, Collusive Price Leadership, Jr. *Industrial Economics*, Sep.: 93-111.
- Shapiro, Carl, 1989, Theories of Oligopoly Behavior, in R. Schmalensee and R. D. Willig (ed), Handbook of Industrial Organization, Elsevier Science Publishers, NY, NY.
- Sibert, A., 1992, Exchange Rates, Market Structure, Prices and Imports, *Economic Record*, 68: 202: 233-239.
- Stanford, W. G., 1986, Subgame Perfect Reaction Function Equilibria in Discounted Duopoly Supergames are Trivial, Jr. *Economic Theory*, 39: 226-232.
- Tirole, J., 1988, A Theory of Oligopoly, The MIT Press, Cambridge, MA.
- Yang, Jiawan, 1997, Exchange Rate Pass-Through in US Manufacturing Industries, *Review of Economics and Statistics*, 95-104.

FOOTNOTES

1. Studies of 'pricing-to-market'/'pass-through' are of interest for several reasons (Menon (1995) provides a good review on the topic). First, they contribute to our understanding of the relationship between exchange rate changes and inflation. Secondly, they reveal an important feature of the competitive process in traded goods markets - how prices respond to cost shocks over time. Finally, these studies can be used to assess the impact of similar disturbances, such as tariff changes, on import prices as argued by Feenstra (1989).
2. Similarly, the imperfect substitutes model of de Melo and Robinson (1989) shows the elasticity of domestic price with respect to foreign price (and thus, indirectly, with respect

to currency movements) to be directly related to both import share and degree of substitutability between domestic and imported goods.

3. The elasticity of conjectural variation (θ_i) with respect to price(p_i) shall be non-positive as long as the reaction function in Figure 1 is not concave to its axis, and this condition is obtained from the convexity assumption of the demand curve.

4. The relationship between θ_i and σ_i is directly derived from Eq. 4. For the derivation, similar to Eq. 7.1, see pp. 99-100 of Dornbusch, whose paper postulates n number of identical domestic firms and n^* number of identical foreign firms.

5. Note that the reaction functions as well as the equilibrium path, is also determined by the level of relative price ratio (p_i/p^*), where the inherent price difference between p_i and p^* is potentially due to product quality difference. For this reason, the firm's price interaction shall be measured by the conjectural variation ($\theta_i = \frac{d \ln p^*}{d \ln p_i}$), or σ_i , as shown in

Eq. 5, in an empirical application of section III in this paper.

6. Beer import price data for the three major exporters are from "Exchange Rates and Prices: the Case of US Imports", written by Smith Jr. in 1996, and the US market (average) price data is from the US Bureau of Labor Statistics: CPI Detailed Report. The notes under Table 1 provide more detailed descriptions on the data used.

7. Details are shown in Ch.4 of Econometric Methods, fourth edition, by Johnston and DiNardo (1997).

APPENDICES

1. Regression Results

Table A1. OLS estimations of Eq. 9
 (** statistically significant at 5 or a lower %)

Parameters	<u>Dependent Variables</u>		
	Δ/p_1	Δ/p_2	Δ/p_3
θ_0	.649E-02	-.264E-02	.451E-02
θ_1	.07	.053	.162
θ_2	.233	.325	.3651
θ_3	1.1 *	.276	-.255
θ_4	.022	.011	-.71E-02
θ_5	-.492 **	-.225 *	.519 **
\bar{R}^2	.2131	.016	.191
SEE	.0325	.02	.042
D-h-alt(1.7, 2.5)	-.942	.37	.894
F (2.9, 4.5)	3.0	.881	2.742
Arch (4.1, 7.4)	1.243	1.343	.668

Note: The 1, 2, and 3 of dependent variables denote the suppliers of Canada, German, and Netherlands respectively. Figures in parentheses are critical values (5%, 1%) of the test statistic. SEE is the standard error of estimation. D-h-alt is the Durbin's h alternative for autocorrelation test if a regression contains lagged values of the dependent variable and if $n \cdot \text{var}(\theta_3) > \text{or} \approx 1$. F is the test for zero slopes. Arch is Engle's autoregressive conditional hetero-scedasticity test of residuals.

Table A2. Trajectories of Kalman filter (Eqs. 10.1-10.3).
 (θ_{ij} refers to the j -th coefficient of supplier i , where $i=1,2,3$ stands for Canada, German, and Dutch respectively)

	θ_{10}	θ_{11}	θ_{12}	θ_{13}	θ_{14}	θ_{15}
1981:1	0.00827	-0.397	0.0794	1.167	0.0797	-0.507
	0.00813	-0.373	0.0938	1.169	0.0777	-0.509
	0.00774	-0.308	0.133	1.174	0.0719	-0.515
	0.00738	-0.258	0.165	1.178	0.0678	-0.519
1982:1	0.00701	-0.196	0.203	1.182	0.0624	-0.525
	0.00672	-0.128	0.242	1.186	0.0563	-0.531
	0.00622	-0.0146	0.308	1.193	0.0461	-0.541
	0.00593	0.0564	0.348	1.198	0.0397	-0.547
1983:1	0.00576	0.0675	0.357	1.2	0.0388	-0.547
	0.00556	0.0967	0.373	1.204	0.0363	-0.547
	0.00507	0.18	0.422	1.212	0.0288	-0.553
	0.00442	0.29	0.491	1.22	0.0189	-0.562
1984:1	0.0039	0.372	0.542	1.226	0.0115	-0.57
	0.00346	0.44	0.586	1.231	0.00526	-0.576
	0.00346	0.418	0.576	1.231	0.00719	-0.574
	0.00348	0.394	0.565	1.23	0.0093	-0.572
1985:1	0.00366	0.332	0.531	1.227	0.0149	-0.566
	0.0039	0.259	0.49	1.223	0.0215	-0.56
	0.00394	0.222	0.472	1.222	0.0248	-0.556
	0.00402	0.185	0.452	1.22	0.0281	-0.553
1986:1	0.0041	0.168	0.444	1.219	0.0293	-0.552
	0.0044	0.101	0.406	1.215	0.0351	-0.546
	0.00462	0.0491	0.377	1.212	0.0395	-0.542
	0.00467	0.0203	0.362	1.211	0.0419	-0.539
1987:1	0.0047	-0.0181	0.344	1.21	0.0452	-0.535
	0.00437	0.0458	0.383	1.215	0.0393	-0.541
	0.00414	0.0712	0.4	1.218	0.0368	-0.542
	0.00391	0.104	0.421	1.221	0.0338	-0.544
1988:1	0.0037	0.154	0.45	1.224	0.0293	-0.549
	0.00329	0.257	0.509	1.23	0.0201	-0.558
	0.00324	0.25	0.506	1.231	0.0205	-0.557
	0.00312	0.257	0.512	1.233	0.0197	-0.557

	020	021	022	023	024	025
1981:1	0.00248	0.0711	0.948	-0.335	0.0283	-0.126
	0.00253	0.0719	0.948	-0.336	0.0283	-0.127
	0.00268	0.0739	0.948	-0.339	0.0281	-0.131
	0.00274	0.0754	0.949	-0.341	0.028	-0.133
1982:1	0.00289	0.0776	0.949	-0.345	0.0279	-0.137
	0.00311	0.0799	0.948	-0.349	0.0278	-0.142
	0.00342	0.0831	0.946	-0.355	0.0276	-0.149
	0.00372	0.086	0.945	-0.361	0.0275	-0.155
1983:1	0.00388	0.088	0.947	-0.366	0.0273	-0.159
	0.00405	0.0903	0.948	-0.37	0.0272	-0.164
	0.00429	0.0932	0.949	-0.376	0.027	-0.169
	0.00449	0.0961	0.951	-0.382	0.0269	-0.175
1984:1	0.00464	0.0984	0.954	-0.387	0.0268	-0.179
	0.00487	0.101	0.956	-0.393	0.0267	-0.185
	0.00493	0.102	0.961	-0.397	0.0267	-0.188
	0.00498	0.103	0.964	-0.4	0.0267	-0.19
1985:1	0.00488	0.102	0.969	-0.4	0.0268	-0.189
	0.00476	0.102	0.973	-0.399	0.0269	-0.187
	0.00475	0.102	0.976	-0.401	0.0269	-0.188
	0.00488	0.103	0.978	-0.405	0.0268	-0.191
1986:1	0.00512	0.105	0.978	-0.41	0.0267	-0.196
	0.00523	0.105	0.979	-0.413	0.0268	-0.198
	0.00547	0.107	0.977	-0.417	0.0267	-0.202
	0.00573	0.109	0.975	-0.421	0.0265	-0.207
1987:1	0.00586	0.11	0.977	-0.425	0.0264	-0.21
	0.00605	0.112	0.977	-0.429	0.0263	-0.214
	0.00627	0.114	0.977	-0.434	0.0261	-0.219
	0.00641	0.115	0.977	-0.438	0.026	-0.222
1988:1	0.00642	0.116	0.978	-0.438	0.026	-0.222
	0.00652	0.117	0.976	-0.44	0.026	-0.224
	0.00675	0.119	0.975	-0.444	0.0258	-0.229
	0.00698	0.121	0.974	-0.448	0.0256	-0.233

	030	031	032	033	034	035
1981:1	0.00422	0.205	0.419	-0.215	-0.00551	0.453
	0.00413	0.204	0.42	-0.213	-0.00578	0.454
	0.00393	0.203	0.424	-0.208	-0.00646	0.455
	0.00373	0.202	0.425	-0.205	-0.00702	0.459
1982:1	0.00353	0.201	0.426	-0.202	-0.00763	0.463
	0.00344	0.2	0.429	-0.201	-0.00795	0.465
	0.00326	0.197	0.437	-0.196	-0.00871	0.465
1983:1	0.00316	0.195	0.441	-0.193	-0.0092	0.464
	0.00305	0.195	0.442	-0.191	-0.00948	0.466
	0.00292	0.194	0.444	-0.189	-0.00986	0.467
	0.00271	0.191	0.451	-0.184	-0.0106	0.468
1984:1	0.00245	0.189	0.458	-0.179	-0.0114	0.47
	0.00225	0.187	0.463	-0.175	-0.012	0.472
	0.00211	0.185	0.466	-0.173	-0.0124	0.475
	0.00215	0.186	0.462	-0.176	-0.0121	0.478
1985:1	0.00221	0.186	0.457	-0.18	-0.0117	0.481
	0.0023	0.188	0.45	-0.184	-0.0112	0.485
	0.00243	0.19	0.442	-0.189	-0.0106	0.489
	0.00247	0.191	0.437	-0.192	-0.0103	0.493
1986:1	0.00255	0.191	0.432	-0.196	-0.00989	0.496
	0.00269	0.192	0.427	-0.2	-0.00946	0.497
	0.00291	0.193	0.419	-0.206	-0.00874	0.499
	0.00309	0.194	0.412	-0.21	-0.00816	0.501
1987:1	0.00316	0.195	0.408	-0.212	-0.00795	0.502
	0.0032	0.196	0.403	-0.214	-0.00773	0.504
	0.0031	0.194	0.407	-0.212	-0.00808	0.506
	0.00303	0.193	0.409	-0.21	-0.00833	0.506
1988:1	0.00294	0.192	0.411	-0.208	-0.00861	0.506
	0.00287	0.191	0.414	-0.207	-0.00887	0.507
	0.00271	0.189	0.42	-0.203	-0.00946	0.507
	0.00267	0.189	0.422	-0.202	-0.00957	0.506
	0.00263	0.188	0.423	-0.2	-0.0097	0.505

2. VAR Estimation for Price-Leadership

For the examination of the interrelationship, we consider the following simple system of price equations:

$$\Delta p_{i,t} = c_i + \sum_{j=1}^p a_{i1j} \Delta p_{1,t-j} + \dots + \sum_{j=1}^p a_{i4j} \Delta p_{4,t-j} + e_{i,t}, \quad \text{for } i=1, \dots, 4,$$

where $\Delta p_{i,t}$ = first difference of the beer import price, including the market average price p^* , from supplier i at time t ,

p = the number of lags of the endogenous variables,

a_{ikj} = coefficient for the k -th endogenous variable (i.e., Δp_k) with the j -th lag for the dependent variable Δp_i ,

$e_{i,t}$ = independently and identically distributed disturbance terms, while $E(e_{i,t}, e_{j,t})$ for all i, j , is not necessarily zero.

There are ongoing debates over the necessity of stationarity of data series in VAR analysis (See Enders, Ch. 5). We here use the first difference series in correspondence to our empirical estimation of Eq. 9. To determine the polynomial-lag length (p), each equation is estimated using lag lengths of 4 and 2 quarters. The AIC (Akaike Information Criterion) shows the preference to the model of lag-4, but the model of 2-lag is also a strong candidate due to its low SBIC (Schwarz Bayes Information Criterion). These values are reported in Table A3.b. Using χ^2 -tests, we determine that a lag length of only 2 quarters is the appropriate one: we would not be able to reject the null of only 2 lags because the calculated statistic (40.72) is less than the 90 and 95 % of χ^2 -tail with 35 degree of freedom.

The variance decompositions are reported in Table A3.a and Granger-causality tests are in parentheses of the table. Other examinations, including the contemporaneous correlation between error terms, are shown below the table. A test of causality is whether the lags of one variable enter into the equation for another variable. The forecast error decomposition tells us the proportion of the movements in a sequence due to its own shocks versus shocks to the other variable. The correlations between innovations are relatively low in most cases:

this indicates that the effect of dependent variable ordering is relatively insignificant. Based on the result of Granger-causality tests, we consider the variance decomposition using a Choleski decomposition such that p_3 (Dutch export price) innovations contemporarily affect all prices, p_2 (German price) innovations contemporarily affect all price but p_3 , and p^* (market price) innovations contemporarily affect themselves and p_1 (Canadian price), and finally p_1 innovations contemporarily affect only p_1 .

Granger-causality tests indicate that effects of p_1 on its own time-series are highly significant, and the cross-causality effect from p^* to p_1 is also significant at 1% level. Otherwise, each price weakly affects own time-series without serious cross-effects. Block-exogeneity tests are also performed to determine the potential exogeneity of the remaining variables. It should be noted that the causality test is a weaker condition than the condition for exogeneity in determining the effect of innovations to the market price or other prices in the market. A block exogeneity test is useful in the decision of whether to incorporate a variable into a VAR. The tests, also reported in Table A3.b., tell us that lags of P_i Granger cause either P_j or P_k , where $i, j, k = 1, 2, \text{ or } 3$, or p^* , and $i \neq j \neq k$ at 95% confidence level, and we thus conclude all prices are not exogenous to the system.

The direction of causality from Granger tests can be also confirmed from forecast variance composition, which displays the percentage of forecast error explained by all price shocks. In sum, based on test outcomes, Canadian beer exporters appear to be a strict follower to p^* as well as to own price shocks. Two European suppliers however appear to act as being exogenous-to- p^* in some degree, even though they turn out to be non-exogenous to the whole price system. Canadian exporters are p^* -takers, but, considering Block-exogeneity test results of p^* , the market price is overall determined in a manner of being less related to prices of foreign import beer. Especially German exhibits highly insignificant test results, implying that the market perceive German beers to be most exogenous in pricing behavior, along with the observation of very stable market share around 10% in the US foreign beer consumption.

Table A3. Summary of test statistics of VAR estimation
 (** statistically significant at 99 % confidence level with test criterion
 $F_{2,35-9} = 4.22(5\%)$ and $7.72(1\%)$)

a. Variance decomposition and Granger-causality test in parentheses

Percent of forecast Error variance in	Typical shock in			
	P1(Canada)	P2(German)	P3(Dutch)	P*(market)
P1	64.5 (10.8**)	4.5 (1.8)	10.1 (.46)	20.9 (10.4**)
P2	5.4 (1.16)	75.6 (3.23)	1.66 (1.03)	2.5 (.15)
P3	11.5 (2.7)	8.5 (3.95)	77.1 (3.09)	2.9 (2.65)
P*	4.7 (1.4)	11.4 (.26)	4.2 (1.3)	79.7 (3.7)

b. General tests

- χ^2 -test stat. for lag-length of 4 versus 2: 40.72 with d.f. 32
- AIC/SBIC: 11.64/3.31 for lag-length 4
12.07/2.32 for lag-length 2
- contemporaneous correlation in innovations and prices:

	e_1	e_2	e_3		$\Delta/P1$	$\Delta/P2$	Δ/P^*
e_2	.033			$\Delta/P2$.026		
e_3	.165	.45		$\Delta/P3$	-.089	.264	
e^*	.096	.225	-.115	Δ/P^*	.224	.301	.034

4. Block-exogeneity test:

χ^2 -test with 9 d.f.: P1(21.52), P2(20.44), P3(26.85), P*(8.23)
 with Critical value =5.99(5%) and 9.2(1%).

GENERAL CONCLUSION

Firms involved in international trade are subject to fluctuations in exchange rates as well as price uncertainty itself. The three papers of this dissertation deal with topics that are somewhat different to each other in the area of international market analysis. The main contribution of this dissertation is on its extension of the current literature by focusing on international firms' real decisions with respect to changes in financial variables or structure attributing to the firms' behaviors. The study deals especially with real and financial decision models of a risk-averse international firm when the firm faces unstable exchange rates over time.

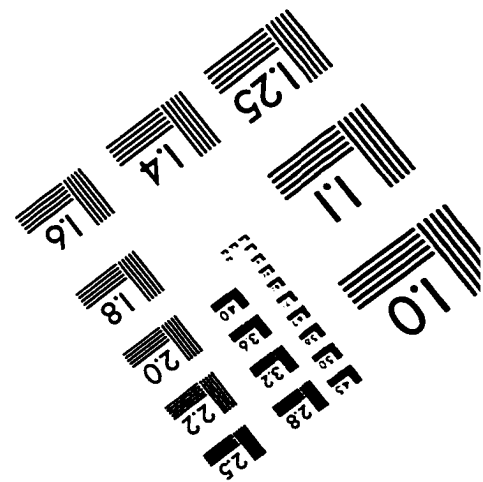
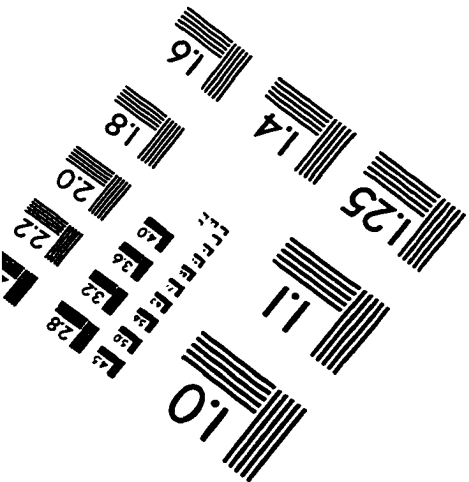
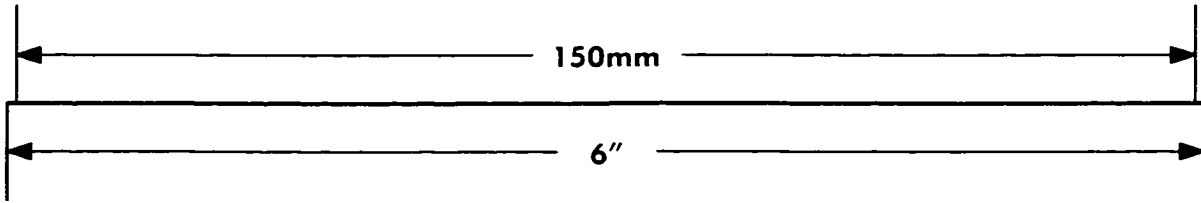
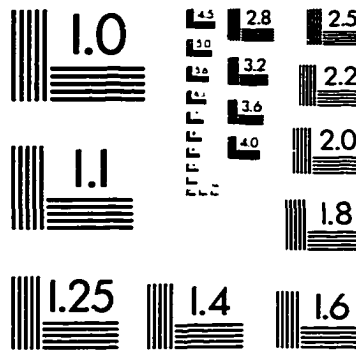
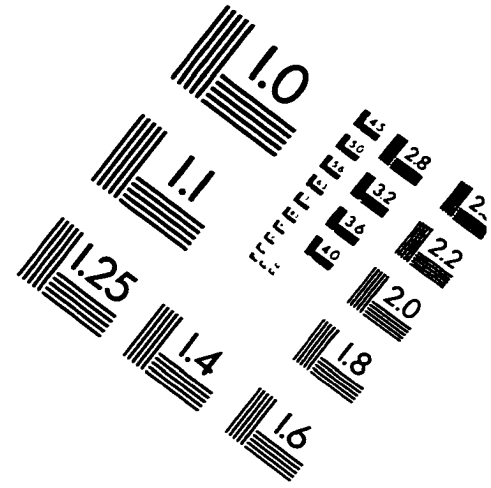
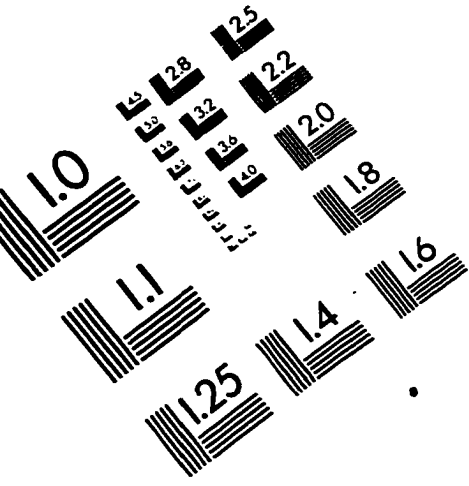
The first two papers relate the firm's ex-ante real decisions to the portfolio theory in correspondence to the recent attention to the issue of risk management. Chapter 1, the first paper, extends the analysis of the current hedging literature by including another realistic scheme, which is the diversification of importing channels of homogeneous products into multiple suppliers. As a result, the importing firm faces not only input price risk but also exchange rate uncertainty in the multiplicative form. Results and their intuitions are summarized in results (R1-R5) as well in three propositions. The overall implication of these results is that the existence of currency futures matters to the decision maker because it is the optimal hedging level that eventually determine the bowing property or covariance effect of the portfolio variance.

The second paper, Chapter 2, examines another risk-diversification model when a risk-averse international processing firm chooses the import mixture of its major material input from multiple suppliers. This article extends the paper by Wolak and Kolstad in 1991 American Economic Review. The main framework of the Chapter 2 is parallel to the idea of security line of the capital asset pricing model, as in their paper. The shortcomings of their work is, however, apparent in the sense that their approach is limited only to the importer's incentive to diversify away the systematic price risk, by postulating homogeneous products. This study assumes, instead, non-homogeneous products and also examines the supplier-side impact on the equilibrium price. The theoretical section of the paper shows equilibrium relationship in the market prices among three key explanatory variables, which are the expected price, the systematic price risk relative to the optimal market price, and the

supplier's monopolistic market power. The Chinese wheat import market is analyzed as an empirical application in the international trade. The results overall support the theoretical implication that the monopolistic power should be included as a critical explanatory factor. In sum, unless the market power of all suppliers is negligible, the analysis purely depending on the price-based portfolio should not be a valid approach in an empirical study of real asset allocation such as the import diversification.

The third paper, Chapter 3, shows how the firm's price leadership affects exchange rate pass-through. Recent study of the pass-through has drawn heavily on the models of industrial organization, based on the convexity property of demand schedules. Based on an extended Dixit-Stiglitz model, the paper asserts that the phenomenon of pass-through should be viewed within the corresponding market system, under which consumers and producers act in response to price signals generated by the interplay of supply and demand in more or less freely operating markets. In other words, pass-through is adversely determined by the international firm's markup level and/or factors attributing to the firm's competitive pressure in the industry. This article also offers an empirical example of pricing behavior of imported beer in the US, focusing on the supplier's pricing interaction with the market price. Because there are open debates over the stability of pass-through level in a time-varying manner, the Kalman-filter methodology is used to capture any potential structural change in parameters. Some of the shortcomings of this study are mentioned throughout as well as the conclusion parts of each chapter and are left for future researches.

IMAGE EVALUATION TEST TARGET (QA-3)



APPLIED IMAGE, Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989

© 1993, Applied Image, Inc., All Rights Reserved