Demand Diversification Under Uncertainty and Market Power*

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This paper justifies theoretically and empirically the diversification behaviour of an importing firm when it chooses the mixture of potentially differentiated products of its major input under 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 latter 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 analysed to answer the questions raised by the basic statistics.

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I. Introduction

The classical asset pricing theory, such as Capital Asset Pricing Model (CAPM), can be applied to quantify the relative risk of commodity prices. Wolak and Kolstad, in their 1991 paper on input demand diversification, show a way to choose the mixture of risky input suppliers, and how to quantify risk characteristics of input prices relative to the market price. Their model follows a framework similar to that used to assess the relative risk of securities in the CAPM. In doing so, however, it is limited to the homogeneity assumption of product quality. This restriction is released in this study, so that the model is

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geared to justify the diversification behaviour of a buyer, an importing firm or a trader, of heterogeneous products under price uncertainty.

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, Wolak and Kolstad show that the optimization problem can be decomposed into a two-stage process, like the cost-minimization problem. The monetary value of the composition of these optimal shares determines the value of a market portfolio as a benchmark with which to compare 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, Wolak and Kolstad’s paper 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.

From a realist’s viewpoint, homogeneity of products should not be an acceptable economic posture, except few limited cases. In other words, the trade-off between the expected price and the measure of risk, as implied by the CAPM, should be significantly affected by monopolistic market power of the suppliers. 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 and/or monopolistic competition (Scherer and Ross, 1991). A negative and linear relationship, based purely on price uncertainty, 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 Wolak and Kolstad’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 and Thomodakis, 1980; Chen et al., 1986; Sun, 1993; Peyser, 1994). These papers appear to have focused exclusively on the effects of a monopoly’s market power, its capital-labour ratio, and the wage rate (Sun, 1993), 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.

Section II first briefly explains the structure of Wolak and Kolstad’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 then 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. When the homogeneity restriction is relaxed, the theoretical section demonstrates that:

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 Wolak and Kolstad.
2. The systematic price risk (β*) relative to the optimal market portfolio can be decomposed into the net risk measure and a residual term due to the market power.
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.

If monopolistic market power of suppliers is present, then this power will increase the expected dollar price of risk, and thus positively affect β*. This is basically because the importer does not choose the quantity shares based on the criterion of cost-minimization, once 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*. The latter effect is the only one considered by Wolak and Kolstad 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 Wolak and Kolstad based on their concept of the relative risk measure (β*). Section III examines the Chinese wheat import market as an empirical application, and the results overall support the theoretical implications. Section IV concludes the paper.

II. Theoretical Model

Wolak and Kolstad demonstrate 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. They 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 several suppliers for the purpose of trading or production of outputs. The purchase prices \( (\tilde{w}_i) \) available from all \( n \) suppliers are unknown at the time of the quantity-share decision. 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 need not be considered with the homogeneous-product assumption. The value of the optimal portfolio, denoted as \( D_o = \sum s_{i}^o H_i \), is then defined as the sum of prices \( (H_i) \) weighted by optimal quantity shares \( (s_{i}^o) \) for \( i = 1, \ldots, n \) suppliers.

In this real asset of import share allocation problem, the set of the optimal share portfolio is analogous to the market portfolio and \( \beta_i^o \) is analogous to the market-specific measure of risk on the rate of return to the \( i \)-th security in the CAPM. Thus, Wolak and Kolstad show that we may derive an equilibrium relationship between the expected price \( (W_i \text{ or } E(\tilde{w}_i)) \) and the measure of risk \( (\beta_i^o) \) of any supplier \( i \)'s price relative to the value of optimal portfolio \( (\tilde{W}_o) \)

\[
W_i = E(\tilde{w}_i) + (E(\tilde{W}_o) - E(\tilde{w}_i)) \beta_i^o, \quad \text{where} \quad \beta_i^o = \frac{\text{cov}(\tilde{W}_o, \tilde{w}_i)}{\text{var}(\tilde{W}_o)} \tag{1}
\]

\( E(\tilde{w}_i) \) 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.

Equation (1) is exactly parallel to the CAPM except that \( E(\tilde{w}_i) \) has replaced the rate of return on the risk-free asset and the measure\( (\beta_i^o) \) 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 that of any other combination of \( q_j \)'s for all \( j \). This occurs because the purchasing firm is willing to pay more for the input with a less risky price. Thus, \( W_i \) has a negative linear relation with \( \beta_i^o \) 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 \( \beta_i^o = 0 \).

Wolak and Kolstad’s model framework is geared only toward a buyer’s perspective of input cost minimization in deriving the optimal portfolio. Thus, the measure \( (\beta_i^o) \) of each price risk relative to \( \tilde{W}_o \) is derived from a purely price-based
DEMAND DIVERSIFICATION UNDER UNCERTAINTY

portfolio of the firm. This negative relation, caused by the importer’s incentive to diversify away the price risk however will not strictly hold under imperfect market conditions. If products are imperfect substitutes, then the importer may take more account of the monopolistic power of certain varieties of products than of their price risk in his decision-making.

To allow for the heterogeneity of imports, while utilizing the relationship in Equation (1), we need to relate a supplier’s monopolistic market power ($u_i$) to its relative price risk, by taking into account the suppliers’ impact on the observed equilibrium price. The optimal value of the market portfolio should be also defined as $D^* (\equiv \sum s_i^* H_i)$, where $s_i^*$, or a set of $s_i^*$’s for $i = 1, \ldots, n$, stands for the optimal mixture of quantity shares with imperfect substitute products. The set is different from $s_o$, the optimal set of shares for the homogeneous products, due to different returns on each product in the importer’s revenue. This specification of optimal shares yields the corresponding market specific risk, $\beta^* (\equiv \text{cov}(H^*, \tilde{w})) / \text{var}(H^*)$ relative to $H^*$.

Because the vectors of prices and $\beta^*$’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. Several studies have shown such conditions, and the relationship between market power and the systematic risk ($\beta_i$), or the so-called beta coefficient, of the rate of return on the firm’s security. Sun (1993), and Chen et al. (1986), for instance, considered a Bertrand player in a simple model setting. The shareholder wealth-maximizing producer operates for a single period after which it is dissolved at zero salvage value. The firm faces stochastic price on its outputs, which are non-homogeneous to other competitors’, at the time of production decision, and money capital is raised in a financial market characterized by Sharpe-Lintner equilibrium. Since the CAPM requires a single-period decision framework, it is assumed that the firm’s assets and production potential are exhausted completely within one period. A simple linear technology is also imposed, since the major focus is on the output price, or input price for an importing firm, in which several suppliers compete in a single market in this import diversification framework.

The objective of this firm is to maximize the shareholders’ wealth or the firm’s market value ($V_i$). According to the valuation formula provided by the Sharpe-Lintner CAPM, $V_i$ is the present value of the net cash flow ($\bar{f}_i$), net of capital depreciation, and is expressed as:

$$V_i = (\psi_i W_i - c_i) \cdot q(W, I)(1 + r)$$  (2)

where $q(W, I)$ is the conditional demand for the commodity $i$ (from supplier $i$) by importing firm, $r$ is the risk-free rate of interest, $I$ is the income, and $c_i$ is a constant marginal and average short-run. $\psi_i$ is the certainty equivalent of the stochastic component of price, $(1 + \tilde{\epsilon}_i)$, given by $\psi_i = E(1 + \tilde{\epsilon}_i) - \lambda \sigma_{\tilde{\epsilon}} = 1 - \lambda \sigma_{\tilde{\epsilon}}$, where $\lambda$ is the market price of risk, $\tilde{R}_m$ is the stochastic rate of return on the
capital market portfolio, and $\sigma_{i,m}$ is the covariance of $\bar{e}_i$ with the rate of return on the market portfolio. The certainty equivalent price is then $(E(\bar{w}_i) - \lambda \sigma_{i,v(i,m)}) = (E(1 + \bar{e}_i) - \lambda \sigma_{i,v(i,m)}) W_i = \psi_i W_i$, where $\sigma_{i,v(i,m)}$ is the covariance between $\bar{w}_i$ and $\bar{R}_m$.

Using these terms, $E\pi_i$ becomes $(\psi_i W_i - c_i q_i)$, and the cov($\psi_i W_i$, $q_i$) is expressed as $\sigma_{\psi_i W_i, q_i} = W_i \sigma_{i,m} q_i$.

The supplying firm chooses $W_i$ to maximize $V_i$ at

$$\psi_i W_i = \frac{c_i}{1 - u_i}$$

where $\psi_i W_i$ is the certainty equivalent price. $u_i$ stands for $\frac{-W_i}{\frac{\partial q_i}{\partial W_i}}$, the reciprocal of the positive elasticity of own demand ($q_i$) with respect to the expected price ($W_i$), and also indicates the certainty equivalent spread between price and marginal cost as a proportion of price ($u_i = \psi_i W_i - c_i$). 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 the 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.

The main concern of this paper is to relate $\beta_i^*$ to the supplier’s monopolistic market power ($u_i$). Based on this framework, the systematic risk of a firm can be represented as a function of the firm’s certainty equivalent market power $u_i$ in the following way. In the CAPM, the systematic risk ($\beta_i$) of the rate of return on the security of the firm $i$ is measured by the relationship between the rate of return ($\bar{R}_i$) on the firm’s securities and the rate of return ($\bar{R}_m$) on the capital market portfolio. For an explicit form of $\beta_i$, similar to Chen et al. (1986), and Subrahmanyam and Thomadakis (1980) let us denote $\bar{R}_i = \frac{\bar{P}_i}{V_i} - 1$, and $\bar{R}_m = \frac{\bar{P}_m}{V_m} - 1$, where $\bar{P}_i = \sum \bar{P}_i$, $\bar{P}_m$, and $V_i = \sum V_i$.

Financial market participants are interested in the market value of suppliers, $V_i$, while the importer’s concern is on an optimal mix of suppliers. In the equilibrium analysis of an import, or any demand, diversification, the capital market rate of return ($\bar{R}_m$) can be restated with $W^* = (\sum \bar{w}_i \cdot s^*)$, the monetary value of an importer’s optimal demand portfolio, as follows. Given

1. 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 et al., 1986).
DEMAND DIVERSIFICATION UNDER UNCERTAINTY

the industry (or the import market in this paper)-specific portion of the CAPM market, we may express the CAPM market rate of return ($\hat{R}_m$) as an expectation-and variance-independent fraction (say $\tilde{f}_p$) of the rate of return of the industry (say $R_{mp}$)

$$\hat{R}_m = \hat{R}_{mp} \cdot \tilde{f}_p$$

where $\hat{R}_{mp} = \frac{\bar{\pi}_{mp}}{V_{mp}} - 1$

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

$$\hat{R}_{mp} = \frac{\sum (\hat{w}_i - c_i)q_i^*}{V_{mp}} - 1 = \frac{Q \cdot (\hat{W}^* - \sum c_i s_i^*)}{V_{mp}} - 1$$

(4)

where $Q$ is the total optimal import demand at the time-period, and $V_{mp}$ is expressed as $\frac{1}{1 + r} \cdot \frac{Q \cdot M^*}{\var}$ from Equation (5), where $M^*$ stands for $\sum (\psi_i W_i - c_i) s_i^*$, which is a market characteristic rather than a firm-specific factor.

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

$$\beta_i = \frac{\text{cov}(R_i, R_m)}{\sigma^2_m} = \frac{\text{cov}(\pi_i, R_m)}{\sigma^2_m V_i} = \frac{W_i q_i^* \sigma_{im}}{\sigma^2_m V_i}$$

(5)

On the other hand, the independence assumption of $\hat{R}_{mp}$ from $\hat{R}_m$ yields $\beta_i = \frac{\hat{f}_p \cdot \text{cov}(R_i, R_{mp})}{\hat{f}_p^2 \cdot \var R_{mp}}$, following the covariance analysis provided by Bohenstedt and Goldberger (1969). Based on the definitions of $\hat{R}_m$ and $\beta_i^*$, and the relationships for $\hat{R}_{mp}$ (Equation (4)) and $V_i$ (Equation (2)), we then obtain

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

$$= \frac{V_{mp} q_i^*}{\hat{f}_p Q V_i} \beta_i^* = \frac{\sum (\psi_i W_i - c_i) s_i^*}{\hat{f}_p (\psi_i W_i - c_i)} \beta_i^* = \frac{M^*}{\hat{f}_p m_i} \cdot \beta_i^*$$

(6)

where $\hat{f}_p$ indicates the expected $\tilde{f}_p$, $\sigma^2_m$ is the variance of $\hat{R}_m$, 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 $s^*$ is not feasible. From the supplier’s perspective, however, it is possible to draw a functional form of $W^\prime_i$. Note that the supplier’s optimality condition (Equation (3)) is based on the equilibrium model assumption that the supplier’s revenue function directly reflects the importer’s preference over that product. Now, we may express the explicit form of $\beta^i_*$, by combining Equations (5) and (6), with some model parameters that affect the equilibrium relationship of demand diversification as

$$\beta^i_* = \frac{\text{cov}(w^i_i, W^*)}{\text{var} W^*} = \left[ \frac{c_i \sigma_{i,m} f_i \bar{p}(1 + r)}{\psi_i \sigma_{i,m}^2 M^*} \right] \left[ \frac{1}{1 - u_i} \right]$$ or simply, $\beta^i_* = \beta^p_\psi \cdot \frac{1}{1 - u_i}$

(7)

Equation (7) summarizes one way of analysing the equilibrium relationship between key determinants of $\beta^i_*$ 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 in the discussion below Equation (3). Equation (7) shows that $\beta^i_*$ is positively related to $u_i$ (or $1 - u_i$), the supplier $i$’s monopolistic power in the certainty equivalent form, under the normal condition of positive $\sigma_{i,m}$. In an extreme, $\beta^i_*$ is a monotonically increasing function of $\frac{1}{1 - u_i}$, if the demand shock ($\hat{c}$) 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 et al., 1986).

Also, $\beta^i_*$ 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

2. To examine a positive relationship between $u_i$ and $\beta^i_*$ in a more intuitive way, consider only two suppliers. $\hat{H}^*$ is the sum of $s_1^* \tilde{w}_i$ and $s_2^* \hat{w}_i$ or $(1 - s^*) \hat{w}_i$, where $s_1^*$ and $s_2^*$ are the optimal shares for the supplier 1 and 2 with stochastic prices $\hat{w}_i$ and $\tilde{w}_i$. For the supplier 1 with higher market power, an increase in $\tilde{w}_i$ will lead to a higher increase in $\hat{H}^*$ than in the case with a lower or without market power. That is because the direct effect (i.e., $H_1$ is higher with market power), and the indirect effect (i.e., the decrease in $s^*$) is smaller (and so is the increase in $s^*$). Note that $\beta^i_*$ is independent of the level of $Q$, and that $s^*$ is less sensitive to the price changes, given $q_i$’s monopolistic effect in the market of $Q$. In other words, the changes in $(\tilde{w}_i - \hat{H}^*)$ are lower with more market power than the changes without or small degree of market power. Thus, given var($\hat{H}^*$), cov($\tilde{w}_i, \hat{H}^*$) becomes larger with market power due to the close stochastic movements in var($\hat{H}^*$) and cov($\tilde{w}_i, \hat{H}^*$), and $\beta^i_*$, cov($\tilde{w}_i, \hat{H}^*$), var($\hat{H}^*$), becomes larger toward one.
movement is highly correlated with the capital market movement of the rate of return. Since $\sigma_{(e(i), W^*)}$, or the covariance term between $(\tilde{e}_t, W^*)$, is the positive fraction of $\sigma_{im}$ (expressed as $\sigma_{im} = \frac{\beta_i}{\beta_i^*} \cdot \sigma_{(e(i), W^*)}$ 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 ($H_i$), partially due to existence of the market power, and/or the high quantity share ($s_i$) of the product $i$.

Equation (7) also shows that we may express net risk measure ($\beta_i^n$) relative to $W^*$ as a fraction of $\beta_i^*$. This simple orthogonal decomposition visualizes how much of the import price variation is explained by the risk measure given $W^*$ 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 $W^*$, but the $\beta_i^n$ refers to the net systematic risk term of $\beta_i^*$, conditional on observed $W^*$. Under the existence of market power in a normal sense (i.e., $0 < u_i < 1$), we observe the positive departure of $\beta_i^n$ from $\beta_i^*$, and the spread increases in correspondence to the increased $u_i$. That is, if products are 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 $\beta_i^*$ 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 of 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 that supplier’s power positively affects the measure of $\beta_i^*$, and thus disturbs the CAPM-type negative equilibrium relationship between $\beta_i^*$ and the expected price ($W_i$). The degree of significance of market power in a demand analysis is an empirical issue. But this theoretical section examines one way to extend the framework of Wolak and Kolstad, which entirely depends on the issue of importers’ risk diversification, based on their concept of the systematic risk measure ($\beta_i^*$) relative to the value of the market portfolio.

III. Empirical Application: Wheat Imports in China

III.1. Background and statement of problems

This section analyses the Chinese wheat import market as an empirical application. 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. An upstream institute, MOFERT, decides the total import quantity $Q$ to fill the gap between domestic demand and supply. And then, the sole state trading agency, China National Cereal, Oils and Foodstuffs Import/Export Corporation (CEROILS), determines the optimal combination of suppliers in Chinese wheat imports. Price is the most important factor that the agency considers in the decision of the mixture of suppliers, and product quality is a close second; quality is measured by quarantine objects, live insects, dockage, protein level etc. Governmental relationship is another important factor, 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 contracts, short-term contracts, and spot-market purchase. Because there always is room to renegotiate the price of long-term agreements based upon current market conditions, the wheat imports decisions are very flexible (USDA, various issues).

There is a 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 also vary for different types of wheat. Thus, as pointed out by Wolak and Kolstad, 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 0.4 and 0.8% in general compared to 0.2 and 0.3% for Canadian and Australian wheat. The high dockage reduces milling yields and thus raises the price paid on a millable material basis. High dockage also raises the cleaning and fumigation cost for the government agency with more live insects and Johnston grass seed. These inconsistent qualities provide the importing agency with another stochastic source for price renegotiation after the delivery via either deduction from the gross weight or penalties specified in contracts (Crook et al., 1993).

Wheat types are imperfect substitutes for one another within the same commodity group. Thus, in the analysis of a model of diversification, it is natural to consider the monopolistic market power of suppliers, as well as the time-series components of stochastic price. These market conditions should make the wheat import market a challenging empirical application of the theoretical model. This paper postulates Bertrand play for the suppliers, and thus any non-competitive

3. The measure of $u_i$ is estimated from an econometric model of systems of demand equations in our empirical application (Section III.2). But for 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 non-economic reasoning, such as trade embargo.
pricing behaviour 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 criticisms of the Armington assumption, but it avoids the complexity raised by the case of multi-class wheat export by a single country (e.g., the 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 market power.

Data on monthly wheat import prices for China, measured in yuan, the Chinese currency unit, and annual import quantities from major exporters are obtained from USDA. Over the last two decades or so, China has imported three classes of wheat: hard spring; hard winter; and soft wheat. 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 the three major suppliers (which account for almost 90% of the total supply) Canada, US, and Australia, and Table 1 summarizes mean and standard deviations of import prices and quantity shares for all five suppliers.

For the sample period, China imported wheat simultaneously from several major exporters who charge different prices. There were instances in the data when the price from one exporter was consistently above other exporters’ prices for an extended period of time, yet China continued to import highly priced wheat. This appears to violate the criterion of expected cost minimization. Should we follow Wolak and Kolstad’s logic, China may tradeoff the level of import cost against its variability in the decision of how to allocate 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 China shows a higher preference for certain types of products. As noted, this paper’s objective is to explain 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 raise questions about the expected cost minimization model of input choice. Specifically, the import prices of Canadian and Australian wheat are above all those of other suppliers even after the quality premium is applied. These prices are the most volatile among the price time series, yet the two countries supply an 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 least stable. Our major concern is with the three major suppliers. But, the final observation is, the combined share of EC and Argentina is about one-third of the US share alone, even though these two suppliers are able to charge about the same low price as the US with a relatively low price variability in the market.

### Table 1 Summary Statistics for Prices and Quantity Shares (1978:7–1995:6)

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Import price</th>
<th>Quantity share(%)</th>
<th>Import price: quality-adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>3.7 (0.474)</td>
<td>5.5 (0.044)</td>
<td>3.813</td>
</tr>
<tr>
<td>Australia</td>
<td>4.23 (0.916)</td>
<td>19.8 (0.144)</td>
<td>4.013</td>
</tr>
<tr>
<td>Canada</td>
<td>4.18 (0.7)</td>
<td>37.2 (0.103)</td>
<td>3.954</td>
</tr>
<tr>
<td>EC</td>
<td>3.34 (0.489)</td>
<td>5.2 (0.054)</td>
<td>3.462</td>
</tr>
<tr>
<td>USA</td>
<td>3.6 (0.365)</td>
<td>32.8 (0.173)</td>
<td>3.599</td>
</tr>
</tbody>
</table>

Notes: Mean and standard errors are in parentheses.
The last column 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., (1993) 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. (See Appendix for a fuller description of the data.)

Source: World Grain Statistics; USDA (various issues).

Overall, the observations from Table 1 raise questions about the expected cost minimization model of input choice. Specifically, the import prices of Canadian and Australian wheat are above all those of other suppliers even after the quality premium is applied. These prices are the most volatile among the price time series, yet the two countries supply an 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 least stable. Our major concern is with the three major suppliers. But, the final observation is, the combined share of EC and Argentina is about one-third of the US share alone, even though these two suppliers are able to charge about the same low price as the US with a relatively low price variability in the market.

#### III.2 Empirical methods and results

This section is developed to justify import diversification behaviour, by answering the questions arising from Table 1, mostly based on the estimation of the net price risk measure ($\beta'$) relative to $\hat{W}^*$, and the measure of certainty equivalent monopolistic market power of suppliers ($u_i$). As an initial step, non-structural vector autoregression (VAR) is employed to drive the time-conditional expected import prices for the five suppliers. The VAR approach has the desirable property, in short-run forecasting and in examining the interrelationships among a set of economic variables, that all variables of price series are treated symmetrically. Therefore, we rely significantly neither on any incredible
4. 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 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 the high contemporaneous correlation among variables, and the tendency to lead (i.e., Granger-cause) the market price by some price series (e.g., US). – See Appendix A2 for details.

Notes: Standard deviations are in parentheses.

\[ \text{Var}(\tilde{\beta}_i) = 2.1(10^3). \]
expected price series are negatively related to their own risk measure. This certainly 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 for any supplier. In other words, expected prices become lower (higher) to compensate for their increased (decreased) systematic risk of price relative to the value of the market portfolio. The table also apparently shows the positive $\text{cov}(\tilde{e}_{ij}, \tilde{W}_t^*)$, the covariance between $\tilde{e}_{ij}$ and $\tilde{W}_t^*$, for the three major suppliers of Canada, US and Australia. According to our theoretical model, a positive $\text{cov}(\tilde{e}_{ij}, \tilde{W}_t^*)$, adapted as a proxy of $\sigma_{\text{m}}$, is associated with the existence of market power and/or the significant market share of supplier $i$. Due to the positive relationship between $\text{cov}(\tilde{e}_{ij}, \tilde{W}_t^*)$ and $\beta_i^*$, the high covariance also implies high values of $\beta_i^*$’s for the suppliers.

As predicted, the big three suppliers yield higher estimated $\beta_i^*$’s than the rest of the group, but further examinations are necessary for the underlying cause for the high $\beta_i^*$’s. That is, a high $\beta_i^*$ can be due to either market power or significant market share of suppliers, or both. Positive correlation of $(\tilde{W}_t^*, \tilde{W}_t^*)$ for Canada and the US is also observed in the time-series, and strong market power may induce such higher correlation. For instance, Canada has the highest estimated market power (Table 3b), and also a considerably higher correlation at 0.829 (Table 2). In sum, the relative risk ($\beta_i^*$) does affect the determination of expected price, which is implied by the negative correlation of $(\tilde{W}_t^*, \beta_i^*)$ in the price time-series of all suppliers. Therefore, $\beta_i^*$ should not be accepted as a true risk measure for our purpose of analysing the hedging role of products imported, as examined in the diagnosis.

Figure 2 plots the sample mean of normalized $\tilde{W}_t$ (expected price) and $\beta_i^*$ for the purpose of a cross-sectional comparison. Unlike the time-series result, Figure 2 does not exhibit the negative cross-sectional relationship in Equation (1). Rather, a positive relationship among suppliers seems to appear in this scattered graph, and this contrasts to the theoretical and empirical result of Wolak and Kolstad in their application to the Japanese steam coal import market. These investigations may indicate that other factors, such as the monopolistic market

![Figure 2 Average Expected Price ($\tilde{W}_t$) vs. Beta ($\beta_i^*$)](image-url)
power of the suppliers, and/or its relationship with $\beta^*_n$ are critical in analysing the cross-sectional behaviour of Chinese wheat import diversification.

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

$$
\log q_{it} = a_{it} + a_{i1} \log q_{i,t-1} + a_{i2} \log W_{it} + (1 - a_{i3}) \log W_{it}^{-1}
+ a_{i4} \log(q_{i,t-1}^{-1}) + a_{itrend} + h_{it}; \ i = 1, \ldots, 5
$$

(8)

$q_{i,t-1}$ refers to the one-period lagged quantity demanded, $W_{it}^{-1}$ is the average normalized expected price of non-other than $W_{it}$, $q_{i,t}^{-1}$ is the total quantity imported net of $q_{i,t}$, and $h_{it}$ is the i.i.d regression error. Equation (8) 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., $|a_{it}| < 1$). Since the explanatory variables are different in each of the five 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 parentheses are reported in Table 3a, and the estimated market powers are shown in Table 3b.

Results show that it is appropriate to use the trend stationary specification with the first-order lagged dependent variable as a regressor; i.e., $|a_{i1}| < 1$, for $i = 1, \ldots, 5$, and $a_{i4}$ 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, 1997). The monopolistic market power($u_i$) is obtained from the regression. For the short-run, or impact estimates, $u_{i(SR)}$ is measured as the reciprocal of demand elasticity, $-\left(\partial \log(q_{i,t})/\partial \log(W_{it})\right)^{-1} = -(1/a_{i3})$. The long-run (or dynamic) market power, $u_{i(LR)}$, which is our concern, is measured as $-\left[a_{i4}/(1 - a_{i3})\right]^{-1}$. This is because, the detrended series of $\log(q_{i,t})$ is the stationary process at AR(1), the series, $\{\log(q_{i,t}) - a_{i1} \cdot \text{time}\}$, is supposed to have the same value at time $t$ and $t - 1$ in the long run. The estimates of $a_{i4}$ (or $q_{it}n_{it}$, 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.

Note that, from Equation (7), once we achieve estimates for $u_i$ and $\beta^*_n$, we are able to derive an estimate of the net risk measure($\beta^*_n$) relative to $W^*$, as a fraction of $\beta^*_n$, 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, $\beta^*$, and $\beta^*_n$. The results show that the net
Table 3  Conditional Demand Estimation

<table>
<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Australia</th>
<th>Canada</th>
<th>EEC</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \log q_i )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
</tr>
<tr>
<td>( \text{RHS} )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
<td>( \alpha_i )</td>
</tr>
<tr>
<td>( \alpha_i (\log q_i) )</td>
<td>-9.79(10.2)</td>
<td>-0.36(0.25)*</td>
<td>-13.4 (6.5)**</td>
<td>2.54(1.4)**</td>
<td>-0.31 (0.1)**</td>
</tr>
<tr>
<td>( \alpha_i (\log W_i) )</td>
<td>12.8 (1.63)**</td>
<td>0.36(0.15)**</td>
<td>-4.24(1.4)**</td>
<td>-1.06(0.2)**</td>
<td>0.04 (0.03)</td>
</tr>
<tr>
<td>( \alpha_i (\log q_i) )</td>
<td>8.24 (2.15)**</td>
<td>-0.17(0.17)</td>
<td>-2.11(0.98)**</td>
<td>0.21(0.19)</td>
<td>0.001(0.01)</td>
</tr>
<tr>
<td>( \alpha_i (\log q_i) )</td>
<td>-29.4 (10.0)**</td>
<td>0.04(0.22)</td>
<td>-2.04(5.09)</td>
<td>4.21(1.2)**</td>
<td>0.19 (0.09)**</td>
</tr>
<tr>
<td>( \alpha_i (\log q_i) )</td>
<td>5.08 (8.95)</td>
<td>0.46(0.19)**</td>
<td>8.06(8.52)</td>
<td>-0.11(1.18)</td>
<td>0.06 (0.11)</td>
</tr>
</tbody>
</table>

Notes: * 10% significance ** 5% significance

b. Estimated market power (\( u_i \)) and quantity response elasticity (\( q_{ni} \))

<table>
<thead>
<tr>
<th></th>
<th>( u_i(LR) )</th>
<th>( u_i(SR) )</th>
<th>( q_{ni}(LR) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>0.102</td>
<td>0.075</td>
<td>1.865</td>
</tr>
<tr>
<td>Australia</td>
<td>0.151</td>
<td>0.235</td>
<td>-1.652</td>
</tr>
<tr>
<td>Canada</td>
<td>0.556</td>
<td>0.474</td>
<td>0.176</td>
</tr>
<tr>
<td>EC</td>
<td>0.471</td>
<td>0.49</td>
<td>4.372</td>
</tr>
<tr>
<td>US</td>
<td>-0.067</td>
<td>-0.124</td>
<td>-0.199</td>
</tr>
</tbody>
</table>

Notes: 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(US) < 1.113(Arg.) < 1.178(Aust.) < 1.892(EC) < 2.25(Can.).
2. \( q_{ni} \) refers to the changes in \( q_i \) with respect to the change in \( q_i \) in percentage terms and \( q_{ni}(SR) \) is simply \( \alpha_i \).

Table 4  Summary of Estimation Results

<table>
<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Australia</th>
<th>Canada</th>
<th>EEC</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 1/(1 - u_i) )</td>
<td>1.112</td>
<td>1.178 (3)</td>
<td>2.25 (1)</td>
<td>1.892</td>
<td>0.937 (5)</td>
</tr>
<tr>
<td>( W_i = E(\tilde{v}_i) )</td>
<td>3.703</td>
<td>4.23 (1)</td>
<td>4.182 (2)</td>
<td>3.346</td>
<td>3.599 (4)</td>
</tr>
<tr>
<td>( \beta_i^* )</td>
<td>0.021</td>
<td>1.068 (1)</td>
<td>0.959 (2)</td>
<td>0.043</td>
<td>0.899 (3)</td>
</tr>
<tr>
<td>( \beta_i^* )</td>
<td>0.019</td>
<td>0.907 (2)</td>
<td>0.426 (3)</td>
<td>0.022</td>
<td>0.959 (1)</td>
</tr>
</tbody>
</table>

Notes: These are average values over the relevant time: 79.7–94.6. Normalized \( W_i \) values reported in Table 2. The magnitude rankings of the corresponding variable for the three major suppliers are in parentheses.

systematic risk(\( \beta_i^* \)) of some suppliers (especially, Canada and US) is quite significantly different from \( \beta_i^* \); i.e., \( \beta_i^*(\text{Canada}) \) is the second largest at 0.959 contrary to \( \beta_i^*(\text{Canada}) = 0.426 \), which is the median value in the whole group, and \( \beta_i^*(\text{US}) \) is largest, contrary to \( \beta_i^*(\text{US}) \), which is much less than \( \beta_i^*(\text{Australia}) \).

Even though the intercept term (\( E(\tilde{v}_i) \)) of Equation (1) is not a major concern of this paper, as in Wolak and Kolstad, a time-series of risk premium at time \( t(\text{RP}) \) is derived, and plotted in Figure 3. Following Wolak and Kolstad, \( \text{RP} \), is
Figure 3 Risk Premium (RP)

defined as \((E(H_t) - E(D_t)) / E(D_t)\), where \(E(D_t)\) and \(E(H_t)\) are expected values for the optimal risky portfolio and for the riskless portfolio, respectively, as introduced in Equation (1). In other words, the value of RP, is the negative of the ratio of market price of risk, \(E(D_t) - E(H_t)\), over the expected market price for the risky portfolio. The series of RP in this paper is measured roughly after adjusting market power effects in observed and forecast prices, based on our estimates of \(W_i\) and \(u_i\). Also note that the optimal mix of quantity shares, as well as prices, in these portfolios differ from the set of \(s^*_i\) in \(W^*_i\). Thus for the derivation of \(E(D_t)\) and \(E(H_t)\), the market-power term is first adjusted in \(W_i\), series, and then the corresponding optimal quantity shares for the five suppliers, given the adjusted prices, are calculated in a way similar to that of Wolak and Kolstad.

Complete confidence in the estimated values of RP is impossible, since the measure is based on estimates from the previous regressions; i.e., the plots of RP, 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%, on average for 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. (1993), the average premium China is willing to pay for wheat with no price risk should decrease.

5. The first set of optimal shares in \(E(W_{i,t})\) correspond to the solutions from 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 (Wolak and Kolstad, 1991, Equations (8) and 10)). The second optimal mixture of shares in \(E(H_{i,t})\) indicates the portfolio of suppliers, which has no market risk, given the risky prices. To compute this portfolio, Wolak and Kolstad solve for the minimum-variance weighted-average price subject to the constraint that its covariance with \(W_{i,t}\) is zero. The solution is shown in their Equation (25). The calculation of these two types of optimal shares in this paper is strictly based on their equations (Equations (8) and (25)), while assuming, instead of estimating, the risk coefficient (\(\lambda\)) to be 0.75 (Black, 1993). For the detail of derivation of the shares, consider Wolak and Kolstad (1991), and for the empirical procedure of this paper, consider Appendix A4.
Finally, relying mainly on the results of Table 4, we may justify the behaviour of Chinese wheat import diversification, especially, by answering the specific questions raised in the last part of Section III.1 in the following way.

(1) Note that the first question is on the data for Canadian wheat: this has the highest price and price variance, next closely to Australia, but the most stable quantity share among the major three suppliers. Results show that Canada exercises the greatest supplying power in the Chinese wheat market, and this strong power seems to be the key explanation why its products maintain sizeable market shares despite the high first two moments of actual price. Furthermore, within the big three group of Canada, the US and Australia, the lowest $\beta^*$ value of Canada largely indicates that consistent imports of Canadian products provide the importer with a good hedge against market price variation. Thus, the importer benefits in risk control and in his preference for Canadian products by maintaining sizeable and stable shares of the products.

For Australian data, results show generally imitate those for Canada, and the US, to a less marked extent: i.e., the second largest $u_{\text{LR}}$ (and also $u_{\text{SR}}$), and the second lowest $\beta^*$ among the major suppliers. One thing to note is the negative response ($a_{\text{LR}}$ or $u_{\text{LR}}$) of Australian wheat demand with respect to changes in $q_{\text{LR}}$, which is highly significant and negative in contrast to the rest of suppliers, and this reflects the independence of the demand from the other market demands. This may reflect the substitute aspect of Australian wheat for the other products due to its southern geographical location, based on a revision of the Chinese importing agency’s annual importing plan to fulfill an 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, a share far below that of the US on average. Despite its geographical niche (and perhaps its superior quality), Australian wheat suppliers appear to have so increased their price over time (see Figure 1) as to lose the significant market occupancy.

(2) The US data exhibit three aspects. First, the US has the lowest $u_{\text{LR}}$ and $u_{\text{LR}}$ over all suppliers. Secondly, the US has the highest net systematic price risk ($\beta$), and, finally, they exhibit the considerable negative sensitivity ($q_{\text{LR}}$) toward the increase in $q_{\text{LR}}$, total market demand net of the US (i.e., the estimated value of $q_{\text{LR}}=0.119 < 1.865$ (Argentina), 0.176 (Canada)). Overall, it seems 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 to stabilize 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. The third observation indicates that the US products play a substitute role, rather than a primary choice. These results should explain the reason why the US share is less than that of Canada on 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 the US to have significant market demands in the Chinese wheat market.

(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 the EEC and Argentina despite a comparable low price and price variability. These three suppliers are the group that charges the lowest prices and have the 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 depend 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 \( a_{3(US)}, q^n_{(US)} \) are negative and statistically insignificant, unlike these for the other two suppliers, despite being a major supplier. These examinations suggest that wheat import from the US is generally treated as the best ‘residual’ (or ‘substitute’) in terms of the large quantity available and product range from the viewpoint of Chinese importing agency. In other words, once some base amount of wheat is purchased from non-US sources (especially, Canada), CEROILS then appears to allocate a share of all additional purchases of several classes to the US, as reported by Crook et al. (1993).

IV. Conclusion

Wolak and Kolstad in their 1991 paper demonstrate one way to justify the behaviour of import diversification by examining a negative relationship between expected import price \( W_i \) and systematic price risk \( \beta^* \) 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 their approach is limited only to the importer’s perspective assuming homogeneity of products imported. In the theoretical section, equilibrium relationships among these key explanatory variables, \( W_i, \beta^*, u_i \), and the monopolistic market power \( u_i \) are derived by allowing the supplier’s optimality conditions within the modified framework of the CAPM.

The main argument is that if the monopolistic market power of suppliers is present in the importing agent’s decision-making, then \( u_i \) positively affects \( \beta^* \). The underlying cause for the positive relationship is the increased expected monetary value of risk in accordance with high market power of an input supplier. The existence of differentiated products thus disturbs the negative and linear relationship, which reflects the systematic risk-diversification effort of the importer, between \( W_i \) and \( \beta^* \). This paper further derives an orthogonal decomposition of \( \beta^* \) 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. The Chinese wheat import market is analysed as an empirical application in international trade. The results overall confirm the theoretical framework that monopolistic market power should be a critical factor, in its way of affecting \( W_i \) and \( \beta_i^* \), to be considered in a demand analysis of non-homogeneous products. Unless the market power of all suppliers is virtually negligible, an analysis purely based on the price-based portfolio may mislead us when conducting an empirical study of a real asset allocation model, such as an import diversification case.

Appendix

A.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 US has started an export-aid programme, called an Export Enhancement Program (EEP), to reduce its wheat export price to China since the early beginning of 1987, and these price arrangements were allowed for in the set of US price data. Thus the US export price data is the average of the three classes adjusted by the EEP bonus rate, which is calculated as the ratio of unitary export value over the average price. The EC uses the Common Market restitution programme to reduce the price of agricultural exports to specific countries, and these prices net of export refunds can be directly obtained from the World Wheat Statistics. 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 programme in Canada is not, however, available to the public. As a result, a common method is to apply the EEP rate for the US, to both the Canadian and the Australian price sets, and this has been done in this paper.

A.2 Estimation of Expected Price in a VAR

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

\[
 w_i, t = c_i + \sum_{j=1}^{p} a_{ij} w_{i,j+1} + \ldots + \sum_{j=1}^{p} a_{5j} w_{5,j+1} + e_{ji}, \quad \text{for } i = 1, \ldots, 5 \quad (A1)
\]

\( w_{i,t} \) = the actual Chinese wheat import price from the \( i \)-th supplier at time \( t \),
\( c_i \) = the \( 1 \times 15 \) vectors containing a constant, 11 seasonal (monthly) dummy variables, a time trend, and two level dummies to account for the Chinese currency (yuan) depreciation (1994:1) and the subsidy programme (1987:7),
\( p \) = the number of lags for the endogenous variables,
\( a_{ij} \) = coefficient for the \( k \)-th endogenous variable (i.e. \( w_k \)) with \( j \)-th lags for the dependent variable \( w_{j,t} \).
$e_{it} = \text{independently and identically distributed disturbance terms, while } E(e_{it}, e_{jt})$
for all $i, j$, is not necessarily zero.

There is the issue of whether the variables in a VAR need to be stationary. 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 $a_{ij}$, for all $j = 1, \ldots, p$, are zero, then the knowledge of the $w_t$ series does not reduce the forecast error variance of the $w_t$ series. Formally speaking, $\{w_t\}$ does not Granger-cause $\{w_t\}$, and, unless there is a contemporaneous response of $\{w_t\}$ to $\{w_t\}$, the $\{w_t\}$ series evolves independently of $\{w_t\}$. If, instead, any of the coefficients in these polynomials differ from zero, there are interactions between the two series.

Each equation is estimated using 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 $\chi^2$-tests, it appears that a length of 12 is the most appropriate choice. In addition to that, alternative test criteria 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, 1995, p. 315), and the criterion is to choose the model with the lowest value of these statistics. Table A1 shows that AIC is the lowest in the model of 12 lags without the seasonal dummies but SBIC is preferable for the model with the same lags with dummies. Among them, since we fail to reject the null of the model without seasonal dummies at 1% significance level with $\chi^2$-tests, we decided to choose model (4) in Table A1.

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 five price series. Variance decompositions are presented in Table A2 for two orderings: that based on the relative shares of suppliers (I: Can., US, Aust., Arg., EEC) on average, and an ordering based on the relative average price (II: Aust.,

<table>
<thead>
<tr>
<th>Model/test-stat.</th>
<th>AIC</th>
<th>SBIC</th>
<th>$\chi^2$-tests (alternative to model(1))</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 12-lag length</td>
<td>2.156</td>
<td>−5.934</td>
<td></td>
</tr>
<tr>
<td>(2) 6-lag length</td>
<td>3.499</td>
<td>−7.030</td>
<td>363.04**</td>
</tr>
<tr>
<td>(3) 3-lag length</td>
<td>3.976</td>
<td>−7.773</td>
<td>197.59**</td>
</tr>
<tr>
<td>(4) 12-lag w/o seasonal dummies</td>
<td>2.088</td>
<td>−6.897</td>
<td>60.77</td>
</tr>
</tbody>
</table>

Note: ** rejects the null of the restricted model at 5% significance.
<table>
<thead>
<tr>
<th>LHS/RHS variables</th>
<th>Argentina ordering(I/II)</th>
<th>Australia (I/II)</th>
<th>Canada (I/II)</th>
<th>EEC (I/II)</th>
<th>US (I/II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>24.1/22.2</td>
<td>24.8/32.7#</td>
<td>22.4/7.4#</td>
<td>20.2/20.2</td>
<td>8.7/17.5</td>
</tr>
<tr>
<td></td>
<td>(25.41**)</td>
<td>(1.36)</td>
<td>(0.49)</td>
<td>(9.85**)</td>
<td>(2.34**)</td>
</tr>
<tr>
<td>Australia</td>
<td>7.5/4.6</td>
<td>38.0/46.8</td>
<td>26.7/3.1#</td>
<td>17.4/17.4</td>
<td>10.4/26.1</td>
</tr>
<tr>
<td></td>
<td>(2.77**)</td>
<td>(35.74**)</td>
<td>(1.66)</td>
<td>(16.54**)</td>
<td>(3.29**)</td>
</tr>
<tr>
<td>Canada</td>
<td>3.2/2.0</td>
<td>18.8/42.7</td>
<td>48.4/14.5</td>
<td>12.1/12.1</td>
<td>17.5/28.6</td>
</tr>
<tr>
<td></td>
<td>(2.94**)</td>
<td>(1.10)</td>
<td>(29.91**)</td>
<td>(10.91**)</td>
<td>(2.98**)</td>
</tr>
<tr>
<td>EEC</td>
<td>17.1/16.2#</td>
<td>18.1/27.6#</td>
<td>20.3/9.4#</td>
<td>36.0/36.0</td>
<td>8.5/10.8</td>
</tr>
<tr>
<td></td>
<td>(1.17)</td>
<td>(1.56)</td>
<td>(1.50)</td>
<td>(3.48**)</td>
<td>(2.29**)</td>
</tr>
<tr>
<td></td>
<td>(2.75**)</td>
<td>(1.59)</td>
<td>(0.60)</td>
<td>(11.89**)</td>
<td>(15.27**)</td>
</tr>
</tbody>
</table>

Note: ** rejects the null of the restricted model at 5% significance.

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 caused by its own shocks as opposed to 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 significantly influences the results. Granger-causality tests are also performed for all incidences and are reported in the parentheses of Table A2. An interesting hypothesis to examine is whether price movements in Canada, as a share leader on 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 neither is the case and conclude in favour 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’ prices, 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 a fairly high percentage of the variance decomposition to most cases in both orderings. Argentina, and perhaps Canada, on the other hand, appear to act as a follower, reacting to innovations in other prices, rather than its own innovations having an influence on the others (Enders, 1995).

Since the interrelationship of price movements is not the major concern for the VAR analysis here, combined with outcomes of Table A2, we re-estimated Equation (1A) 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.

A.3 Brief Description on Estimation of \( \beta_i^* \)

Time \( t \)-conditional series of \( \beta_i^* \) is defined as \( \{E[N_i]/E(D_{it})^2\} \) for all \( i = 1, \ldots, 5 \) suppliers, where \( N_i \) and \( \{D_{it}\}^2 \) indicate \([\{\bar{W}_{it1} - W_{it}\}, \bar{W}_{it5}^* - E, \bar{W}_{it5}^*\}]\) and \([\bar{H}_{it1}^* - E, \bar{H}_{it5}^*\}]\), respectively. Since we have already obtained series of \( N_i \) and \( \{D_{it}\}^2 \) from the estimation of expected prices (i.e., \( W_{it} \) for \( i = 1, \ldots, 5 \)), the next step is to derive the time-dependent expectation of these series. To do so, two separated vector auto-regressions, say \( V_1 \) and \( V_2 \), without any restriction, of order one are run: one for five \( N_i \) series and the other for the six series of \( \{[D_{it}]^2\} \) and \( \{[\bar{W}_{it1}^* - W_{it}]\} \) for five suppliers. Formally, these two systems of equations we will estimate are expressed as, \( \text{lhs}_{i} = c_{i} + \sum_{j=1}^{m} a_{ij} \text{rhs}_{i,j-1} + r_{i,j} \). For the regression \( V_{1t} \), \( i = 1, \ldots, 5 \), and \( m = 5 \), and, for \( V_{2t} \), \( i = 1, \ldots, 6 \) and \( m = 6 \). And, \( \text{lhs} \) and \( \text{rhs} \) variables are numerators and denominator(s) of \( \beta_i^* \) as defined above, while \( c_{i} \) is the \( 1 \times 2 \) vector containing a constant and time trend, \( a_{ij} \) is coefficient for the \( j \)-th endogenous variable (i.e. \( \text{rhs} \)) with first lag for the dependent variable \( \text{lhs}_{i,j} \), \( r_{i,j} \) independently and identically distributed disturbance terms, while \( E(e_{i,j}, e_{j,j}) \) 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 \( \beta_i^* \) is the common value for the series, but the series of \( \{\bar{W}_{it1} - W_{it}\}^2 \) for five 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 A3 and Table A4. Based on these results, the seemingly

<table>
<thead>
<tr>
<th>LHS/RHS</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
<th>N5</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>92.2 (0.22)</td>
<td>1.0 (0.42)</td>
<td>3.5 (0.5)</td>
<td>3.0 (1.05)</td>
<td>0.27 (0.17)</td>
</tr>
<tr>
<td>N2</td>
<td>19.3 (1.29)</td>
<td>48.8 (0.95)</td>
<td>25.2 (0.52)</td>
<td>5.1 (2.3*)</td>
<td>1.57 (0.58)</td>
</tr>
<tr>
<td>N3</td>
<td>26.6 (1.63)</td>
<td>24.1 (0.36)</td>
<td>44.3 (0.74)</td>
<td>4.35 (1.9*)</td>
<td>0.74 (0.34)</td>
</tr>
<tr>
<td>N4</td>
<td>17.1 (1.72)</td>
<td>17.2 (1.8*)</td>
<td>47.9 (0.26)</td>
<td>15.3 (1.95*)</td>
<td>2.59 (0.73)</td>
</tr>
<tr>
<td>N5</td>
<td>15.0 (0.63)</td>
<td>53.9 (0.14)</td>
<td>10.4 (0.82)</td>
<td>2.3 (0.59)</td>
<td>18.3 (0.38)</td>
</tr>
</tbody>
</table>

Notes: * significant at 10% level or better.

The numbers 1 through 5 indicate Argentina, Australia, Canada, EC, US, respectively. Parentheses report Granger-Causality Statistics (\( t \)-value under order one). Further, \( N(i) = \{[\bar{W}_{it1} - W_{it}]\}^2 \).
Table A4  Forecast Error Variance Decomposition (4-year horizon) for Denominator (\(V_{it}\))

<table>
<thead>
<tr>
<th>LHS/RHS</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>Dm</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>97.6</td>
<td>0.48</td>
<td>0.33</td>
<td>0.01</td>
<td>1.08</td>
<td>0.47</td>
</tr>
<tr>
<td>D2</td>
<td>7.59</td>
<td>60.6</td>
<td>23.9(1.8*)</td>
<td>2.2(1.7*)</td>
<td>3.39</td>
<td>2.3</td>
</tr>
<tr>
<td>D3</td>
<td>49.6(−2.9*)</td>
<td>10.9</td>
<td>32.7</td>
<td>4.13(−2.9*)</td>
<td>1.58</td>
<td>1.05</td>
</tr>
<tr>
<td>D4</td>
<td>4.15</td>
<td>24.4(8.3*)</td>
<td>32.8</td>
<td>25.7(2.0*)</td>
<td>1.06</td>
<td>12(−4.3*)</td>
</tr>
<tr>
<td>D5</td>
<td>8.36</td>
<td>25.5</td>
<td>9.5</td>
<td>5.26</td>
<td>51.1</td>
<td>0.32</td>
</tr>
<tr>
<td>Dm</td>
<td>24.4</td>
<td>34.1</td>
<td>28.8(2.2*)</td>
<td>1.9</td>
<td>3.4</td>
<td>7.3</td>
</tr>
</tbody>
</table>

Note: \(D(t) = [(\bar{r}_{it} - \bar{W}_{it})^2]\) and \(D_m = [(\bar{r}_{it} - \bar{w}_{it})^2]\). Parentheses report only statistically significant Granger-Causality statistics.

Table A5  SUR Estimation for Numerator of \(\beta^*_i\)

<table>
<thead>
<tr>
<th>LHS/RHS</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
<th>N5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0024</td>
<td>0.0035**</td>
<td>0.0043**</td>
<td>−0.0042*</td>
<td>0.0031**</td>
</tr>
<tr>
<td>Trend</td>
<td>−0.002</td>
<td>−0.002**</td>
<td>−0.002**</td>
<td>−0.002**</td>
<td>−0.0012*</td>
</tr>
<tr>
<td>Yr86</td>
<td></td>
<td></td>
<td>0.0018*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N1(−1)</td>
<td>−0.129</td>
<td>−0.201**</td>
<td>−0.286**</td>
<td>−0.252</td>
<td></td>
</tr>
<tr>
<td>N2(−1)</td>
<td>−0.136</td>
<td>−0.186</td>
<td>3.15**</td>
<td>−0.393**</td>
<td></td>
</tr>
<tr>
<td>N3(−1)</td>
<td></td>
<td>0.353*</td>
<td>−0.491</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N4(−1)</td>
<td>−0.074</td>
<td>0.297*</td>
<td>−0.062</td>
<td>−0.434*</td>
<td></td>
</tr>
<tr>
<td>N5(−1)</td>
<td></td>
<td></td>
<td>0.287</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: * significant at 10% level ** significant at 5% level
Yr86 is a dummy variable because of the low market share of the US in 1986.

Table A6  SUR Estimation for Denominator of \(\beta^*_i\)

<table>
<thead>
<tr>
<th>LHS/RHS</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>Dm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0098**</td>
<td>0.0026**</td>
<td>0.011**</td>
<td>−0.017**</td>
<td>0.003**</td>
<td>0.0032**</td>
</tr>
<tr>
<td>Trend</td>
<td>−0.0006*</td>
<td>−0.0008</td>
<td>−0.0006**</td>
<td>−0.00007</td>
<td>−0.00014*</td>
<td></td>
</tr>
<tr>
<td>Yr86</td>
<td></td>
<td></td>
<td>0.0015</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1(−1)</td>
<td>−0.148</td>
<td>−0.395**</td>
<td></td>
<td>19.01**</td>
<td>−0.142</td>
<td>−0.095*</td>
</tr>
<tr>
<td>D2(−1)</td>
<td>−0.202</td>
<td>0.095</td>
<td>19.01**</td>
<td>−0.142</td>
<td>−0.133</td>
<td></td>
</tr>
<tr>
<td>D3(−1)</td>
<td>0.153*</td>
<td>0.265*</td>
<td>3.436*</td>
<td>0.315**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D4(−1)</td>
<td>−0.0081*</td>
<td>−0.039**</td>
<td>0.293**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5(−1)</td>
<td></td>
<td></td>
<td></td>
<td>−0.152</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dm(−1)</td>
<td></td>
<td></td>
<td></td>
<td>−13.46**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

unrelated regression (SUR) is run, and the results are also reported below in Table A5 and Table A6 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 \(\beta^*_i\)-series for the five suppliers.
A.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 $E(\bar{w}_c)$ corresponds to the solutions of solving the problem of maximizing the agent’s expected utility in a MV specification. The only difference between Equations (8) or (10) in Wolak and Kolstad (1991) and this paper is that, risk coefficient ($\lambda$) is assumed to be 0.75, following Black (1993), instead of restricting $\lambda Q_t$ to being a constant over time, where $Q_t$ is the total quantity demanded. The second optimal mixture of shares in $E(\bar{w}_c)$ indicates 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 Wolak and Kolstad. These optimal shares are available from the author on request.

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

$$W_{a(i,t)/\bar{a}(i,t+1)} - 1 = \text{constant}_{(i)} + e_{(i,t)} \quad \text{for } i = 1, \ldots, 5$$

where $W_{a(i,t)}$ and $\bar{a}_{a(i,t+1)}$ 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 five equations and the corresponding matrix is

$$\begin{bmatrix}
1.91 & 0.99 \\
-0.11 & 0.29 & 1.16 & 1.76 \\
-2.8 & -4.40 & -0.35 & 26.5 \\
-0.02 & 1.44 & 1.75 & -7.0 & 2.37
\end{bmatrix}$$

References


Copeland, Thomas E. and J. Fred Weston, 1988, Financial Theory and Corporate Policy, Addison-Wesley, Boston MA.


