ON THE RISK-ADJUSTED EFFECTIVE PROTECTION RATE

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Abstract—Using the assumptions of the Capital Asset Pricing Model this paper presents a measure of the effective protection rate which adjusts for the industry's risk. It is shown that if the tariff on the final good is greater (smaller) than the weighted average tariff on the traded inputs, then the effective protection increases (decreases) as one moves from an industry with low risk (low beta) to an industry with high risk (high beta), holding other things constant. The empirical methodology of the new measure is also provided, as well as several illustrations from U.S. industries.

I. Introduction

THIS paper presents a new measure of the effective protection rate which takes into account the existence of uncertainty and stock market valuation of random returns. The new measure—the Risk-Adjusted Effective Protection Rate (RAEPR)—uses the Capital Asset Pricing Model (CAPM) to demonstrate the dependence of the rate of protection on an industry's risk. We prove that when the tariff on the final good is greater (smaller) than the weighted average tariff on traded inputs,[1] the effective protection increases (decreases) as one moves from an industry with low risk (or low beta) to one with high risk (or high beta) other things held constant. We also show how the measure can be calculated empirically and present several illustrations.

The paper is organized as follows. In the next section the effective protection rate is defined in both a deterministic and an uncertain environment. The RAEPR is presented in section III, the empirical methodology and some illustrations of the measure from U.S. industries in section IV. The empirical findings are placed in perspective in the final section.

II. The Effective Protection Rate in Deterministic and in Uncertain Environments

By specifying the effects of tariffs on the value added of an industry rather than on the price of the final output of the protected industry, the effective protection rate analyzes how the structure of nominal tariffs affects the production pattern of a country. It is defined as the percentage increase in the value added as a result of the tariff structure, i.e., $g \equiv (V_t - V)/V$, where V^t and V are the value added per unit of output with and without protection.

In a deterministic framework, the free trade value added per unit of industry i, $i = 1, \dots, n$, is

$$V_i = P_i - \sum_{j=n+1}^{m} a_{ij} P_j$$

while the post-tariff value added is defined as

$$V_i^t = (1 + t_i) P_i - \sum_{j=n+1}^{m} a_{ij} (1 + t_j) P_j$$

where P_i and P_j are the free trade prices of one unit of commodity i and imported (or domestically produced) intermediate good (the traded input) j; t_i and t_j are their respective tariffs; and a_{ij} is the number of units of intermediate good j, $j = n + 1, \dots, m$, that are required to produce one unit of final output of commodity i, $i = 1, \dots, n$. Hence the deterministic effective protection rate (DEPR) of industry i, denoted by g_i^D, is

$$g_i^D = \frac{t_i P_i - \sum_{j=n+1}^{m} a_{ij} t_j P_j}{P_i - \sum_{j=n+1}^{m} a_{ij} P_j}. \tag{1}$$

Note that several assumptions are made above which are common to some of the theoretical studies (for example, Ruffin (1969)) and most of the empirical studies (for example, Balassa (1965)) on the DEPR. The first is that the tariff is fully effective, i.e., it raises the domestic good's price by the full amount of the tariff. We also assume that the coefficients a_{ij} are constants and that domestic and foreign goods are perfect substitutes. These assumptions will be maintained throughout the analysis.

Consider the effective protection rate in an uncertain environment where a stock market exists.[2]

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[1] The terms traded inputs and intermediate goods will be used interchangeably.

[2] In countries where stockmarkets are not well developed, a utility approach to the firm operating under uncertainty should be undertaken (see Baron (1970), Sandmo (1971), Batra (1974), and Mayer (1976)).

One standard approach in the literature on behavior of firms under uncertainty (cf. Baron (1970), Batra (1974), Helpman and Razin (1978), Mayer (1976), and Sandmo (1971)) is that factor inputs are chosen ex ante so that they are certain and that output is determined ex post after the resolution of uncertainty.[3] Assume that sector i produces commodity i, denoted by X_i, $i = 1, \ldots, n$, using a domestic input L_k (non-traded input), $k = 1, \ldots, K$, and a traded intermediate good X_j, $j = n+1, \ldots, m$. The random output of this sector depends on its employment of traded and non-traded inputs as well as on the state of the world, α, $\alpha = 1, 2, \ldots, S$. We can therefore write

$$X_i(\alpha) = \theta_i(\alpha) f_i(L_1, \ldots, L_k, X_{n+1}, \ldots, X_m) \quad \text{for} \quad \alpha = 1, 2, \ldots, S; \quad i = 1, \ldots, n.$$

Note that the choice of factor inputs is made by firms before the realization of a state of the world. The choice is made so as to maximize the firm's net value on the stock market. We assume that initial stockholders bear all factor costs. Thus, the return to the investors (in gross terms) is the value of the output produced, since their initial investment entitles them to a claim on the total output.[4] The gross return to the final stockholder of sector i is the value of output $P_i(\alpha)X_i(\alpha)$ where $P_i(\alpha)$ is the price of good i at state α. Following Helpman and Razin (1978), we call $f_i(\cdot)$ the number of real equities produced by sector i. A real equity provides its holder with $\theta_i(\alpha)$ units of good i in state α. We assume homogeneous expectations and choose units such as $E_\alpha[\theta_i(\alpha)] = 1$. Then, a_{ij} is the number of units of traded input j that are required in order to produce one real equity of type i.

What is the tariff's impact on equity prices? Since a tariff increases the unit price of the final output by $100t_i$ per cent in every state of the world, it increases the return on each unit of type i real equity by $100t_i$ per cent. That is, the return in state α is $(1 + t)P(\alpha)\theta(\alpha)$ with a tariff (versus $P_i(\alpha)\theta_i(\alpha)$ under free trade). Let the price of the real equity of type i in the free trade situation be q_i; then to eliminate arbitrage opportunities the post tariff price of this real equity should be $(1 + t)q_i$.[5] Since tariffs on the imported inputs do not change the pattern of return of real equity, they do not affect real equity prices.

What is the appropriate definition of effective protection in an uncertain environment, where there exists a stock market to share the risk? In the stock market model where equities are produced ex ante and resource allocation is determined by equity prices, the appropriate concept of value added is the value of the equity less the unit cost of the traded inputs, i.e.,

$$v_i^* = q_i - \sum_{j=n+1}^{m} a_{ij} P_j, \qquad i = 1, \ldots, n$$

and the post tariff value added is

$$V_i^{*t} = (1 + t_i)q_i - \sum_{j=n+1}^{m} a_{ij}(1 + t_j)P_j, \qquad i = 1, \ldots, n.$$

Hence the effective protection rate of industry i in an uncertain environment is

$$g_i^D = \frac{t_i q_i - \sum_{j=n+1}^{m} a_{ij} t_j P_j}{q_i - \sum_{j=n+1}^{m} a_{ij} P_j}, \qquad i = 1, \ldots, n. \quad (2)$$

III. The Risk-Adjusted Effective Protection Rate

In order to derive more specific results concerning the variations in the effective protection rate under uncertainty as the industry risk varies and to apply this measure empirically, we must impose restrictive assumptions on the investor's preferences. We assume that the investor is a mean-variance maximizer. This assumption is commonly used in the theory of finance, and it enables us to derive a risk-adjusted effective protection rate by making use of the Sharpe-Lintner CAPM.[6]

According to the CAPM, in equilibrium all securities will lie along the line called the Security Market Line. Since investors are risk averse, increasing increments of compensation (expected return) are required if they are to bear increasing

[3] This might appear incongruous with the spirit of effective protection since inputs and outputs are not treated symmetrically. However, in order to determine effective protection in an industry, resource flow to that industry must be given.

[4] Alternatively, the firm can finance purchase of inputs either by new equities alone or by a combination of equities and bonds (see Helpman and Razin (1978), pp. 66–67, 85–91; and Stiglitz (1974)).

[5] $(1 + t)$ and free trade of type i equities would give you exactly the same return as one post tariff equity of type i.

[6] See Sharpe (1964) and Lintner (1965).

risk. The Security Market Line (S.M.L.) equation is

$$R_i = R_f + \beta_{iM}(R_M - R_f) \tag{3}$$

where

- R_i is the expected return on equity i,
- R_f is the risk-free rate,
- R_M is the expected return on the market portfolio, and
- $\beta_{iM} = \operatorname{cov}(R_i, R_M)/\operatorname{var} R_M$ is the sensitivity of the expected return on equity i to the expected return on the market.

The market value of the i^{th} security, q_i, is obtained by discounting the end period expected return—$E_\alpha[P_i(\alpha)\theta_i(\alpha)]$—by a discount rate that reflects and compensates for the uncertainty (systematic risk) associated with $P_i(\alpha)\theta_i(\alpha)$. This discount rate R_i can be derived from the S.M.L. equation after we have identified the beta associated with the i^{th} real equity. The price of the i^{th} real equity can then be explicitly written as

$$q_i = E[P_i(\alpha)\theta_i(\alpha)]/(1 + R_i). \tag{4}$$

Substituting (4) into (2) we have the new measure of effective protection which takes account of production and price uncertainty, namely,

$$g^{RA} = \frac{t_i E[P_i(\alpha)\theta_i(\alpha)]/(1 + R_i) - \sum a_{ij} t_j P_j}{E[P_i(\alpha)\theta_i(\alpha)]/(1 + R_i) - \sum a_{ij} P_j}, \quad \alpha = 1, 2, \ldots, S. \tag{5}$$

The only difference between the deterministic measure g_i^D in (1) and the risk-adjusted measure g_i^{RA} in (5) is that instead of the term P_i we have

$$E[P_i(\alpha)\theta_i(\alpha)]/(1 + R_i), \qquad \alpha = 1, 2, \ldots, S.$$

Recall that R_i, which was derived from the S.M.L., is likely to be different across industries, reflecting the risk involved in the production. Therefore, even with the same nominal tariffs on traded inputs and on final goods, as well as the same input coefficients, effective protection rates will vary because of the different risks involved in the production of the two goods. This may be summarized as:

THEOREM: *Assume that the CAPM holds. Consider two industries, i and h, identical in all respects except for their assets risk, β. For concreteness, suppose $\beta_i > \beta_h$. Let $t = \Sigma_j a_{ij} t_j P_j / \Sigma_j a_{ij} P_j$ be the weighted average tariff on the intermediate commodities. If the common tariff rate on the final good in the two industries is above (below) the average t, then the risk-adjusted effective protection rate in i will be greater than (less than) that in h. That is,*

$$\text{if } t_h = t_i > t, \quad \text{then } g_i^{RA} > g_h^{RA}$$

and

$$\text{if } t_h = t_i < t, \quad \text{then } g_i^{RA} < g_h^{RA}.$$

Proof: If $\beta_i > \beta_h$, then from the S.M.L. equation we have that $R_i > R_h$. Let

$$P = E[P_h(\alpha)\theta_h(\alpha)] = E[P_i(\alpha)\theta_i(\alpha)], \quad \alpha = 1, 2, \ldots, S.$$

Then

$$g_i^{RA} = \frac{t_i P/(1 + R_i) - t\sum a_{ij} P_j}{P/(1 + R_i) - \sum a_{ij} P_j}$$

and

$$g_h^{RA} = \frac{t_i P/(1 + R_h) - t\sum a_{ij} P_j}{P/(1 + R_h) - \sum a_{ij} P_j}.$$

First, observe that if $t_i = t$ then $g_i^{RA} = g_h^{RA} = t_i$ and the change in the risk of the industry does not change the RAEPR. Taking the derivative of g_i^{RA} with respect to R_i, we obtain

$$\frac{dg_i^{RA}}{dR_i} = \frac{P\sum_i a_{ij} P_j}{\left[P - \sum_i a_{ij} P_j (1 + R_i)\right]^2}(t_i - t).$$

The sign of this derivative depends on the difference between the tariff on the final good and the weighted average tariff on the traded inputs.

Hence, if $t_i > t$ then $dg_i^{RA}/dR_i > 0$ or $g_i^{RA} > g_h^{RA}$ and if $t_i < t$ then $dg_i^{RA}/dR_i < 0$ or $g_h^{RA} > g_i^{RA}$. Q.E.D.

The usual case is $t_i > t$, so that the effective protection increases as we move from an industry with low risk (h) to an industry with high risk (i), holding other things constant. The economic reasoning underlying this result is that when the risk associated with the industry involved increases, the certainty equivalent of the uncertain value added (the present value of the uncertain value added) decreases, because the risk-adjusted discount rate increases. This decrease in the value added leads, other things constant, to an increase in the effective protection rate (see Corden (1971), p. 36).

IV. Empirical Methodology and Some Illustrations

In this section we provide an empirical methodology for estimating the new measure, the RAEPR, as well as some illustrations from U.S. industries. To do this, we must first modify equations (1) and (5) so that they will accommodate the available data.

Denote t as the weighted average of all input tariffs, and $\Sigma a_{ij} P_j$ as the total cost of material. Then (1) becomes

$$g_i^D = \frac{t_i P_i - t \sum_{j=n+1}^{m} a_{ij} P_j}{P_i - \sum_{j=n+1}^{m} a_{ij} P_j} \tag{6}$$

and (5) becomes

$$g_i^{RA} = \frac{t_i E_\alpha [P_i(\alpha)\theta_i(\alpha)]/(1+R_i) - t \sum_{j=n+1}^{m} a_{ij} P_j}{E_\alpha P_i(\alpha)\theta_i(\alpha)/(1+R_i) - \sum_{j=n+1}^{m} a_{ij} P_j} \tag{7}$$

where $m - n$ is the number of traded inputs. Next, we transform these equations in line with the data available in the 1977 *Census of Manufactures*, which is aggregative in nature. The heading "Cost of Material" refers to the charges actually paid for items put into production during the year including freight charges and the like, while the "Value of Shipment" is the received net selling value. Thus, we multiply both the denominator and the numerator in (6) and (7) by the output-activity level of the industry—$f_i(\cdot)$. So we have,

$$g_i^D = \frac{t_i P_i f_i(\cdot) - t \sum a_{ij} P_j f_i(\cdot)}{P_i f_i(\cdot) - \sum a_{ij} P_j f_i(\cdot)} \tag{8}$$

and

$$g_i^{RA} = \frac{t_i E_\alpha [P_i(\alpha)\theta_i(\alpha) f_i(\cdot)]/(1+R_i) - t \sum a_{ij} P_j f_i(\cdot)}{E_\alpha [P_i(\alpha)\theta_i(\alpha) f_i(\cdot)]/(1+R_i) - \sum a_{ij} P_j f_i(\cdot)}. \tag{9}$$

At this point, we make a crucial "supercast" assumption. That is, the realized returns (the ex post revenues as they appear in the 1977 *Census of Manufactures*) are taken as the expected return. Hence the data available in the 1977 *Census of Manufactures* can be interpreted as the expected values. The number under the classification of Value of Shipment can be considered as $(1 + t_i) E_\alpha [P_i(\alpha)\theta_i(\alpha)] f_i(\cdot)$ which is the total post tariff expected revenues. To arrive at the expected revenues under free trade, we divide by $(1 + t_i)$. Similarly, the number under the classification of Cost of Material is taken as the total post tariff cost of material, namely, $(1 + t)\Sigma a_{ij} P_j f_i(\cdot)$. To arrive at the cost of material under free trade, we divide this number by $(1 + t)$.

The industry's risk-adjusted discount rate R_i, sometimes called the true cost of capital, is measured by making use of (3) which is the main equation of the CAPM. As a proxy for the risk-free rate, we use, as is standard, the Treasury bill rate which on January 10, 1977 was 4.3%. The difference between the return on the market and the risk-free rate has been termed the market risk-premium whose average over the past 50 years has been 8.8% per annum. The third input to equation (3), the industry asset beta, is quite difficult to assess. It depends on the sensitivity of the demand for the industry product or services and on its cost of factor of production. Hence, one may expect industries characterized by highly cyclical demand and/or large fixed cost to have higher betas than those in industries with more stable demand and/or greater freedom to vary cost. In order to arrive at estimates of an industry's asset betas, one might use the available estimates of the industry's equity betas as a benchmark, since the beta value of the industry's stock depends on the beta of its assets and its degree of financial leverage. This dependence can be represented by

$$\begin{aligned}\text{Industry Asset Beta} = {}& \text{Industry Debt Beta} \times \frac{\text{Debt}}{\text{Debt + Equity}} \\ &+ \text{Industry Equity Beta} \times \frac{\text{Equity}}{\text{Debt + Equity}}\end{aligned} \tag{10}$$

or

$$\beta_A = \beta_D \frac{D}{D+E} + \beta_E \frac{E}{D+E}.$$

One may observe that if the industry is totally equity financed, then the asset beta is equal to the stock beta. For the purpose of this illustration we

TABLE 1.—SUMMARY STATISTICS FOR AGGREGATED INDUSTRIES

Industry	Expected Post Tariff Value of Shipment	Expected Free Trade Value of Shipment	Post Tariff Input Cost	Weighted Average Tariff on Inputs (%)	Free Trade Input Cost	Industry Equity Beta	Industry Asset Beta	Risk-Adjusted Discount Rate (%)	Nominal Tariff (%)	EPR (%)	RAEPR (%)
Beverages Brewers: 1977 (million dollars)	6,652.6	6,522.2	3,877.2	4.9	3,690.0	0.99	0.77	11	2	−2	−3.2
Drugs Industry: 1977	14,247.80	12,721.25	3,756.8	5.6	3,557.58	1.12	0.91	12.3	12	14.5	14.9
Shoes Industry: 1977 (million dollars)	3,296.9	3,027.5	1,432.5	4.64	1,369.2	1.06	0.57	9.3	8.9	12.4	13.1

shall assume the firm's debt betas are zero.[7] Hence, (10) can be reduced to

$$\beta_A = \beta_E E/(D + E). \tag{11}$$

Data

Three sources of data were used for this study. The first, the 1977 *Census of Manufactures*, provided us with the value of shipments and the cost of material, both of which are contained in table 3a of Summary Statistics for the industry for 1977. Furthermore, table 7 (Material Consumed by Kind: 1977) in the census provided us with inputs data which can be transformed into input-output tables.

In determining the tariffs either on individual inputs or on the final output, we referred to a publication called tariff schedule of the *United States Annotated* (1981). This publication lists three different tariffs regarding each article. The lowest rate applies to the products of a very few Least-Developed–Developing-Countries. The highest rate applies to the products of Communist Countries except China. The third tariff (the Most-Favored-Nation), which is adopted by this study, applies to all other countries.

In determining the industry equity beta, the industry long-term debt, and the industry market value at the beginning of 1977, we referred to unpublished material by Merrill Lynch, Pierce, Fenner and Smith, Inc.

[7] Such an assumption is used in Brealy and Myers (1981, p. 169). It does not exclude bankruptcy possibilities.

Table 1 presents summary statistics for the year 1977 of the following three industries: Beverage-Brewers, Drugs, and Shoe industries. Table 2 presents the statistics for the 4-digit industries underlying the above three aggregated industries. When we moved from the aggregative level to the 4-digit level, we assumed that both had the same asset beta.

V. Empirical Findings

The results concerning the nominal tariffs (NTs), DEPRs and the RAEPRs are presented in the second column and the last two columns of tables 1 and 2. It is apparent that the differences either between the NTs and EPRs, or between EPRs and RAEPRs are not substantial. The reason is that these illustrations are based on U.S. data where the value added is especially large, while the systematic risk and nominal tariffs are very small. For example, the value added in the drugs industry is 72%, and the weighted average on inputs is almost half of the tariff on the final product. Hence, the difference between *NT* and *EPR* is only 2.5%. These reasons also account for the small difference (0.4%) between the RAEPR and the EPR. In addition to these, the systematic risk and therefore the discount factor are very small in the United States by comparison to other countries. Solnik (1974) has found that while the systematic risk (i.e., the risk that cannot be diversified away by investing in a large number of stocks) in the United States is only 27% of the total risk, it is

TABLE 2.—SUMMARY STATISTICS FOR FOUR DIGIT LEVEL INDUSTRIES

Industry (million dollars)	Expected Post Tariff Value of Shipment	Expected Free Trade Value of Shipment	Post Tariff Input Cost	Weighted Average Tariff on Inputs (%)	Free Trade Input Cost	Industry Asset Beta	Risk Adjusted Discount (%)	Nominal Tariff Rate (%)	EPR (%)	RAEPR (%)
2082, Malt Beverages	6,652.6	6,522.2	3,877.2	4.9	3,696.0	0.77	11	2	−2	−3.2
2833, Medical and Botanicals	1,889.9	1,687.4	616.1	5	586.8	0.91	12.3	12	15.7	16.5
2831, Biological Products	898.5	802.2	390.4	3.2	378.3	0.91	12.3	12	19.86	21.93
2843, Pharmaceutical Preparations	11,459.4	10,231.6	2,831.3	6	2,671.0	0.91	12.3	12	14.1	14.5
3142, House Slippers	201.2	191.6	83.3	5.2	79.2	0.57	9.3	5	4.9	4.9
3143, Men's Footwear Except Athletic	1,734.5	1,598.6	795.7	4.5	761.4	0.57	9.3	8.5	12.1	13.1
3144, Women's Footwear Except Athletic	1,361.2	1,237.5	553.5	4.7	528.6	0.57	9.3	10	13.9	14.6

43.8% in Germany, 44% in Switzerland, and 39% in Italy.[8]

One shortcoming of the above illustrations should be noted. It was implicitly assumed that the production length of time is one year for each product. Obviously, a more in-depth look is needed to assess the exact length of time involved.

One systematic pattern can easily be observed in the results. Whenever the EPR is greater (smaller) than the NT, the RAEPR is even greater (smaller) than the EPR. This pattern is in line with the theoretical result arrived at in the theorem since in computing the DEPR we naturally attributed it no risk, and therefore, the RAEPR measure is composed of the same data except that it includes a correction for risk (i.e., higher risk).

[8] If the risk premium were 15% then the RAEPR in Medical and Botanical would be 16.9%, which is significantly greater than the standard measure of 15.7%.

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