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ABSTRACT

We perform the first empirical study to focus on the relationship between trade protection and investment in R&D. Our results support predictions from the theoretical literature that temporary tariffs stimulate R&D, although we find no evidence that this effect diminishes as the termination of protection approaches as predicted by some theoretical models. We also find little evidence that quotas reduce R&D as predicted by multiple theoretical works. Finally, our results indicate that temporary tariffs result in decreased capital investment, perhaps because firms use periods of temporary protection to shutdown unprofitable facilities. This reveals an important distinction in firm behavior with regard to investment in tangible versus intangible capital during periods of trade protection.

Keywords: Research and Development, Strategic Protection

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I. Introduction

A commonly-cited justification for trade protection is that it can help domestic firms realize the cost savings stemming from the investment in physical capital and R&D that should take place during periods of temporary protection. Insulation from the competitive global marketplace is apparently warranted since the efficiencies provided by increasing returns to scale and R&D may take considerable time to materialize. Interestingly, there is almost no empirical work that tests whether firms actually increase investment in R&D during periods of trade relief. The following paper is intended to help fill this hole in the literature.

The success of multiple GATT rounds in lowering broadly-administered, long-term trade protection has shifted the focus of protection towards more narrowly defined circumstances, such as 'dumping', foreign subsidization, and patent infringement.[1] Most current protection, therefore, is based on the supposed need to offset unfair trade practices of foreign firms and governments, rather than achieving goals stemming from strategic trade or infant industry arguments. Since the goal of these policies is to punish unfair trade practices, one might not necessarily expect any clear link between their implementation and domestic investment in R&D. In contrast, we can more easily surmise a connection between R&D and safeguard protection, which is now the primary recourse for industries battered by *fairly* traded imports.[2] Instead of focusing on the misdeeds of foreign firms, domestic industries seeking safeguard protection are more fundamentally indicating that they need a period of respite in order to return to profitability.[3] The success of safeguards in returning firms to long-term health is in part based on the actions of these firms during their period of temporary protection. One logical strategy would be to invest in R&D, especially since surviving globally competitive markets appears increasingly rooted in a firm's ability to innovate and incorporate new technology. However, a firm that is pessimistic about its ability to ever compete in the face of international competition might choose to avoid costly R&D. Moreover, a firm that believes it can extend its period of protection may also choose to avoid investment in R&D, instead relying on the competitive advantage it receives from safeguards.

In the following paper, we study the influence of trade protection in the form of safeguards on R&D expenditures during the period 1975-2005. Besides incorporating frequently cited determinants such as

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[1] From 1945-2007, average tariffs in the US fell from 25% and to 3.2%. The Trade Act of 1974 covers legislation concerning antidumping (section 731), countervailing duties (section 701), and intellectual property infringement (section 337), which serve to protect US firms from unfair pricing, illegal subsidization, and patent infringement by foreign firms. See Section 19 U.S.C. §1671-1677 and 19 U.S.C. §1337.

[2] US Legislation covering safeguards is found in Section 201 of the Trade Act of 1974. See 19 U.S.C. §2251-2254 and 19 U.S.C. §2451.

[3] In reality, firms pursuing safeguard protection often to claim that their difficulties stem from the illegal trade practices of foreign industries, as was witnessed in the steel safeguard case in 2002. Firms may choose to pursue safeguard protection not because they believe foreign trade practices are fair, but instead because safeguard protection is more comprehensive than antidumping and countervailing protection. See Finger *et al.* (1985) for an analysis of a firm's decision to seek safeguard protection versus antidumping and countervailing duty protection. From a statutory perspective, however, safeguards serve the function of protecting domestic industries from fairly traded imports, and therefore are more restrictive in certain ways. First, they require more evidence of domestic injury than AD and CVD protection ("serious" injury versus "material" injury.) Second, their maximum duration is generally four years, with the possibility of a four year extension, while AD and CVD protection can be extended for decades. Finally, safeguards must be accompanied by offsetting trade compensation. See Agreement of Safeguards, Article XIX of GATT 1994.

firm size, cash flow, and capital stock, we compare the impact of safeguards that were applied in the form of tariffs versus those that were implemented as quotas. While there are numerous theoretical articles that study the distinct effects of tariffs and quotas on investment in R&D, we believe this to be the first empirical paper to test how these two different forms of protection actually impact R&D. In sum, our results indicated that while temporary tariff protection results in an increase in R&D investment by firms, there is no statistically significant relationship between the imposition of temporary quota protection and R&D investment.

In the following section, we provide an overview of the literature on the relationship between protection and R&D. Section III discusses empirical models of R&D and the methodology used in this paper, while Section IV reviews the data and Section V presents our estimation method. Empirical results are presented and discussed in section VI, while section VII concludes.

II. Literature Review

In part of the strategic trade policy line of research that developed in the 1980s, Krugman (1984) illustrates that trade barriers, whether in the form of tariffs or quotas, could cause firms to increase investment in R&D. In his model, R&D expenditures increase with the output of the firm because greater output generates more profits which can then be used to finance R&D. Investment in cost-saving R&D reduces the marginal costs of the firm. In this model, trade protection serves to increase the output of the domestic firm at the expense of its foreign competitors, thereby increasing R&D investment by domestic firms and reducing investment by its foreign competitors. The cost advantage brought on by the R&D investment then allows the domestic firm to increase its market share in all markets even after domestic protection is removed.

Subsequent theoretical studies, however, have found that the impact of protection on R&D could vary depending on the form of protection imposed, the form of competition in the industry, and the certainty with which protection is imposed. We summarize some of these predictions in Table 1.

Grossman and Helpman (1991), for example, illustrate that trade liberalization could potentially increase or decrease firm investment in R&D. On the one hand, trade liberalization puts firms in different countries in direct competition with one another, thus giving them an incentive to pursue technological innovation in order to become more competitive. On the other hand, firms facing increased competition from abroad experience a decrease in the profitability of their R&D investments, thus reducing their incentive to invest. The authors find that policies that protect a country's traditional manufacturing sector tend to reduce the number of innovative industries, while increasing total investment in R&D.

In a seminal paper, Reitzes (1991) uses a model with two-stage Cournot competition to show that a tariff will lead to increased investment in cost-reducing R&D, while a quota reduces R&D. Cabral *et al.* (1998) finds that quotas reduce R&D under Bertrand competition as well, so long as the quota is close to the free trade level.[4] If the quota becomes sufficiently binding, however, R&D will increase. The authors point out that this last result is consistent with the frequently cited infant industry argument that quotas (and

[4] Interestingly, R&D by the foreign duopolist is found to rise under such a quota, since the quantitative restriction removes the negative strategic impact of cost-reducing R&D.

other protection) can help spur domestic investment. Bouet (2001) incorporates uncertainty with regard to the outcome of cost-reducing investment in his model of R&D. He finds that under both Bertand and Cournot competition, quotas (in the form of VERs) reduce R&D, while tariffs increase R&D.

Because we focus on temporary safeguard protection, our study most directly tests the predictions of Miyagiwa and Ohno (1999), which analyzes the impact of temporary protection. Miyagiwa and Ohno (1999) allow for uncertainty with regard to the duration of temporary protection in their model of R&D. They conclude that if the government policy is credible, tariff protection will stimulate investment in R&D; the optimal level of investment decreases towards the free-trade level as the end of protection approaches. Restrictive quantitative protection can also cause firms to increase investment in R&D. However, if the government imposes a quantitative restriction that is not "sufficiently restrictive," the level of investment will fall below the free-trade level, and then rise steadily to the free-trade level as the end of protection approaches. These findings hold under both Cournot and Bertrand competition.

Note that in the Miyagiwa and Ohno (1999) model, if the temporary protection is not credible--in other words, if the firm believes that such protection may be removed ahead of schedule if the firm increases its R&D or may be extended even the firm fails to invest in R&D--then temporary tariff protection may actually retard investment in cost-saving technology.

Miyagiwa and Ohno's (1999) results regarding quotas are consistent with most of the other theoretical articles cited above: quotas may deter domestic R&D. These findings would suggest that industries that successfully negotiated VERs, such as autos and steel in the 1980s, may have engaged in less R&D, thus extending or deepening the technology gap that would result in future competitive failings with overseas producers. They may have also led to the eventual need for safeguard protection, which the steel industry obtained in early 2002.[5]

There are very few empirical studies of the relationship between trade and investment in R&D. Previous empirical studies focus on the relationship between the level of imports and R&D investment, rather than the impact of protection itself on R&D. For example, Zietz and Fayissa (1992) estimate the impact of import penetration rates on firm R&D to sales ratios, using a panel of 20 manufacturing industries between 1972 and 1987. They find that an increase in import competition leads to a rise in R&D expenditures, but only for high-tech industries.

Scherer and Huh (1992) study the same relationship using a panel of 308 manufacturing firms between 1971 and 1987. They find that on average, firms decrease R&D in the short run when faced with increased import competition, although firm response varies significantly based on the size and level of diversification of the firm.

Most recently, Funk (2003) uses a panel of manufacturing companies between 1979 and 1994 to estimate a simple neoclassical research investment model. He attempts to explain firm-level R&D using, among other variables, the import penetration ratio and real exchange rate facing the firm. He finds that firms

[5] Safeguards for the steel industry were implemented in 2002. Tornell (1997) develops a model of rational disinvestment, and points to the US steel industry's failure to the reinvest economic rents it obtained from trade protection during the 1970s and 1980s as evidence of such behavior.

with no foreign sales tend to decrease investment in R&D when faced with increased import competition, while exporting firms increase R&D investment in response to exchange rate depreciation.

Of these three econometric studies, only Scherer and Huh (1992) control for trade protection in their empirical specifications of R&D. Moreover, they combine safeguard and other types of protection into a single variable, making no distinction on the form of protection (tariff versus quantitative restrictions) or the type of protection (safeguards, VERs, antidumping and countervailing duties, etc.).[6] The failure of the authors to find strong evidence regarding any direct relationship between protection and R&D may be due to the amalgam nature of their trade barrier variable. We believe that our focus on a single policy (safeguards) allows us to more easily isolate the distinct effects of quota and tariff protection, which has been of particular interest in the theoretical literature.[7]

In short, our results indicate that tariffs lead to an increase in R&D, which is consistent with Reitzes (1991), Boulet (2001), as well as Miyagiwa and Ohno (1999) under their assumption of a credible government policy. Our results also reveal a negative but statistically insignificant relationship between quota protection and R&D, which would otherwise have lent support to the theoretical predictions of Reitzes (1991), Boulet (2001), and Miyagiwa and Ohno (1999). We note that in contrast to the other articles, Cabral, Kujal, and Petrakis (1998) predict that R&D would rise in response to sufficiently binding quotas. As we discuss in the following sections, the lack of statistical significance of our quota variable may stem from the fact that quantitative safeguard protection has a differential impact on R&D investment depending on how restrictive the protection.

III. Empirical Models of R&D

As discussed in Becker and Pain (2003), there is a large literature devoted to studying the impact of firm- and industry-specific factors, as well as various public policy variables, on R&D investment. Firm-specific characteristics that have generated statistically significant coefficients include net profits, debt, and size (as measured by either sales or market power). Cash flow has proven to be especially important in some studies, perhaps because imperfect capital markets prevent firms from raising sufficient outside funds to finance their R&D investment, thereby forcing them to rely on limited internal funds.[8]

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[6] By focusing on safeguard protection, we study the impact of trade relief that has been implemented specifically to protect firms from the serious damage caused by a surge in import flows. Other forms of protection, such as antidumping and countervailing duties, protect firms from unfair trading practices of foreign firms and do not require evidence of serious damage due to increased import flows. Since different forms of protection have different statutory requirements for implementation, it is quite possible that their application reflects different circumstances regarding foreign competition. For example, countervailing duties indicate foreign subsidization and one might expect their implementation to have a different impact on domestic R&D than safeguards, which don't necessarily involve illegal subsidization whatsoever.

[7] Other articles that shed light on the relationship between protection and R&D include Lenway *et al.* (1996) and Hartigan *et al.* (1986). Lenway *et al.* (1996) show that US steel firms that were most active in lobbying for protection were also less innovative. While this is not an explicit test on how protection impacts R&D, it clearly suggests that protection results in less investment in R&D. Hartigan *et al.* (1986) uses event study methodology to show that shareholders of firms petitioning for safeguard protection have almost no reaction to critical decisions regarding the implementation of protection. This suggests that investors do not believe that safeguards will increase future profits, perhaps because they assume that firms will fail to engage in efficiency-improving measures such as R&D while safeguards are in place.

[8] See, for example, Harnoff (2000) and Bond, Harnoff and Van Reenen (2006).

The most widely studied industry-level determinant of R&D investment is the degree of product market competition. Theoretical models indicate that firms in competitive markets have more of a profit incentive to invest in R&D than those firms in more concentrated industries such as monopolies. On the other hand, monopolies may want to preemptively discourage potential competitors from developing and patenting new technologies by investing more in R&D, thereby obtaining a lead in the race to obtain a patent. Because theoretical models cannot determine which of these effects is stronger, the question of whether greater monopoly power leads to more or less innovation is an empirical one. As discussed above, studies such as Scherer and Huh (1992) and Zietz and Fayissa (1994) specifically study the impact of foreign market competition on R&D investment with conflicting results.

Finally, there is a large literature investigating the impact of various public policies, including tax credits and R&D subsidies, on investment levels. Hall and Van Reenen (2000) provide an excellent overview of this literature. To our knowledge this is the first empirical study of the impact of another set of public policy instruments that could theoretically stimulate investment: tariffs and quotas.

There are nearly as many empirical methods to study firm-level investment in R&D as there are determinants of this investment. For example, numerous researchers have attempted to estimate structural models of investment, such as q models or Euler equations, including Hayashi and Inoue (1991) and Blundell *et al.* (1992).[9] These empirical models have almost without fail been rejected, as they find an extremely weak relationship between investment and average q, have the wrong signs on many explanatory variables, and suggest an extremely slow speed of adjustment to the desired capital stock level.

Because these structural models have performed so poorly, more recent empirical research of R&D investment have used a less structural approach, such as accelerator models or error correction models. As detailed in Harhoff (2000), investment accelerator models hypothesize that there is a relationship between the log of the firm's output (y_{it}), the user cost of capital (j_{it}), and the log of the firm's desired stock of capital (k_{it}) in period t:

$$k_{it} = a + y_{it} - \sigma j_{it} . \quad (1)$$

In this equation, the parameter σ represents the elasticity of substitution for a firm with a constant return to scale CES production function. An approximation of the first difference of equation 1 is typically defined as:

$$\frac{I_{it}}{K_{i,t-1}} = \delta + \Delta y_{it} - \sigma j_{it} \quad (2)$$

where δ is the rate of depreciation, I_i is firm investment, and K_i is the firm's capital stock. Empirical models of equation 2 typically measure the firm's unobserved cost of capital as a function of time and firm dummy variables. A corresponding R&D equation can be derived in a similar way by treating R&D and investment symmetrically.

In the presence of adjustment costs, capital stock cannot adjust immediately to the target level of capital specified in equation 1. As discussed in Bond *et al.* (2006), this adjustment process may be complex, and

[9] In the simplest terms, the average q measures the ratio of the value of the firm to the replacement costs of its capital.

should be determined by the data. They suggest nesting equation 1, the long-run capital stock equation, with an autoregressive-distributed lag dynamic regression, such as:

$$k_{it} = \alpha_0 + \alpha_1 k_{i,t-1} + \alpha_2 k_{i,t-2} + \beta_0 y_{it} + \beta_1 y_{i,t-1} + \beta_2 y_{i,t-2} + \gamma_0 j_{it} + \gamma_1 j_{i,t-1} + \gamma_2 j_{i,t=2} + \varepsilon_{it} \qquad (3)$$

This model can be re-written in error-correction form to separate the short-run from the long-run effects of output on investment as follows:

$$\begin{aligned} \Delta k_{it} = {} & \alpha_0 + (\alpha_1 - 1)\Delta k_{i,t-1} + \beta_o \Delta y_{it} + (\beta_0 + \beta_1)\Delta y_{i,t-1} + \gamma_0 \Delta j_{it} + (\gamma_0 + \gamma_1)\Delta j_{i,t-1} \\ & - (1 - \alpha_1 - \alpha_2)(k - y)_{i,t-2} + [\beta_0 + \beta_1 + \beta_2 - (1 - \alpha_1 - \alpha_2)] y_{i,t-2} \\ & + (\gamma_0 + \gamma_1 + \gamma_2) j_{i,t-2} + \varepsilon_{it} \end{aligned} \qquad (4)$$

Our empirical model closely follows Bond *et al.* (2006) in assuming that the user cost of capital, j, can be controlled for using year- (μ_t) and firm-specific (η_i) effects. Because previous research has found cash flow to be an important determinant of firm investment, we include current and lagged terms of the ratio of cash flow (C_{it}) to the beginning of the period capital stock, and approximate Δk_{it} in a manner identical to the approximation used in equation 2. Unlike Bond *et al.* (2006), our primary variables of interest are those capturing the impact of temporary import protection in the form of safeguards. Our estimating equation is:

$$\begin{aligned} \frac{I_{it}}{K_{i,t-1}} = {} & \mu_t + \rho_1 \frac{I_{i,t-1}}{K_{i,t-2}} + \omega_o \Delta y_{it} + \omega_1 \Delta y_{i,t-2} + \theta(k - y)_{i,t-2} + \phi y_{i,t-2} + \psi_o \frac{C_{it}}{K_{i,t-1}} \\ & + \psi_1 \frac{C_{i,t-1}}{K_{i,t-2}} + T_{it}(\tau_o + \tau_1 Years_{it}) + Q_{it}(\kappa_0 + \kappa_1 Years_{it}) + \eta_i + \varepsilon_{it} \end{aligned} \qquad (5)$$

where T_{it} is a dummy variable that equals one if the government has imposed temporary safeguard protection in the form of a tariff, Q_{it} is a dummy variable that equals one of the government has imposed temporary safeguard protection in the form of a quota, and $Years_{it}$ is the number of years the safeguard protection has been imposed.

We constrain the coefficient on $y_{i,t-2}$ to equal 0, which is consistent with a long-run constant returns to scale production function. The parameter θ should be less than zero if the hypothesis of "error correction" is correct. In other words, if the capital stock is above its desired level, then future investment should be lower. If the safeguard protection is credible and the Miyagiwa and Ohno (1999) model is correct, we would expect $\tau_0 > 0$ and $\tau_1 < 0$; credible but temporary tariff protection increases investment above the free-trade level, but the level of investment decreases towards the free-trade level as the end of protection approaches. In contrast, under this same theoretical model, credible and *non-binding* quota safeguard protection would result in $\kappa_0 < 0$ and $\kappa_1 > 0$.

Equations 1-5 detail an empirical model of investment. We follow Bond *et al.* (2006) in treating R&D investment and capital investment nearly symmetrically. Because firms do not provide any information on the value of R&D capital stock, we measure the change in R&D stock using annual R&D expenditures rather than approximating this change using the ratio of investment to capital stock. Our estimating equation of R&D expenditures is:

$$\Delta r_{it} = \mu_t^R + \rho_1^R \Delta r_{i,t-1} + \omega_O^R \Delta y_{it} + \omega_1^R \Delta y_{i,t-2} + \theta^R (r-y)_{i,t-2} + \phi^R y_{i,t-2} + \psi_0^R \frac{C_{it}}{K_{i,t-1}}$$
$$+ \psi_1^R \frac{C_{i,t-1}}{K_{i,t-2}} + T_{it}(\tau_0^R + \tau_1^R Years_{it}) + Q_{it}(\kappa_0^R + \kappa_1^R Years_{it}) + \eta_i^R + \varepsilon_{it}^R \qquad (6)$$

where r_{it} is the log of R&D expenditures. The predictions for the parameters are identical to those discussed for equation 5.

IV. Data

The United States imposed safeguard protection on 19 separate occasions between 1975 and 2005 for periods ranging from two to five years. As can be seen from Table 2, safeguard protection took a number of forms during this time period, including tariffs, orderly marketing arrangements (OMA), tariff-rate quotas (TRQ), and quotas. Although the United States awarded the most safeguard protection to the steel industry, other firms benefitting from protection include producers of such diverse products as lamb meat, clothespins, motorcycles, and wood shingles.

According to information collected from the U.S. International Trade Commission (ITC), slightly over 280 firms benefitted from safeguard protection between 1975 and 2005.[10] Because we only observe R&D expenditures in the public companies included in the COMPUSTAT dataset, our sample includes just 20 percent of the total list of beneficiaries, or 64 firms, which were public U.S. companies during their period of safeguard protection. The list of these firms is included in Table 3.

We collected financial data for each firm, including the value of their sales and R&D expenditures in each fiscal year, from Standard and Poor's COMPUSTAT North America dataset. For each firm we include all available financial data between fiscal years 1970 through 2005; because each firm is observed only in those fiscal years in which it is included in the COMPUSTAT database, our final dataset is an unbalanced panel of 64 firms over periods ranging from 5 to 36 years. A complete list of variable definitions is included in the Data Appendix.

We account for escape clause protection using both dummy variables and time trend variables. For example, the *Tariff Dummy (T)* equals one when tariff safeguard protection is in place for at least half of the firm's fiscal year and the *Quota Dummy (Q)* is a similarly defined variable when the safeguard protection is in the form of a quota or orderly marketing arrangement. The time trend variable interacted with both the *Tariff* and *Quota* dummy variable is calculated using the log of the number of years the protection has been in place. In some specifications we define this as the number of years since the protection has been renewed. Escape clause protection is typically imposed for between one and three years, but the protection can be renewed or extended by the President.

[10] A list of firms benefitting from safeguard protection was compiled by the authors from the list of domestic firms included in the individual ITC reports associated with each escape clause investigation. The list is available from the authors upon request.

We include an additional 690 control firms from the COMPUSTAT database that report the same primary four-digit Standardized Industrial Code (SIC) as the beneficiaries in the safeguard beneficiaries sample. There are 34 four-digit SIC codes represented in our sample.

Table 4 includes summary statistics from both the beneficiary firm and control sample.

V. Estimation

To estimate the dynamic regression models specified in equations 5 and 6 using an unbalanced panel of many firms with a small number of time periods, we use the system GMM estimator developed by Blundell and Bond (1998).[11] In a dynamic panel, the unobserved panel level effects (η_i) are by construction correlated with the lagged dependent variables. Arellano and Bond (1991) develop a generalized method of moments (GMM) estimator to deal with this endogeneity; moments are formed from the first differenced errors of the estimating equations and instruments. Lagged levels of the dependent, predetermined, and endogenous variables are used as GMM-type instruments. First-differences of the strictly exogenous variables are used as standard instruments.

The Arellano and Bond (1991) estimator may perform poorly if the autoregressive process is too persistent; specifically, if the autoregressive process is too persistent then lagged levels of the dependent and endogenous variables are weak instruments. The Arellano and Bond estimator may also suffer from weak instruments if the ratio of the variance of the panel effects to the variance of the idiosyncratic error (ε) is too large. Blundell and Bond (1998) improve upon the Arellano and Bond (1991) estimator by developing a system that uses additional moment conditions; these additional moment conditions come from using lagged differences of the model's variables as instruments for the level equation.[12] The precise instruments that we use are reported in the notes to each table, but we basically use lags of all the firm-level variables in the model.

The method requires that there be no autocorrelation in the idiosyncratic errors. We test this assumption using the Arellano-Bond test for serial correlation in the first-differenced errors.[13] We also test the validity of the moment conditions using the Sargan test of over-identifying conditions.

VI. Results

We report the results from the R&D equation in Table 5. Column 1 combines the dummy variables capturing the tariff and quota safeguard protection into a single dummy variable, *Protection*. The specifications presented in columns 2 through 4 analyze the differential effects of tariff and quota safeguard protection on R&D investment, and explores whether the impact of such protection on investment changes over the period of protection, as theorized by Miyagiwa and Ohno (1999).

As predicted by the model, the error correction term (the R&D to output ratio) is negative and significant in all of the specifications. Both lags of the output growth terms are positive and statistically significant. Like many other studies, we find no significant impact of cash flow on R&D expenditures in any of our specifications. Although not reported here, the parameter estimates from specifications excluding all safeguard protection variables are virtually identical to those presented in Table 5. The Arellano-Bond

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[11] Although we observe some of the firms in our sample for as many as 36 years, most firms are observed for a much shorter time period and as few as five years.

[12] The model assumes that the panel-level effect is unrelated to the first observable first-difference of the dependent variable.

[13] The first difference of IID errors are auto-correlated; rejecting the null hypothesis of no serial correlation at orders higher than one implies that the moment conditions are misspecified.

diagnostic tests fail to find evidence of second-order serial correlation in the first differenced errors, while the Sargan diagnostic tests fail to reject the over-identifying restrictions in the model.

The parameter estimates from the baseline specification presented in Column 1 indicate that firms significantly increase their R&D investment during the imposition of safeguard protection, suggesting that safeguard protection successfully encourages industries hurt by import surges to undertake readjustment measures to prepare for future international competition.

As discussed above, however, the Miyagiwa and Ohno (1999) model predicts that while tariff protection stimulates investment in R&D, the optimal level of investment decreases towards the free-trade level as the end of protection approaches. Intuitively, because of the tariff protection, the domestic firm earns higher profits from innovation; the earlier the discovery during the period of protection, the higher the stream of profits from the innovation, thus the firm has the highest incentive to innovate at the beginning of the safeguard protection. In contrast, quantitative restrictions may or may not have the same positive impact on R&D investment. If the government imposes quantitative restriction that are not "sufficiently restrictive," the level of investment is below the free-trade level, and rises steadily to the free-trade level as the end of protection approaches. In this case, the new technology is actually less profitable under a quota than during free trade. We explore the possible differential impact of tariff and quota protection on R&D investment in the specifications reported in columns 2 through 4.

We find strong evidence that firms increase R&D investment when tariff safeguard protection is imposed in all three specifications, as predicted by Miyagiwa and Ohno (1999), Reitzes (1991), and Boulet (2001). However, we find no evidence that this increase in investment decreases over the period of protection, as reported in columns 2 and 4. We tried a variety of specifications for the time trend variable, but all results were qualitatively the same as those presented here.[14] It is important to note, however, that the empirical results do not necessarily reject the Miyagiwa and Ohno (1999) hypothesis, which specifically models the impact of temporary protection with a *credible* removal date. In reality, firms may realistically expect that the safeguard protection will be renewed for an indefinite amount of time; of the 19 instances of safeguard protection considered in this research, 11 were renewed at least one time by the federal government for periods ranging from six months to three years.[15] Moreover, it may be the case that R&D projects are not generally undertaken in less than a two or three year period and require a constant stream of funding during this time. Furthermore, R&D projects that yield promising early results may result in increased spending. Thus, there is reason to expect that R&D spending would not diminish to any significant degree as the termination of protection approaches, despite the predictions of Miyagiwa and Ohno (1999).

Although the parameter estimates associated with our quantitative restrictions are negative, as predicted by Miyagiwa and Ohno (1999) if restrictions are not sufficiently binding, the estimates are statistically insignificant. The insignificance of these parameters may be due to the fact that while many of the safeguard quantitative restrictions imposed by the government over the years have been non-binding (resulting in a decrease in R&D investment), other periods of temporary quantitative barriers have been binding enough to encourage an increase in R&D investment.

A review of the seven periods of quantitative safeguard restrictions imposed by the United States between 1975 and 2001 suggests this may be the case. For example, in 1998 the United States imposed quantitative restrictions on U.S. imports of wheat gluten. As reported by the U.S. International Trade

[14] For example, in various specifications we defined the time trend as a simple linear trend (number of years of protection) and accounted for the possibility that firms could readjust their R&D investment strategy following the renewal of temporary safeguard protection.

[15] In contrast, the steel safeguards imposed in 2002 were removed prior to their schedule elimination date.

Commission (2001), the quota fill rates from individual countries reached or exceeded 100 percent in the first year of protection. However, a number of our most important trading partners (including Canada and Mexico) were excluded from the quota which limited its effectiveness. Similarly, the United States restricted imports of footwear from Taiwan and Korea in 1977. However, during the period of safeguard protection, the United States experienced a growth in imports of footwear from other countries and producers in Taiwan and Korea were able to change their designs in order to avoid the quota (U.S. Congressional Budget Office (1986)). In contrast, the U.S. General Accounting Office (1989) reported that the quota program established for stainless and other steel products in 1983 and 1984, "helped contain the import surge at its peak, contributing to the decline in import market share in 1985." Orderly Marketing Agreements were negotiated with 19 countries, and in 1985 steel imports from countries bound by these quotas equaled 102.9 percent of the aggregate total of quotas, suggesting that the quotas were highly restrictive. Given the varying levels of restrictiveness of the quantitative restrictions, it is perhaps not surprising that the coefficients measuring the impact of quantitative restrictions on R&D investment are insignificant.

Sensitivity analysis suggests that these results are fairly robust to our sample of firms. For example, in specifications not reported here we found no evidence that firms characterized as highly R&D intensive reacted differently to safeguard protection when compared to others.[16] In another specification we excluded all firms from the electronic and electrical equipment industry (SIC 36), which accounted for half of our sample; the results were qualitatively the same as those presented here.

We report the results from the investment equation in Table 6. As before, column 1 combines the dummy variables capturing the tariff and quota safeguard protection into a single dummy variable, *Protection*. The specifications presented in columns 2 through 4 analyze the differential effects of tariff and quota safeguard protection on investment, and explores whether the impact of such protection on investment changes over the period of protection, as predicted by the Miyagiwa and Ohno (1999) model.

As in the R&D equation, the error correction term (the investment to output ratio) is negative and significant in all of the specifications while both lags of the output growth terms are positive and statistically significant. Surprisingly, the coefficient on lagged cash flow is actually negative and significant, indicating not only does a lack of cash flow not retard investment, it actually increases it. Although it is unclear what is driving this surprising result, it is not driven by the inclusion of the protection variables; results were virtually identical in unreported specifications excluding the protection variables.

The coefficient estimates associated with the impact of safeguard protection on capital investment are markedly dissimilar to those from the R&D specifications. Unlike with R&D, we find no statistically significant impact of safeguard protection on capital investment, as reported in column 1. Unlike the R&D specification, parameter estimates reported in column 2 and 3 suggest that capital investment actually *decreases* during periods of tariff safeguard protection, in direct contrast to the results in all of the theoretical models discussed in Section 2.[17]

What could be causing this surprising result? First, it is important to note that the theoretical models discussed in Section 2 deal specifically with firm investment in R&D or *cost-saving* technologies. We are aware of no theoretical models that specifically study the impact of temporary protection on capital investment and, particularly, investment in such things as capacity levels.

[16] We define highly R&D intensive firms as those with an R&D to sales ratio in the top 25 percent of the sample.
[17] As before, the coefficients associated with the quantitative restriction variables and the time trend are statistically insignificant.

Indeed, in order to qualify for safeguard protection, firms need to show that they have been seriously injured by increased imports; one statistical measure that the U.S. International Trade Commission relies upon is the capacity utilization rate. For example, U.S. International Trade Commission reports indicate that the wheat gluten industry had a capacity utilization rate of 54.3 percent when safeguard protection was imposed in 1998, while the line pipe industry had a capacity utilization rate of 55.6 percent when their protection was imposed in 2000. It seems perfectly reasonable for firms to choose not to expand capacity through capital investment given these conditions. Indeed, one way of improving competitiveness could be to disinvest in unprofitable enterprises or products, thus resulting in a decrease in the desired capital stock level. Anecdotal evidence suggests that this may have happened in some industries. For example, the adjustment plan of the broom corn broom industry included investment in robotic technology to produce wire-wound brooms automatically. When this technology failed to become available, many firms either reduced or eliminated their production of broom corn brooms (U.S. International Trade Commission (1999)).

In summary, the results provide strong evidence that firms increase their investment in R&D during periods of temporary tariff protection as predicted by a number of theoretical models, but there is little evidence that this protection positively impacts capital protection. Moreover, quantitative restrictions do not appear to have the same positive impact on R&D investment as tariffs.

VII. Conclusion

We believe this study to be the first empirical work focusing on the relationship between trade protection and R&D, despite the existence of numerous theoretic articles exploring this same subject. We analyze the impact of U.S. safeguards imposed during 1975-2005 on investment in R&D, distinguishing between measures that were applied in the form of quotas versus those implemented as tariffs. Safeguards are particularly appropriate to study such a relationship since they grant firms temporary relief from *fairly* traded imports and indicate a need to adjust strategies that will help firms return to competitiveness (rather than to offset unfair foreign trade practices such as dumping and foreign subsidization). Increasing R&D is one reasonable strategy that injured firms might employ during their period of temporary protection, although the theoretical literature suggests that tariff measures would be more likely to stimulate R&D than quota protection. Our results seem to confirm these predictions.

We follow Miyagiwa and Ohno (1999), which focuses on temporary protection, and employ the system GMM estimator developed by Blundell and Bond (1998) to test whether tariffs and quotas impact R&D, and also whether such affects trail off as the end of protection approaches. Our results indicate that tariffs result in increased R&D spending, although we find no evidence that this effect wears off as the termination date nears. We also find no statistically significant link between quantitative protection and R&D, although the coefficient on the quota variable is negative, consistent with multiple theoretic works which suggest that quotas result in reduced R&D. The insignificant quota coefficient may stem from the fact that in some cases quotas were non-binding, which would result in reduced R&D according to Miyagiwa and Ohno (1999), while in other cases quotas were binding, leading to the opposite outcome. These opposing effects, therefore, may have cancelled each other out, resulting in the insignificant quota coefficient.

Finally, our results indicate that firms respond to safeguard tariffs by reducing capital investment. This is opposite of our findings regarding tariffs and R&D, and may be due to the fact that injured firms use their period of temporary protection to shut down inefficient facilities and unprofitable ventures. We believe this result to be an important finding, for it suggests that firms treat investment in tangible capital differently from investment in intangible capital, at least during periods of trade protection. This matter warrants further investigation, which we hope to undertake in future work.

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Data Appendix

Our sample includes 64 escape clause beneficiary firms and 690 control firms from the same four- digit SIC codes as the beneficiary firms. All financial data is from the Standard and Poor's COMPUSTAT North America database. The sample includes data from fiscal years 1970-2005, although each individual firm is observed only in those years in which it appears in the COMPUSTAT database, ranging from 5 to 36 years. This Appendix briefly describes the variables included in the analysis, their COMPSTAT definitions, and information on how the COMPUSTAT data was adjusted by the authors. COMPUSTAT North America data item names for each variable are included in brackets.

Research and Development (R). All costs incurred during the year related to the development of new products or services in millions of dollars [XRD]. Data is adjusted for inflation using the input price index for R&D investment produced by the Bureau of Economic Analysis.

Investment (I). Cash outflow used for additions to the company's property, plant and equipment, excluding amounts arising from acquisitions, in millions of dollars [CAPX]. Data is adjusted for inflation using the SIC-based producer price indexes produced by the Bureau of Labor Statistics.

Output (Y). Gross sales minus discounts and returned sales for which credit is given to customers in millions of dollars [SALE]. Data is adjusted for inflation using the SIC-based producer price indexes produced by the Bureau of Labor Statistics.

Cashflow (C). Income after all expenses (but before dividends) before depreciation, in millions of dollars [IB + DP]. Data is adjusted for inflation using the SIC-based producer price indexes produced by the Bureau of Labor Statistics.

Capital Stock (K). Capital stock is computed by adjusting the historic capital stock data from COMPUSTAT for inflation using the SIC-based producer price index produced by the Bureau of Labor Statistics *(P^{SIC})*; the COMPUSTAT variable is defined as the cost, before accumulated depreciation, of tangible fixed property used in the production of revenue, in millions of dollars [PPENT]. We apply a perpetual inventory method with a depreciation rate (δ) of 8 percent for all years following the first year after 1970 for which historic capital stock data is available using the following equation:

$$P_t^{SIC} K_t = (1-\delta) P_{t-1}^{I} K_{t-1} \left(\frac{P_t^{SIC}}{P_{t-1}^{SIC}}\right) + P_t^{SIC} I_t$$

Tariff Dummy (T). Dummy variable that equals one when tariff safeguard protection is imposed. We define firms as receiving safeguard protection only if the safeguard was in place for at least half of the firm's fiscal year.

Quota Dummy (Q). Dummy variable that equals one when safeguard protection in the form of a quota or orderly marketing arrangement is imposed. We define firms as receiving safeguard protection only if the safeguard was in place for at least half of the firm's fiscal year.

Time Trend (T). The log of the number of years the protection has been in place.

Table 1
The Impact of Protection on R&D Investment

Article \ Protection	Tariff (Cournot)	Tariff (Bertrand)	Quota (Cournot)	Quota (Bertrand)
Reitzes (1991)	R&D ↑	-	R&D ↓	-
Cabral, Kujal, and Petrakis (1998)	-	-	R&D ↓	R&D ↓ if quota close to free trade level
				R&D ↑ if quota sufficiently binding
Bouet (2001)	R&D ↑ When success of R&D uncertain	R&D ↑ When success of R&D uncertain	R&D ↓ When success of R&D uncertain	R&D ↓ When success of R&D uncertain
Miyagiwa and Ohno (1999)	R&D ↑ if credible policy	R&D ↑ if credible policy	R&D ↓ if credible policy	R&D ↓ if credible policy
	R&D ↓ if non-credible policy	R&D ↓ if non-credible policy	R&D ↓ if non-credible policy	R&D ↓ if non-credible policy

Table 2
Safeguard Protection, 1975-2005

Case No.	Product	Initiation	Termination	Years of Protection	Form of Protection
201-005	Stainless Steel and Alloy Tool Steel	6/14/1976	2/13/1980	3.7	Quota, OMA
201-018	Footwear	7/28/1977	6/30/1981	3.9	OMA
201-019	Television Receivers	7/1/1977	6/30/1982	5.0	OMA
201-029	CB Radio Receivers	3/27/1978	4/11/1981	3.0	Tariff
201-035	High-carbon ferrochromium	11/3/1978	11/13/1981	3.0	Tariff
201-036	Clothespins	2/18/1979	2/22/1984	5.0	Quota
201-037	Bolts, nuts, and screws of iron or steel	12/26/1978	1/5/1982	3.0	Tariff
201-039	Non-electric cookware	1/17/1980	1/16/1984	4.0	Tariff
201-043	Mushrooms	11/1/1980	10/31/1983	3.0	Tariff
201-047	Heavyweight motorcycles	4/1/1983	10/9/1987	4.5	TRQ
201-048	Stainless steel and alloy tool steel	7/19/1983	9/1/1989	6.1	TRQ, OMA
201-051	Carbon and certain alloy steel products	10/1/1984	9/31/1989	5.0	OMA
201-056	Wood shingles and shakes	7/6/1986	6/1/1991	4.9	Tariff
201-065	Broom corn brooms	11/28/1996	12/3/1998	2.0	Tariff
201-067	Wheat gluten	5/30/1998	6/1/2001	3.0	Quota
201-068	Lamb meat	7/7/1999	11/15/2001	2.4	TRQ
201-069	Certain steel wire rod	3/1/2000	3/1/2003	3.0	TRQ
201-070	Circular welded carbon quality line pipe	3/1/2000	3/1/2003	3.0	Tariff
201-073	Steel	3/20/2002	12/5/2003	1.7	TRQ, Tariff

Table 3
Public Firms Benefitting from Safeguard Protection, 1975-2005

Company	Case
AK Steel Holding Company	201-070, 201-073
Allegheny Ludlum Corp.	201-048
Anchor Hocking Corp.	201-039
Andrea Electronics Corp.	201-019
Archer Daniels Midland Co.	201-067
Armco Inc.	201-005, 201-048, 201-051
Babcock & Wilcox Co.	201-005
Barry (R G) Corp.	201-018
Bethlehem Steel Corp.	201-005, 201-037, 201-048, 201-051
Buell Industries Inc.	201-037
Carpenter Technology Corp.	201-005, 201-048, 201-073
Corning Inc.	201-039
Crucible Inc.	201-005
Ekco Group Inc.	201-039
Elco Industries, Inc.	201-037
Emhart Corp.	201-037
Fairchild Industries, Inc.	201-037
Federal Screw Works	201-037
General Electric Co.	201-019
General Housewares	201-039
GTE Corp.	201-019
Harley-Davidson Inc.	201-047
Interlake Corp.	201-035, 201-051
IPSCO Inc.	201-070, 201-073
Ispat Inland Inc.	201-069, 201-073
Jones & Laughlin Industries, Inc.	201-005
Kaiser Steel Corp.	201-005
Keystone Consolidated Industries, Inc.	201-051, 201-069
Lancaster Colony Corp.	201-039
Leggett & Platt Inc.	201-073
Lincoln Logs Ltd.	201-056
LTV Corp.	201-070
Lukens Inc.	201-051
McRae Industries	201-018
Midwest Grain Products, Inc.	201-067
Mirro Corp.	201-039
Mite Corp.	201-037
Monogram Industries	201-037
Motorola, Inc.	201-019
National Steel Corp.	201-051
Official Industries, Inc.	201-018
Pathcom, Inc.	201-029
Penn Engraving and Manufacturing Corp.	201-037
Phoenix Footwear Group Inc.	201-018

Table 3, Continued
Public Firms Benefitting from Safeguard Protection, 1975-2005

Company	Case
RCA Corp.	201-019
RELM Wireless Corp.	201-029
Republic Steel Corp.	201-005
Revere Copper & Brass Inc.	201-039
Rexnord Holdings. Inc.	201-037
Sony Corp. of America	201-019
SPS Technologies Inc.	201-037
Standex International Corp.	201-039
Suave Shoe Corp.	201-018
Timken Co.	201-005, 201-048, 201-073
Union Carbide Corp.	201-035
U.S. Steel Corp.	201-005, 201-037, 201-048, 201-051, 201-070, 201-073
VSI Corp.	201-037
Wear-Ever Proctor Silex Inc.	201-039
WEJ-IT Corp.	201-037
Wellco Enterprises	201-018
Wells-Gardner Electronic Corp.	201-019
Weyerhaeuser Co.	201-056
Youngstown Sheet & Tube Co.	201-037
Zenith Electronics Corp.	201-019

Table 4
Summary Statistics

	Mean	Std. Error	Min	Max
	Safeguard Beneficiaries			
R&D	137.56	527.80	0.00	4,947.00
Investment	340.09	1,212.56	0.00	15,520.00
Sales	3,999.84	12,440.91	0.00	151,802.00
Cashflow	425.92	1,852.78	-4,418.00	27,171.00
Capital Stock	1,719.76	5,103.00	0.00	67,528.00
Years of Tariff Safeguard Protection per Firm	0.11	0.14	0.00	0.66
Years of Quantitative Safeguard Protection per Firm	0.10	0.18	0.00	1.00
Years in Sample	20.11	11.20	2.00	36.00
Number of Firms	64			
	Control Firms			
R&D	73.77	425.80	0.00	6,286.73
Investment	244.47	1,361.75	0.00	65,028.00
Sales	2,014.04	7,871.32	-5.81	105,672.00
Cashflow	302.94	1,625.39	-50,579.50	28,569.00
Capital Stock	1,421.94	7,083.57	0.00	128,063.00
Years in Sample	11.86	8.85	1.00	36.00
Number of Firms	694			

Table Notes: All financial data in millions of dollars.

Table 5
The Impact of Safeguard Protection on R&D

	(1)	(2)	(3)	(4)
Δr_{it-1}	-0.066*	-0.067*	-0.068*	-0.068*
	(0.031)	(0.031)	(0.031)	(0.031)
Δy_t	0.105*	0.108*	0.108*	0.107*
	(0.042)	(0.042)	(0.042)	(0.042)
Δy_{t-1}	0.094*	0.096*	0.096*	0.096*
	(0.026)	(0.026)	(0.026)	(0.026)
C_t / K_{t-1}	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
C_{t-1} / K_{t-2}	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
$(r\text{-}y)_{t-2}$	-0.022*	-0.023*	-0.024*	-0.024*
	(0.008)	(0.008)	(0.008)	(0.008)
Protection_t	0.091*			
	(0.039)			
Protection_t*Log(Years_t)	-0.037			
	(0.041)			
Tariff_t		0.124*	0.144*	
		(0.050)	(0.042)	
Tariff_t*Log(Years_t)		0.032		0.100*
		(0.050)		(0.042)
Quota_t		-0.011	-0.067	
		(0.039)	(0.060)	
Quota_t*Log(Years_t)		-0.067		-0.081
		(0.048)		(0.053)
Sargan (p-value)	0.379	0.378	0.378	0.414
LM(1)	-9.455	-9.457	-9.453	-9.465
LM(2)	-1.380	-1.352	-1.357	-1.351
Observations	6,438	6,438	6,438	6,438
Firms	630	630	630	630

Notes: Standard errors are in parentheses. * indicates those coefficients significant at the 95 percent level. A full set of year dummy variable is included in each specification. Sargan is the Sargan-Hansen test of the over-identifying restrictions. LM(k) is the Arellano-Bond test statistic for k^{th} order serial correlation in the first-differenced errors. Instruments used include Δr_{t-3} to Δr_{t-6}, Δy_{t-3} to Δy_{t-6} and C_{t-3}/K_{t-4} to C_{t-6}/K_{t-5} in the differenced equations and the lagged difference of Δr_t, Δy_t, and C_{t-1}/K_{t-2} in the levels equations.

Table 6
The Impact of Safeguard Protection on Investment

	(1)	(2)	(3)	(4)
I_t/K_{t-1}	-0.021	-0.023	-0.022	-0.020
	(0.037)	(0.037)	(0.037)	(0.037)
Δy_t	0.209*	0.208*	0.208*	0.209*
	(0.060)	(0.060)	(0.060)	(0.060)
Δy_{t-1}	0.242*	0.242*	0.241*	0.243*
	(0.030)	(0.030)	(0.030)	(0.030)
C_t / K_{t-1}	-0.007*	-0.007*	-0.008*	-0.008*
	(0.003)	(0.003)	(0.003)	(0.003)
C_{t-1} / K_{t-2}	0.004	0.004	0.004	0.004
	(0.003)	(0.003)	(0.003)	(0.003)
$(r-y)_{t-2}$	-0.212*	-0.212*	-0.212*	-0.212*
	(0.027)	(0.027)	(0.027)	(0.027)
$Protection_t$	0.093			
	(0.095)			
$Protection_t$*Log($Years_t$)	-0.084			
	(0.072)			
$Tariff_t$		-0.056**	-0.037**	
		(0.031)	(0.020)	
$Tariff_t$*Log($Years_t$)		0.026		-0.006
		(0.031)		(0.020)
$Quota_t$		0.253	0.092	
		(0.210)	(0.089)	
$Quota_t$*Log($Years_t$)		-0.191		-0.057
		(0.151)		(0.048)
Sargan (p)	0.161	0.170	0.180	0.151
LM(1)	-6.196	-6.357	-6.204	-6.095
LM(2)	-0.886	-0.912	-0.895	-0.862
Observations	6,967	6,967	6,967	6,967
Firms	505	505	505	505

Notes: Standard errors are in parentheses. *, ** indicates those coefficients significant at the 95 and 90 percent level, respectively. A full set of year dummy variable is included in each specification. Sargan is the Sargan-Hansen test of the over-identifying restrictions. LM(k) is the Arellano-Bond test statistic for k^{th} order serial correlation in the first-differenced errors. Instruments used include I_{t-3}/K_{t-4} to I_{t-6}/K_{t-7}, Δy_{t-3} to Δy_{t-6} and C_{t-3}/K_{t-4} to C_{t-6}/K_{t-5} in the differenced equations and the lagged difference of I_t/K_{t-1}, Δy_t, and C_{t-1}/K_{t-2} in the levels equations.