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Are all trade protection policies created equal? Empirical evidence for nonequivalent market power effects of tariffs and quotas

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ABSTRACT

Over the past 50 years, the steel industry has been protected by a wide variety of trade policies, both tariff- and quota-based. We exploit this extensive heterogeneity in trade protection to examine the well-established theoretical literature predicting nonequivalent effects of tariffs and quotas on domestic firms' market power. Using plant-level Census Bureau data for steel plants from 1967 to 2002, we find evidence for significant market power effects for binding quota-based protection, but not tariff-based protection, particularly with respect to integrated and minimill steel producers. Our results are robust to calculation with two standard measures of market power and controlling for potential endogeneity of trade policies.

1. Introduction

An extensive literature dating back to at least Bhagwati (1965) demonstrates that tariffs and quotas that limit imports in an identical way may have nonequivalent effects on economic behavior and outcomes. One of the most well-known examples of this nonequivalence is that tariffs and quotas can have quite different effects on the degree of market power exercised by domestic and foreign firms. This result is demonstrated by Harris (1985) and Krishna (1989) in oligopoly settings where a foreign firm and a domestic firm compete for the domestic market. The key result is that the strict quantitative limit set by a quota restricts the foreign firm's best response in a systematic way that facilitates collusive pricing by the firms, therefore raising prices, market power and profits. In contrast, tariffs do not impose any binding constraints on prices and quantities and, thus, are not predicted to have any effect on market power.

Despite the theoretical literature establishing the nonequivalent market-power effects of quotas vis-à-vis tariffs, there has been virtually no work to examine this hypothesis empirically.[4] A number of studies, including Berry et al. (1999) and Goldberg and Verboven (2001), have estimated significant market impacts of quantitative restrictions on exports of automobiles in US and European markets, but they do not examine whether tariffs have equivalent effects. Winkelmann and Winkelmann (1998) use the experience of a large trade protection liberalization event in New Zealand to estimate significant negative terms-of-trade effects to New Zealand for products that were formerly protected by quotas, but no such effects for those that were tariff-protected. However, since the authors do not have cost data and identify estimates from primarily cross-sectional variation, it is difficult to connect their results to market power effects. Kim (2000) estimates the impact of trade protection programs on productivity, market power, and scale efficiency for the

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[4] A predecessor paper to this one by a subset of the authors (Blonigen et al., 2007) also considers these issues, but with industry-level data that does not allow the precision and robustness of this paper's results using highly detailed plant-level data.

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Korean industrial sectors from 1966 through 1988. The analysis finds that quotas have a statistically significant impact on market power, whereas price-based forms of protection do not, but cannot conclude that their impacts are different due to the size of the standard errors.

In this paper, we directly examine the hypothesis of nonequivalent market-power effects of quotas and tariffs using a detailed panel of US steel plants and a control group of non-ferrous metal plants from 1967 through 2002. The US steel industry has been the recipient of practically every form of trade protection over this time period (see Table 1 for a timeline of events). In fact, the steel industry accounts for over one-third of the more than 1500 US AD and CVD cases since 1980, and steel is one of only a few high-profile industries that have enjoyed quotas or safeguard remedies. In addition, there has been significant heterogeneity in trade protection across various steel products and at different points in time, providing a rich variation to identify our estimates. Our plant-level data includes detailed measures of inputs, production, and prices, allowing us to use well-established techniques to estimate market power for US steel-makers. The panel nature of the data allows us to control for unobserved plant-level fixed effects. We are also careful to account for the potential endogeneity of trade protection and market power.

While a primary focus of our analysis is the difference in market-power effects of tariffs and quotas, our data allow us to also estimate market-power effects of a variety of other trade protection programs, including antidumping (AD) duties and countervailing duties (CVD).[5] Staiger and Wolak (1989), Prusa (1994), and Veugelers and Vandenbussche (1999) provide models that indicate that the structure of AD investigations and duty determination can facilitate collusion amongst domestic and foreign firms serving a domestic market and, thus, also raise market power of these firms. Konings and Vandenbussche (2005) analyze a firm-level data set of European firms who petitioned and received AD protection in the 1990s and find that there was a significant increase in market power of firms after the imposition of AD duties. Similarly, Pierce (2011) finds that US manufacturing plants responded to antidumping duties by increasing prices and markups. In contrast, Nieberding (1999) examines whether the withdrawal of 1982 US AD cases against imported steel affected market power for three large US steel producers and finds only mixed evidence for any positive effects.

We are unaware of any theoretical models that suggest that CVDs would increase market power. CVDs are designed to countervail subsidization by a foreign government and, therefore, the calculation of the CVD is unaffected by firm behavior. In contrast, the calculation of AD duties are directly affected by foreign firm pricing behavior, and it is these well known rules by which AD duties adjust to foreign firm pricing that allows the domestic and foreign firms to potentially coordinate collusive pricing. Given this, we propose a second related nonequivalence hypothesis that AD duties increase market power of domestic firms, whereas CVDs do not. Our analysis will be able to directly examine whether there are any differential market-power effects of AD duties and CVDs, as well as the extent to which these trade protection programs differ in their effects from tariffs and quotas.

Table 1
US steel trade protection events.

1969–1974	Voluntary restraint agreements (VRAs) with Japan and the EC.
1978–1981	Trigger price mechanism applied to all imports.
1982	Antidumping (AD) and countervailing duty (CVD) cases filed against EC countries. Subsequently terminated for VRAs on EC imports.
1984	AD and CVD cases filed against non-EC countries. Subsequently terminated for comprehensive VRAs.
1984–1989	Comprehensive VRAs with all significant import sources.
1989–1992	Extension of VRAs.
1992–1993	AD and CVD cases filed against significant import sources after VRAs expire. AD and CVD remedies applied to only subset of products.
1998–2000	Multiple AD and CVD cases against Japan and other Asian countries.
2002–2003	Safeguard remedies in form of tariffs placed on steel imports, excluding FTA partners and developing countries.

Unlike AD or CVD duties, which are country and even firm-specific, safeguard tariffs provide protection across a wide array of import sources and are applied uniformly against foreign firms in targeted countries. Thus, individual foreign firms have little incentive to alter their pricing behavior in order to reduce their tariffs, as contrasted with the previously discussed dynamics that may arise with foreign firms facing AD duties. Thus, our expectation is that safeguard tariffs do not have an effect on markups.

Our paper's econometric analysis provides a number of important results. First, we find significant support for nonequivalent effects of quotas and tariffs, as theory would suggest. The various forms of tariff-based protection programs (ad valorem tariffs, CVD duties, and safeguard tariffs) show little evidence of positive market power effects, while quantitative restrictions in the form of voluntary restraints agreements (VRAs) when binding are associated with increases in market power that are both statistically and economically significant. And, in most cases, statistical tests reject the hypothesis that quantitative restrictions and tariff-based forms of protection have equal effects on markups. These results are clearest when we examine the effects of trade policies by steel plant type. The evidence suggests that the significant market power effects associated with VRAs are similar for both types of steel production plants (minimill and integrated), but do not exist for steel processing plants where broad-based quota programs affected not only their final product, but also their purchased primary steel inputs. The evidence for a market power effect of AD duties is much less persuasive. We estimate a positive effect of AD duties more often than not, but it is rarely statistically significant.

The remainder of the paper proceeds as follows. In the next section, we briefly describe the US steel industry and its substantial history of trade protection. Section 3 describes our empirical methodology and data, Section 4 presents our empirical results and Section 5 concludes.

2. US steel industry and its history of trade policies

2.1. US steel producers

The US steel industry is composed of two major types of producers: integrated mills and mini-mills. Integrated mills use large blast furnaces to make pig iron from iron and coke, which is then melted into raw steel in basic oxygen furnaces. Until recently, integrated mills accounted for the majority of steel production in the United States. Integrated mills often include on-site or nearby finishing and rolling mills that further finish the semi-finished steel forms, such as ingots, slabs, and billets, into finished products, such as bars and sheets. Over time, a process of “continuous casting”, whereby molten steel is formed directly into

[5] There is a literature that has analyzed the impacts of various trade protection programs in the steel industry, though the frequent focus is to analyze just one type of trade protection program, rather than compare effects across trade protection programs. Crandall (1981) and Canto (1984) examine the effect of the US VRAs from 1969 to 1974, finding that these VRAs had only a very modest effect in raising import prices for US steel firms. Lenway et al. (1990) and Lenway et al. (1996) provide event study analysis evidence that steel firms' profitability was increased by the announcement of voluntary restraint agreements (VRAs) in 1982 and 1984. More recently, Chung (1998) finds that AD and CVD duties from 1982 through 1993 had only modest impacts on import penetration, while Bown (2004) and Durling and Prusa (2006) find that AD and safeguards significantly decrease trade in targeted products. Liebman (2006) finds little evidence that the 2002–2003 safeguard actions affected US steel prices. In addition to the literature cited that uses econometric techniques to evaluate trade policies ex post, there is also a significant literature that examines these policies with computable general (or partial) equilibrium models, including de Melo and Tarr (1990) and many US federal government agency reports. These studies also typically focus on only single trade protection instances and do not explore differing effects of trade protection programs.

finished products has spread throughout the industry. Examples of integrated steel companies include US Steel and Bethlehem Steel.

The past three decades have also seen an ever-increasing share of steel production due to mini-mill steel plants which melt recycled steel scrap with electric arc furnaces (EAFs) into raw steel and steel products.[6] There are a number of cost efficiencies possible from mini-mill production, particularly in the much smaller plant size and hence, capital costs, required for an EAF. Historically, mini-mill producers have primarily produced lower-quality steel products, such as wire rods and steel bar products, because of the greater impurities in steel made from recycled scrap steel, rather than iron ore. However, over time, technologies have been developed that have begun to allow mini-mill producers to break into higher-quality steel markets, such as plate and sheet products. While Nucor is the well-known example of a mini-mill-based steel company, there are scores of smaller mini-mill steel plants across the United States.

In addition to these steel-producing plants, there are also steel-processing plants that produce many of the same basic steel products as the integrated and mini-mill plants using purchased steel. Steel processors differ substantially from integrated and mini-mill plants, however, in that they do not produce raw steel and instead purchase it from steelmaking plants for use as their primary input. Products that are made at steel processors include steel pipes and tubes, as well as wire and related wire products.

Since trade policies do not discriminate on the type of plant producing these products, we include all three types of steel plants in our analysis. However, there are certainly economic reasons to suggest that the effect of trade policies may differ across these types of plants. This is particularly true of the processors, since steel trade policies may not only raise import protection on their final good, but also their main input. As discussed below, we do find the clearest evidence for the positive effect of VRAs on market power among steelmaking plants—both integrated and mini-mill—while processors do not benefit from the VRAs.

2.2. Brief history of US steel trade policies

Prior to the 1960s, the US steel industry was far more concerned with fending off anti-trust charges than securing trade relief from the federal government.[7] A string of factors, however, led to the industry's permanent shift from dominant world exporter to net importer.[8] In reaction to pressure from the large, integrated steel producers and the United Steel Workers Union (USW), President Johnson negotiated the industry's first VRA with Japan and the European Community (EC) in 1969. When the VRA expired in 1974, a surge of imports in 1977 led to renewed calls for quantitative restrictions as well as AD and CVD petitions. In order to avoid either outcome, President Carter implemented the Trigger Price Mechanism (TPM), which was enacted in 1978. Under the TPM the domestic industry agreed to refrain from filing AD and CVD petitions as long as import prices did not fall below Japanese production costs (the world's lowest-cost industry) plus an 8% profit margin.

The TPM was renewed in 1980, but the industry was convinced that the policy was failing to provide sufficient protection from subsidized European imports and began filing petitions for AD and CVD protection in January of 1982 which terminated the TPM program. In order to avoid trade frictions that would result from significant AD and CVDs, President Reagan negotiated VRA agreements across a wide range of steel products with the EC in October of 1982.

Although European steel imports were not permitted to exceed 5.5% of the US market, overall import penetration remained high due to a strong dollar and import diversions to non-EC sources. This likely contributed to the industry filing a large set of AD and CVD petitions in early 1984 and ultimately filing a safeguard petition (historically known as a Section 201 Escape Clause action in the US) in 1984. These trade protection actions led to the negotiation of a comprehensive VRA for all finished steel products and limiting total import market share to 18.4% in the last couple of months of 1984. The VRAs were put into place for a roughly five-year period to end in October of 1989.

In late 1989, citing the industry's strong performance, President George H. Bush renewed the VRAs for two-and-a-half additional years, rather than the full five years requested by the industry. When the VRAs ended in early 1992, the steel industry immediately filed a large number of AD and CVD petitions once again. While many industry observers expected intervention by the administration, President Bush instead allowed the cases to reach their completion. In July of 1993, affirmative AD and CVD determinations were ruled in favor of the domestic industry in only about a half of the value of imports under review. In several instances, competition from mini-mills, rather than imports, were seen as the real cause of injury by the US International Trade Commission. The ruling was perceived as a major defeat for the industry and was cited by Moore (1996) as an indication of the industry's loss of political clout.

Through the rest of the 1990s, steel producers used AD and CVD actions targeted at a limited number of specific products to secure trade relief. One possible reason for such limited action was the strong economy and modernized US operations. For the first time in decades, integrated producers were globally competitive, touted by some experts as an industry that had survived its austere, rationalization period and which was now enjoying a much-deserved "renaissance" (Ahlbrandt et al., 1996).

A string of unexpected shocks in 1998 brought this period quickly to an end. Most notable were currency crises in East Asia and Russia which led to import surges and subsequent AD and CVD filings in the late 1990s. By the early 2000s, about one-third of the industry had fallen into bankruptcy, leading President George W. Bush to implement safeguard tariffs ranging from 8 to 30% on many major steel products in 2002. However, a number of major import sources were excluded including Canada and Mexico, as well as less-developed countries. Moreover, downstream industries successfully lobbied for exceptions over the ensuing safeguard period further watering down the amount of affected imports. Finally, the safeguard tariffs were terminated prematurely in early 2004 due to a WTO dispute panel ruling against the US safeguard action.

3. Methodology and data

3.1. Empirical specification

Our focus in this paper is the ability of US steel plants to price above marginal cost and how this ability varies with trade policy changes.[9] There are a couple of standard ways in which the previous literature estimates market power using plant- or firm-level data (see Tybout, 2003). We employ the more direct method of estimating market power, which we call the price–cost margin (PCM) as our primary measure. But we also show that our results are robust to using

[6] Data from various issues of the American Iron and Steel Institute's *Annual Statistical Yearbook* show that the percent of US domestic steel produced by using EAFs has increased from about 15% in 1970 to over 50% today.

[7] This confrontation even led to President Truman's unsuccessful attempt to nationalize the industry in 1952.

[8] These factors included: 1) a crippling strike in 1959 that required downstream users to seek non-domestic sources, 2) increasingly efficient, subsidized European and Japanese operations, 3) the discovery of large iron ore deposits outside the US, and 4) a strong dollar. As such, between 1960 and 1968, US import penetration climbed from 4.7% to 16.7% of total US steel consumption. See Moore (1996) for a more detailed discussion of the history of steel trade protection in the US through the early 1990s.

[9] While the theory also suggests that trade policy may affect foreign firms' market power, we do not examine this because we do not have the data to do so.

an estimation specification proposed by Roeger (1995), which is an extension of Hall (1988).

We calculate the price–cost markup proxy (PCM_{ijt}) directly for each plant i producing product j in year t as total sales minus variable costs over sales:

$$PCM_{ijt} = \frac{Sales_{ijt} - Mat_{ijt} - Lab_{ijt}}{Sales_{ijt}},$$

where $Sales_{ijt}$ is sales, Mat_{ijt} is expenditures on materials and energy and Lab_{ijt} is expenditures on labor, all at the plant-level.[10] This standard construction of the PCM is clearly a proxy for the price–cost markup since we observe variable costs, but cannot observe marginal cost directly. As such, it has measurement error. However, since it is the dependent variable, it is common to assume that this measurement error is part of the mean-zero error term.

The central hypotheses in this paper concern the differential impacts that trade protection policies imposed on foreign competitors of the plants in our sample can have on a plant's ability to price above marginal cost. To empirically examine this, we regress the PCM on a set of product-specific trade policies (TP_{jt}^k) indexed by k. Given our earlier discussions, we expect both quotas and AD duties to significantly increase the PCM, while tariffs and CVDs have insignificant effect. An important feature of the theoretical analysis proposing nonequivalence between tariffs and quotas is that these types of protection programs have different effects on market power for the same level of import penetration. Thus, we also include an import penetration measure (IM_{jt}) as a righthand side covariate so that we can estimate the impact of various trade protection programs on markups controlling for the level of import penetration.[11] We expect the coefficient on import penetration to be negative, as the competitive pressure from import penetration should be expected to lower price–cost margins of US plants. We also include a number of other controls that have been commonly hypothesized to affect the PCM. The first is a measure of downstream demand growth (GR_{jt}). Gallet (1997) finds that markups in the steel industry can vary with the business cycle and Konings and Vandenbussche (2005) also finds that this is an important control variable for their estimation. Following past studies, we also include the product's Herfindahl index of market concentration (HI_{jt}) as a control variable, since market structure will affect competitiveness, as well as a plant's capital intensity (KI_{ijt}). Finally, we include plant-specific effects (ρ_i) to control for any time-invariant characteristics of the plant that could influence its ability to price above cost. The resulting specification is

$$PCM_{ijt} = \gamma_0 + \sum_{k=1}^{K} \gamma_k TP_{ijt}^k + \gamma_{k+1} IM_{jt} + \gamma_{k+2} GR_{jt} + \gamma_{k+3} HI_{jt} + \gamma_{k+4} KI_{ijt} + \rho_i + \nu_{ijt}, \quad (1)$$

where ν_{ijt} is the assumed mean-zero error term.

Endogeneity of trade policies is a concern that could violate the assumed orthogonality between our error term and our covariate matrix. For example, one obvious source of endogeneity of our trade policy variables is the increased propensity of firms to lobby or petition for trade relief when facing a degradation of their markups. There are endogeneity issues that one could also raise with some of our other control regressors, including import penetration and Herfindahl index. Thus, after presenting OLS estimates, we provide instrumental-variable (IV) estimates where we employ a number of instruments to control for the potential endogeneity of our trade policy and other control variables.

These instruments include lags of all our trade policy variables and exogenous control variables. We also include a number of other instruments based on global trade negotiations, which affect the implementation of trade policy. The first is a dummy variable for any year prior to the completion of the Uruguay Round, after which quota-based trade protection programs were essentially eliminated for use by member countries. Second, we include a dummy variable for years after the conclusion of a major General Agreement on Tariffs and Trade (GATT) round, when specific trade protection reductions were being phased in, as well as interactions with our lagged trade policy variables. Years after GATT rounds lead to mandated decreases in some of the trade protection programs, but may then create increased demand for trade protection programs not covered by the recent GATT round.[12]

An alternative specification used to examine the effect of various factors on market power stems back to Hall (1988), which was then extended by Roeger (1995) to overcome an endogeneity issue. We examine our hypotheses with this specification to verify the robustness of our results. The methodology involves deriving an expression of a plant's Solow residual using both the primal and dual of the plant's optimization problem, and then first-differencing to eliminate common terms that are a potential source of endogeneity. Applying this Hall–Roeger specification to our current problem yields the following estimation equation:

$$\Delta Y_{ijt} = \theta_0 \Delta X_{ijt} + \sum_{k=1}^{K} \theta_k \left(TP_{jt}^k \times \Delta X_{ijt}\right) + \theta_{k+1}\left(IM_{jt} \times \Delta X_{ijt}\right) + \theta_{k+2}\left(GR_{jt} \times \Delta X_{ijt}\right) + \theta_{k+3}\left(HI_{jt} \times \Delta X_{ijt}\right) + \theta_{k+4}\left(KI_{ijt} \times \Delta X_{ijt}\right) + \varepsilon_{ijt}. \quad (2)$$

The dependent variable (ΔY_{ijt}) in Eq. (2) is a term measuring the growth in sales revenue for a plant adjusted for the growth in capital expenditures, whereas the ΔX_{ijt} term is the weighted average growth in plant's expenditures on variable inputs, labor and materials (adjusting for the growth in capital expenditures).[13]

Regressing ΔY_{ijt} on ΔX_{ijt} yields an estimate of a firm's price–cost ratio (price divided by marginal cost). Thus, to examine the effect of other covariates on this markup term, one must employ a varying coefficient model that leads to the interactive terms one finds in Eq. (2) between ΔX_{ijt} and our trade policy and control variables.[14] The term ε_{ijt} is an assumed mean-zero error term.

There are also potential endogeneity concerns with our trade policy and other control variables in this specification, even though the dependent variable is quite different than the PCM specification. Thus, we rely on the same set of instruments as in the PCM specification.[15] On a final note, the estimated effects of our variables on market power are not directly comparable across the PCM and Hall–Roeger specifications because the PCM specification measures market

[10] See, for example, Eq. 13.2 and related discussion in Tybout (2003) and Eq. (8) and related discussion in Konings and Vandenbussche (2005).

[11] There is a related literature that looks at imports as "market discipline," in that greater import penetration likely correlates with a more competitive market, lower markups for all firms/plants (e.g., see Kee and Hoekman, 2007).

[12] As a robustness check, we also estimated a specification where we excluded a number of control variables that could be endogenous—import penetration, the Herfindahl index, and capital intensity—and found that this did not qualitatively affect any of our estimated trade policy effects.

[13] Formally, $Y_{ijt} = \left(\hat{Q}_{ijt} + \hat{P}_{ijt}\right) - \left(\hat{K}_{ijt} + \hat{R}_{ijt}\right)$ and $X_{ijt} = \alpha_{N_{ijt}}\left[\left(\hat{N}_{ijt} + \hat{P}_{N_{ijt}}\right) - \left(\hat{K}_{ijt} + \hat{R}_{ijt}\right)\right] + \alpha_{M_{ijt}}\left[\left(\hat{M}_{ijt} + \hat{P}_{M_{ijt}}\right) - \left(\hat{K}_{ijt} + \hat{R}_{ijt}\right)\right]$, where hats denote growth rates, Q is the quantity of output, P is the price of output, K is the quantity of capital, R is the rental price of capital, N is the quantity of labor, P_N is the price of labor, M is the quantity of materials, P_M is the price of materials and α denotes the factor share of inputs.

[14] More details on deriving this estimation equation can be found in Konings and Vandenbussche (2005).

[15] One limitation of the Roeger derivation is an assumption of constant returns to scale. Klette (1999) provides an extension to the approach of Hall and Roeger to relax this assumption. However, when we implement Klette's specification with our sample, our estimates cannot reject constant returns to scale. Thus, we estimate Eq. (2), which maintains an assumption of constant returns to scale.

power as the difference between the price and marginal cost divided by the price, whereas the Hall–Roeger specification measures changes to the ratio of the price to marginal cost.

3.2. Variables and data

We use the U.S. Census Bureau's Census of Manufactures (CM) for the data in this analysis. The CM is conducted every five years and collects plant-level data for all US manufacturers,[16] including the total value of shipments, book value of capital, raw material usage and employment. In addition, the CM tracks the full set of products produced by each plant, which allows us to identify the plants producing steel products that received trade protection. Our panel dataset includes CM data from 1967, 1972, 1977, 1982, 1987, 1992, 1997 and 2002.

Our sample consists of two main groups of plants. The first is our focus group of US steel plants producing products in SIC 331 (Steel Works, Blast Furnaces, and Rolling and Finishing Mills). A few of the steel wire-related products also have associated SIC 349 (Miscellaneous Fabricated Steel Products) product codes when the product is produced by a steel processor rather than a steel-producing plant. For example, wire cloth produced by a steel-producing plant is coded as SIC 33157, whereas wire cloth produced by a steel-processor plant is coded as SIC 34964. This distinction is what allows us to identify steel processors from steel producers in our data.

The second group of observations is plants producing non-ferrous metal and primary products listed under SIC categories 333, 334, and 335 (Primary Nonferrous Metal, Secondary Nonferrous Metal, and Nonferrous Rolling and Drawing, respectively). These non-ferrous metal producing plants are included to serve as a control group. The level of trade protection activity in these products is quite minimal relative to the steel (i.e., ferrous) metal industries, yet they have analogous product categories and production processes as the steel plants in SIC 331. Having a control group is particularly important with respect to the VRA trade policies where virtually all of the steel categories fell under a VRA, making it problematic to separately identify the effect of the VRA on steel plants from an unobserved year effect when estimating on the set of steel plants alone. While using the full CM as a control group might provide an interesting robustness check, data availability and collection difficulties make this infeasible.

We then match trade policy and other control variables to the plants' 5-digit SIC product codes.[17] There are five different types of protection programs that were applied to steel products in our database over our sample period. The first program we examine is standard ad valorem tariffs ($Tariff_{jt}$), which were in place for the majority of the sample, though some had fallen to zero by the last year of the sample. The relevant data were collected from the NBER Trade Database (www.nber.org/data/) and tariff duties were calculated by dividing duties collected by the customs value of the imports for the associated product codes.[18] Tariffs by import product codes (Tariff Schedule of the United States of Annotated (TSUSA) or Harmonized System (HS)) were aggregated to five-digit SIC (SIC5) categories using concordances in various issues of *Current Industrial Reports: Steel Mill Products*, published by the U.S. Census Bureau of the U.S. Department of Commerce.

Second, are voluntary restraint agreements or quotas (VRA_{jt}), which happened over two distinct periods. The first was from 1969 through 1974, which were placed on all steel products, including steel pipes and tubes. Only one year of our sample fully overlaps with this period, 1972, and, thus, we create a "1" for any product subject to a VRA in 1972 and a "0" otherwise. The second VRA period on steel products was in effect from the end of 1984 to early 1992.[19] Again, only one year of our sample fully overlaps with this period, 1987, and, thus, we create a "1" for any product subject to a VRA in 1987 and a "0" otherwise.[20] A key condition for nonequivalence between tariffs and quotas with respect to market power is that the quota truly constrains (or binds) the total quantity imported. It is difficult to measure how much a quota binds. However, there is anecdotal evidence that the steel VRAs in 1972 did not significantly constrain imports (see Kiers, 1980; Scheuerman, 1986), while 1987 was a year when quota "fill rates" of the VRAs across all covered steel products were at their peak and, thus, quite binding (see Moore, 1996). Thus, our ex ante expectations are that it is more likely that we find significant market power effects of VRAs in 1987 than in 1972.

The third and fourth types of protection programs were antidumping (AD_{jt}) and countervailing duties (CVD_{jt}). Information on these investigations and duties were gathered from relevant *Federal Register* notices. In particular, we gather information on affected import product codes (TSUSA or HS), foreign country source, applied duty rates and length of time these duties were in place, and then construct average trade-weighted AD and CVD duty rates for our SIC5 sectors using the import volume of the affected product and country source in the year prior to the case available from the NBER Trade Database and the concordance between import product codes and SIC5 products available in *Current Industrial Reports: Steel Mill Products*, mentioned above.

The fifth trade protection program during our sample that we examine is the steel safeguard tariffs ($SafeTariffs_{jt}$) that were put into place in March 2002; i.e., early in the last year of our sample. Steel safeguard tariff rates are reported and available from the U.S. Department of Commerce at http://www.ita.doc.gov/media/FactSheet/0303/fs_steel_ex_032103.html. We constructed trade-weighted average safeguard tariffs for our SIC5 products in the same fashion as our AD and CVD duties, being sure to take into account the imports from country sources that were exempt from the safeguard remedy, such as the North American Free Trade Agreement partner countries.

There are a few trade protection programs applied to the steel industry during our sample years that we do not include in our reported regression estimates. The TPM ran from January 1978 to January 1982, and thus does not overlap with any of our sample's closest years — 1977 or 1982. Second, there were two special safeguard actions that led to trade protection in the form of tariff-rate quotas on wire rods and circular welded line pipe from March 2000 to March 2003. These programs overlap with our last sample year, 2002. However, they also pertain to very specific products that comprise only a small share of one of our SIC5 products, particularly circular welded line pipe. Not surprisingly, when we include dummy variables indicating the affected SIC5 products in 2002, we estimate statistically insignificant effects on markups and none of our other variables are qualitatively affected. Thus, we do not present results from specifications with these variables in our empirical tables below.

Beyond the trade protection variables, we rely on four main control variables. The first is a measure of import penetration for a

[16] The CM collects limited data for small manufacturers, which are referred to as "administrative records." Because output and input data may be imputed for these plants, however, they are excluded from this analysis, as is standard in research utilizing the CM.

[17] While the majority of plants in our sample produce in only one SIC5 product category, there is a non-trivial portion of the sample that are multi-product plants. For these plants, we create weighted trade policy variables using the plant's share of sales in each SIC5 category as weights. Our results are qualitatively identical when we instead assign a plant to the SIC5 category that comprises the largest share of its sales.

[18] The NBER Trade Database currently only provides data through the year 2001, and so we rely on purchased official merchandise import data from the Foreign Trade Division of the U.S. Census for the year 2002.

[19] Products covered under the VRAs are listed in U.S. International Trade Commission (USITC) publication 1729 (August 1985), *Annual Survey Concerning Competitive Conditions in the Steel Industry and Industry Efforts to Adjust and Modernize*.

[20] We also directly test for nonequivalence using an independent estimate of the ad-valorem equivalent of the 1985–1991 VRA, as discussed in Section 4.4.

product in a given year (IM_{jt}), which we construct as the share of imports in the sum of imports plus domestic shipments. We rely on data from various annual yearbooks of the American Iron and Steel Institute for products where there is a direct correspondence to our SIC5 products. For a handful of our products (particularly wire-related products), there is not a clear correspondence, and so we use data on imports from the NBER Trade Database for imports and *Current Industrial Reports: Steel Mill Products* for domestic shipment data.

The second control variable is a real demand growth measure, which we calculate as the weighted average of real GDP growth by downstream sectors. We gather real GDP growth by sector and year from table B-13 of the *Economic Report of the President*, 2006, and then weight by the share of total shipments purchased by the downstream sector as reported in the 1992 US input–output tables. The product codes in the input–output tables are not as detailed as our SIC5 products, so we often have to apply the same demand growth values across multiple SIC 5 product codes. We construct changes in growth over the prior year, but note that our results are qualitatively equivalent when we calculate growth over the prior 5 years. Table 2 provides a list of the SIC5 products covered in our sample and average trade policy coverage over our sample years by product and trade policy.

The third and fourth variables—product-level Herfindahl index and plant-level capital intensity—are calculated using data from the CM. The product-level Herfindahl index is calculated as the sum of squared plant-level market shares for all plants producing the

Table 2
Average values of trade policy variables over sample years by product.

SIC5	Product	Tariff rate	AD duty	CVD	1987 VRA	1972 VRA	Safeguard tariffs
		Ad valorem	Ad valorem	Ad valorem	Binary	Binary	Ad valorem
33122	Steel ingot, blooms, slabs, etc.	5.50%	0.00%	0.00%	0.125	0.125	0.00%
33126 and 33170	Steel pipe and tubes	4.19%	3.45%	0.03%	0.125	0.125	0.73%
33123	Hot-rolled steel sheet and strip	6.05%	3.86%	0.13%	0.125	0.125	1.93%
33124	Hot-rolled steel products	3.84%	5.33%	0.63%	0.125	0.125	1.16%
33125 and 33155	Steel wire	5.23%	0.00%	0.00%	0.125	0.125	0.01%
33127 and 33167	Cold-rolled steel sheet and strip	6.81%	4.92%	0.42%	0.125	0.125	2.39%
33128 and 33168	Cold-formed steel bars	6.40%	2.16%	0.07%	0.125	0.125	1.97%
3312C	Steel rails	0.52%	5.05%	15.89%	0.125	0.125	0.00%
33151 and 34961	Steel wire rope, cable, and strand	5.25%	0.43%	0.00%	0.125	0.125	0.00%
33152	Steel nails and staples	0.92%	2.78%	0.00%	0.125	0.125	0.00%
33156 and 34966	Steel fencing and gates	0.54%	0.00%	0.00%	0.125	0.125	0.00%
33157 and 34964	Steel wire cloth	7.39%	0.00%	0.00%	0.000	0.125	0.00%
33311	Copper smelter products	0.77%	0.00%	0.00%	0.000	0.000	0.00%
33312	Refined primary copper and copper-base alloy	1.18%	0.00%	0.00%	0.000	0.000	0.00%
33347	Aluminum ingot	1.61%	0.00%	0.00%	0.000	0.000	0.00%
33348	Aluminum extrusion billet	1.61%	0.00%	0.00%	0.000	0.000	0.00%
33391	Zinc residues and other zinc smelter products	4.34%	0.00%	0.00%	0.000	0.000	0.00%
33392	Refined primary zinc	1.87%	0.00%	0.00%	0.000	0.000	0.00%
33395	Precious metals and precious metal alloys	0.00%	0.00%	0.00%	0.000	0.000	0.00%
33398	Other primary nonferrous metals, N.E.C.	0.97%	0.43%	0.06%	0.000	0.000	0.00%
33412	Copper (secondary refining)	1.18%	0.00%	0.00%	0.000	0.000	0.00%
33413	Lead (secondary refining)	2.96%	0.00%	0.00%	0.000	0.000	0.00%
33414	Zinc (secondary refining)	1.87%	0.00%	0.00%	0.000	0.000	0.00%
33415	Precious metals and precious metal alloys (secondary refining)	0.00%	0.00%	0.00%	0.000	0.000	0.00%
33416	Other nonferrous metals, N.E.C. (secondary refining)	0.77%	0.00%	0.00%	0.000	0.000	0.00%
33417	Aluminum ingot (secondary refining)	1.61%	0.00%	0.00%	0.000	0.000	0.00%
33418	Aluminum extrusion billet (secondary refining)	1.61%	0.00%	0.00%	0.000	0.000	0.00%
33511	Copper wire, bare and tinned (non-electrical)	4.04%	0.02%	0.00%	0.000	0.000	0.00%
33513	Copper and copper-base alloy rod, bar, and shapes	2.87%	0.05%	0.00%	0.000	0.000	0.00%
33514	Copper and copper-base alloy sheet, strip, and plate	3.10%	5.45%	0.29%	0.000	0.000	0.00%
33515	Copper and copper-base alloy pipe and tube	2.51%	0.00%	0.00%	0.000	0.000	0.00%
33531	Aluminum plate	3.27%	0.00%	0.00%	0.000	0.000	0.00%
33532	Aluminum sheet and strip	3.27%	0.00%	0.00%	0.000	0.000	0.00%
33533	Plain aluminum foil	4.87%	0.00%	0.00%	0.000	0.000	0.00%
33534	Aluminum welded tube	6.79%	0.00%	0.00%	0.000	0.000	0.00%
33541	Extruded aluminum rod, bar, and other extruded shapes	2.83%	0.36%	2.41%	0.000	0.000	0.00%
33542	Extruded and drawn aluminum tube	6.79%	0.00%	0.00%	0.000	0.000	0.00%
33551	Aluminum and aluminum-base alloy wire and cable (except covered or insulated) — PRODUCED in rolling mills	3.50%	0.00%	0.00%	0.000	0.000	0.00%
33552	Rolled aluminum bar and rod	2.76%	0.48%	3.15%	0.000	0.000	0.00%
33553	Aluminum ingot	1.61%	0.00%	0.00%	0.000	0.000	0.00%
33554	Aluminum extrusion billet	1.61%	0.00%	0.00%	0.000	0.000	0.00%
33561	Nickel and nickel-base alloy mill shapes (including nickel-copper alloys)	5.34%	0.00%	0.00%	0.000	0.000	0.00%
33562	Titanium and titanium-base alloy mill shapes (excluding wire)	13.70%	0.00%	0.00%	0.000	0.000	0.00%
33563	Precious metal mill shapes	0.40%	0.00%	0.00%	0.000	0.000	0.00%
33569	All other nonferrous metal mill shapes	7.13%	0.00%	0.00%	0.000	0.000	0.00%
33571	Aluminum and aluminum-base alloy wire and cable (except covered or insulated)—produced in drawing mills	3.50%	0.00%	0.00%	0.000	0.000	0.00%
33572	Copper and copper-base alloy wire, strand, and cable (for electrical transmission)	4.81%	0.00%	0.00%	0.000	0.000	0.00%
33573	Other bare nonferrous metal wire	5.69%	0.00%	0.00%	0.000	0.000	0.00%
33575	Nonferrous wire cloth and other woven wire products	6.36%	0.00%	0.00%	0.000	0.000	0.00%

product in a given year. Capital-intensity is defined as plant-level book value of capital divided by total value of shipments.

4. Empirical results

4.1. Base model estimates

Column 1 of Table 3 presents results from estimating Eq. (1)—which we term our "base model" of estimates from the PCM specification with plant fixed effects. The data fit the model well, with an R^2 statistic of 0.61 and an F-statistic that easily rejects the null hypotheses of jointly zero coefficients.

As discussed above, prior theory suggests that the VRA and AD duties have a positive impact on plants' market power, while strictly tariff-based trade policy programs (tariffs, CVDs, and safeguard tariffs) have no effect on market power. The estimated coefficients in column 1 of Table 3 find mixed evidence for these predictions. While the 1987 VRA variable shows a positive, statistically significant coefficient at the 1% level, the 1972 VRA coefficient and antidumping duty coefficients are insignificant, though positive, as expected. Meanwhile, the tariff variable has a positive and statistically significant coefficient, though the other tariff-based trade policies (safeguard and CVDuty) have unexpectedly negative signs, with the coefficient on the CVDuty variable statistically significant. The coefficients on our control variables are insignificant, with the exception of the capital intensity variable, where a negative coefficient suggests that capital-intensive plants have lower markups.

There are a couple issues with these base OLS regressions that we address sequentially in the next three columns of Table 3. First, our controls may be inadequate to control for economy-wide shocks that could affect not only markups, but also levels of trade protection. Inclusion of year dummies in our specification (column 2) leads to insignificant coefficients on our trade policy variables, though we note that the closest to statistical significance, with a p-value around 0.12, is the coefficient on the 1987 VRA. Import penetration takes the expected negative sign and is now statistically significant in this specification that includes year dummies.

The second issue is endogeneity. In column 3 of Table 3, we report results from instrumental variables estimates with plant fixed effects, using the instruments described in the methodology section above, as well as year dummies.[21] These results provide quite supportive evidence for the nonequivalence hypotheses.[22] In particular, the coefficient estimates on the VRA and ADDuty variables are all positive, as expected, and the coefficients on the 1987 VRA and ADDuty variables are statistically significant at standard confidence levels. The stronger evidence of a significant market power effect from the 1987 VRA relative to the 1972 VRA, which we also find generally for all our results reported below, accords with the anecdotal evidence (discussed in Section 3.2) that the 1987 VRAs were much more likely binding on import levels. The coefficient on the 1987 VRA says that the VRA led to an average increase in the mark-up (difference between price and marginal cost divided by price) of 6.1 percentage points. Likewise, the coefficient on the ADDuty variable says that each percentage point increase in the ADDuty increases the mark-up by 0.37 percentage points. These are relatively sizeable effects with an average sample PCM of around 25%.

In contrast, the tariff-based measures all take an unexpected negative sign in our preferred estimates. It is a bit puzzling that the safeguard and CVDuty variables have negative and statistically significant coefficients. One concern with the CVDuty variable is multicollinearity with the ADDuty variable. CVDuty cases rarely occur without a companion ADDuty case on the same product, while ADDuty cases often occur without a companion CVDuty case. This means that there is significant independent variation in the ADDuty variable, but identification of the CVDuty coefficient may be driven by just a small number of product–year observations where there was a CVDuty case without a companion ADDuty case.

We note that it is possible that our control group of firms—non-ferrous metal producing plants—is not ideal for identifying the impact of a broad-based trade protection program (like the VRAs) on our focus (steel plants) from other macroeconomic events. A number of the non-ferrous metals (e.g., aluminum and copper) are reasonably close substitute products for steel in a number of downstream industries. Thus, when a trade protection program raises market power broadly across steel products, it may also do so in non-ferrous substitutes, due to a demand shift into non-ferrous products.

In this way, our control group may bias our estimates from verifying a significant positive effect of the VRAs. We think this is much less of an issue for AD and CVD trade protection programs in our sample where only a very specific product (e.g., steel wire) is targeted, as identification comes from a much larger set of unaffected non-ferrous and steel products which are clearly not substitute products. However, when we

Table 3
Price–cost margin (PCM) estimation of the effects of various trade policies on steel plant markups.

	Predicted sign	FE estimates	FE estimates	Instrumental variable estimates	Instrumental variable estimates
Trade policy effects					
$Tariff_{jt}$	0	0.0027***	0.0014	−0.0021	−0.0042
		(0.0008)	(0.0013)	(0.0033)	(0.0054)
1972 VRA_{jt}	+	0.0061	0.0044	0.0147	0.0256
		(0.0075)	(0.0091)	(0.0343)	(0.0203)
1987 VRA_{jt}	+	0.0361***	0.0165	0.0610*	0.0307
		(0.0069)	(0.0106)	(0.0336)	(0.0204)
$ADDuty_{jt}$	+	0.0003	−0.0004	0.0037*	0.0015
		(0.0006)	(0.0007)	(0.0019)	(0.0021)
$CVDuty_{jt}$	0	−0.0018***	0.0006	−0.0091***	−0.0038*
		(0.0007)	(0.0007)	(0.0030)	(0.0022)
$Safeguard_{jt}$	0	−0.0011	−0.0011	−0.0051**	−0.0017
		(0.0010)	(0.0012)	(0.0023)	(0.0015)
Other controls					
IM_{jt}	−	−0.0002	−0.0004*	−0.0009***	−0.0012*
		(0.0002)	(0.0002)	(0.0003)	(0.0006)
GR_{jt}	+	−0.0001	0.0024	0.0031	0.0024
		(0.0003)	(0.0018)	(0.0023)	(0.0019)
HI_{jt}	+	0.0300	0.0131	−0.0052	−0.6769*
		(0.0480)	(0.0493)	(0.3063)	(0.3876)
KI_{ijt}	?	−0.0199**	−0.0201**	−0.0344***	−0.0369***
		(0.0086)	(0.0087)	(0.0034)	(0.0034)
Year dummies		No	Yes	Yes	Yes
Plant fixed effects		Yes	Yes	Yes	No
First-differenced data		No	No	No	Yes
R^2		0.61	0.61		
F-test (or Chi-squared)		5.78***	7.76***	41,439.32***	281.15***
Observations		14,555	14,555	13,302	7708

Notes: This table reports OLS regression coefficients of the price–cost margin on trade policy effects and other controls. Variable descriptions can be found on pages 14 and 15. Robust standard errors are in parentheses and ***, **, and * denote statistical significance of a coefficient at the 1%, 5% and 10% levels, respectively. The test statistic for joint significance is an F statistic for columns 1 and 2 and a chi-squared statistic for columns 3 and 4.

[21] We note that the F statistics for our first stage regressions are well above typical rule-of-thumb values indicating an appropriate level of explanatory power for our instruments.

[22] One additional potential concern is that not including the import price of steel as a regressor could create an omitted variable bias, since trade policies may be high when import prices are low. When we re-estimate our results including the import price of steel as a regressor, the coefficient on import price is insignificant and the other coefficients are qualitatively unaffected.

eliminate the aluminum, brass, and copper products from our sample that are the closest substitutes for steel products, we estimate qualitatively similar empirical results.[23]

Since we use lags of our trade policy variables for some of the instrument set, one may be concerned with consistency of our estimates in the presence of plant-level fixed effects (e.g., see Blundell and Bond, 1998). We find no evidence that lagged trade policy variables are correlated with our dependent variable, which should largely mitigate this concern. Nevertheless, in column 4 of Table 3, we also provide results with a first-differences (FD) IV estimator. While the substantially reduced sample size affects precision of our estimates, we find qualitatively identical estimates on our trade policy variables in terms of signs (VRAs and AD are positive in sign, while other tariff-based measures are negative in sign) and relative magnitudes. We note that the coefficients for the effect of trade policies are estimated more precisely—and the evidence for nonequivalence is even clearer—in the IV FD specification when we control for heterogeneity by type of steel plant in the next section.

4.2. Differences across integrated, mini-mill, and processing steel plants

An important issue for our estimates is one of heterogeneous effects across types of steel plants. Particularly in the beginning of our sample, the large integrated steel producers were often the only type of firms publicly instigating petitions for trade protection. While this may suggest they were the ones most likely to gain from trade protection, it may also be due to their relatively large size in the industry and incentives for smaller mini-mill plants to free ride even though the benefits from trade protection were proportionally as large as for the integrated plants. Also, as mentioned, processing plants are quite different from the other two because they purchase basic steel—their primary input—rather than produce it on-site. With trade protection often applied simultaneously across a number of steel products, the processing plants' reliance on purchased steel may translate into different market power effects as well, as trade policies in the sector affect their input purchases, not just their output markets.

To explore this issue, we re-estimate columns 3 and 4 of Table 3 and include interactions between our regressors and dummy variables for each type of plant (excluding integrated mills to avoid perfect multicollinearity).[24] Using these estimates, we can decompose trade policy effects by type of plant, which we present in Table 4.

The results provide even clearer evidence for the nonequivalent market power effects of tariffs and VRA than in the pooled sample. First, there continues to be no evidence of positive market power effects from tariff-based protection. Second, the significant market power effects of the binding VRAs in 1987 are clearly for the steel-producing plants (integrated and mini-mills), not for the steel processors. This is consistent with the notion that the VRAs are increasing costs for the primary steel products purchased by the steel processors, mitigating the impact of VRAs on their final product. An interesting result is that there is evidence of significant market power effects for both the 1972 and 1987 VRAs, with magnitudes that are quite similar across the integrated and mini-mill plants. Lastly, we note that these results are highly similar across both the FE and FD instrumental variables specifications.

Table 4
Trade policy effects on market power by steel plant type.

PCM markup calculation						
	Integrated (FE)	Integrated (FD)	Mini-mill (FE)	Mini-mill (FD)	Processor (FE)	Processor (FD)
$Tariff_{it}$	-0.0309^{*}	-0.0246	0.0013	-0.0021	-0.0472^{**}	-0.0334
	(0.0183)	(0.0295)	(0.0025)	(0.0046)	(0.0200)	(0.0303)
1972 VRA_{it}	0.0845^{**}	0.0506	0.1216^{**}	0.0450	0.0145	0.0370
	(0.0374)	(0.0479)	(0.0576)	(0.0385)	(0.0661)	(0.0600)
1987 VRA_{it}	0.0797^{***}	0.0809^{***}	0.0745^{**}	0.0737^{***}	0.0096	0.0006
	(0.0243)	(0.0263)	(0.0342)	(0.0243)	(0.0309)	(0.0317)
AD_{it}	-0.0019	0.0028	-0.0013	0.0030	-0.0032	-0.0022
	(0.0025)	(0.0042)	(0.0024)	(0.0028)	(0.0034)	(0.0045)
CVD_{it}	-0.0029	-0.0053	-0.0040	-0.0043^{*}	-0.0457	-0.0038
	(0.0045)	(0.0197)	(0.0027)	(0.0022)	(0.0286)	(0.0389)
$Safeguard_{it}$	-0.0100^{**}	-0.0098^{**}	-0.0027	-0.0039	-0.0016	-0.0044
	(0.0041)	(0.0049)	(0.0033)	(0.0031)	(0.0054)	(0.0062)

Notes: This table reports IV regression coefficients of the PCM measure of markups on trade policy variables by plant type. Estimates by plant type are obtained by interacting trade policy variables with dummy variables for the "mini-mill" and "processor" plant types as described in the text. Columns 1, 3 and 5 report results with the fixed effect (FE) IV estimator and columns 2, 4 and 6 report results with the first differences (FD) IV estimator. All regressions also include year fixed effects. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance of a coefficient at the 1%, 5% and 10% levels, respectively.

4.3. Robustness check: Hall–Roeger estimates

As a robustness check, we have also estimated the effects of trade policies on market power using the Hall–Roeger set-up, as presented in Eq. (2), for all our reported specifications. The Hall–Roeger estimates provide results that are qualitatively quite similar to the PCM estimates in all cases. While all these results are available upon request, for brevity we report only our preferred specification in Table 5-IV estimates with year dummies and allowing for heterogeneous effects across plant types. Note that because the Hall–Roeger specification mandates that one first-difference the data, eliminating time-invariant plant-specific effects, we do not separately include plant fixed effects in the specification reported in Table 5.

The results are quite similar to our PCM results in Table 4. First, we estimate a large and statistically significant effect of the 1987 VRA on

Table 5
Trade policy effects on market power by steel plant type Roeger markup calculation.

	Integrated	Mini-mill	Processor
$Tariff_{it}$	-0.1781	0.0412^{*}	-0.1291
	(0.1375)	(0.0228)	(0.1656)
1972 VRA_{it}	0.5285	1.8722	-1.2396
	(0.8723)	(1.4992)	(1.5416)
1987 VRA_{it}	0.9354^{***}	0.5284^{*}	1.1775^{***}
	(0.2911)	(0.2746)	(0.4183)
AD_{it}	0.0405	-0.0178	0.0468
	(0.0387)	(0.0391)	(0.0569)
CVD_{it}	-0.0544	-0.0643^{**}	0.7610
	(0.0416)	(0.0284)	(0.6304)
$Safeguard_{it}$	-0.0586	0.0267	-0.1256
	(0.0456)	(0.0605)	(0.0811)

Notes: This table reports IV regression coefficients of the Roeger measure of markups on trade policy variables by plant type. Estimates by plant type are obtained by interacting trade policy variables with dummy variables for the "mini-mill" and "processor" plant types as described in the text. The regression includes year fixed effects, but plant fixed effects are excluded because the Roeger markup calculation already involves first-differencing of plant-level data. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance of a coefficient at the 1%, 5% and 10% levels, respectively.

[23] A referee also raised the concern that we are estimating significant market power effects associated with VRAs because they are measured as dummy variables, whereas our other trade policy variables are continuous measures. To examine this, we alternatively created dummy variables for our CVD, AD, and safeguard tariff variables for instances where they were above their median values and get very similar results; i.e., we do not estimate positive significant market power effects for these tariff-based variables even when they are specified as dummy variables, and there continues to be evidence for a significant positive 1987 VRA effect.

[24] Mini-mill plants are not explicitly identified in the CM data. However, production capacities of mini-mill plants are significantly smaller than for integrated plants—a fact that is well documented and can be seen in the bi-modal nature of capacities in our sample's distribution of plant capacities. We use this feature of the data to identify mini-mill plants.

market power, which extends across all steel plant types. Second, the coefficients on virtually all other trade policy variables are statistically insignificant and often take an unexpected sign. Again, this is very similar to our PCM estimates. One exception is that there is statistically significant positive coefficient on tariffs for mini-mills in the Hall–Roeger estimates, though it is an order of magnitude smaller than the coefficient on the 1987 VRA. Similar to the PCM FD results, the coefficient on the 1972 VRA is positive and large in magnitude for integrated and mini-mill steel producers, but statistically insignificant. On a final note, the magnitude of the 1987 VRA is relatively large in these Hall–Roeger estimates, as it suggests that the VRA allowed integrated firms to increase markups over marginal cost by 53% (mini-mills) to 117% (processors).

4.4. A more direct test of non-equivalence?

The theory of non-equivalence compares the market-power effects of tariffs and quotas that have an equivalent impact on imports. We have controlled for this by including import penetration as a regressor, so that our coefficient estimates tell us the effect of these trade policies on market power *for a given level of imports*. However, one concern with our estimates is that our VRA variables are measured as a binary variable indicating the presence of any VRA, while the other trade policy variables are measured as an ad valorem tariff. That is, unless we measure quantitative and tariff-based policies in the same units, we are not making a proper comparison regarding their respective markup effects. Again, this criticism is only valid if our import measure is not adequately controlling for the equivalent size of the trade policies.

To address this, we make use of an independent estimate of the U.S. International Trade Commission (1989), which calculated the steel VRA in 1987 to have an ad valorem equivalent of 4.23%. Using this estimate, we can directly examine whether there is equivalence between the market power effects of the 1987 VRA and our tariff-based measures by formally testing the null hypothesis that the coefficient on the VRA is equal to 4.23 times the tariff-based coefficients. Table 6 provides these tests across our many specifications reported in the paper. In 23 of the 33 tests of this hypothesis, we can reject that they are equal, providing further evidence of the non-equivalence of tariffs and binding quotas.

5. Conclusion

This paper provides one of the first empirical analyses of the hypothesis of nonequivalent market power effects of tariffs and quotas using a more comprehensive and detailed dataset than any previous study on this issue. We use plant-level Census Bureau data to examine changes in the market power of US steel plants as they were buffeted by a wide variety of trade protection policies during our sample years of 1967 through 2002. We find evidence that binding quantitative restrictions significantly increase market power, while tariff-based policies do not. These results are consistent with a theoretical literature that predicts that binding quotas, unlike tariffs, can facilitate collusive pricing by domestic and foreign firms. As expected, these results hold for the steel-producing plants in our sample, but not for the steel-processing plants that rely on purchased steel for inputs. We find only weak evidence (at best) that AD duties have positive effects on market power, a possibility that has been discussed in a prior literature.

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References

Ahlbrandt, R.S., Fruehan, R.J., Giarratani, F., 1996. The Renaissance of American Steel: Lessons for Managers in Competitive Industries. Oxford University Press, New York, NY.
Berry, S., Levinsohn, J., Pakes, A., 1999. Voluntary export restraints on automobiles: evaluating a trade policy. The American Economic Review 89, 400–430.
Bhagwati, J.N., 1965. On the equivalence of tariffs and quotas. In: Baldwin, R.E. (Ed.), Trade, Growth and the Balance of Payments: Essays in Honor of Gottfried Haberler. North-Holland, Amsterdam, pp. 53–67.
Blonigen, B.A., Liebman, B.H., Wilson, W.W., 2007. Trade policy and market power: the case of the US steel industry. NBER Working Paper No. 13671.
Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics 87, 115–143.
Bown, C.P., 2004. How different are safeguards from antidumping? Evidence from US trade policies toward steel. Mimeo.
Canto, V.A., 1984. The effect of voluntary restraint agreements: a case study of the steel industry. Applied Economics 16, 175–186.
Chung, J.W., 1998. Effects of US trade remedy law enforcement under uncertainty: the case of steel. Southern Economic Journal 65, 151–159.
Crandall, R.W., 1981. The US Steel Industry in Recurrent Crisis. Brookings Institution, Washington, DC.
de Melo, J., Tarr, D., 1990. Welfare costs of US quotas in textiles, autos and steel. The Review of Economics and Statistics 72, 489–497.
Durling, J.P., Prusa, T.J., 2006. The trade effects associated with an antidumping epidemic: the hot-rolled steel market, 1996–2001. European Journal of Political Economy 22, 675–695.
Gallet, C.A., 1997. Cyclical fluctuations and coordination in the US steel industry. Applied Economics 29, 279–285.
Goldberg, P.K., Verboven, F., 2001. The evolution of price dispersion in the European car market. The Review of Economic Studies 68, 811–848.
Hall, R.E., 1988. The relation between price and marginal cost in U.S. industry. Journal of Political Economy 96, 921–947.
Harris, R., 1985. Why voluntary export restraints are "voluntary". Canadian Journal of Economics 18, 799–809.

Table 6
Results of hypothesis tests for equality of tariff equivalent of 1985–1991 VRA with various tariff-based forms of protection.

Estimation technique	IV (FE)	IV (FD)	IV (FE)			IV (FD)			IV		
Markup calculation	PCM	PCM	PCM			PCM			Roeger		
Sample	Pooled	Pooled	Integrated	Mini-mill	Processor	Integrated	Mini-mill	Processor	Integrated	Mini-mill	Processor
Tariffs	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	Yes
CVD	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	No
Safeguard	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes

Notes: Table displays the results of hypothesis tests for equality of coefficients of tariff equivalent of 1985–1991 VRA with tariff-based forms of protection. A cell entry of "Yes" indicates that the null hypothesis of equality of quota and tariff-based protection is rejected at a 10% level of significance. A cell entry of "No" indicates that we cannot reject the null hypothesis. Results in Column 1 are derived from regression results in Table 3, Column 3. Results in Column 2 are derived from regression results in Table 3, Column 4. Results in Columns 3–5 are derived from regression results in Table 4, Columns 1, 3 and 5. Results in Columns 6–8 are derived from regression results in Table 4, Columns 2, 4 and 6. Results in Columns 9–11 are derived from regression results in Table 5, Columns 1–3.

Kee, H.L., Hoekman, B., 2007. Imports, entry, and competition law as market disciplines. European Economic Review 51, 831–858.
Kiers, L., 1980. The American Steel Industry: Problems, Challenges, Perspectives. Westview Press, Boulder, CO.
Kim, E., 2000. Trade liberalization and productivity growth in Korean manufacturing industries: price protection, market power, and scale efficiency. Journal of Development Economics 62, 55–83.
Klette, T.J., 1999. Market power, scale economies and productivity: estimates from a panel of establishment data. The Journal of Industrial Economics 47, 451–476.
Konings, J., Vandenbussche, H., 2005. Antidumping protection and markups of domestic firms. Journal of International Economics 65, 151–165.
Krishna, K., 1989. Trade restrictions as facilitating practices. Journal of International Economics 26, 251–270.
Lenway, S., Rehbein, K., Starks, L., 1990. The impact of protectionism on firm wealth: the experience of the steel industry. Southern Economic Journal 56, 1079–1093.
Lenway, S., Morck, R., Yeung, B., 1996. Rent seeking, protectionism and innovation in the American steel industry. The Economic Journal 106, 410–421.
Liebman, B.H., 2006. Safeguards, China, and the price of steel. Weltwirtschaftliches Archiv 142, 354–373.
Moore, M.O., 1996. Steel protection in the 1980s: the waning influence of big steel? In: Krueger, A.O. (Ed.), The Political Economy of Trade Protection. University of Chicago Press for National Bureau of Economic Research, Chicago, IL, pp. 15–34.
Nieberding, J.F., 1999. The effect of US antidumping law on firms' market power: an empirical test. Review of Industrial Organization 14, 65–84.
Pierce, J.R., 2011. Plant-level responses to antidumping duties: evidence from U.S. manufacturers. Journal of International Economics 85, 222–233.
Prusa, T.J., 1994. Pricing in the presence of antidumping law. Journal of Economic Integration 9, 260–289.
Roeger, W., 1995. Can imperfect competition explain the difference between primal and dual productivity measures? Estimates for U.S. manufacturing. Journal of Political Economy 103, 316–330.
Scheuerman, W., 1986. The Steel Crisis: The Economics and Politics of a Declining Industry. Praeger, New York, NY.
Staiger, R.W., Wolak, F., 1989. Strategic use of antidumping law to enforce tacit collusion. NBER Working Paper No. 3016.
Tybout, J.R., 2003. Plant- and firm-level evidence on "new" trade theories. In: Choi, E.K., Harrigan, J. (Eds.), Handbook of International Trade. Blackwell Publishing, Malden, Oxford, UK, pp. 388–415.
United States International Trade Commission, 1989. The Effects of the Steel Voluntary Restraint Agreements on U.S. Steel Consuming Industries, Investigation 332-270. United States International Trade Commission, Washington, DC.
Veugelers, R., Vandenbussche, H., 1999. European anti-dumping policy and the profitability of national and international collusion. European Economic Review 43, 1–28.
Winkelmann, L., Winkelmann, R., 1998. Tariffs, quotas, and terms of trade: the case of New Zealand. Journal of International Economics 46, 313–332.