The Effect of Trade on Market Power —Evidence from Developing Economies

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Abstract

The rise of market power has sparked off increasing public debate over the past decade. Using a novel large-scale firm-level dataset, this paper examines the effect of trade liberalization on corporate market power in emerging and developing economies. We find that opening up to trade significantly reduces market power by promoting competition and improving resource allocation. The cumulative impact is estimated at 4 percent reduction in average markups over a 5-year horizon post each trade liberalization episode. We also draw on machine learning algorithms to account for nonlinearities in the relationship and show that trade reform is complementary to other structural reforms.

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I. INTRODUCTION

How does trade liberalization affect corporate market power? What is the size of impact? Is the effect heterogeneous across firms with different sizes and ownerships, and in different sectors? Do contemporary structural reforms play a role in propagating the effects of trade liberalization shock?

Answering these questions is not easy. On the one hand, international trade intensifies competition among firms, thereby alleviating the distortions associated with market power (Levinsohn, 1993; Harrison, 1994; Krishna and Mitra, 1998; Konings et al., 2001). Rogoff (2003) conjectures that globalization and deregulation have lowered profit margins, affecting the conduct of monetary policy and ultimately the extent of inflation. Tybout (2003) presents a review of the literature and concludes that markups generally fall with import competition. More recently, Chen et al. (2009) find that trade openness exerts a competitive effect in the short run, with prices and markups falling and productivity rising. Feenstra and Weinstein (2010) confirm a pro-competitive effect of trade based on large markup reductions in US market shares during 1992–2005. Edmond et al. (2015) illustrate through a quantitative model that trade can significantly reduce markup distortions if there is extensive misallocation and if opening to trade exposes hitherto dominant producers to greater competitive pressure.

On the other hand, as trade liberalization reduces tariffs of intermediate goods, the costs of final producers also fall, leading to increases in price-cost margins (Helpman and Krugman, 1989; Kasahara and Rodriguez, 2008; Goldberg et al., 2010; Brandt et al., 2017). De Loecker et al. (2016) study the effects of India's tariff reductions on both final goods and inputs and find that the net effect was an increase in markups. Fan et al. (2018) also show that input tariff reductions induce an incumbent importer/exporter to increase product markups, based on evidence from disaggregated Chinese firm-product data.

Using a large firm-level dataset covering 83 emerging and developing economies for the period 2000–2017, we evaluate the effects of international trade on market power based on various indicators of trade liberalization and markups. The results show that opening to international trade is associated with limiting domestic market power. The lower trade tariffs the lower the markups, and the same holds for non-tariff trade barriers. On average, the cumulative effects of each trade liberalization episode amount to four percent reductions in markups over a five-year horizon.

We further investigate the underlying mechanisms and confirm a pro-competitive effect: higher import penetration and import volumes lead to significant declines in markups, and the effect is more profound in the tradable sector, especially in the information technology sector. Therefore, intensified international competition and increased imports force domestic firms to behave more competitively and squeeze their profit margins. We also predict and verify a resource allocation effect, as firms with higher markups experience a larger reduction in markups after opening up to trade. In other words, trade liberalization reduces markup dispersion, which represents a potential source of resource misallocation (Fernandes, 2007; Lu and Yu, 2015). We also find that larger firm sizes and increased export volumes are associated with higher markups, attenuating the impact of tariff reductions on market power. What likely happens is that trade liberalization fosters economies of scale so that larger firms and firms which are able to compete in international markets can charge higher markups for their products (Lileeva and Trefler, 2010).

Finally, we explore complementarities between trade reforms and other structural reforms. To do this, we use the machine learning technique and zoom in on sub-Saharan Africa, where structural reform packages, in addition to lowering trade barriers, have been adopted in recent years to spur productivity and efficiency. Our results suggest that concurrent structural reform measures, especially those undertaken in the real sector, reinforce the effect of trade reforms in limiting market power. This finding has important policy implications, as future reform packages should pay attention to these complementarities to ensure their effects.

Our study makes at least three contributions to the existing literature. First, although this is by no means the first attempt at establishing the relationship between trade liberalization and market power, in contrast with previous studies that concentrate on advanced economies (Konings et al., 2001; Chen et al., 2009; IMF, 2019a) or focus on the case study of one particular developing economy (Levinsohn, 1993; Harrison, 1994; Amiti and Konings, 2007; De Loecker et al., 2016; Fan et al., 2018), we use a comprehensive, possibly the largest, firm-level dataset coverinfg 83 emerging and developing economies, and within this group of economies special attention is given to one of the largest but less studied regions: sub-Saharan Africa, where trade is key to development and sustained long-term economic growth.

Second, our analysis also contributes to an ongoing discussion of relating trade policy to welfare outcomes (Edmond et al., 2015; Arkolakis et al., 2019). We not only identify waves of trade reforms but also quantify the gains using local projection methods. The underlying mechanisms have also been examined empirically, confirming that the pro-competitive and resource allocation channels play key roles in linking tariffs and markups.

Third, this paper is innovative methodologically in employing machine learning techniques to distinguish the magnitude of the influence of different structural reforms on market power and identify the relative importance and interactions between these reforms. Macroeconomic environments in which trade reforms were undertaken could vary significantly and affect market power in a way that trade liberalization indicators alone cannot capture. We have to control for an array of macro-level factors including for instance the income level, output growth, and institutional environment (Christiansen et al., 2009; Spilimbergo et al., 2009; Bordon et al., 2016; Dabla-Norris et al., 2016; ElFayoumi et al., 2018; Kouamé and Tapsoba, 2018). The problem of overfitting then arises given a large number of controls. We account for this by using random forest—a machine learning algorithm that helps overcome overfitting and potential nonlinearities in the estimation and find that trade reform constitutes the most salient factor to curb the market power of firms.

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 outlines the empirical strategies. Section 4 presents the results of different empirical models. Section 5 reports robustness checks and Section 6 presents the conclusions.

II. DATA

The complete dataset used covers 83 emerging and developing economies over the period 2000–2017. Table 1 presents the list of economies in the sample—which is made mainly of developing economies, including 29 sub-Saharan countries and 8 emerging economies—and the

summary of data statistics. The sample covered was dictated by the availability of variables at the firm level.

2.1 Firm Markup

Theoretically defined as the price to marginal cost ratio (P/MC), the markup is generally constructed following De Loecker and Warzynski (DLW, 2012) in recent literature. Specifically, based on the firm's cost minimization problem (first-order condition), DLW show that a firm's markup (μ) can be expressed as:

$$\mu = \frac{P}{MC} = \frac{\beta_k}{\alpha_k} \quad (1)$$

where β_k is the output elasticity of any input k and α_k is the expenditure share of the same input in sales. To estimate output elasticities, we assume a common technology within a given industry and apply the control function approach of Olley and Pakes (1996) in the spirit of Hall (1986). For each firm i, the production function is represented by a Cobb-Douglas model as follows:

$$y_{it} = \beta v_{it} + ak_{it} + w_{it} + \varepsilon_{it} \quad (2)$$

where y_{it} is output, v_{it} is variable input, k_{it} is the stock of capital and w_{it} is productivity. For each industry in the NACE Rev. 2 classification (see Eurostat, 2008), a two-step approach to estimate β is followed. In the first step, output is estimated based on variable inputs and fixed capital (and their squares and interaction terms) and the residuals obtained from this estimation are interpreted as productivity. In the second step, productivity is assumed to follow a Markov process and is obtained using a GMM estimation of equation (2) assuming moment conditions consistent with intuitive assumptions about the timing of investment decisions (Cherif et al., 2020). Thus, for a firm i in industry j, taking the log of firm markup yields the following equation:

$$\ln ln\left(\mu_{ij}\right) = \ln ln\left(\beta_j\right) - ln(\alpha_i) \quad (3)$$

In an alternative approach, the markup is defined as the ratio of operating revenue (OR) to the cost of goods sold (COGS), which includes direct labor and materials (Diez et al., 2019).

To construct the two measures, firms' operating and financial information is obtained from the Orbis database (Orbis Bureau van Dijk; Moody's Analytics). Since data on quantities of output, capital and variable inputs are not available, the markup estimation uses as approximations to those variables the reported operating revenues, tangible and intangible fixed assets, and the cost of goods sold. The entire dataset covers about 400,000 firms.[1]

2.2 Trade Liberalization Indicator

The mean tariff score from the Economic Freedom of the World Index (Fraser Institute) based on information from the World Tariff Profiles (World Trade Organization) is used to estimate the degree of trade liberalization. On a scale from 0 to 10, a higher score indicates greater freedom to

[1] For more details see also Cherif et al (2020).

trade internationally. The non-tariff trade barriers score, constructed based on Global Competitiveness Report (World Economic Forum), is also used in the analysis to capture how much non-tariff barriers reduce the ability of imported goods to compete in the domestic market.

For robustness, we also use alternative indicators of trade liberalization, namely the overall tariff score, the unweighted mean tariff rate, and the weighted mean tariff rate. The *overall tariff score* is derived from a combination of the mean tariff rate, the standard deviation of tariff rates, and revenues from taxes on international trade. The formula used to calculate the *unweighted mean tariff rate* for each country is:

$$\frac{V_{max} - V_i}{V_{max} - V_{min}} * 10 \quad (4)$$

where V_i represents the country's mean tariff rate. The values for V_{min} and V_{max} are set at 0% and 50%, respectively, since all countries have mean tariff rates within this range, except for two or three extreme observations. This formula allocates a rating of 10 to countries that do not impose tariffs. As the mean tariff rate increases, countries are assigned lower ratings. The rating will decline toward 0 as the mean tariff rate approaches 50% (See Gwartney et al., 2019).

The empirical analysis also includes the *weighted mean tariff rate* indicator, which yields additional information on the variation in trade protection levels across different sectors and how they change over time. To construct this indicator, product-level tariff data is compiled and organized according to the 2-digit Harmonized System (HS) of the UNCTAD Trade Analysis Information System (TRAINS), and weighted according to bilateral trade volumes obtained from the UN Commodity Trade database (COMTRADE). Then, using the concordance principles between the HS codes and the 2-digit ISIC industry classification (Pierce and Schott, 2009) that map the product-level tariff data to different industries, we obtain the detailed time series for tariff rates at the industry level for each economy.

The advantage of using detailed tariff data is obvious: by creating a dynamic measure of exposure to foreign competition by industry for each economy, it allows us to identify the more nuanced effects of lowering import barriers, as there are multiple aspects in which trade policy measures differ across industries. However, careful judgment has to be exercised to determine which tariff rate is actually applied to a particular import, since different tariff rates including Most Favored Nation (MFN), Bound Tariff (BND), etc. may exist for the same commodity line. Besides, this indicator needs to be properly scaled for comparability with other variables such as non-tariff trade barriers. Thus, we choose to use the mean tariff score in our baseline regressions.

2.3 Trade Reforms

Based on the mean tariff score, a trade reform variable is constructed as a dummy variable that takes the value of one when an economy achieves a positive change in the score of at least one

standard deviation, and this change is not undone in the following years. In this way, we identify trade reforms that are not reversed to study the dynamic effects of trade reforms.[2]

2.4 Other Structural Reforms

Indicators of different structural reforms are needed to implement the random forest methodology, which will be used to disentangle the relative importance of different structural reforms in shaping competition in domestic markets. For most economies, trade liberalization usually takes place in conjunction with a package of structural reforms in fiscal, financial, and real sectors. All these reforms can potentially shape domestic competition, and therefore it is important to distinguish the relationship of domestic market power with changes in the degree of trade liberalization from relationships with other reforms as well as evaluating their complementarity.

The structural reform indicators are constructed using the IMF Monitoring of Fund Arrangements database (MONA), which contains conditionality and outcomes of all Fund supported programs since 2002. We focus on the structural benchmarks recorded in the MONA database, which are non-quantifiable reform measures that are critical to achieving program goals, assuming that they represent major structural reform episodes. We organize the structural benchmarks into three categories according to their impact on the fiscal, financial, and real sectors as shown in Table 2 (see also Kouamé and Tapsoba, 2018). To construct the indicators of structural reforms, we apply the centered-reduced normalization method as in OECD (2008). The normalized reform indices are defined as follows:

$$Reform_{kt} = \frac{N_{kt} - N_t}{\sigma_t} \tag{5}$$

where N_{kt} is the total number of successful structural reforms in economy k during the last review of the IMF board in year t; N_t is the average number of successful structural reforms for all economies in year t; and σ_t is its standard deviation. In this way we transform structural reform variables into a comparable unit.

2.5 Other Variables

Following the literature, the models to study markups control for several firm characteristics—obtained from Orbis— that could confound the relationship between trade liberalization and firms' market power. Firm size is measured by the (log of) firm assets, which may influence markups due to concentration in the sector. Firm (log) age is used as indicator of expertise accumulated and the leverage ratio as indicator of a firms' debt level. To test whether

[2] The construction of the reform indicator follows only a statistical criterion. An alternative approach, the "episodical" approach would determine periods of trade reform based on existing case studies in the literature and announcements or policymakers of major reform efforts. This is, it would not be based on a mechanical criterion but on a qualitative classification of those episodes according to how they are considered in the literature and news. Given the number of economies considered in this paper (83), we find it more appropriate to follow the statistical criteria described above.

ownership structure affects a firm's response to trade liberalization, we create a public dummy that equals 1 if a firm is controlled by government, and 0 otherwise. A listed dummy is also included and equals 1 for firms publicly traded on a stock exchange, and 0 otherwise. The categories of the 2-digit International Standard Industrial Classification of All Economic Activities (ISIC) is used to construct indicators to capture industry effects that do not change over time.

A rich set of country-level variables is also included to reflect the macroeconomic environment in which a firm operates, such as an indicator of institutional quality, an indicator of economic policy uncertainty, the level of per capita GDP in PPP terms, the contemporaneous growth of GDP, and the inflation rate. These macroeconomic variables are collected from the World Bank World Development Indicators (WDI), the Economic Policy Uncertainty Index (EUI), and the IMF World Economic Outlook (WEO) database. To examine the different effects of imports and exports on markups, we include the level of trade openness: measured by the sum of exports and imports relative to an economy's GDP, and split this into imports and exports as a percentage of GDP. The import penetration ratio, calculated as the ratio of imports over total domestic demand, is used to account for the degree of foreign competition.

3. EMPIRICAL STRATEGIES

In this section, we present the empirical strategies used to identify the association between trade liberalization and corporate market power: different versions of panel regressions; a local projection method to estimate the dynamic relationship between trade reforms and markups, and a random forest algorithm, which is a machine learning model to disentangle the effects of different factors and assess their substitutability or complementarity.

3.1 Panel Regressions

The first step to identify the relationship between trade liberalization and market power is based on the following panel regression set-up:

$$Markup_{i,j,k,t} = \beta_0 + \beta_1 Trade\ Liberalization\ Indicator_{k,t-1} + \beta_2 Markup_{i,j,k,t-1} + \beta_3 C \quad (6)$$

where $Markup$ is the natural log of the markup as defined above for firm i in industry j in economy k at time t. The trade liberalization indicator is the mean tariff score of economy k at time $t - 1$. This indicator is lagged in the estimations to avoid endogeneity issues. C and F are vectors of macroeconomic and firm characteristics; and γ, ρ, and φ are firm, year and industry-year fixed effects, respectively. The indicator of non-tariff trade barriers is also included with a lag among the variables in vector C. Firm-fixed effects control for unobservable firm-specific characteristics, in addition to year-fixed effects and industry-year fixed effects that capture trends in specific industries. The coefficient of interest is β_1 which is associated with the trade liberalization indicator. If β_1 is negative and significant, it means a higher mean tariff score—lower tariff barriers—is associated with significantly weaker market power as proxied by lower markups.

The baseline specification shown above does not allow to assess how the relationship of trade liberalization and domestic market power evolves over time. In order to do so, it is necessary to study how markups evolve after episodes of trade reform. As noted above, a trade reform in a given economy is defined as an episode in which the mean tariff score increases by at least one standard deviation compared with the history of the economy and this increase is not reversed afterwards. Thus, in equation (6) we substitute the mean tariff score with a reform dummy that takes the value of 1 in the year of the reform and allow for several lags of it.
In equation (7), H represents the time periods, from 0 to 5, for which the lagged relationship of trade reform and domestic market power are evaluated. Examining the significance and magnitude of the sum of the different a_h enables us to estimate the cumulative effect of trade reforms.

$$Markup_{i,j,k,t} = \beta_0 + \sum_{h \in H} \alpha_h Trade\ reform_{k,\,t-h} + \beta_2 Markup_{i,j,k,t-1} + \beta_3 C_{k,t-1} + \beta_4 F_{i,t-} \quad (7)$$

3.2 Impulse Response Function

An additional method to evaluate the dynamic effects of trade reforms is to analyze impulse responses using the local projection method (LPM) proposed by Jordá (2005), as is shown in equation (8). In this model, the left-hand side variable is the cumulative change in markup from period t to $t + h$, with t denoting the year and h going from 0 to 5. The set of variables in the right-hand side includes the trade reform indicator defined above as the impulse variable and a collection of control variables including the vectors of variables C and F defined above, plus one lag of them and the collection of fixed effects. The aim is to identify the projected effect of the trade reform indicator in the h years following the reform event. The construction of the trade reform indicator yields an identification strategy of unexpected policy changes as long as it is reasonable to assume that such large changes in the indicator are unrelated to other variables in the model.

$$\Delta(Markup_{i,j,k,t+h} - Markup_{i,j,k,t}) = \alpha + \beta_h Trade\ Reform\ Indicator_{k,\,t} + \sum_{p=0,1} \gamma_h C_{k,t-} \quad (8)$$

3.3 Random Forest Algorithm

The random forest algorithm is designed to better identify the effects of a factor when other factors are present. If a reduction in tariffs across industries and over time is correlated with other reforms or policy measures, such as financial liberalization, tax policy changes, or labor market reforms, it is possible that empirical methods could attribute the impact of other structural reforms to trade liberalization. To control for the concurrent reforms, it is useful to include various structural reform indices in our regressions. However, this may lead to overfitting when using a standard OLS regression as the only method, especially in the presence of several correlated variables. In addition, an OLS model requires a number of assumptions which may not necessarily apply in the case of structural reforms, for instance, the linearity of the effects estimated.
An alternative method to study the effects of different reforms consists in using the assumption-free decision-tree approach, which is computationally efficient and works well in

cases where there are important nonlinearities and interactions. A decision tree uses an if-else logic hierarchically depending on different "features" in order to predict a "response". The random forest algorithm modifies the decision-tree approach by imposing randomness in the selection of both the sample and features to be studied while minimizing the problem of overfitting and lack of generalization of a standard OLS regression. Rather than imposing an overly complex structure, the random forest methodology seeks to improve predictive power by generating numerous decision trees, splitting over a random subset of features —including the trade liberalization indicator, indicators of other reforms and the other variables in the baseline model— and taking an average of all the individual decision tree estimates. By averaging the results, the random forest estimation reduces the variance without increasing bias (see Breiman, 2001).

In our random forest model, the "response" occurs in the markup—the indicator of market power and there is a total of 12 "features" or predictors that may affect the response, including other structural reform indicators, country-level, industry-level, and firm-level characteristics. We first use a 50-50 split to partition the whole dataset into the training set and the test set. The hyper parameters to be determined are the number of regression trees in the forest and the number of features to be considered at each tree node. In general, the more the trees the better the results to be obtained. This parameter is preset at 500, but as it is shown later the error rate converges quickly at around 100 trees. Having tuned the number of trees, we find that the lowest error rate is obtained when the number of randomly selected features to be considered is 4.

For each tree node in the final ensemble of 500 trees, the optimal node-splitting feature selected from a set of 4 features that are picked randomly from the 12 features is used to split the data into two sub-nodes. The criterion for selecting the optimal node-splitting feature is to do it in such a way that the correlation between different trees decreases and thus the average response of multiple regression trees is expected to have lower variance than the individual regression trees. Each tree stops splitting when all the samples in the node have the same response or are locally constant. The predicted value of the response of the variable of interest is the mean prediction of all individual regression trees.

Figure 1 provides a simplified demonstration of the random forest structure. In this figure, we singled out one binary decision tree out of the 500 similar decision trees in the random forest. For this tree in particular, the 4 randomly chosen features for node splitting are trade reform, real sector reform, fiscal reform, and financial reform. The first tree node bifurcates based on the value of trade reform indicator. If the value does not exceed 0.02, then the next optimal node-splitting feature is the real sector reform indicator. For observations whose indicator for real sector reform is equal to or less than 0.78, this node stops splitting and we end up with an estimated markup equal to 0.452. In other words, for a given observation with 0.01 (≤ 0.02) in trade reform indicator and 0.75 (≤ 0.78) in real sector reform indicator, the fitted value of its markup would be 0.452. The depth of this tree node is 3, which is the number displayed in the bracket. We iterate this training and a total of 500 trees is generated. The predicted markup is thus the mean of markups at the terminal nodes.

To evaluate the importance of different structural reforms for markup prediction we focus on the ranking of variable importance score. The importance score measures by how much removing a variable decreases accuracy and vice versa. The idea is that if accuracy remains the same when one variable is randomly ommited, that variable cannot be considered important. Using this

method, the analysis of different reform periods in different countries may help to explain the wide variation of outcomes when countries implement seemingly similar packages of structural reforms, as it allows the identification of the relative importance of the different reforms. This method can provide useful information for the design of future reform packages.

4. RESULTS AND DISCUSSION

4.1 The Effects of Trade Liberalization on Markups

To evaluate the relationship of market power and trade tariffs, several models are estimated. In the preferred regression model, the level of markups (in logs) is a function of the following variables: at the firm level, the (log) of firm assets, the leverage ratio and the age of the firm (all lagged). For each economy, the indicators of barriers to trade are the mean tariff score and the indicator of non-tariff barriers; the (lagged) indicator of institutional quality captures the environment in which firms operate in terms of institutions and regulations; and to control for the level of development of the economy we include the level of per capita GDP in PPP terms and the growth of GDP and consumer prices. In addition, the models include fixed effects to control for invariant through time characteristics at the firm level and industry-year fixed effects.

Lower trade barriers are associated with more limited market power. The results across models suggest that the higher the mean tariff score (the lower the tariffs) the lower are markups, and the same holds for non-tariff barriers, which is consistent with the findings of Navas and Licandro (2011), Arkolakis et al. (2015), and Ahmed and Zaki (2016). More specifically, a one-unit improvement in the mean tariff score is associated with a statistically significant decrease in markups of 1.1 percent. This result is robust to the exclusion of several firm- and macroeconomic control variables, as shown in columns 1 and 2 of Table 3. The preferred model is shown in column 3. To examine the potential effects in the results of the inclusion of the lagged dependent variable in our panel data setting, we check the results omitting the lagged markup. Column 4 indicates that the omission of the lagged dependent variable does not induce a meaningful change in the estimate.

4.2 The Dynamic Effects of Trade Reforms

The evaluation of the effects of tariffs on domestic competition should consider that those effects do not occur only in one year and market adjustments take time to materialize (see Saggay et al., 2007, for the cumulative effects of trade reforms). To study the dynamic effects of a tariff reform on markups we estimate several versions of equation (7). Table 4 shows that after five years markups have been reduced in a statistically significant way by about 4.3 percent following a trade reform, and Figure 2 shows the cumulative decline over time.

An additional way to evaluate the dynamic effects of tariff reforms on markups is provided by the local projections method (LPM), which is used to project, based on previous data, the cumulative response of markups after a reform for different horizons. One regression as in equation (8) is estimated for each horizon: h=0,…, 5. The point estimate and standard error corresponding to the reform indicator from each regression are used to depict the projected response of markups in the

years following the reform. Figure 3 shows the estimates obtained and their significance. The cumulative response after five years is a 3.8 percent reduction in markups and is statistically significant at the 1 percent level. This result is similar to the estimated lagged effect of the reform obtained above.

4.3 The Underlying Mechanisms

Trade liberalization is widely believed to induce pro-competitive effects (Levinsohn, 1993; Harrison, 1994; Krishna and Mitra, 1998; Konings et al., 2001). In response to greater foreign competition and increased imports, firms' markups should decline as profit margins fall (Chen et al., 2009, Feenstra and Weinstein, 2010; Edmond et al., 2015). To shed light on the pro-competitive channel, a useful measure of foreign competition in domestic markets is import penetration, defined as the ratio of imports to total domestic demand—GDP minus exports plus imports (Altomonte and Baratieri, 2015). The results of the model estimated are shown in Table 5, column 1. A positive and significant coefficient suggests that firms in economies where there is more import penetration have a more marked decline in market power in response to tariff reductions, confirming the pro-competitive effects of trade.

The effect of international competition on market power can also be evaluated by looking into the relationship between the degree of integration to international trade and the level of markups. In the following models, the mean tariff score is substituted with indicators of trade flows. The results show that an increase in trade integration with the rest of the world is associated with a reduction in the average markup (Table 5, column 2), lending further evidence to the pro-competitive gains from trade.

Furthermore, to test for differentiated effects of increased exports and imports (Baier et al., 2019), an additional model is estimated in which the indicator of openness to trade is decomposed into the imports-to-GDP ratio and the exports-to-GDP ratio. We should expect these two indicators to have opposite signs as more openness to imports exerts direct competition to local firms and should help compress markups, while more opportunities to export help expand markets for domestic firms which can reach economies of scale and thus increase profitability. The estimates show the expected signs and are statistically significant (Table 5, column 3). It is also interesting to note that the magnitude of the negative estimate for imports is about 3 times the positive estimate of exports. A higher ratio of imports-to-GDP by 10 percentage points is associated with average markups that are on average 1.3 percent lower, while the same difference in the ratio of exports-to-GDP is associated with an increase in the average markup of 0.5 percent. These results indicate that opening domestic market to foreign competition helps to limit domestic market power but also allows export-oriented firms to increase profitability.

In addition to export volumes, a firm's size, ownership and initial market power also influence how it reacts to trade liberalization, as can be seen in Table 5, column 4. While private firms show a reduction in markups associated with trade liberalization, firms with majority ownership by the government tend to increase their markups. This could be because public firms tend to be more protected and are less susceptible to foreign competition, but the most likely reason we identify in the data is that public firms tend to operate in nontradable sectors: only about 24 percent of public firms are in tradable sectors. Thus, these firms may benefit from increased availability of cheaper inputs and at the same time not facing increased competition. Larger firm size also attenuates the relationship between trade liberalization and markup. Economies of scale

give larger firms an additional edge when confronted with foreign competitors, hence their markups decrease less than firms with smaller sizes. Foreign ownership does not play a siginificant role, as manifested by the insignificant estimate of the foreign dummy.

Meanwhile, firms with higher markups see a larger reduction in their markups associated to tariff changes, pointing to yet another channel through which free trade benefits the economy—the resource reallocation channel. Trade liberalization not only reduces markups in general, but also reduces markup dispersion, which constitutes an important source of resource misallocation (Lerner, 1934; Robinson, 1934; Kahn, 1935). According to Robinson (1934), first-order efficiency is achieved when markups are the same across products. In a world with markup variations, firms with higher markups employ resources at suboptimal levels, while those with lower markups produce more than optimal, resulting in efficiency losses (Opp et al., 2014; Lu and Yu, 2015). Thus, the markup adjustments brought about by trade liberalization can potentially help achieve a more efficient allocation of resources.

Tariff changes can have differentiated effects in specific sectors (Yang and Hwang, 1999). This hypothesis is explored in the models shown in Table 5, columns 5 and 6, where dummies corresponding to different sectors are interacted with the mean tariff score indicator. The markups in the tradable sector (which includes manufacturing, agricultural, fishing and mining products) are more strongly associated with changes in tariffs, with an additional decline associated with lower tariffs, and this additional decline comes from manufactured products. The reduction in the average markups in the manufacturing sector is larger than for economy-wide average markups. On top of the approximately 1 percent decline in the average markup, there is a statistically significant additional decrease in manufacturing markups of about 0.4 of a percentage point. Looking into the sector of information and communications technology (ICT) is of special interest, as it is typically fast growing and highly concentrated. For this sector, more opening to foreign competition, as reflected in an improvement in the mean tariff score, is associated with an additional reduction in average markups of about 2 percent, on top of the 0.9 percent average reduction observed across all sectors (column 5). This additional effect of liberalization on ICT markups could be associated to the relatively high capital intensity in this sector, as opening the imports of capital goods may contribute to more competition in this sector and the reduction of markups of incumbents. Thus, an effective tool to limit market power in the ICT sector is the opening to competition from abroad and of imports equipment and technology. However, concerning head-to-head competition from firms from abroad, it should be recognized that this will require careful design and implementation because this sector is heavily reliant on networks (in addition to large infrastructure and asset requirements) that creates a trend toward natural monopolies. In this case, adequate regulation may play an important role in addition to efforts to increase competition.

4.4 Concurrent Structural Reforms

To better understand the relationship between different structural reforms and market power, it is necessary to differentiate the magnitude of their effects. In this section, we zoom in on sub-Saharan Africa, which hosted most IMF programs and adopted various structural reforms during the sample period. The IMF MONA database allows us to construct the necessary indices

to track the different structural reforms and study their interplay. More specifically, using the random forest algorithm, we can analyze the relative importance of our main indicator of trade liberalization, the mean tariff score, and other indicators of structural reforms to explain changes in markups. In the regression trees used, every node implies a condition about how to split values in a single feature, where the condition is to provide sufficiently low variance with adequate predictive power. For each tree we can compute how much each feature contributes to decreasing the variance over the trees. The greater the contribution, the higher the variable importance score, and the more important the feature is in predicting the response.

Our random forest model achieves good performance with a relatively small number of tree nodes. The mean squared error (MSE) estimated stabilizes at 0.02 with only about 100 tree nodes (Figure 4) and is relatively similar to that calculated against the test data. The mean squared error shown in the figure is calculated as:

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2 \tag{9}$$

where n is the number of data points, y_i represents the observed values, and $\hat{y}_i$ stands for the predicted value of the response.

The indicator of interest to be obtained from the model is the ranking of variable importance. The scores of this indicator shown in Figure 5 reveal that trade liberalization (a decrease in tariff barriers that is reflected in an increase in the mean tariff score) has the largest impact on markups, followed by real sector reforms, fiscal reforms, and financial reforms. This result reiterates that trade liberalization is an effective tool to limit market power in domestic markets beyond other reforms.

We continue with a primer exploration of the complementarity and substitutability between different structural reforms by adding the indices constructed for structural reforms in other sectors (fiscal, financial and real sectors) based on the MONA database, and interactions between the trade reform indicator and other structural reform indices to the baseline model. According to the results in Table 6, other contemporaneous structural reforms do not seem to have brought about significant reductions in the markup of firms when carried out in isolation. In fact, financial reforms per se seem to help increase markups, most likely by decreasing financial intermediation costs. However, there are complementarities between trade liberalization and other reforms, as suggested by the negative coefficient associated to the interaction terms: for a given level of tariff rate, the higher the structural reform index the lower the markups. The complementarity is statistically significant for the interaction between trade reforms and real sector reforms, and while the interaction term also shows a negative sign for the financial sector reforms and the fiscal reforms, they are non-significant. This pattern is consistent with the results of Macedo and Martins (2008) who find a positive spillover of structural reforms on international competitiveness using data for the European Union.

4.5 The Endogeneity Concerns

Establishing the causal relationship between trade liberalization and market power is challenging, as it is subject to a well-known endogeneity problem: certain industries have more political power to lobby governments for protection (Grossman and Helpman, 1994; Amiti and Konings, 2007). We have already controlled for this potential bias by including firm and hence industry fixed effects in various model specifications. Additionally, from an individual firm's perspective, tariff reductions are exogenous. We also lag explanatory variables to reduce the bias on parameter estimates. To further assuage endogeneity concerns, we complement the fixed effects panel regressions with the study of trade liberalization events, or trade reforms. These events/reforms constitute "natural experiments" that produce exogenous variation in tariff rates. They often occur as part and parcel of more comprehensive reform packages and are liable to have differential effects across firms, which helps with our identification.

5. ROBUSTNESS CHECKS

In order to check the robustness of the results, alternative models are estimated using different definitions of trade liberalization and markup measures, as well as different control variables and additional factors. Tables 7 report the results.
In column 1, the markup variable used as dependent variable in the baseline model is substituted with a markup indicator directly calculated from the financial information of each firm: the (log) ratio of operating revenues to the cost of the goods sold. The result indicates an insensitivity of estimates to this alternative definition. In columns 2-4, we use the original markup series as the dependent variable but the indicator of trade liberalization is substituted alternatively with the overall tariff score (a higher indicator means less trade protection), the unweighted mean tariff rate (a higher indicator means greater trade protection), and the weighted mean tariff rate (a higher value means greater trade protection). The coefficient on the overall tariff score is negative and significant, whereas those on different tariff rates are positive, implying that greater trade protection is associated with stronger market power of firms in domestic markets. Finally, in columns 5 and 6, we include the return on assets at the firm level obtained from the Orbis database as an additional variable to control for firm productivity, a factor that could affect markups in the absence of changes in competition, and replace the inflation rate with the index for economic policy uncertainty within the set of macroeconomic control variables. In all cases, the baseline results and conclusions remain robust.

6. CONCLUSION

This paper analyzes the relationship between trade liberalization and domestic market power in emerging and developing economies and offers particular insights on sub-Saharan Africa. Using a new firm-level panel dataset covering about 400,000 firms from 2000 to 2017, we find that trade liberalization, which takes the form of lower trade barriers and increased trade integration, significantly reduces corporate market power and enhances competition. The results are robust across different model specifications. As the full effect of trade liberalization materializes over time, we use the local projection method to unravel the adjustment processes in firms' dynamics in response to changes in trade policies. The results suggest that a trade reform leads to significant declines in markups of about 4 percent over the 5-year period following the initial reform. These dynamic effects were also identified with panel regressions.

To explore the economic channels underlying such impact, we allow the trade liberalization indicator to interact with various firm, industry, and macroeconomic characteristics. Firms with larger sizes and public ownership tend to gain an advantage in the face of international competition, while firms in the tradable sector, particularly the information technology industry, are more sensitive to changes in tariffs. Furthermore, increased flows of imports tend to reduce markups while increased exports are associated with an increase in markups, with the magnitude of the relationship with imports being about 3 times that of exports. Therefore, increased trade integration not only helps to limit market power in domestic markets but also allows export-oriented firms to be more profitable thanks to the opportunity of expanding their markets and achieving economies of scale. Our results also suggest that markup adjustments can potentially reduce markup dispersion and achieve more efficient resource allocation.
Finally, we draw on the random forest algorithm to examine the relative importance of different structural reforms. The model suggests that trade liberalization has the largest impact on markups, followed by real sector reforms, fiscal reforms, and financial reforms. The substitutability and complementarity of reforms concerning their effects on domestic competition is also investigated. There are reinforcing effects between trade liberalization and other reforms and the complementarity is the strongest between trade and real sector reforms, followed by reforms in the financial and fiscal sectors.

Despite the rise of trade protectionism attitudes seen worldwide that threaten to roll back decades of liberalization efforts, this paper provides solid empirical evidence suggesting that trade liberalization is an effective policy option to limit the rise of market power and improve competition in emerging and developing economies.

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Tables

Table 1. Country Coverage

Sub-Saharan African countries	Other emerging and developing economies	
Angola	Albania	Lebanon
Benin	Algeria	Macedonia
Botswana	Armenia	Mexico
Burkina Faso	Azerbaijan	Mongolia
Cameroon	Bangladesh	Morocco
Cape Verde	Belarus	Myanmar
Cote d'Ivoire	Bhutan	Nepal
Ethiopia	Bolivia	Nicaragua
Gabon	Bosnia and Herzegovina	Papua New Guinea
Gambia	Brazil	Paraguay
Ghana	Bulgaria	Peru
Kenya	Cambodia	Moldova
Liberia	Colombia	Romania
Malawi	Costa Rica	Serbia
Mali	Dominican Republic	Sri Lanka
Mauritius	Ecuador	Sudan
Mozambique	Egypt	Taiwan
Namibia	El Salvador	Thailand
Nigeria	Georgia	Tunisia
Rwanda	Guatemala	Turkey
Senegal	Honduras	Uzbekistan
Seychelles	Indonesia	Venezuela
South Africa	Iraq	Vietnam
Swaziland	Iran	Yemen
Togo	Jamaica	
Uganda	Jordan	
Tanzania	Kazakhstan	
Zambia	Kosovo	
Zimbabwe	Kyrgyzstan	
	Laos	

Source: Orbis

Table 2. Construction of Structural Reform Indices

Sector	Definition
Fiscal	1. Revenue measures, excluding trade policy;

	2.	Revenue administration, including customs;
	3.	Expenditure measures, including arrears clearance;
	4.	Combined expenditure and revenue measures;
	5.	Debt management;
	6.	Expenditure auditing, accounting, and financial controls;
	7.	Fiscal transparency (publication, parliamentary oversight);
	8.	Budget preparation (e.g., submission or approval);
	9.	Inter-governmental relations;
	10.	PRSP development and implementation;
	11.	Anti-corruption legislation/policy;
	12.	Pensions reforms;
	13.	Other social sector reforms (e.g., social safety nets, health and education).
Financial	1.	Financial sector legal reforms, regulation, and supervision;
	2.	Restructuring and privatization of financial institutions;
	3.	Central bank operations and reforms;
	4.	Central bank auditing, transparency, and financial controls.
Real	1.	Private sector legal and regulatory environment reform (non-financial sector);
	2.	Natural resource and agricultural policies (excluding public enterprises and pricing)
	3.	Civil service and public employment reforms, and wages;
	4.	Public enterprise pricing and subsidies;
	5.	Privatization, public enterprise reform and restructuring, other than pricing;
	6.	Price controls and marketing restrictions;
	7.	Labor markets, excluding public sector employment.

Source: the IMF MONA database

Table 3: Markups and Trade Barriers

	Log of markup			
	(1)	(2)	(3)	(4)
Mean tariff score	-0.011***	-0.010***	-0.011***	-0.012***
	(0.001)	(0.001)	(0.001)	(0.001)
Lagged markup	0.207***	0.199***	0.199***	
	(0.003)	(0.004)	(0.004)	
Non-tariff trade barriers	-0.003***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	-0.008***	-0.005***	-0.006***	-0.007***
	(0.001)	(0.001)	(0.002)	(0.002)
Log of assets		-0.001	-0.001	0.003***
		(0.001)	(0.001)	(0.001)
Leverage		0.002***	0.002***	-0.000
		(0.001)	(0.001)	(0.000)
Firm age		0.006**	0.005*	0.006**
		(0.002)	(0.003)	(0.003)
Log of per capita GDP			0.041***	0.044**
			(0.016)	(0.019)
GDP growth			0.033**	0.029*
			(0.014)	(0.016)
Inflation			0.000**	0.000**
			(0.000)	(0.000)
Number of observations	1,349,023	1,052,486	1,052,473	1,111,840
Number of firms	434,833	366,124	366,120	393,097
R-squared	0.055	0.051	0.051	0.011
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: The Effects of Tariff Reform on Markups

	Log of markup					
	(1)	(2)	(3)	(4)	(5)	(6)
Reform	-0.013***	-0.016***	-0.017***	-0.013***	-0.014***	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Reform lag 1		0.007***	0.005***	0.004***	0.009***	0.011***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Reform lag 2			-0.005***	-0.006***	-0.006***	-0.003***
			(0.001)	(0.001)	(0.001)	(0.001)
Reform lag 3				-0.007***	-0.008***	-0.013***
				(0.001)	(0.001)	(0.001)
Reform lag 4					-0.014***	-0.018***
					(0.001)	(0.001)
Reform lag 5						-0.015***
						(0.001)
Lagged markup	0.181***	0.181***	0.181***	0.181***	0.181***	0.180***
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Non-tariff trade barriers	-0.010***	-0.008***	-0.010***	-0.011***	-0.010***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	-0.002	-0.001	-0.001	-0.012***	-0.016***	-0.033***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Log of assets	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Leverage	0.006**	0.005**	0.006**	0.006**	0.006**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Firm age	0.005***	0.006***	0.005***	0.005***	0.006***	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log of per capita GDP	-0.197***	-0.233***	-0.234***	-0.192***	-0.154***	-0.052**
	(0.021)	(0.022)	(0.022)	(0.024)	(0.023)	(0.025)
GDP growth	-0.134***	-0.084***	-0.096***	-0.113***	-0.079***	-0.035
	(0.021)	(0.022)	(0.022)	(0.023)	(0.023)	(0.023)
Inflation	-0.073***	-0.111***	-0.095***	-0.065***	-0.067***	0.078***
	(0.017)	(0.018)	(0.017)	(0.019)	(0.019)	(0.023)
Number of observations	872,563	872,563	872,563	872,563	872,563	872,563
Number of firms	316,259	316,259	316,259	316,259	316,259	316,259
R-squared	0.043	0.043	0.043	0.043	0.043	0.043
Sum effects		-0.009***	-0.017***	-0.022***	-0.033***	-0.043***
Prob > F		0.000	0.000	0.000	0.000	0.000
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the firm level. ***p<0.01, ** p<0.05, * p<0.1.

Table 5: The Underlying Mechanisms

	Log of markup					
	(1)	(2)	(3)	(4)	(5)	(6)
Import penetration	-0.129***					
	(0.010)					
Trade openness		-0.068***				
		(0.005)				
Import/GDP			-0.125***			
			(0.009)			
Export/GDP			0.046***			
			(0.014)			
Mean tariff score				-0.038***	-0.009***	-0.009***
				(0.003)	(0.001)	(0.001)
Mean tariff score * domestic				-0.002		
				(0.002)		
Mean tariff score * public				0.112***		
				(0.030)		
Mean tariff score * size				0.003***		
				(0.000)		
Mean tariff score * lagged markup				-0.042***		
				(0.005)		
Mean tariff score * tradable					-0.002**	
					(0.001)	
Mean tariff score * manufacturing						-0.004***
						(0.001)
Mean tariff score * other tradable						0.003
						(0.003)
Mean tariff score * ICT						-0.020***
						(0.007)
Number of observations	1,050,622	1,050,622	1,050,622	666,959	1,050,607	1,050,607
Number of firms	365,865	365,865	365,865	230,852	365,859	365,859
R-squared	0.050	0.050	0.050	0.066	0.048	0.048
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Complementary Effects of Structural Reforms

	Log of markup			
	(1)	(2)	(3)	(4)
Mean tariff rate	0.107**	0.141**	0.139**	0.160**
	(0.047)	(0.056)	(0.061)	(0.063)
Financial reform		0.003		
		(0.002)		
Fiscal reform			0.003	
			(0.003)	
Real sector reform				0.002
				(0.002)
Tariff rates * financial reform		-0.015		
		(0.013)		
Tariff rates * fiscal reform			-0.013	
			(0.016)	
Tariff rates * real sector reform				-0.017**
				(0.001)
Lagged markup	0.350***	0.349***	0.350***	0.349***
	(0.040)	(0.040)	(0.040)	(0.040)
Non-tariff trade barriers	-0.003	-0.003	-0.003	-0.004
	(0.006)	(0.006)	(0.006)	(0.006)
Institutional quality	-0.034*	-0.043**	-0.041**	-0.039*
	(0.019)	(0.021)	(0.021)	(0.020)
Log of assets	0.013	0.013	0.013	0.013
	(0.009)	(0.009)	(0.009)	(0.009)
Leverage	0.020	0.021	0.021	0.020
	(0.042)	(0.043)	(0.043)	(0.043)
Firm age	-0.054***	-0.054***	-0.054***	-0.054***
	(0.018)	(0.018)	(0.018)	(0.018)
Log of per capita GDP	0.159**	0.178**	0.167**	0.172**
	(0.076)	(0.080)	(0.078)	(0.076)
GDP growth	0.161	0.162	0.144	0.151
	(0.182)	(0.180)	(0.182)	(0.183)
Inflation	-0.151	-0.156	-0.145	-0.174
	(0.130)	(0.130)	(0.131)	(0.131)
Number of Observations	2,540	2,540	2,540	2,540
Number of firms	357	357	357	357
R-squared	0.173	0.175	0.174	0.175
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

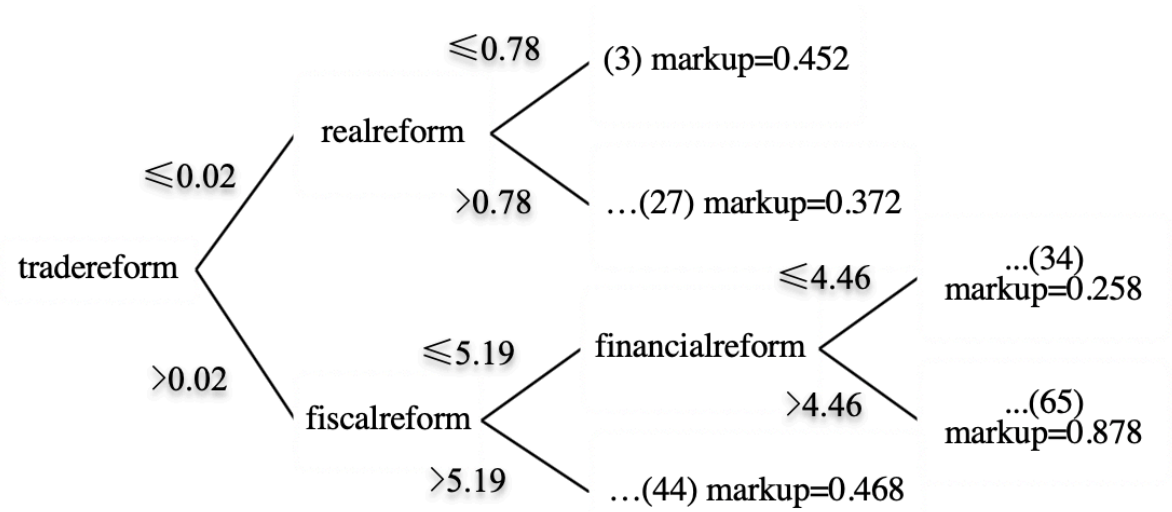
Table 7. Robustness Checks

	Log of markup					
	(1)	(2)	(3)	(4)	(5)	(6)
Mean tariff score	-0.005***				-0.010***	-0.011***
	(0.001)				(0.001)	(0.001)
Overall tariff score		-0.010***				
		(0.001)				
Unweighted mean tariff rate			0.208***			
			(0.015)			
Weighted mean tariff rate				0.025***		
				(0.007)		
Lagged markup	0.136***	0.197***	0.197***	0.226***	0.210***	0.197***
	(0.004)	(0.004)	(0.004)	(0.012)	(0.004)	(0.004)
Non-tariff trade barriers	-0.010***	-0.004***	-0.004***	0.002	-0.002***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Institutional quality	-0.007***	-0.006***	-0.005***	-0.015***	-0.003*	-0.007***
	(0.002)	(0.001)	(0.002)	(0.004)	(0.001)	(0.002)
Log of assets	-0.011***	-0.001**	-0.001**	-0.002	-0.002**	-0.001**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Leverage	0.003	0.002***	0.002***	-0.009*	0.003***	0.002***
	(0.002)	(0.001)	(0.001)	(0.005)	(0.001)	(0.001)
Firm age	0.007***	0.007***	0.006***	0.001	0.005***	0.006***
	(0.002)	(0.001)	(0.001)	(0.006)	(0.001)	(0.001)
Return on assets					-0.003	
					(0.002)	
Log of per capita GDP	-0.033**	0.002	-0.006	0.054	-0.001	-0.007
	(0.013)	(0.012)	(0.012)	(0.043)	(0.012)	(0.012)
GDP growth	-0.331***	-0.043***	-0.037***	0.070*	0.052***	-0.048***
	(0.016)	(0.013)	(0.013)	(0.036)	(0.013)	(0.013)
Inflation	0.059***	-0.006	0.017	-0.001***	0.014	
	(0.015)	(0.013)	(0.014)	(0.000)	(0.014)	
Economic policy uncertainty index						-0.007***
						(0.002)
Number of Observations	1,195,313	1,050,622	1,050,607	74,901	1,041,107	1,050,354
Number of firms	432,110	365,865	365,859	22,655	363,166	365,703
R-squared	0.029	0.050	0.050	0.069	0.055	0.050
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.

FIGURES

Figure 1. Random Forest Tree for Markup Prediction



Source: Author's calculations.

Figure 2: Cumulative Lagged Effects of Tariff Reform on Markups

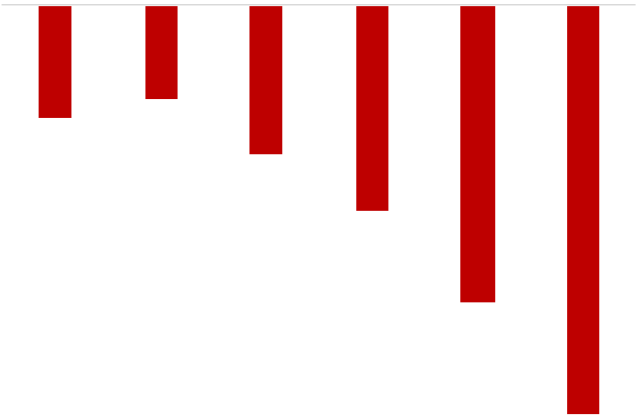


Figure 3: Cumulative Projected Effects of Tariff Reform on Markups

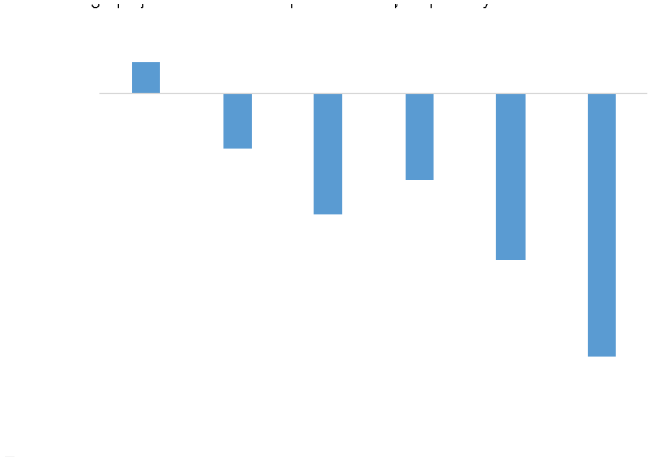


Figure 4. Mean Squared Error of Random Forest Model

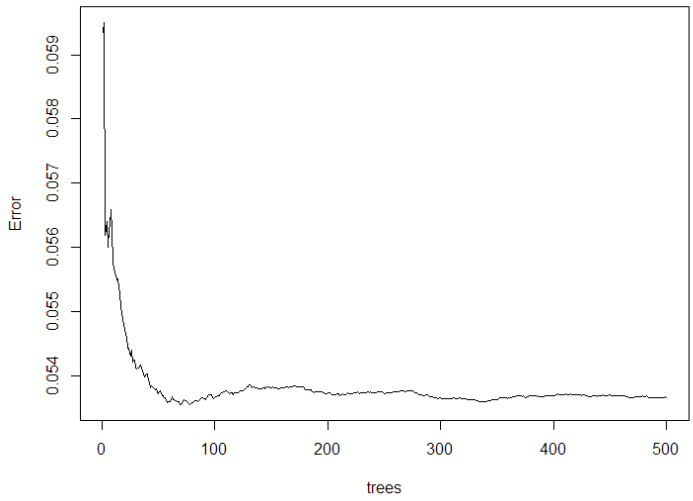


Figure 5. Variable Importance Plot of Random Forest Model