Competition with Multinational Firms: Theory and Evidence

Balázs Muraközy

Institute of Economics,

Centre for Economic and Regional Studies, Hungarian Academy of Sciences

Katheryn Niles Russ

University of California, Davis and NBER

25 January 2014

Preliminary and Incomplete

Abstract

Do multinational firms wield more market power than their domestic counterparts? Using Hungarian firm-level data between 1993 and 2007, we find that markups are 19 percent higher for foreign-owned firms than for domestically owned firms. Moreover, markups for domestically owned firms are significantly lower in industries where multinationals have a greater technological edge, suggesting that Ricardian differences in technology and endogenous markups constitute important dimensions for a models of foreign direct investment. We innovate within a canonical Ricardian model of endogenous markups and heterogeneous firms to provide analytical distributions of market shares and markups *when goods are imperfect substitutes* to provide structure for our empirical analysis. Our model explains about half of the multinational markup premium identified in the empirical analysis.

JEL codes: F12; F13; F15; F23

Keywords: multinational firm; heterogeneous firms; Bertrand competition

---

The authors thank Pol Antras, Zadia Feliciano, Robert Feenstra, and Peter Neary for helpful suggestions, as well as seminar participants at Oxford University and the 2013 WEAI Summer Meetings. Muraközy gratefully acknowledges financial support for this project from the Hungarian-American Enterprise Scholarship Fund and logistical support from UC Davis.

Email: murakozy@econ.core.hu

Email: knruss@ucdavis.edu

1 Introduction

Local production by multinational firms is twice as large as the volume of exports. Even in developed countries, multinational enterprises (MNEs) can account for large fractions of output and employment.[1] Because they are such large players in the global marketplace for both goods and labor, the size of their profits is a subject of lively and constant discussion among a range of policymakers and pundits. Exactly how big is the profit margin for the MNE? Although this depends to a large degree on the ability of the firm to charge high markups over marginal cost, little is known about the extent of this market power or how it affects their domestically owned competitors.

The purpose of this paper is to (1) provide a theoretical foundation to analyze the degree of market power held by MNEs versus firms native to the host country and (2) document the relationship between the markups of MNEs and their domestically owned competitors using firm-level data. To accomplish this, we innovate within a canonical Ricardian model of heterogeneous firms and strategic pricing when goods are *imperfect* substitutes to derive closed-form distributions of markups. We use these distributions as the foundation for a firm-level empirical analysis of MNEs' and native firms' pricing behavior. Using a large panel of data for Hungarian firms, we find that multinational firms do, indeed, have greater market power than domestically owned firms as measured by markups. Further, a technological edge in multinational firms is correlated with lower markups among their domestic competitors in the same industry.

The idea that MNE activity results in greater market power is not new, but is almost entirely unexplored in trade theory and empirics. Thus, our findings *are* quite new, especially in the context of manufacturing firms. Perhaps due to the scarcity of firm-level data for which sufficiently detailed data is available, there is little empirical evidence on the markups charged by MNEs relative to domestically owned firms in the existing literature. A notable exception is Sembenelli & Siotis (2008), the only paper of which we are aware that analyzes

[1] See Kleinert et al. (2012), for instance.

the markups charged by target firms before versus after a merger in the manufacturing sector. Using Spanish firm-level data, they find that following acquisition by a foreign firm, a domestic target increases its markup. The authors attribute this increase in markups to cost savings arising from improved efficiency after the merger. They characterize these cost savings as arising from the transfer of superior technology or managerial know-how.

We study markups of foreign-owned firms formed both by mergers and by greenfield FDI. We use the De Loecker & Warzynski (2012) method to decompose markups from physical total factor productivity (TFP). First, we demonstrate that MNEs charge higher markups than domestically owned firms– approximately 19 percent higher for greenfield establishments and 7.4 percent higher for affiliates established through cross-border mergers and acquisitions (M&As). We call this a foreign markup premium. A number of studies indicate that MNEs are, on average, technologically more advanced than their domestic rivals (Temouri et al. (2008), and Alfaro and Chen (2013) provide new evidence and useful surveys). Using our measures of physical TFP, we confirm this stylized fact. We observe variation in the degree of this technological edge across industries, finding that a greater TFP differential is associated with a higher foreign markup premium.

On the modelling front, path-breaking works by Hymer (1976), Knickerbocker (1973), Neary (2007), and Mràzòva & Neary (2013) conceptualize a world where the decision to invest overseas achieves higher markups or is principally driven by this motive in a strategic sense. Models of MNEs with heterogeneous firms (Helpman et al. (2004), Nocke & Yeaple (2007), Russ (2007), and Ramondo & Rappoport (2010)) characterize MNEs as being more efficient than the average domestically owned firm, giving them a higher market share as a result. However, they assume preferences that impose a constant markup, precluding an examination of market power. De Blas & Russ (2013*b*) (hereafter DBR) develop a model of multinational activity with heterogeneity in labor productivity, combined with strategic pricing, but assume that goods are perfect substitutes to do so, making market share either zero or one. So the literature can discuss market share in relation to MNEs when firms are

heterogeneous, but has not yet linked market share to their market power.[2]

The relationship between the foreign markup premium and TPF differentials that we observe in the data indicates that Ricardian technological differentials and endogenous markups are potentially important dimensions of models of foreign direct investment. In this paper, we draw on the intuition from the models above, but are able to derive, for the first time, a closed-form distribution of markups in the case where firms are heterogeneous and goods are imperfect substitutes. This gives us a conceptual foundation for the empirical analysis, which ultimately demonstrates that for foreign-owned firms in Hungary, having a technological advantage goes hand-in-hand with higher markups. In building the model underpinning the empirical analysis, we advance the current theory of heterogeneous firms and strategic pricing by presenting analytical distributions for market shares and markups, which in the studies above either had to be numerically simulated or were degenerate. Although dispersion in markups in our model is driven almost entirely by differences in technological efficiency, abstracting from issues such as quality or strategic takeovers, it explains about half of the markup premium enjoyed by foreign-owned firms in Hungary. In theory, the technological edge enjoyed by MNEs can arise from scale effects, from strategic takeovers of close rivals, or from better technology or management. We are agnostic as to what drives the efficiency, as long as it allows them to charge a lower price than competitors.

Hungary in our sample period provides a rare opportunity to study the differences between domestic and foreign-owned firms, and especially, to compare firms which were earlier acquired by foreigners with greenfield multinational affiliates. The majority of privatization took place in the beginning of the 1990s creating many foreign-owned firms by 1993-94, when our analysis starts. Liberalization and growth also led to the entry of many greenfield foreign

[2]Studies of trade with endogenous markups and heterogeneous firms have made this link for exporters. Recent theoretical models depict high markups and market shares as arising from a technological edge. For instance, Bernard et al. (2003), Melitz & Ottaviano (2008), Atkeson & Burstein (2008), Rodriguez-Lopez (2013), and Edmond, Midrigan, and Xu (2012), as well as Garetto (2012) and De Blas & Russ (2010), all present models where domestically owned firms' markups at home and when exporting are increasing in the efficiency of the firm relative to its competitors. The Ricardian models in this literature all must either be simulated or rely on the assumption that goods are perfect substitutes within an industry to get a distribution of markups.

affiliates in the second half of the 1990s, which we can follow during our period.

It is also useful to study a country in which the level of available technology is quite low relative to the countries where resident multinationals are headquartered. Although little evidence is available documenting MNE's market power in the manufacturing sector, far more analyses of markups exist related to foreign direct investment in the financial sector and it points to a similar relationship between technological superiority and higher markups. Available evidence suggests that (1) net interest margins, similar to the markup, increase after a cross-border merger, (2) foreign affiliates of banks with parents in rich countries charge higher markups than domestic banks in poor countries, and (3) foreign affiliates of banks with parents in less developed countries charge lower markups than domestic banks in rich countries. All of these stylized facts are consistent with the Ricardian approach to markups for nonfinancial exporting firms in DBR and banks in De Blas & Russ (2013*a*), so we use this modelling framework as a jumping-off point for our model and investigation of the manufacturing sector, finding ways around a number of technical challenges involved in deriving closed forms for the distribution of markups when goods are imperfect substitutes.[3]

The rest of the paper is organized as follows. In Section 2, we present a model of Bertrand competition, deriving an analytical distribution of market shares and markups. In Section 3 we describe a comprehensive dataset with the balance sheets of more than 2,500 manufacturing firms operating in Hungary in the years 1993-2003. This panel dataset allows us to calculate firm-year-specific markups. In Section 4, we analyze the data using the empirical model derived in Section 2 and present the results, concluding in Section 5 with a discussion of future questions and research.

[3]In this sense, the world of differentiated and variegated manufactured goods stands in contrast to the case of the banking sector, where it is perhaps more natural to think of loans with the same terms of repayment as perfect substitutes.

2 Theoretical Framework

Suppose that final goods producers in the home country assemble a number of composite goods within each sector j given a Cobb-Douglas technology so that total output of the final good Y is given by

$$Y = \prod_{j=1}^{J} Y_j^{\beta_j},$$

where $\beta_j > 0$ for all j, $\sum_j \beta_j = 1$, and each composite good j uses inputs from a continuum of industries with measure one. These intermediate inputs are assembled with a constant elasticity of substitution, $\eta > 1$, with Y_j given by

$$Y_j = \left(\int_{j-1}^{j} Y_{ij}^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}}.$$

The corresponding aggregate price index is then a composite of the sectoral price indices, with the sectoral price indices given by

$$P_j = \left(\int_{j-1}^{J} P_{ij}^{1-\eta} di \right)^{\frac{1}{1-\eta}}.$$

Within every single intermediate goods industry i in any sector j, there is a finite number of firms K_j, each of which produce their own variety. As in Atkeson & Burstein (2008), output within each intermediate goods industry i is governed by the elasticity of substitution between varieties $\rho > \eta$,

$$Y_{ij} = \left(\sum_{k=1}^{K_j} q_{ijk}^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}.$$

We assume that firms set prices to compete with each other in each sector, paying attention to how their own prices affect the industry price index in Bertrand competition, with the

industry price index P_{ij} given by

$$P_{ij} = \left(\sum_{k=1}^{K_j} P_{ijk}^{1-\rho} \right)^{\frac{1}{1-\rho}}.$$

Then, each supplier k of good j will charge a markup over marginal cost according to its market share s_{ijk},

$$M(S_{ijk}) = \frac{\varepsilon(S_{ijk})}{\varepsilon(S_{ijk}) - 1} C_{ijk},$$

where C_{ijk} represents the marginal cost of a domestically owned firm k within industry i in sector j, $\varepsilon(s_{ijk}) = \eta s_{ijk} + \rho(1 - s_{ijk})$ is the price elasticity of substitution facing each firm, and s_{ijk} is the firm's market share in the industry. Market share for each home firm k can be derived as a function of prices,[4]

$$S_{ijk} = \frac{P_{ijk}^{1-\rho}}{\sum_{k-1}^{R} P_{ijk}^{1-\rho}} \tag{1}$$

Note that the larger the firm is in terms of industry market share, the closer its markup tends toward the Dixit & Stiglitz (1977) markup, $\frac{\eta}{\eta-1}$, governed by the elasticity of substitution between industries, as in Atkeson & Burstein (2008) and later Amiti et al. (n.d.). As market share shrinks, a firm's markup also shrinks toward $\frac{\rho}{\rho-1}$, the lowerbound governed by the elasticity of substitution between varieties within an industry.

2.1 Market share

Within this context, there is a monotonic relationship between a firm's market share and its markup—ranking firms by market share is analogous to ranking them by their markups. Here, we present a way to obtain an analytical distribution for market share and thereby discern the behavior of the distribution of markups in the closed economy and in the presence

[4]See Kucheryavyy (2012) for a full discussion of pricing behavior within this preference structure when firms are heterogeneous under both Bertrand and Cournot competition.

of multinational producers. Although only a finite number of firms, K_j, compete in each industry, we have a continuum of industries. In each industry, there is a distribution of market shares. We will derive the distribution across industries of this within-industry distribution. Thus, our distribution of market shares across industries is a continuous random variable.

2.1.1 Autarky

We start with the observation that many studies in trade treat the distribution of firm size as resembling a power law and take this as our aim for a closed-economy distribution. To arrive at that point, we begin with the conjecture that intermediate goods prices are distributed inverse Weibull (Fréchet). So the probability that a firm drawn at random in the economy charges a price less than or equal to some value p in sector j is given by $F_j(p) = e^{-\frac{w}{T_j}p^{-\theta}}$, where T_j is a technology parameter, w the wage, and θ the dispersion parameter. The price charged by some firm k in industry i within the sector, P_{ijk}, is thus a random variable. Under the simplifying assumption that the dispersion parameter θ is equal to $\rho - 1$ we have a closed form for the distribution of prices,[5]

$$P_{ijk}^{1-\rho} \sim \text{Exponential}\left(T_j w^{-1}\right) \sim \text{Gamma}\left(T_j w^{-1}, 1\right). \tag{2}$$

The sum of the prices of all firms that compete with a firm k within an industry i in sector j is the distribution of the sum of $K_j - 1$ exponential distributions, which is simply a Gamma distribution, Gamma$((K_j - 1)T_j w^{-1}$,1). Thus, the market share of a randomly chosen home firm within some randomly chosen industry under autarky is distributed according to a Beta

[5]The following expression comes about because any exponential distribution is also a Weibull distribution, therefore the inverse of any exponential distribution is inverse Weibull (Fréchet). An exponential distribution is also a special case of a Gamma distribution. See Leemis & McQueston (2008), as well as their interactive website (http://www.math.wm.edu/ leemis/chart/UDR/UDR.html) for more detail about the relationships between the Weibull, Exponential, and Gamma distributions.

distribution,[6]

$$S_{ijk}^{\text{CLOSED}} = \frac{P_{ijk}^{1-\rho}}{\sum_{k=1}^{K} P_{ijk}^{1-\rho}} \sim \text{Beta}\left(T_j w^{-1}, (K-1)T_j w^{-1}\right). \tag{3}$$

The power law is a special case of the Beta distribution, when $(K_j - 1)T_j w^{-1} = 1$. The expected market share for a randomly chosen firm in a randomly chosen industry i within sector j is given by

$$E\left[S_{ijk}^{\text{CLOSED}}\right] = \frac{T_j w^{-1}}{T_j w^{-1} + (K_j - 1)T_j w^{-1}} = \frac{1}{K_j}, \tag{4}$$

which naturally is decreasing in the number of firms in each industry within the particular sector, K_j. Since the expected market share of any firm is decreasing in the number of rival firms, and the markup is monotonically increasing in market share, the average *markup* below will also be decreasing in the number of rivals.

2.1.2 Competing with multinationals

If multinationals are present, they may set prices based on a distribution of costs that reflects a greater average efficiency than is available among firms in the host country. Thus their prices are the realization of a random variable with a lower mean. We embody the superior technology accessible to multinationals operating in the host country within the parameter $T_j^* > T_j$. Their prices, weighted by the exponent $\rho - 1$, again reflect a Gamma distribution, but one with a different shape parameter than the home firms with which they compete. In this case, the market share of a particular firm is no longer distributed Beta, but rather Dirichlet (see Frigyik et al. (2010), p.13 for proof):

$$S_{ijk} = \frac{P_{ijk}^{1-\rho}}{\sum_{k=1}^{K_j} (P_{ijk})^{1-\rho} + \sum_{k^*=1}^{K_j^{MNE}} \left(P_{ijk^*}^{MNE}\right)^{1-\rho}} \sim \text{Dirichlet}\left(\gamma_{j1}, ..., \gamma_{jK_j}, \gamma_{j1}^*, ...\gamma_{jK_j^{MNE}}^*\right), \tag{5}$$

[6]See again Leemis & McQueston (2008) for the relationship between the Gamma and Beta distribution.

where $\gamma_{jk} = T_j w^{-1}$ for all $k \in \{1, ..K_j\}$ and $j \in \{1, ..., J\}$, and $\gamma^*_{jk} = T^*_j w^{-1}$ for all $k^* \in \{1, ..K^{MNE}_j\}$ and $j \in \{1, ...J\}$. In economic terms, the Dirichlet reflects the distribution of the industry-level distribution of market shares. So, given that a firm chosen at random from the population of all firms in the sector charges a price P_{ijk}, it gives us a distribution for the market share the firm might have within its own industry if K_j home firms and K^{MNE}_j foreign firms are competing within each industry in the sector.[7]

Though it is less fat-tailed than a power law distribution, the Dirichlet distribution can reflect very high concentration, depending on the underlying technological parameters. For our purposes, it is useful to shed light on the behavior of markups. The marginal distribution for market share– that is, the distribution of the market share for some domestically owned firm k in an industry i and sector j, is a Beta$(T_j w^{-1}, (K_j - 1)T_j w^{-1} + K^{MNE}_j T^*_j w^{-1})$ distribution.[8] Although we will relax these assumptions in our empirical investigation, we have assumed for simplicity that the technologies underlying the price-setting behavior by firms, as well as the number of domestic versus foreign competitors, is identical across industries within a particular sector j. Thus, from this point we drop the subscripts i and k, so our density for a randomly chosen firm's market share can be written as

$$f_{S_j}(s) = \frac{B(K_j T_j w^{-1} + K^{MNE}_j T^*_j w^{-1})}{B(T_j w^{-1}) B((K_j - 1)T_j w^{-1} + K^{MNE}_j T^*_j w^{-1})} s^{T_j w^{-1} - 1} (1-s)^{(K_j - 1)T_j w^{-1} + K^{MNE}_j T^*_j w^{-1} - 1}. \tag{6}$$

With this marginal distribution, calculating the expected market share of any domestically owned firm k in the home country is straightforward:

$$E[S_j] = \frac{T_j}{K_j T_j + K^{MNE}_j T^*_j} \tag{7}$$

Because our theory implies that markups are increasing in market share, we can use the

[7]The Dirichlet is also known as a multivariate Beta distribution, which is quite intuitive given that our closed economy distribution was Beta.

[8]See Frigyik et al. (2010) for a discussion of the marginal distribution from a Dirichlet distribution. More intuitively, the Dirichlet is also known as a multivariate Beta distribution, so its marginal distributions are naturally Beta (see Johnson & Kotz (1972), Chapter 40).

distribution to analyze the expected market share of multinational firms relative to domestic firms in the host country. We can see that greenfield FDI, by increasing K_j^{MNE}, would decrease the market share of the average domestically owned firm in the host country.[9] Similarly, one can see that the market share of the average multinational is increasing in any technological advantage that the parent country has relative to the host (home) country,

$$E\left[S_j^*\right] = \frac{T_j^*}{K_j T_j + K_j^{MNE} T_j^*} = \frac{T_j^*}{T_j} E[S_j]. \tag{8}$$

The expected market share of an individual foreign-owned firm $E\left[S_j^*\right]$ is clearly highest in host countries with low technology T_j relative to its own source country's technology T^*.[10]

2.2 Markups

In accordance with our earlier discussion, the markup $M_j(S_j)$ is given by

$$M_j = \frac{\eta S_j + \rho(1 - S_j)}{\eta S_j + \rho(1 - S_j) - 1}.$$

Being a function of the market share, we use the probability density for market share, $F_{S_j}(s)$ derived above, to derive the distribution of the markup for a home-owned firm,

$$F_{M_j}(\mu) = \Pr\left(M_j \leq \mu\right) = \Pr\left(s \leq \frac{\rho - [1 - \mu^{-1}]^{-1}}{\rho - \eta}\right) = 1 - \left[\frac{(\mu - 1)(\rho - \eta}{\mu - \eta(\mu - 1)}\right]^{-(\tilde{T}_j - T_j w^{-1})}, \tag{9}$$

[9] Takeovers would have a similar but possibly more muted effect, as it may leave the total number of firms intact, but increase the technology available to merged firms, leaving the remaining domestic firms at a disadvantage.

[10] See Appendix A for a derivation of the covariance between the market share of a home firm and the total market share of MNEs in a randomly chosen industry.

where $\tilde{T}_j$ is equal to the composite technology of all domestic and foreign competitors, $K_j T_j w^{-1} + K_j^{MNE} T_j^* w^{-1}$.[11] The probability that the markup is no greater than some value m is zero when m is equal to the lowerbound, $\frac{\rho}{\rho-1}$, one when it is equal to the upperbound $\frac{\eta}{\eta-1}$ and increases continuously in m in between, demonstrating the properties of a continuous probability measure for $0 < \eta < \rho$.

Using the same method to derive the cumulative probability distribution for foreign-owned firms in the home country, $F_{M_j^*}(\mu)$ yields

$$F_{M_j^*}(\mu) = \Pr\left(M_j^* \leq \mu\right) = \Pr\left(0 \leq s \leq \frac{\rho - [1-\mu^{-1}]^{-1}}{\rho - \eta}\right) = 1 - \left[\frac{(\mu-1)(\rho-\eta}{\mu - \eta(\mu-1)}\right]^{-(\tilde{T}_j - T_j^* w^{-1})}, \tag{10}$$

where here s represents the market share of a particular randomly chosen foreign firm. This allows us to show that markups for foreign-owned firms on average are higher than their home-owned competitors in the following proposition.

Proposition 1 *The expected markup of a foreign-owned firm is higher than that of home-owned firms in the same industry within a sector j whenever foreign-owned firms originate in a country with superior technology T_j^*.*

Proof. The cumulative probability $F_{M_j^*}(m)$ is less than $F_{M_j}(m)$ whenever $T_j^* > T_j$, the definition of first-order stochastic dominance. ■

Thus, foreign-owned firms on average will charge higher markups in industries within sectors where $T_j^* > T_j$

DBR suggest that multinationals formed by takeovers might be subject to special technological hangups that cause their underlying technology to be characterized by a geometric

[11] More explicitly, we compute the right-hand side using Equation 6 as

$$F_{M_j}(\mu) = \int_0^{\frac{\rho-[1-\mu^{-1}]^{-1}}{\rho-\eta}} f_{S_j}(s)ds,$$

average of their native and host country technologies. Let $T_j^{\text{M\&A}}$ be the technology underlying the production and pricing behavior of merged firms, with $T_j^{\text{M\&A}} = (T_j^*)^{1-h} T_j^h$, where h between zero and one represents the hangup involved in transferring the parent's technology to the acquired firm. Let $F_{M_j^{\text{M\&A}}}(m)$ be the cumulative distribution of markups for these merged firms, which takes the same form as $F_{M_j}(m)$, but substituting $T_j^{\text{M\&A}}$ for T_j^* in Equation 10. Then, the following corollary follows directly from Proposition 1.

Corollary 2 *The expected markup of foreign-owned firms established through mergers and acquisitions is less than or equal to that of foreign-owned firms established through greenfield firms whenever there is a technological hangup specific to the cross-border merger.*

Proof. $F_{M_j^{\text{M\&A}}}(m) > F_{M_j^*}(m)$ whenever $h > 0$. Thus, the distribution of markups for greenfield firms stochastically dominates that for cross-border acquisitions. ■ Thus, we predict that acquired foreign affiliates charge markups somewhere between the level of greenfield establishments and domestically owned firms.[12]

Not only do foreign firms charge higher markups than their home competitors, but they put pressure on home firms to reduce their own markups. It is straightforward to show that competing with rivals from a country with more advanced technological development results in less market power for native firms in the host market.

Proposition 3 *The expected markup of a home-owned firm is decreasing in the level of technology available to foreign-owned firms T^*.*

Proof. The derivative of the cumulative distribution for the markup, $F_{M_j}(m)$, with respect to T_j^* is positive. Thus, a distribution of home firm markups with a low T_j^* first-order stochastically dominates a distribution with a high T_j^*. ■ Proposition 3 implies that a technological edge among foreign-owned firms squeezes the profit margins of their domestically owned competitors.

[12]There may be richer competitive effects if the merger affects the number of domestic competitors in the industry, K_j. We abstract from this complexity, which is explored in more detail in DBR.

We call the ratio of the expected markup of a randomly chosen foreign firm k^* to the expected markup of a randomly chosen home firm in a particular sector j the *foreign markup premium*, $E[M_j^*] - E[M_j]$. Note that technological spillover or adoption, which would bring the level of home technologies closer to that of foreign-owned firms ($T_j \to T_j^*$), would work to close the gap between foreign and home markups.

Corollary 4 *The foreign markup premium is decreasing in the difference between foreign and home technologies.*

Proof. From Proposition 1, we have that $E[M^*] > E[M]$ for any foreign-owned firm k^* and home firm k whenever $T_j^* > T_j$. From Equations 9 and 10, we see that

$$\lim_{T_j \to T_j^*} E[M_j^*] - E[M_j] = 0.$$

■

While these results are quite intuitive and rooted in observations by Hymer (1976) and Caves (n.d.), they have not before been formalized mathematically in a framework with an arbitrary number of firms producing imperfect substitutes. Thus, our closed-form distributions are an advance in the theoretical analysis of multinational firms. We use them as a foundation for our empirical analysis.

3 Data and Empirical Approach

3.1 Data

We use a panel of firm-level dataset collected by the Hungarian Tax Authority, which contains information on Hungarian firms between 1986 and 2011, but in our main empirical analysis we restrict the sample to the period between 1995 and 2007 in order to focus on years after the early phases of transition as well as before the crisis beginning in 2008. The sample consists of all double-bookkeeping Hungarian enterprises. The data covers balance sheet and

income statements, including sales, exports, material costs, different accounting measures of capital, the number of employees and 4-digit industry identifier. The data was extensively cleaned, with a careful attention to harmonizing industry codes across years and filling in missing observations. Because markup estimates tend to be noisy for very small firms, we only include firms with at least 20 employees in our sample[13]. We restrict our attention to manufacturing firms.

A key variable in our investigation is the ownership status of each firm. The dataset includes information on the foreign ownership share in each year. Hence, we classify firms as foreign-owned when the foreign equity share is at least 10%.[14] We also distinguish between greenfield and acquired firms. First, we can observe whether a firm was acquired by foreigners after 1986, and we call such enterprises *acquired*. The second group is that of *greenfield* firms which were founded after 1986, and were foreign at the first year of existence. In our sample all firms were state-owned in 1986, hence we can classify each of them as domestic, privatized or greenfield.

The number of firms in each category is shown in Table 1. The overwhelming majority of privatization in manufacturing firms took place before 1995, hence the number of acquired firms did not change much in our sample period. On the other hand, many domestic and greenfield firms entered during the dynamic, export-led growth period between 1995 and 2001, followed by a small amount of attrition after 2001.

3.2 Estimating markups

We use the method proposed by De Loecker & Warzynski (2012) to estimate both TFP and markups from the balance sheet data. This method relies on the Ackerberg et al. (2006) procedure when estimating productivity and estimates markups from the relationship between the change in input usage and output growth. The intuition is that when competition is perfect, input shares relative to revenue should equal the elasticity of output with respect

[13]But including smaller firms does not affect the results importantly.
[14]Changing this threshold to 25 or 50% does not affect our results.

Year	Domestic	Acquired	Greenfield
1995	1560	416	335
1996	1746	445	406
1997	1900	488	472
1998	2151	513	533
1999	2278	524	540
2000	2412	519	606
2001	2631	534	670
2002	2682	521	712
2003	2622	459	705
2004	2545	425	693
2005	2522	396	706
2006	2443	367	697
2007	2390	356	688
Total	29882	5963	7763

Table 1: Sample size

to inputs, while with market power these two quantities deviate. This approach is based on conditions derived from cost minimization, and does not rely on any specific market structure. An important assumption of the method is that the firm is able to vary the input in question freely.

The DLW methodology enables one to estimate the markup in different ways, using different sets of information. One possibility is to use a value added production function and identify the markup from the behavior of labor. The second possibility is to estimate a gross output production function, which provides opportunity to estimate markups from both material and labor inputs. Because of this richer choice set provided by the gross output production function, we opt for using the second. The gross output production function for any firm k in industry i within sector j is:

$$\begin{aligned} revenue_{ijkt} = \beta_l l_{ijt} + \beta_\kappa \kappa_{ijkt} + \beta_m m_{ijkt} + \beta_{ll} l_{ijkt} t^2 + \beta_{\kappa\kappa} \kappa_{ijkt}^2 + \beta_{mm} m_{ijkt}^2 \\ + \beta_{l\kappa} l_{ijkt} \kappa_{ijkt} + \beta_{lm} l_{ijkt} m_{ijkt} + \beta_{\kappa m} \kappa_{ijkt} m_{ijkt} + \omega_{ijkt} + \epsilon_{ijkt} \end{aligned} \tag{11}$$

where k denotes firm, i the industry, and j the sector; t indexes years; $revenue_{ijkt}$ is gross output; l_{ijkt} is the number of employees, κ_{ijkt} is tangible assets and m_{ijkt} is material costs (all

in logs). The variable ω_{ijkt} is the productivity shock observable by the firm in the beginning of the period while ϵ_{ijkt} is an idiosyncratic productivity shock and/or measurement error. We estimate this translog production function by 2-digit industries.

The gross output function provides an opportunity to estimate markups both from the choice of materials and labor. One can argue that materials usage is more flexible than labor, hence it may be preferable to use materials to estimate cost efficiency and the corresponding markup. The formulae for the markups identified from labor (μ^l_{ijkt}) and material use (μ^m_{ijkt}), respectively, are:

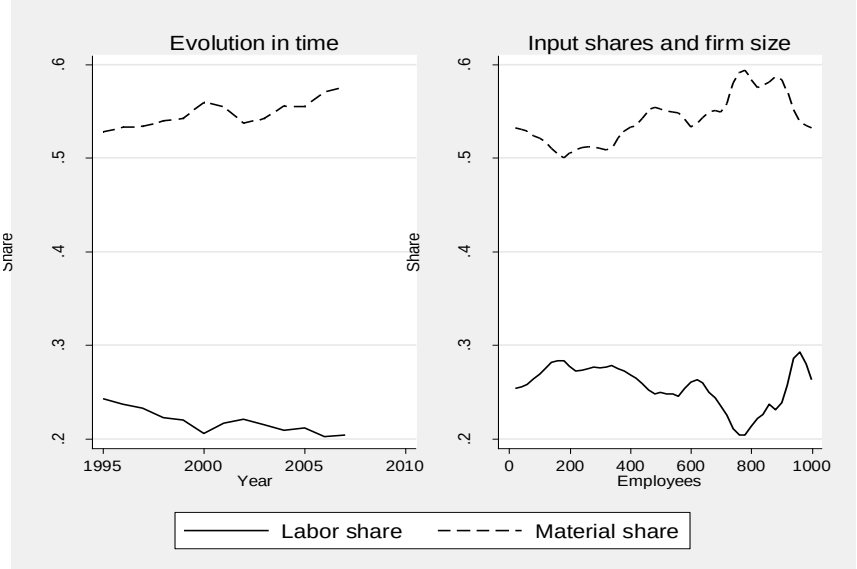
$$\mu^l_{ijkt} = \frac{\lambda^l_{ijkt}}{\alpha^l_{ijkt}} \text{ and } \mu^m_{ijkt} = \frac{\lambda^m_{ijkt}}{\alpha^m_{ijkt}}, \tag{12}$$

where λ^l_{ijkt} is the firm's output elasticity for labor, $\lambda^l_{ijkt} = \hat{\beta}_l + 2\hat{\beta}_{ll} l_{ijkt} + \hat{\beta}_{l\kappa}\kappa_{ijkt} + \hat{\beta}_{lm} m_{ijkt}$, while α^l_{ijkt} is the share of labor costs in revenue (corrected with the idiosyncratic shock).

The estimated output elasticities are quite similar for all firms within each industry, hence the bulk of identification comes from variation in input spending shares. This, however, may raise some questions, because there is likely be substitution between labor and materials, which is not necessarily taken into account in these measures. Furthermore, the degree of substitution between these inputs may be systematically related to important firm characteristics. First, larger firms may have access to more high quality inputs and are also more productive, hence they may buy more inputs arm-length rather than producing them themselves. Indeed the share of labor compensation in value added is decreasing in firm size, while the share of materials is increasing (see Figure 1, right pane). Second, multinational status may also be related to labor share not only because multinationals are larger, but also because they may be able to import high-quality inputs at a lower costs. Third, trade liberalization and economic growth may have improved the availability of inputs also led to an increase in material share over the time period of the sample (see Figure 1, left pane).

The systematic differences between firms in input shares introduces problems when esti-

Figure 1: Input shares



mating markups with Equation (12). In fact, empirically the two markups measures based on only labor vs. only materials are negatively correlated, showing that this substitution between labor and materials dominates the positive correlation coming from the underlying market power.

In order to increase the robustness of the estimates by reducing bias from this substitution, we calculate a geometric average of the two markups to report in our main regressions and also report results with different estimated markups as robustness checks. We call this average the composite markup measure for the firm:

$$\mu_{ijkt}^{COMP} = \sqrt{\frac{\lambda_{ijkt}^{m}\lambda_{ijkt}^{l}}{\alpha_{ijkt}^{m}\alpha_{ijkt}^{l}}} \tag{13}$$

Note that these methods provide one markup estimate for each firm-year combination. The estimated markup is a weighted average of the markups in each of the firm's markets, hence (without additional assumptions) we cannot estimate separately the markups for the domestic and foreign market.

3.3 Empirical predictions

We will test four predictions derived in section 2.2. For convinience, we summarize them here.

- Prediction 1: The expected markup of a foreign-owned firm is higher than that of home-owned firms in the same industry whenever foreign-owned firms originate in a country with superior technology T_j^*.
- Prediction 2: The expected markup of foreign-owned firms established through mergers and acquisitions is less than or equal to that of foreign-owned firms established through greenfield activity whenever there is a technological hangup specific to the cross-border merger.
- Prediction 3: The foreign markup premium is increasing in the difference between foreign and home technologies. Empirically we will classify industries into two sectors, one with larger and one with smaller foreign technological advantage, and test whether foreign markup premium is larger in the former one.
- Prediction 4: The expected markup of a home-owned firm is decreasing in the level of technology available to foreign-owned firms T_j^* relative to domestic firms T_j. We will test whether domestic firms have lower markups in the sector with higher foreign technological advantage.

3.4 Distributions of markups and productivity

The previously described procedure yields two additional key characteristics of firm performance in addition to markups. First, the procedure includes estimating the *revenue productivity* or TFP for each firm ($\omega_{ijkt} + \epsilon_{ijkt}$). Second, by dividing markups with (the exponential of) revenue productivity, one can estimate a measure for *unit cost.* In this subsection we provide some descriptive statistics about these variables.

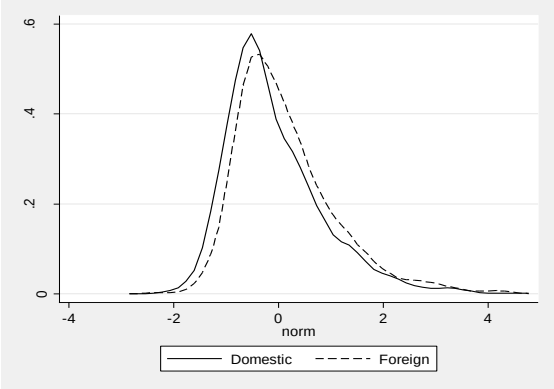
Figure 1 shows the distribution of these key variables for 2003. In order to make different industries comparable, we have standardized the variables with 4-digit industry average and standard deviation. An important property of these distributions is that - especially markups and revenue productivity - are strongly non-normal, featuring fat tails. This validates the emphasis of our theory on non-normal distributions of these variables. Even more importantly, in line with Prediction 1, the graphs show that the markup and revenue productivity distributions of foreign firms stochastically dominate that of domestic firms, while domestic firms stochastically dominate foreign ones in terms of unit costs. Foreign firms are more likely to be produce with lower costs and charge higher markups.

Figure 3 illustrates the evolution of different markups for the three groups of firms. The top graph shows the composite markup. Its level is around 1.5, and, in line with Proposition 2, it is highest for greenfield firms followed by privatized and domestic firms. Also, it shows some convergence because domestic markups increase to similar levels as their foreign counterparts. Finally, this proxy for markups does not feature any obvious trend.

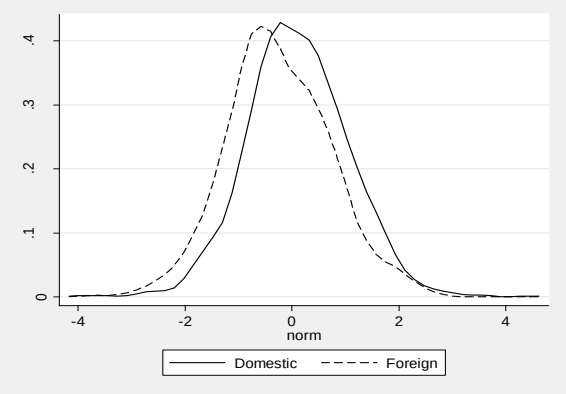
The remaining two graphs investigate the evolution of alternative markup estimates: the middle and the bottom graphs show markups identified only from the material and labor use, respectively. While the levels of the markups are different, importantly, the ranking of the three groups of firms is very similar with all three measures, and each measure show some degree of convergence between domestic and foreign firms. The markups identified from only one input, however, exhibit trends in line with the trend in input shares.

3.5 Empirical specification

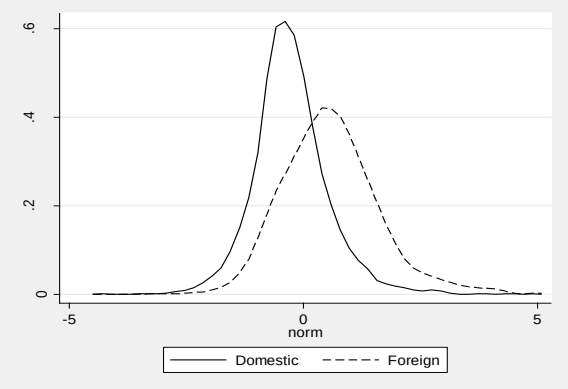
When testig Predictions 1 and 2, we model the estimated markup with variables describing ownership, productivity, competition and other important determinants of markups. The



(a) Markups

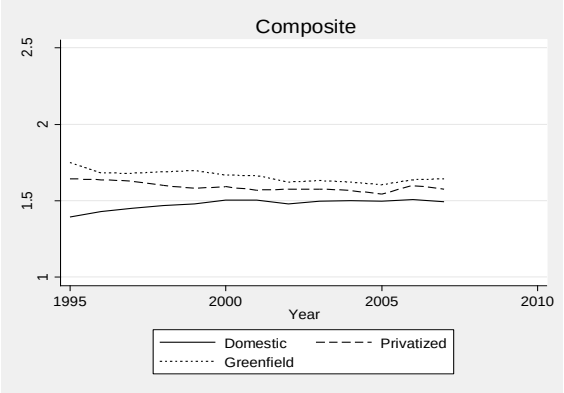


(b) Costs

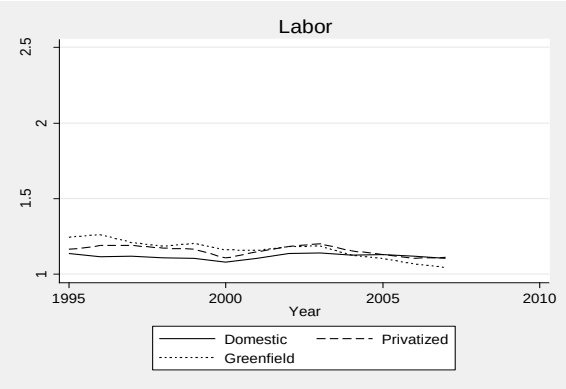


(c) TFP

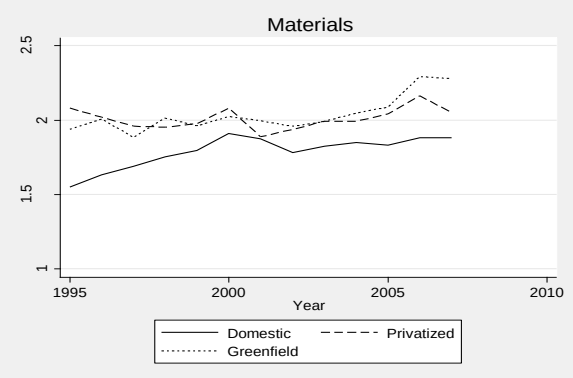
Figure 2: Distribution of markups, TFP and unit cost



(a) Composite



(b) Labor



(c) Materials

Figure 3: Evolution of different (translog) markup measures

estimated equation is:

$$\mu_{ijkt}^{COMP} = \sum_{f \in \{\text{M\&A, G}\}} \alpha_f * I_{ijkt}^f + \beta * X_{ijkt} + \delta_{ijt} + \zeta_{ijkt} \tag{14}$$

where k indexes firms and t years. The variable μ_{ijkt} is the estimated markup for the individual firm k operating within industry i in sector j, X_{ijkt} is the vector of explanatory variables, δ_{ijt} is (4-digit) industry-year fixed effects (in our theory, this fixed effect should be equal for all industries within any sector j, but we allow it to vary across industries within the sector) and ζ_{ijkt} is the idiosyncratic error. We cluster the standard errors by firm. Our most important explanatory variables are the set of dummies indicating foreign ownership, as discussed above.

This strategy identifies the differences in markups between foreign and domestic firms. In different specifications, we also attempt to understand how much of these differences are explained by productivity and market share, which are the main drivers of these differences in the theory.

To capture the technology of the firm, we use the revenue TFP estimate coming from the De Loecker & Warzynski (2012) process. Note that 'correcting' this with estimated markups to calculate physical productivity would lead to endogeneity, because any measurement error in the markup would show up in the physical productivity measure as well.

Market structure is captured with two variables. First, we calculate domestic market share of the firm in the 2-digit sector j by using Eurostat data on production, imports and exports. Second, as competition in export markets may differ from domestic competition, we also include variables representing the proportion of exports relative to the sales of the firm. Note that this variable may also control for product quality to the extent that firms producing higher quality goods are more likely to export.

Larger firms may also charge different markups even when controlling for market share. We add sales quintile dummies reflecting the relative size of the firm in its 2-digit sector.

Note that our identification of the key variables comes mainly from cross-sectional variation. This is in line with our theoretical approach, which is cross sectional and does not include entry and exit. A more practical problem with within-firm identification would be that due to the fact that there are very few changes in firm ownership, it is not possible to include firm fixed effects or use a matching estimator.

For testing Predictions 3 and 4, we classify each 4-digit industry into one of two sectors: one with a larger and one with a smaller technology gap. We proxy the technology gap by calculating the productivity gap between foreign affiliates and domestic firms. In particular the average markups for 4-digit industry i will be denoted by $\overline{tfp}_{ijt}$ and $\overline{tfp}^*_{ijt}$ for domestic and foreign firms, respectively. Following this, we calculate the *foreign differential in TFP*, the (log) difference between the average productivity of foreign and domestic firms ($\overline{tfp}^*_{ijt} - \overline{tfp}_{ijt}$). Finally, we classify 4-digit industries in each year to the sector a large technology gap when the foreign premium in TFP is larger than the median.

Empirically, being in the sector with large technology gap will be represented by a dummy variable, $highgap_{ijt}$.[15] Also, for tractability we do not distinguish between acquired and greenfield firms in this case. In particular, to test Prediction 3, we will estimate the following regression:

$$\mu^{COMP}_{ijkt} = \alpha * foreign_{ijkt} + \beta * highgap_{ijt} * foreign_{ijkt} + \delta_{ijt} + \zeta_{ijkt} \tag{15}$$

According to Prediction 3, a positive β would indicate the the markup premium of foreign firms is larger in industries with larger foreign advantage.

When estimating this equation, we use 4-digit industry-year fixed effects, and cluster standard errors at the firm level. An important issue is that Prediction 3 is about the distribution of market shares across industries within a sector, hence here one industry, rather than one firm, represents one observation. Hence we weight observations to generate

[15]Note that using a continuous variable representing the tfp gap between foreign- and domestically owned firms yields very similar results.

the same weight for each industry-year.[16]

In order to test Prediction 4 about the markups of domestic firms in sectors with different technology gaps, we add the $highgap_{ijt}$ dummy to regression (15). Note that this variable does not vary within industry-year, hence we can only add industry and year dummies rather than industry-year dummies. The estimated equation becomes:

$$\mu_{ijkt}^{COMP} = \alpha * foreign_{ijkt} + \beta * highgap_{ijt} * foreign_{ijkt} + \gamma * highgap_{ijt} + \iota_{ij} + \eta_t + \zeta_{ijkt} \quad (16)$$

Prediction 4 claims that $\gamma < 0$, showing that domestic firms are forced to decrease their markups in the sector with high technology gap.

4 Results

Table 2 presents averages of key variables. First, there are large differences in terms of employment. Acquired firms are much larger than domestic firms, and their average size is more or less constant during the sample period. The average size of domestic firms was declining before 2001, which is mainly explained by the large number of new entrants in this dynamic period. The size of greenfield firms is between the domestic and privatized firms on average. These firms were growing quickly, nearly catching up with acquired firms by the second half of the 2000s.

The trends in markups reflect the same trends as shown in the previous section.

Finally, in line with earlier results (Brown et al. (2006)), foreign firms are significantly more productive than domestic firms. In contrast to markups, however, we do not see convergence between the average TFP of domestic and foreign-owned firms.

[16]But running the regression at the industry level yields similar results

Year	Employees			Markup			TFP		
	Dom.	Acqu.	Greenf.	Dom.	Acqu.	Greenf.	Dom.	Acqu.	Greenf.
1995	157.21	315.36	172.48	1.43	1.53	1.80	3.04	3.11	3.37
1996	137.70	314.03	168.52	1.42	1.60	1.74	3.05	3.14	3.36
1997	129.94	306.95	185.75	1.42	1.53	1.72	3.04	3.13	3.36
1998	117.14	310.52	193.95	1.36	1.54	1.71	3.06	3.12	3.37
1999	107.82	312.80	213.40	1.39	1.55	1.77	3.05	3.17	3.35
2000	102.54	288.99	216.47	1.33	1.44	1.67	3.04	3.14	3.35
2001	95.18	272.52	235.71	1.37	1.51	1.69	3.12	3.20	3.38
2002	92.00	252.95	226.93	1.38	1.56	1.69	3.12	3.26	3.43
2003	86.09	253.51	228.47	1.40	1.51	1.67	3.10	3.22	3.41
2004	83.31	259.80	230.55	1.35	1.44	1.55	3.08	3.24	3.39
2005	81.13	293.86	236.98	1.37	1.41	1.50	3.07	3.24	3.39
2006	81.52	307.49	247.07	1.34	1.40	1.44	3.06	3.24	3.40
2007	78.43	302.11	252.80	1.32	1.44	1.45	3.08	3.25	3.41

Table 2: Descriptive statistics

4.1 Foreign markup premium

Table 3 presents our baseline results. Column (1) shows the differences across firms when only controlling for industry-year fixed effects. Greenfield firms have the highest markups: the point estimate suggests that their premium is close to 20% relative to domestic firms. Acquired firms' markups are between domestic and greenfield firms, with a 7.5% point premium.

In order to see how much of the differences in markups are explained by differences in productivity, we include TFP in column (2). We use a lagged value to handle simultaneity problems. TFP has a large and positive coefficient, reinforcing that productivity explains a large part of markup differences. The coefficients of the multinational variables fall by half, showing that measured TFP differences pick up about half of differences in markups.

In order to understand better the sources of markup premia of foreign firms, in column (3) we control for the market share and export status of firms. Market share, besides being another proxy for the efficiency of the firm, is also important in the more general but less tractable version of our model where goods within an industry are not perfect substitutes, or $\rho < \infty$. In this general version of the model, cost efficiencies across firms are fully captured by

their market share, so controlling for market share should reduce or eliminate any difference in the relative markups charged by foreign versus domestic firms. In line with our expectations both market share and export status are positively related to markups. Including these variables reduces the magnitude of the foreign status variables, but the greenfield dummy still remains significant.

Finally, in column (4) we also include firm size dummies. Again, as expected, firm size is positively associated with markups. Interestingly, with the inclusion of all these variables the foreign dummies become insignificant.

All in all, the results suggest that greenfield firms charge higher markups than acquired foreign firms, while domestic firms charge lower markups even than acquired foreign firms. This difference is mostly explained by the higher productivity, market share and size of foreign affiliates.

4.2 Robustness

Table 4 presents our baseline results with other markup measures as dependent variables. Columns (1) and (2) present results with the markup estimated only from material use, Columns (3) and (4) show results when the markup is identified from only the labor variable. In columns (5) and (6) we estimate a Cobb-Douglas production function instead of the translog in our baseline model and use the composite markup.

Importantly, the point estimates for the two multinational variables are very similar to the previous estimates: the premium for greenfield firms is between 20 and 30 percentage points while that of privatized firms is somewhat smaller. As before, differences in productivity explain a large deal from these raw differences.

Table 5 shows additional robustness checks. In columns (1) and (2) we split the sample into two subperiods: 1995-2000 and 2001-2007, respectively. This sample split suggests that foreign premia were significant in both periods; also, greenfield firms charged higher markups in both periods than acquired firms. The premia, however, are somewhat smaller in the later

DepVar: Firm Markup	(1)	(2)	(3)	(4)
Acquired	0.074***	0.037**	0.012	-0.022
	(0.015)	(0.015)	(0.015)	(0.015)
Greenfield	0.192***	0.109***	0.084***	0.025
	(0.019)	(0.020)	(0.020)	(0.021)
TFP (lagged)		0.493***	0.519***	0.540***
		(0.064)	(0.061)	(0.063)
Market share			0.458***	0.229***
			(0.047)	(0.049)
Exporter			0.040***	-0.028**
			(0.011)	(0.012)
Size: 2nd q.				0.096***
				(0.011)
Size: 3rd q.				0.181***
				(0.014)
Size: 4rd q.				0.235***
				(0.017)
Size: 5th q.				0.297***
				(0.022)
Observations	35,378	35,378	35,378	35,378
R-squared	0.315	0.357	0.372	0.395

Table 3: Baseline results

DepVar: Firm Markup	(1) material TL	(2) material TL	(3) labor TL	(4) labor TL	(5) composite CD	(6) composite CD
Acquired	0.051*	0.038	0.161***	0.034	0.080***	0.038**
	(0.030)	(0.030)	(0.048)	(0.046)	(0.015)	(0.015)
Greenfield	0.159***	0.130***	0.317***	0.038	0.203***	0.109***
	(0.039)	(0.040)	(0.058)	(0.058)	(0.019)	(0.019)
TFP (lagged)		0.171***		1.678***		0.551***
		(0.053)		(0.110)		(0.044)
Observations	35,389	35,389	34,435	34,435	35,378	35,378
R-squared	0.193	0.194	0.279	0.324	0.378	0.422

Table 4: Results wit different markup estimators

period, in line with the descriptive statistics. This robustness check provides evidence that the patterns we observe are not only a characteristic of a transition period: transition was over by 2000, hence these patterns should be more general.

An important question is whether our results are driven by composition effects or within-firm changes in markups. To focus on firms which were present in the sample for a long term, in column (3) we restrict the sample to firms with at least 10 observations. While the much smaller sample size leads to less precise estimates, the estimate for greenfield firms is similar to the previous results, while the acquired variable becomes insignificant.

In column (4) we exclude firms with less than 50 employees. One motivation for this is that balance sheet data by smaller firms may be less reliable, hence markup estimates for these firms may be more noisy. This restriction, however, does not change the qualitative results. [17]

Column (5) and (6) includes three variables which may be related both to foreign status and markups. First, foreign firms are likely to pay higher wages. To check the importance of wage differences, we calculate 5 quintile dummies reflecting the average wage paid by the firm relative to the industry average. Second, it is likely that effective tax rates are different between the foreign and domestic firms, because of tax concessions or different tax morale. To control for the differences in tax rates, we calculate the effective tax rate for each firm by dividing the corporate tax bill with before tax earnings. The estimates show that firms that pay higher wages have lower markups. Finally, we control for import penetration at the industry-year level to capture another dimension of competition.

Importantly, while the signs of these new variables are similar to our expectations, they do not affect the estimates of our main variables. The only exception is the inclusion of wages, which lead to a positive and significant greenfield premium even when we control for productivity and market size. Different strategies when paying wages may play an important role in the different markups of domestic and foreign firms.

[17] This is also true when we also restrict the productivity and markups estimation to this subsample of firms

DepVar: Firm Markup	(1) 1995-2000	(2) 2001-2007	(3) balanced	(4) emp>50	(5) tax wage	(6) imp. comp.
Acquired	0.093***	0.064***	0.015	0.078***	0.087***	0.010
	(0.017)	(0.017)	(0.057)	(0.018)	(0.015)	(0.015)
Greenfield	0.247***	0.165***	0.179**	0.210***	0.203***	0.067***
	(0.024)	(0.020)	(0.082)	(0.022)	(0.019)	(0.021)
Wage: 2nd q.					-0.130***	-0.168***
					(0.016)	(0.014)
Wage: 3rd q.					-0.175***	-0.255***
					(0.016)	(0.015)
Wage: 4rd q.					-0.167***	-0.304***
					(0.018)	(0.018)
Wage: 5th q.					-0.098***	-0.328***
					(0.020)	(0.021)
Tax rate					0.002	0.002**
					(0.002)	(0.001)
Imp share					0.019	0.118
					(0.157)	(0.175)
TFP (lagged)						0.565***
						(0.071)
Market share						0.282***
						(0.051)
Exporter						-0.018
						(0.011)
Size: 2nd q.						0.147***
						(0.012)
Size: 3rd q.						0.258***
						(0.015)
Size: 4rd q.						0.346***
						(0.019)
Size: 5th q.						0.450***
						(0.025)
Observations	12,677	22,701	2,776	19,592	32,513	32,513
R-squared	0.315	0.316	0.652	0.389	0.327	0.431

Table 5: Robustness checks

DepVar: Firm Markup	(1)	(2)	(3)	(4)
Foreign	0.086***	0.079***	0.072**	0.075**
	(0.027)	(0.027)	(0.034)	(0.029)
Foreign*highgap	0.105***	0.095***	0.062*	0.089**
	(0.030)	(0.030)	(0.037)	(0.035)
highgap		-0.056***		-0.052***
		(0.017)		(0.018)
TFP (lagged)			0.233	0.047
			(0.194)	(0.129)
industry-year FE	yes	no	yes	no
industry FE	no	yes	no	yes
year FE	no	yes	no	yes
Observations	35,378	35,378	35,378	35,378
R-squared	0.618	0.530	0.625	0.530

Table 6: The difference in markups across sectors

4.3 The role of the difference in technology

Predictions 3 and 4 are statements regarding the relationship between the markup premiun and the differences in technology gap across sectors.

Table 6 shows the results from this exercise. Columns (1) and (3) estimate equation (15) while in columns (2) and (4) we also add the sector dummy as in equation (16).

First, the results are much in line with Prediction 3. The foreign markup premium more than 8 percentage points in the sector with smaller technology gap, while it is around 20 percent in the sectors with larger technology difference. Also, controlling for firm-level TFP leads to only a small decrease in these coefficients.

Columns (2) and (4) also support Prediction 4. Domestic markups in the sector with large technology gap are more than 5 percentage points lower than in the sector with a smaller technology gap. This suggests that entry of more efficient foreign firms leads to a fall in domestic markups.

For a robustness check, in Table 7 we re-run the prevous regressions with the alternative markup measures, which exercise yields similar results.

DepVar: Firm Markup	(1) material TL	(2) material TL	(3) labor TL	(4) labor TL	(5) composite CD	(6) composite CD
Foreign	0.058*	0.065*	0.062	0.069	0.072***	0.069***
	(0.035)	(0.035)	(0.081)	(0.078)	(0.024)	(0.024)
Foreign*highgap	0.083*	0.056	0.338***	0.271***	0.142***	0.115***
	(0.047)	(0.045)	(0.093)	(0.086)	(0.029)	(0.027)
highgap		-0.067**		-0.177***		-0.074***
		(0.027)		(0.056)		(0.017)
industry-year FE	yes	no	yes	no	yes	no
industry FE	no	yes	no	yes	no	yes
year FE	no	yes	no	yes	no	yes
Observations	35,389	35,389	34,435	34,435	35,378	35,378
R-squared	0.396	0.299	0.494	0.386	0.598	0.513

Table 7: The difference in markups across sectors, different markup measures

5 Conclusion

We used a structural model of endogenous markups and heterogeneous firms to derive predictions about the differences in markups of domestic and foreign-owned firms. The model draws from intuition within Ricardian models of trade and FDI (specifically, Bernard et al. (2003), Atkeson & Burstein (2008), and De Blas & Russ (2013*b*)). We consider the Ricardian framework important to capture the relationships we observe in the data between markups and TFP differentials between foreign- and domestically owned firms in the existing literature and which we confirm in our own empirical analysis. We start from a distribution of prices rather than costs, which enables us to derive for the first time analytical distributions for market shares and markups in a setting with Bertrand competition when goods are imperfect substitutes. The distributions highlight the role of technology in governing market power.

This model motivates our analysis of Hungarian firm-level data. We show that markups for foreign-owned firms are higher in general that for domestic firms, especially greenfield firms. Perhaps most interestingly, a technological edge among foreign-owned firms in an industry is associated with lower markups for domestic competitors. Domestically owned firms competing in industries where foreign-owned firms have a TFP differential above the

median charge a markup approximately 5 percent lower, on average, than domestic firms in other industries. Markups for foreign-owned firms in industries with a TFP differential above the median charge a markup between 6 and 10 percent higher than foreign-owned firms in other industries.

In summary, the model and results (1) underscore the usefulness of considering FDI between countries with differing levels of technology within a Ricardian framework and (2) establish that the entry of foreign-owned firms can have nontrivial effects on the profit margins of domestic competitors in some markets with low levels of entry or technological development.

References

Ackerberg, D., Caves, K. & Frazer, G. (2006), 'Structural identification of production functions', *Unpublished* .

Amiti, M., Itskhoki, O. & K onings, J. (n.d.), 'Importers, exporters, and exchange rate disconnect', *(forthcoming) American Economic Review* .

Atkeson, A. & Burstein, A. (2008), 'Pricing-to-market, trade costs, and international relative prices', *American Economic Review* **98**(5), 1998–2031.

Bernard, A. B., Eaton, J., Jensen, J. B. & Kortum, S. (2003), 'Plants and productivity in international trade', *American Economic Review* **93**(4), 1268–1290.

Brown, J. D., Earle, J. S. & Telegdy, A. (2006), 'The productivity effects of privatization: Longitudinal estimates from hungary, romania, russia, and ukraine', *Journal of Political Economy* **114**(1), 61–99.

Caves, R. (n.d.), 'Multinational firms, competition, and productivity in host-country markets', *Economica* **41**(162), 176–193.

De Blas, B. & Russ, K. N. (2010), 'Understanding markups in the open economy', *(forthcoming) American Economic Journal–Macroeconomics* .

De Blas, B. & Russ, K. N. (2013*a*), 'All banks great, small, and global: Loan pricing and foreign competition', *International Review of Economics and Finance* **26**(1), 4 – 24.

De Blas, B. & Russ, K. N. (2013*b*), 'Hymer's multinationals', *Journal of Economic Behavior and Organization* **94**, 381–392.

De Loecker, J. & Warzynski, F. (2012), 'Markups and firm-level export status', *American Economic Review* **102**(6), 2437–71.

Dixit, A. K. & Stiglitz, J. E. (1977), 'Monopolistic competition and optimum product diversity', *The American Economic Review* **67**(3), pp. 297–308.

Frigyik, B. A., Kapila, A. & Gupta, M. R. (2010), 'Introduction to the dirichlet distribution and related processes', *UWEE Technical Report UMWEETR-2010* **0006**.

Garetto, S. (2012), 'Firms' heterogeneity and incomplete pass-through', *Manuscript, Boston University* .

Helpman, E., Melitz, M. J. & Yeaple, S. R. (2004), 'Export versus fdi with heterogeneous firms', *American Economic Review* **94**(1), 300–316.

Hymer, S. H. (1976), 'The international operations of national firms: A study of foreign direct investment.', *The MIT Press: Cambridge, MA* .

Johnson, N. L. & Kotz, S. (1972), *Distributions in Statistics*, John Wiley & Sons Inc., chapter Chapter 40: Multivariate Beta and Gamma Distributions, pp. 231–240.

Kleinert, J., Martin, J. & Toubal, F. (2012), 'The few leading the many: Foreign affiliates and business cycle comovement', *CEPR Discussion Paper* **9129**.

Kucheryavyy, K. (2012), 'Continuity of a model with a nested ces utility function and bertrand competition', *Economics Letters* **117**(2), 473–476.

Leemis, L. M. & McQueston, J. T. (2008), 'Univariate distribution relationships', *Economics Letters* **62**(1), 45–51.

Melitz, M. J. & Ottaviano, G. I. P. (2008), 'Market size, trade, and productivity', *The Review of Economic Studies* **75**(1), 295–316.

Mràzòva, M. & Neary, J. P. (2013), 'Selection effects with heterogeneous firms', *CEPR Discussion Paper* **9288**.

Neary, J. P. (2007), 'Cross-border mergers as instruments of comparative advantage', *The Review of Economic Studies* **74**(4), 1229–1257.

Nocke, V. & Yeaple, S. (2007), 'Cross-border mergers and acquisitions vs. greenfield foreign direct investment: The role of firm heterogeneity', *Journal of International Economics* **72**(2), 336 – 365.

Ramondo, N. & Rappoport, V. (2010), 'The role of multinational production in a risky environment', *Journal of International Economics* **81**(2), 240 – 252.

Rodriguez-Lopez, J. A. (2013), 'Prices and exchange rates: A theory of disconnect', *Review of Economic Studies* **78**(3), 1135 – 1177.

Russ, K. (2007), 'The endogeneity of the exchange rate as a determinant of fdi: A model of money, entry, and multinational firms', *Journal of International Economics* **71**(2), 344–372.

Sembenelli, A. & Siotis, G. (2008), 'Foreign direct investment and mark-up dynamics: Evidence from spanish firms', *Journal of International Economics* **76**(1), 107 – 115.

Temouri, Y., Driffield, N. L. & Higon, D. A. (2008), 'Analysis of productivity differences among foreign and domestic firms: Evidence from germany', *Review of World Economics* **144**(1), 32–54.

A covariance of domestically versus foreign-owned firms

Naturally, home and foreign market shares within industries negatively covary. The degree to which they covary depends on their relative technologies and number of domestic vs. foreign-owned firms. Given the Dirichlet distribution of market shares presented in Sub-Section 2.1.2, the expected market share of foreign-owned multinational firms across industries in the home country, s_j^*, is simply[18]

$$E\left[s_j^*\right] = \frac{K^{MNE}T^*w^{-1}}{KTw^{-1} + K^{MNE}T^*w^{-1}}, \tag{A.1}$$

What is more, using our Dirichlet distribution, we can derive the covariance of the market shares of any particular home firm with the total market share of foreign firms. This is also negative with a magnitude that depends on their relative technology,

$$Cov\left(s_{jk}, s_j^*\right) = \frac{-(Tw^{-1})K^{MNE}(T^*w^{-1})}{\left(KTw^{-1} + K^{MNE}T^*w^{-1}\right)^2\left(KTw^{-1} + K^{MNE}T^*w^{-1}\right) + 1} \tag{A.2}$$

The market shares and therefore markups of existing home firms covary negatively with the degree of foreign presence.

[18]See Frigyik et al. (2010) for a proof of this aggregation property of the Dirichlet distribution.