REALLOCATION, COMPETITION and PRODUCTIVITY: EVIDENCE FROM A FINANCIAL LIBERALIZATION EPISODE*

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Abstract

This paper studies the impact of capital market distortions on misallocation, competition and aggregate productivity. Focusing on distortions in the access to international borrowing across firms, I show that a reduction in these distortions leads to an increase in aggregate productivity through two different channels. First, previously credit-constrained firms respond to better financing terms by increasing their investments in technology, a reallocation effect. Second, non-constrained firms also expand their investments in technology due to increased competition, a pro-competitive effect. I provide evidence for these two channels using firm-level census data around the deregulation of international financial flows in Hungary.

Keywords: TFP, firm-level distortions, market competition, financial liberalization.

JEL: F36, F43, O47.

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1 Introduction

Large differences in income per capita across countries can partly be explained by firm-level distortions that lead to the misallocation of resources and lower aggregate productivity (Restuccia and Rogerson 2008; Hsieh and Klenow 2009; and Restuccia and Rogerson 2013). Capital market distortions are a source of misallocation, as they can prevent highly productive firms from operating at the optimal scale and investing in new technologies (Buera, Kaboski, and Shin 2011; Midrigan and Xu 2014; among others). This paper argues that the effect of capital market distortions on innovation decisions and aggregate productivity can be further amplified through its impact on product market competition. I assess this new mechanism by focusing on one critical distortion present in developing economies: firm-level asymmetries in the access to international capital markets.

In this paper, I show that removing distortions in the access to international borrowing leads to aggregate productivity growth through two different channels. First, it improves financing terms and encourages previously credit-constrained firms to invest in technology. Second, it tightens competition in product markets and leads unconstrained firms to do the same. I test these two channels using firm-level census data around the deregulation of international financial flows in Hungary. This reform revoked a legal provision that had imposed an asymmetry in the access to international borrowing across firms. This pre-reform asymmetry between discriminated firms -those that, by law, were previously shut out of international credit markets- and non-discriminated firms allows me to identify the effects of financial liberalization across firms. The empirical results support the view that financial liberalization episodes are associated with a more efficient allocation of resources across firms and deeper product market competition. Both channels lead firms to invest more in technology and result in an increase of aggregate productivity. This provides, for the first time, firm-level evidence for the micro-mechanisms underpinning the substantial increases in aggregate productivity that follow financial liberalization episodes, a robust correlation previously documented by a large cross-country literature.

To guide my empirical work, I use a simplified version of the step-by-step innovation model of Aghion and Howitt (2009) and add asymmetries in the access to capital markets across firms. I employ the model to show that capital market distortions affect the tightness of competition and the innovation efforts of all firms in the economy. In the model, capital controls restrict access to international borrowing for some firms, but let some other firms borrow internationally at better financing terms. This distortion undermines the competitive pressure of discriminated firms and weakens product market competition. Following the liberalization, discriminated firms innovate more because the decrease in the cost of funds raises their post-innovation profits. Non-discriminated firms also innovate more because increased competition raises their incremental profits from innovating and, hence, their innovation investments aiming at escaping competition.

I use the deregulation of international financial flows in Hungary in 2001 to test these two channels against the data. This deregulation removed existing barriers on international borrowing, and allowed all firms to access global financial markets. The liberalization in Hungary is an ideal case to study, as it was isolated from other major reforms that frequently overlap with financial

liberalization episodes. Furthermore, a key feature of the Hungarian case is that capital controls had distorted the access to international borrowing across firms, allowing me to identify the effect of the reform within Hungary. In particular, capital controls regulated asymmetrically international borrowing of domestic and foreign firms. Whilst domestic firms were not allowed to borrow from international capital markets and could only raise funds locally in a tight credit market, foreign firms were allowed to raise funds abroad and, hence, circumvent the low level of development of the Hungarian financial system. In 2001, all capital controls were lifted and, with them, the ban on domestic firms' international borrowing. In my empirical analysis, I exploit this asymmetry in the access to international funds between domestic and foreign firms prior to the liberalization as a first source of cross-sectional variation. I complement this analysis by adding a second source of cross-sectional variation -differential needs for external finance at the sector level- and testing whether the liberalization affected firms differentially as a function of their exposure to the reform.

The firm-level census data that I analyze (APEH) provides information on firms' balance sheets reported to tax authorities for the entire population of firms during the period 1992-2008. This extensive database allows me to build comprehensive measures of productivity, capital and use of external finance for all firms in the economy over a long panel, and constitutes an advance regarding previous studies in the financial liberalization literature focusing only on small samples of large and public-listed firms. In addition, I complement my analysis with the Business Environment and Enterprise Performance Surveys (BEEPS) of the World Bank and the European Bank for Reconstruction and Development, which report direct information on firms' R&D, innovation activities and financing terms.

I start by documenting that capital controls in Hungary were associated with a low level of financial development, and worse financing conditions and lower leverage for domestic firms, even after controlling for firm-observable characteristics. The liberalization of capital controls in 2001 led to large capital inflows and to an expansion of the local credit supply that substantially improved financing terms for these firms. By 2004, the difference in the interest rate paid by domestic and foreign firms fell five-fold, and the difference in the required collateral dropped by four-fold. This improvement in financing terms was associated with a substantial increase in domestic firms' leverage of 23% and a reallocation of credit towards these firms, which increased their proportion in total credits by seventeen percentage points.

I then turn to assess whether this reduction in capital market distortions is consistent with reallocation towards domestic firms. In line with this first channel, I demonstrate that, while prior to the financial openness domestic and foreign firms' growth rates were not statistically different, following the reform domestic firms started growing much faster. In particular, I find that domestic firms differentially increase their capital intensity (25%), labor productivity (5%), revenue TFP (RTFP) (3%), the probability of conducting R&D (9%) and innovation activities (12%).[1] In line with the easing of financing terms, this expansion is greater in sectors where domestic firms had

[1]It is important to differentiate revenue TFP from physical TFP. Unfortunately, I am only able to measure RTFP given the lack of information on firms' prices. See also Foster, Haltiwanger, and Syverson (2008).

greater needs for external finance. Notably, domestic firms differentially increase their leverage as a function of sector financial needs.

Additionally, my results point to the second, pro-competitive, channel proposed in this paper being operative in data. First, empirical results show that foreign firms' markups decreased by 3% relative to domestic firms. Second, this decline is larger in sectors with greater needs for external finance, which are sectors where competition was initially more distorted as domestic firms were more affected by the asymmetric access to capital markets. I find that foreign firms operating in one standard deviation more financially dependent sector see a 6% larger decline in their markups. Third, I also show that foreign firms increased their labor productivity and RTFP as a function of sector dependence on external finance. Importantly, they did not increase their capital intensity or leverage. This suggests that these firms were not initially credit constrained but were responding to tighter competition by domestic firms in those sectors. Finally, at the industry level, I find that the greater expansion of domestic firms led to reductions in industry concentration, and productivity and markup dispersions within sectors.

The expansion in firms' productivity resulted in an increase in aggregate productivity growth. Notably, the source of this growth completely reversed following the liberalization. Whilst prior to the reform aggregate productivity growth was explained by reallocation effects (83%), after the reform its growth was mainly driven by increases in within-firm productivity (82%). This upsurge in the within-firm component of aggregate productivity growth is consistent with the mechanism proposed in this paper, arguing for the pro-competitive forces of financial openness that lead all firms to increase their productivity.

The empirical identification of the effect of the financial openness is based on the asymmetric access to international borrowing between domestic and foreign firms prior to the reform. To test that the observed effects correspond to the liberalization and not something else, I conduct a full set of robustness tests. First, I estimate the effects by year and show that the differential response of domestic and foreign firms coincide with the timing of the reform as the estimated coefficients do not vary prior to the liberalization, while they monotonically change following it. Second, I demonstrate that results are not driven by sector specific trends as they are robust to considering four-digit sector pre-reform growth trends, and sector-year fixed effects. Third, the general context around the liberalization and its timing minimizes reverse causality concerns, as it was part of a general program of fourteen transition economies to join the European Union (EU). Importantly, by 2001, the deregulation of capital controls in Hungary was the only missing requirement to join the EU. The Hungarian economy was already deeply integrated with the EU and trade and FDI flows remained constant in the years prior to and following the liberalization.[2] Notably, I do not find any differential pattern of growth between exporter and non-exporter firms. Additionally, I also show that other transition economies undergoing the same process of joining the EU but with already deregulated financial accounts did not witness the same pattern of capital inflows observed in Hungary.

[2]Notice that Hungary did not join the Euro zone and, hence, did not have to fulfill any monetary or fiscal criteria.

This paper is related to the misallocation literature emphasizing how firm-level distortions can lower aggregate TFP (Restuccia and Rogerson 2008; Hsieh and Klenow 2009; Peters 2013; and Restuccia and Rogerson 2013). This paper is closest to Peters (2013) who shows that, in an environment where productivity is endogenous, these distortions can not only affect the static allocation of resources, but also firms' dynamic innovation incentives. My paper departs from Peters' (2013) in that I identify in data a particular policy distortion and study how this distortion affects competition and all firms' innovation incentives. Focusing on financial imperfections, Midrigan and Xu (2014) show that financial frictions can preclude credit-constrained firms from adopting more efficient technologies and, in turn, can reduce aggregate productivity.[3] While this paper supports this view, it shows that this channel is amplified by pro-competitive forces leading both constrained and unconstrained firms to adopt new technologies. This is complementary to the view developed by Edmond, Midrigan, and Xu (2014), who uncovered large pro-competitive effects from a removal of another distortion in a trade liberalization reform. The large increase in within-firm productivity that I find is consistent with Bollard, Klenow, and Sharma (2013), who also find that the majority of the increase in aggregate productivity in India following structural reforms is explained by the expansion of within-firm productivity.

This paper adds to a long literature on the relationship between international financial integration and economic growth. Recent cross-country studies find a robust impact of capital account openness on growth, mainly driven by the expansion of aggregate productivity (among them, Levine 2001; Bonfiglioli 2008; and Bekaert, Harvey, and Lundblad 2011).[4] Bonfiglioli (2008) finds a positive effect of financial integration on aggregate productivity over the five years following the reform. Examining longer horizons, Bekaert, Harvey, and Lundblad (2011) report that the effects are not temporary, but permanent. These cross-country studies, however, provide little evidence about the forces driving this expansion. This paper contributes to this literature by proposing -for the first time- a mechanism that can explain the increase in aggregate productivity and using firm-level census data around a particular financial liberalization episode to test it.[5]

The remainder of the paper is structured as follows. In Section 2, I present the model and derive qualitative predictions. Section 3 describes the liberalization of international financial flows in Hungary. Section 4 presents the data. In Section 5, I discuss the identification strategy and test the model's prediction at the firm, industry and aggregate levels. Section 6 concludes.

[3] In a similar vein, Kalemli-Ozcan and Sorensen (2012) show first evidence that misallocation at firm-level correlates with financial obstacles.

[4] In a similar vein, several studies show a positive relationship between financial deepening and productivity enhancements. In particular, they find that countries with more developed financial systems enjoy higher rates of productivity growth. See for example, King and Levine (1993b); King and Levine (1993a); Benhabib and Spiegel (2000); and Beck, Levine, and Loayza (2000).

[5] This paper is also related to the literature addressing whether market competition encourages innovation activities (Nickell 1996; Aghion, Bloom, Blundell, Griffith, and Howitt 2005; and Askenazy, Cahn, and Irac 2013). The effect on unconstrained firms is closely related to industry studies reporting that deeper competition lead incumbents to raise their investments aimed at increasing their productivity (Holmes and Schmitz 2010). This paper is also close to studies assessing whether financial constraints limit innovation activities (Mulkay, Hall, and Mairesse 2000; and Bond, Harhoff, and Reenen 2010), and particularly to Gorodnichenko and Schnitzer (2010) who find that in non-OECD countries, financial frictions restrain domestic firms from undertaking innovation activities.

2 Model

This section presents a small open economy model to study the impact of distortions in the access to international capital markets on competition and firms' investments in technology. I use a simplified version of the step-by-step innovation model of Aghion and Howitt (2009) to which I add asymmetries in the access to capital markets across firms. The model shares two common ingredients with the standard framework. First, firms innovate and this endogenously generates aggregate productivity growth. Second, market competition is endogenous and firms compete in a narrowly defined market. The key departure from the standard model is that I relax the assumption that firms have symmetric access to capital. This deviation reveals novel insights into how distortions in capital markets affect the tightness of market competition and, with it, the expected profits and the innovation efforts of *all* firms in the economy. In this way, distortions in capital markets broadly affect aggregate productivity growth.

2.1 Setup

Consider a one-period small open economy. The economy is capital-scarce, but capital can be imported from the rest of the world. Let labor be internationally immobile. There is a single final good that aggregates a continuum of intermediate industries.

Final Sector

The final good Y is produced by a representative firm in a perfectly competitive market and its price is taken as a numeraire. This firm combines the output y_j of a continuum of measure one of j intermediate industries operating with a Cobb-Douglas production function with a unitary elasticity of substitution for each industry. Formally, $Y = \exp\left(\int_0^1 \ln(y_{(j)})dj \right)$. Given this final good production, the optimal demand for each sector is $y_{(j)} = \frac{Y}{p_{(j)}}$.

Intermediate Sector

-*Timing.* Firms in the intermediate sector make two types of decisions. At the beginning of the period, they choose their optimal innovation efforts. Then, after learning the result of the innovation process, they decide whether to produce. Producing firms earn profits and pay the factors of production at the end of the period. As in the standard model, firms take the innovation efforts of other agents and factor prices as given. For expositional purposes, I consider a partial equilibrium setting.

-*Market Structure and Competition.* I let each intermediate industry be composed of two firms: home and foreign (H and F). These firms compete *à la Bertrand* for a homogeneous good. In

equilibrium, only the firm with the lowest marginal cost will be active. Given the unitary elasticity of the aggregate demand function, the most efficient firm resorts to limiting pricing to deter entry, and sets its price equal to the marginal cost of its competitor.

-*Capital Markets.* I consider a small economy open to international financial markets. I let this economy be small enough such that the international interest rate r^* is exogenous. The economy is capital-scarce and, thus, has to resort to foreign funds to finance its investments. However, the access to foreign funds is asymmetric between domestic and foreign firms. Foreign firms can access them directly, but domestic firms are subject to capital controls.[6] I model capital controls as Farhi and Werning (2012). In particular, I assume that domestic firms have to pay a tax $\tilde{\tau}$ for each unit of funds they raise abroad. This tax is then rebated as a lump sum to the domestic household. The interest rate paid by domestic firms is as follows:

$$(1+r) = (1+\tilde{\tau})\,(1+r^*),$$

where r and r^* are the interest rates paid by domestic and foreign firms, respectively. The interest rate that domestic firms pay is then higher than the interest rate that foreign firms pay. In this framework, capital openness can be seen as a decrease in the tax rate, $\tilde{\tau}$. Notice that if capital markets were fully integrated ($\tilde{\tau} = 0$), the domestic interest rate would equal the international rate, and firms would face equal access to external finance.

-*Production.* To produce, intermediate firms operate with a Cobb-Douglas function,

$$f(q,k,l) = q_{(j)}\, k_{(j)}^{\alpha} l_{(j)}^{1-\alpha},$$

where q, k, and l represent each firm's physical productivity, capital and labor, respectively, and $\alpha \in (0,1)$. Firms buy capital and hire labor to operate. For expositional simplicity, I assume that, at the beginning of the period, foreign firms are at least as productive as home firms, i.e. $q_{(F,j)} \geq q_{(H,j)}$.[7]

-*Technology and Innovation.* As in the standard model, firms' productivity evolves in a quality ladder. More precisely, productivity q is equal to λ^{n_s}, where $\lambda > 1$, and n_s denotes the technology level of a home or foreign firm, $s = \{H, F\}$. Research technology implies that innovation is stochastic and its probability depends on the firm's innovation efforts. In particular, in each inter-

[6]This assumption is made to match the asymmetries in the access to international borrowing prevailing in Hungary before the liberalization. I discuss this in detail in Section 3.

[7]This assumption is consistent with the empirical patterns observed in Hungary prior to the reform, as shown in Section 5. Furthermore, the greater productivity level of foreign firms is not a distinctive trait of the Hungarian economy. As reported by Gorodnichenko and Schnitzer (2010), in developing economies, foreign firms are more productive than domestic firms, both in terms of labor productivity and TFP.

mediate industry innovations can stem from two sources: either the F firm improves the existing technology by λ, or the H firm innovates aiming to obtain a new state-of-the-art technology $\lambda q_{(j)}$ and to become the industry leader.[8][9] Under this specification, the productivity difference between F and H firms in industry j can be expressed as a function of the technological gap between them: $\Delta_{(j)} \equiv n_{(F,j)} - n_{(H,j)}$. In addition, R&D technology is such that if a firm aims an innovation intensity of $x_{(s,j)}$, it has to hire Γ units of labor. This is,

$$\Gamma(x_{(F,j)}, \Delta_{(j)}) = \lambda^{-\Delta_{(j)}} \frac{1}{\phi} \frac{x_{(F,j)}^2}{2} \quad \text{and} \quad \Gamma(x_{(H,j)}) = \frac{1}{\phi} \frac{x_{(H,j)}^2}{2},$$

where ϕ denotes the efficiency of the innovation technology, and $x_{(F,j)}$ and $x_{(H,j)} \in (0,1)$ denote firms' innovation intensities. Note that the efficiency of innovation ϕ is equal for both F and H firms, but foreign firms might enjoy lower innovation costs. In particular, I follow Klette and Kortum (2004), Atkeson and Burstein (2010) and Peters (2013), and let larger firms have lower innovation costs.[10] As Peters (2013), I assume that the innovations of F firms are easier when their technological advantage is greater, i.e. $\lambda^{-\Delta}$. These functional forms simplify the exposition and are appealing because -as I show below- they ensure that firms' innovation efforts differ solely in their asymmetric access to international capital markets. In this way, they allow to isolate the mechanism proposed in this paper, namely how distortions in the access to capital markets affect firms' innovation efforts. Importantly, if the innovation costs of large firms were not scaled out, the model's predictions will hold true.[11]

2.2 Firm Behavior and Aggregate Productivity

In this section, I study how distortions in the access to international capital markets affect firms' innovation incentives and, hence, aggregate productivity growth.[12]

Firm Behavior

I solve intermediate firms' optimal strategies by backward induction. Recall that, at the beginning of the period, intermediate firms choose their innovation intensities and, after learning about the result of the innovation process, they decide whether to produce. Accordingly, I first compute firms' profits from producing activities at the end of the period, and then their optimal innovation efforts.

[8] Notice that, in a one-period Bertrand competition model, a laggard firm -in this case a home firm- would not invest to simply catchup with its rival's technology, as it would earn zero profits. See Grossman and Helpman (1991).

[9] As in the standard model, I assume that the probability of two firms innovating at the same time is negligible. Since these are two independent events, their joint probability is of second order and thus close to zero.

[10] This assumption accounts for the empirical finding that innovation intensity is constant for large firms (Crepon, Duguet, and Mairesse 1998; Klette and Kortum 2004), and guarantees that a firm's growth is independent of its size, i.e. Gibrat's Law.

[11] See Appendix C for further details.

[12] I only focus on the main mechanism and results of the model, but the interested reader can see Appendix C for a detailed derivation.

-Production Activities. Recall that, in this Bertrand competition game, only the firm with the lowest marginal cost in the industry will be active in equilibrium and capture the entire market. After minimizing its production costs and setting its price, the active firm's profit from production activities in industry j is given by $\Pi_{(j)} = (1-\xi_{(j)}^{-1})Y$, where $\xi_{(j)}$ denotes its markup. This expression shows that firm's profit is proportional to its markup, which is the only firm-specific variable in the expression. I turn thus to show how the active firm's markup is determined in equilibrium. The active firm's markup is equal to the industry price over its marginal cost; where the price is set equal to the marginal cost of the firm's closer competitor, and its marginal cost depends on the result of the innovation process. To be more precise, I present separately the cases where either the foreign firm or the home firm is active in equilibrium.

If the foreign firm is active in equilibrium, its markup will be either

$$\xi_{(F,j)}^{post} \equiv \frac{p_{(j)}}{MC_{(F,j)}^{post}} = \tau\, \lambda^{\Delta_{(j)}+1} \quad \text{or} \quad \xi_{(F,j)}^{pre} \equiv \frac{p_{(j)}}{MC_{(F,j)}^{pre}} = \tau\, \lambda^{\Delta_{(j)}}, \tag{1}$$

where *post* and *pre* denote the markup if it succeeds in improving its technology or maintains its initial productivity level. Equations (1) show that the foreign firm's markup has two components. First, as in the standard model, the leader's markup depends on the technology gap with its industry rival. This is, the higher the technology advantage, the higher the price that the leader is able to set and so is its markup. Second, the new feature of the model is that foreign firms' markups are augmented by τ, where $\tau \equiv (1+\tilde{\tau})^{\alpha} > 1$ and represents the difference in borrowing costs for domestic and foreign firms.[13] Equations (1) show that, besides any technological difference that foreign firms might have, their markups are augmented by the difference in the financing terms. In particular, capital controls raise the borrowing that domestic firms face and, thus, their marginal costs. The greater marginal costs of the local firms reduce their competitive pressure and allow foreign firms to set higher prices. As a result, foreign firms obtain higher markups and profits than in the symmetric borrowing cost case where both firms have similar access to capital markets.

If the home firm is active in equilibrium, its markups will be given by:

$$\xi_{(H,j)}^{post} \equiv \frac{p_{(j)}}{MC_{(H,j)}^{post}} = \frac{1}{\tau}\,\lambda. \tag{2}$$

Notice that if the H firm does not succeed in obtaining a frontier technology, it still has greater marginal costs than its foreign rival and remains out of the market. Similar to the foreign firm, equation (2) shows that the home firm's markup depends on the productivity gap and the asymmetric access to capital markets. However, unlike the F firm, home firm's markup is reduced by the differential access to capital markets, τ. The reason is that, even if the home firm manages

[13] Recall that in this small open economy, capital flows from abroad until the return of investment equals the interest rate. Segmented capital markets imply that, in equilibrium, the return of foreign firms' investments equalizes the exogenous international interest rate, and the return of domestic firms' investments equalizes the international interest rate plus the tax. Equations (1) take into account these relationships.

to get a frontier technology and the lowest marginal costs, it still faces higher borrowing costs than its foreign rival. These greater financing terms reduce its markups and profits relative to the symmetric borrowing cost economy, where firms have similar access to capital markets.

-Innovation Activities. At the beginning of the period, firms choose their optimal innovation efforts so as to maximize their expected profits net of the innovation costs. After maximizing their profits, their optimal innovation intensities, $x^o_{(F)}$ and $x^o_{(H)}$, become:

$$x^o_{(F)} = \frac{1}{\tau}\frac{\phi(1-\lambda^{-1})}{w}Y \qquad \text{and} \qquad x^o_{(H)} = \frac{\phi(1-\tau\,\lambda^{-1})}{w}Y. \tag{3}$$

As in the standard textbook model, firms' optimal innovation efforts depend on the market size (Y), the cost of the input used in the innovation process (w), the efficiency parameter (ϕ), and the increment in technology (λ).

The new feature of the model is that firms' optimal innovation efforts also depend on the distortion in the access to international capital markets. As equations (3) show both home and foreign firms' innovation intensities are reduced by the difference in the borrowing cost, τ. In this way, in narrowly defined markets where firms compete with one another, capital market distortions not only reduce the innovation efforts of the home-discriminated firms, but also the innovation efforts of the foreign-non-discriminated firms. Two forces lead to this result. As regards home firms, their innovation efforts are reduced because the higher borrowing costs they face undermine their post-innovation profits. Since the profits they would obtain from being an industry leader are reduced, home firms have less incentives to invest in technology. Concerning foreign firms, their innovation efforts are reduced because, when they are the industry leaders, they have greater monopolistic power to set prices. As discussed above, the difference in the borrowing costs reduces the competitive pressure of home firms and allows foreign firms to set higher prices and to get greater monopolistic rents. This is, the higher their monopolistic prices, the lower their production levels and, thus, their innovation incentives to reduce the production costs. As in the standard case, the benefit of innovation per unit of production decreases.[14]

Hence, distortions in capital markets reduce economy-wide innovation efforts through two channels. First, the cost disadvantage of home firms that lead them to undertake fewer innovation efforts. Second, the weak competitive pressure of home firms that discourage foreign firms from innovating.[15] [16]

[14] This argument stems from the innovation incentive scheme of a single monopolist. See Tirole (1988, chapter 10) for a more detailed description.

[15] Notice that, as in the standard model, I assume that workers are able to insure against the innovation risk. This could be implemented through a mutual fund consisting of a continuum of risk-neutral workers. After being paid, workers deposit their wage payments in the fund and divide them equally among themselves (see also Peters 2013).

[16] Another case that I do not explore in detail is to consider the scenario in which the tax rate is such that innovation activities are unprofitable for home firms, i.e. when $\tau > \lambda$. In this case, even if the home firm succeeds in obtaining a state-of-the-art technology, it still has greater marginal costs than its foreign rival and, hence, is unable to compete in the market. Therefore, home firms have no incentive to undertake innovation activities. Under this framework, only foreign firms are active in equilibrium, and home firms just restrict their price-setting behavior. Furthermore, the larger the difference in the access to international capital markets, the greater foreign firms' monopolistic rents

Aggregate Productivity Growth

In this model, aggregate productivity growth is defined as the growth between the start and the end of the period. As each innovation raises productivity by a factor of λ and home and foreign firms innovate at rates $x^o_{(H)}$ and $x^o_{(F)}$, aggregate productivity growth is given by,

$$g_q = \ln(\lambda)\ (x^o_{(F)} + x^o_{(H)}). \tag{4}$$

From equations (3) and (4), it is straightforward to see that aggregate productivity growth is lower in presence of distortions in the access to international capital markets across firms. As capital controls reduce economy-wide innovation efforts, aggregate productivity grows at a slower pace.

2.3 The Model's Qualitative Predictions

Through the lens of the model, the deregulation of international capital flows can be seen as a reduction in the tax rate. This implies a decrease in the difference in the borrowing costs for home and foreign firms, i.e. τ. To analyze the effect of the deregulation of international borrowing, I take derivatives with respect to τ of the main outcomes, and compare two states with high and low levels of capital controls. As I show below, by decreasing distortions in the access to capital markets, the deregulation of international financial flows promotes aggregate productivity growth through two forces. First, the fall in the cost of capital raises home firms' post-innovation rents and, hence, their incentives to invest in technology. Second, better financing terms increase the competitive pressure of home firms, which encourages their foreign rivals to invest more in technology as well. Through these two forces, financial openness spurs economy-wide innovation activities and aggregate productivity growth. Interestingly, since the reduction in distortions affects the innovation efforts of the home-discriminated firms the most, the technological gap with their foreign competitors decreases. Propositions 1-4 formally state these effects.[17]

Proposition 1: Firms' innovation intensities*. By reducing the distortion in the access to capital markets (decreases in τ), financial openness increases economy-wide innovation intensities. Notably, innovation intensities increase relatively more for home firms.*

and the lower their innovation intensities.

[17] See Appendix A for detailed proofs of the propositions. In these propositions, I assume an additional technical restriction on $\lambda < 2$. This assumption is common in the literature. The parameter λ is related to the frequency of the innovations: the closer λ is to one, more frequent are innovations. Stokey (1995) observes that if innovations occur every few years, a reasonable value for λ would be between 1.02-1.04; if they occur only a couple of times per century, λ would be between a range of 1.25-1.50. The estimations of Bloom, Schankerman, and Reenen (2012), from a panel data from US firms, imply a $\lambda \approx 1.06$. Acemoglu and Akcigit (2011) parameterize λ on 1.05.

Proof: In equilibrium, from equations in (3), $\frac{\partial x^o_{(F)}}{\partial \tau} < 0$ and $\frac{\partial x^o_{(H)}}{\partial \tau} < 0$. Furthermore, $|\frac{\partial x^o_{(F)}}{\partial \tau}| < |\frac{\partial x^o_{(H)}}{\partial \tau}|$.

Proposition 1 states that the reduction in the distortions in the access to international capital markets lead both home and foreign firms to increase their innovation efforts. Home firms invest more in technology because their post-innovation profits increase. In particular, the drop in the tax rate reduces their borrowing costs, which raises the profits they would obtain if they became the industry leader. Foreign firms invest more in technology because the benefit from innovating increases. This is, the drop in the tax rate narrows the gap between domestic and foreign firms' marginal costs and increases the competitive pressure of domestic firms. This deeper competition leads foreign firms to innovate more so as to remain in the market.[18][19] Importantly, as foreign firms are more productive than domestic firms, then -in the average sector- foreign firms are the incumbents and domestic firms are the entrants. Since the distortion affects more the innovation incentive of the entrant-domestic firm that has everything to win than what undermines the foreign market leader than replaces itself, the reduction in distortions increases the domestic firms' innovation efforts more.

Proposition 2: Foreign firms' markups*. A decrease in τ reduces foreign firms' markups.*

Proof: At the end of the period, a foreign firm's markup will be[20]

$$\begin{cases} \xi^{post}_{(F,\Delta)} & \text{with probability} \quad x^o_{(F)}, \\ 0 & \text{with probability} \quad x^o_{(H)}, \\ \xi^{pre}_{(F,\Delta)} & \text{with probability} \quad (1 - x^o_{(F)} - x^o_{(H)}). \end{cases} \tag{5}$$

Under the law of large numbers, a continuum of industries ensures that the foreign firm's markup

[18]This effect is similar to the *escape competition effect* introduced by Aghion, Bloom, Blundell, Griffith, and Howitt (2005). The difference with their model is that here the increase in competition stems from the reduction in the distortion in capital markets. In theirs, market competition is determined by the degree to which firms are able to collude.

[19]More formally, leader firms' innovation efforts depend on the difference between the post- and pre-innovation profits and both of them decrease with the fall in τ. Importantly, pre-innovation profits decrease more. The reason is that capital market distortions affect F firms' profits more, the narrower is their gap with their H competitors. To see this, compare how the introduction of capital controls would affect the F firm's profits in a sector where the F and H firms have the same productivity level with a sector where the F firm is already the industry leader. In the frictionless model, equally productive firms would split the market. Instead, in presence of capital controls, the F firm would enjoy lower marginal costs and capture the entire market. In this way, capital controls would allow the F firm to become a monopolist. In a sector where the F firm would be more productive than the H firm, the F firm would already capture the entire market with or without capital controls. Therefore, the gain from the capital controls is lower when the foreign firm is already technologically ahead of its local competitor.

[20]Notice from equations (1) and (2) that the technology gap Δ between F and H firms is the only industry-specific payoff-relevant variable. To simplify notation, I have dropped the dependence on industry j and denote each industry as a function of the productivity gap.

will be equal to its expected value. More precisely,

$$\xi^{e}_{(F,\Delta)} = \tau\,\lambda^{\Delta+1}x_{(F)} + \tau\,\lambda^{\Delta}(1 - x_{(F)} + x_{(H)}).$$

Then, $\frac{\partial \xi^{e}_{(F,\Delta)}}{\partial \tau} > 0$.

As equations (1) stated, in this model foreign firms' markups stem from two sources: the difference in the borrowing costs and the technological advantage with their local competitors. Both of these drop following the reduction of capital controls. First, less distorted capital markets increases the competitive pressure of domestic firms, which undermines foreign firms' ability to set higher prices and to obtain higher markups. Second, lower borrowing costs encourage home firms to undertake greater innovation efforts, which reduce the technology gap with their foreign rivals. In this way, the reduction in distortion in capital markets lead to decreases in foreign firms' markups.

Proposition 3: Change in the productivity gap between home and foreign firms*. Reductions in τ lead to decreases in the productivity gap between home and foreign firms. In particular, this reduction is greater in sectors where foreign firms were technologically far ahead of their local competitors.*

Proof: $\frac{\partial \Delta^{e}}{\partial \tau} > 0$ and $\frac{\partial \Delta^{e}}{\partial \tau \partial \Delta} > 0$, where Δ^{e} is the expected technology gap in the industry and is equal to $\Delta + x^{o}_{(F)} - (1+\Delta)x^{o}_{(H)}$.

As stated in proposition 1, home firms' innovation efforts increase more after the reform. Their greater innovation efforts imply that they are more likely to overtake their foreign rivals reducing the technology gap with them. In addition, as home firms are more likely to entry, the productivity gap drops more in sectors where the initial gap was the largest.

Proposition 4: Aggregate productivity growth. *Declines in τ increase aggregate productivity growth.*

Proof: From equations (3) and (4), $\frac{\partial g_q}{\partial \tau} < 0$.

The intuition for proposition 4 is simple: as both home and foreign firms increase their innovation efforts, aggregate productivity growth increases.

The new result of the model is that, by removing asymmetries in the access to international capital markets, financial openness promotes aggregate productivity growth through two different

channels. First, the reduction of the borrowing costs raises home firms' post-innovation rents, encouraging them to innovate more. Second, the fall in distortions in the access to capital markets tightens competition and lead their foreign rivals to do the same. In this way, reductions in capital market distortions promote economy-wide innovation efforts leading all firms to innovate more.[21]

3 The Deregulation of International Financial Flows in Hungary

The model above has shown that, by reducing capital market distortions, financial openness reallocates resources towards previously discriminated firms and unchains pro-competitive forces that leads all firms to increase their investments in technology. In the next sections, I use a particular deregulation episode -the liberalization of international financial flows in Hungary in 2001- to test the model's implications against the data.

To regulate capital flows into and out of the economy, countries implement different types of restrictions. Regulations on the foreign exchange (FX) market are one of these, as they limit the extent to which agents are able to acquire foreign currency, hedge the exchange rate risk, and borrow or lend internationally.[22] For these reasons, FX controls are reported by the IMF in its Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) as one of the restrictions on capital flows. In Hungary, regulations in the FX market were the main capital control tool. In 2001, with a view to joining the European Union, regulations in the FX market were lifted and, with this, the deregulation of international financial flows was fully achieved. Notably, this deregulation was isolated from other major reforms and was the only missing requirement to join the EU.[23] The extent of the deregulation of international financial flows is captured by the standard indexes of financial liberalization. For example, in Chinn and Ito (2008)'s index the degree of capital account openness rises by 35%, and in Schindler (2009) the level of capital controls declines by 83%.

Until 2001, foreign exchange operations in Hungary were regulated by the Act XCV of 1995.

[21] Notice that this simple exercise departs from any consideration of specific credit constraints for innovation activities. If, in addition, domestic firms faced tighter credit constraints to innovate than foreign firms, the results presented in this section would be even stronger for domestic firms. One way to think of this through the lens of the model is to consider that firms pay their inputs for production and innovation activities at the beginning of the period. To pay them, firms raise external funds. As I show formally in Appendix C, firms' optimal innovation intensities, equations (3), would be divided by their respective interest rates. Since domestic firms pay a higher interest rate, their innovation intensities would be more affected. The reduction in capital controls would reduce the domestic interest rate and, in turn, foster home firms' innovation intensities relatively more.

[22] Regulations on the FX market are commonly used to protect the economy from abrupt swings in the exchange rate and capital account reversals. These controls were widely implemented during the time of the Bretton Woods, when countries had fixed exchange rates regimes (see Smith, Walter, and DeLong 2012). Lately, during the Great Recession, many emerging markets -as for example Korea and Brazil- imposed restrictions on FX markets to limit the large amount of capital flows into the economy. See for example The Economist October 12 2013, March 27 2011, November 11 and June 17 2010.

[23] To join the EU, all candidate countries have to accomplish the Copenhagen Criteria of 1993. One of these criteria is that candidates have to ensure free movement of capital, the only missing requirement in Hungary. I discuss the general context around the reform in Section 5.2.

This law used three main tools to limit international financial flows. It used two tools to restrict banks' ability to intermediate foreign funds, and one tool to restrict firms from borrowing internationally. The first tool restricting banks' international financial flows was the regulation of the forward FX market. More precisely, the Act XCV banned all kind of forward instruments between the Hungarian Forint and foreign currencies -chiefly among them, FX swaps, and forward and future contracts. Notice that these forward contracts are crucial tools to raise foreign funds as they allow agents to hedge against currency depreciations. Lacking these instruments, agents are exposed to the currency risk. The second tool regulated the spot FX market. The regulations made very costly and difficult for banks to acquire foreign currency for spot transactions for two reasons. First, the FX market was very illiquid, as foreign financial investors were not allowed to participate in the market and there were restrictions on the amount of interbank lending in foreign currency. Second, each individual financial transaction in foreign currency was subject to the approval of the Central Bank (National Bank of Hungary- NBH). In particular, banks had to apply for individual licenses to acquire foreign currency. Using these two tools, the Act XCV substantially affected banks' ability to intermediate foreign funds, as they faced a costly and illiquid spot market and an inexistent market for forward foreign currency transactions.

In this way, the local financial sector was crucially affected by these regulations. As shown by previous studies (Smith, Walter, and DeLong 2012, and Caballero, Cowan, and Kearns 2004 among others), regulations on FX markets discourage banks from raising funds abroad. This was the case of financial institutions in Hungary under the Act XCV. The controls on the spot market and the ban on forward contracts made banks reluctant to borrow internationally and prompted them to base their credit supply on domestic savings. This reliance of banks on local savings led to a low level of financial development, as shown by two key indicators. In 2000, Hungary's credit-to-GDP ratio (0.27) was three times smaller than the OECD average (0.86), and its credit-to-deposit ratio was a third lower (0.83 against 1.2 in OECD countries). The level of this latter ratio denotes the low extent of financial intermediation: the credit supply was significantly smaller than the amount of savings held locally.

The third tool that the Act XCV used to limit international financial flows into the economy was to regulate firms' borrowing in foreign currency. Under this law, only firms declaring to tax authorities to receive foreign currency income were allowed to borrow in foreign currency.[24] Crucially, this regulation divided firms into two groups: those that could only borrow locally in national currency, and those that receiving foreign income could borrow in foreign currency from abroad. In this context, a first group of firms, domestic firms, were limited to finance themselves with local credits in national currency and, hence, were disproportionally affected by the low level of development of the local financial system as they took credit in a highly repressed economy. A second group

[24]In particular, the way in which this Act limited international borrowing was by regulating which firms could have bank accounts in foreign currency. Under this law, only firms reporting in their tax declaration that they were receiving foreign currency income were allowed to apply for *convertible accounts*, i.e. bank accounts denominated in foreign currency. Without declaring foreign currency income, firms were not allowed to open convertible accounts and, thus, could not borrow in foreign currency.

of firms were foreign companies that, unlike domestic firms, could avoid the local restrictions by directly obtaining international funds.[25] Although there is no precise record indicating the exact amount of foreign indebtedness at the firm level, there is substantial evidence that foreign firms used these funds intensively. As reported by IMF (1998), these firms employed two main sources of international funds. First, they enjoyed the relationship between the parent company and its banks to access to foreign bank credit.[26] Second, they intensively used internal capital markets with their parent companies. In 1998, more than one third of total credit in the economy (35%) was internal credit between parent companies and subsidiaries in Hungary. As is well established in the literature (Desai, Foley, and Hines 2003; and Desai, Foley, and Forbes 2008, among others), this use of internal capital markets offers foreign firms financial advantages relative to their local competitors. Thus, by exploiting these two channels, foreign firms enjoyed access to international capital markets.

In this way, FX controls distorted the access to international borrowing between foreign and domestic firms. Whereas the former had access to foreign borrowing, domestic firms only financed themselves locally, in a tighter credit market. In Section 5, I exploit these firm-level distortions prior to the reform to investigate the differential impact of the deregulation of international financial flows between home and foreign firms.

The asymmetry in the access to capital markets was reflected in differences in the level of firms' financing terms. Data from the National Bank of Hungary reveals that, before the liberalization, domestic firms' leverage was a third lower than foreign's.[27] In addition, the BEEPS survey indicates that in 2001 - the year of the reform - less than 5% of domestic firms could obtain credit in foreign currency. The survey also reveals that financing terms were also tighter for domestic firms. They paid interest rates 3.2 percentage points higher than foreign firms, and the required value of the collateral on total debt was 58% greater (see Table 1).[28]

In 2001, the regulations on foreign exchange transactions were lifted. Crucially, the Act XCIII removed all restrictions in the spot market, allowed forward instruments between the Hungarian

[25]While the law legally allowed domestic exporters to borrow internationally, the empirical evidence attests against this possibility and suggests that these firms did not obtain international funding. As I discuss in detail in Section 5.3, prior to the reform, domestic exporters had the same level of leverage and financing terms than domestic non-exporters, and they shared the same post-reform pattern of growth than their non-exporter counterparts (see Tables B3 and B4). It is also worth mentioning that, accordingly with data from the NBH, even after the financial openness, domestic exporters had limited direct access to international capital markets. Three years after the liberalization, in 2004, only fourteen over thousands of domestic exporters reported to have debt in international capital markets. In this way, the empirical evidence strongly suggests that Hungarian exporters and non-exporters were equally constrained from borrowing in international capital markets. For this reason, I treat these firms together and focus my attention on a much sharper contrast revealed in the data: the asymmetry in the access to international borrowing between foreign and domestic firms.

[26]The link between the parent company and its bank to obtain cheaper credit was highly used by subsidiaries in transition economies, see for example Weller and Scher (1999) and Weller and Scher (2001).

[27]This information comes from firms' balance sheets of the APEH database that I use in the empirical section. See Section 4 for a detailed description of the database.

[28]This information comes from the Business Environment and Enterprise Performance Surveys (BEEPS) of the World Bank and the European Bank for Reconstruction and Development. Unfortunately, these surveys do not report firms' financing terms before 2001, and therefore do not allow knowledge of their characteristics in the years prior to the reform. See Section 4 for further details.

Forint and foreign currencies, and abolished restrictions on firms' foreign currency borrowing. Under the new framework, international borrowing became more attractive, particularly for financial institutions. Thereafter, banks could raise funds abroad at lower interest rates and use derivatives to hedge the exchange rate risk. As a result, they substantially increased their foreign funding. Figure 1 plots the evolution of the main financial flows of banks. Comparing the three years preceding and following the reform (1998-2004), net capital inflows of financial institutions rose from 0.6 to 3.3 billion US dollars per year. This expansion had a substantial impact on their external debt, which by 2004 had more than tripled, reaching 20 billions of US dollars. In parallel, banks started employing intensively financial derivatives, a market which developed fast following the reform. Both cross-border and local derivatives soared and, by 2004, they had increased by more than three-fold the value of end-2001. As Figure 1 shows, the expansion of the turnover in the local FX market is mostly explained by FX swaps.

The increase in banks' liquidity yielded an expansion of the credit supply. Table 1 shows that, three years after the reform, the credit-to-GDP ratio had almost doubled and the credit-to-deposit ratio had grown by more than a third. It is important to note that the sum of granted credit exceeded domestic deposits, suggesting that banks used sources of funding other than local savings (i.e. international borrowing). In turn, the expansion of the credit supply led to a large decrease in the lending interest rate (row 3 of Table 1).

Critically, the expansion of the credit supply substantially improved financing terms for domestic firms. According to the BEEPS survey, by 2004, the interest rate differential between domestic and foreign firms had fallen five-fold from 3.2% to 0.65%, and the difference in the value of the required collateral had dropped four-fold from 58% to 11% (rows 6 and 7 of Table 1). In addition, data from the NBH reveals that small and medium enterprises (SME) increased their proportion of total credits by 17 percentage points. Importantly, this expansion was driven by credits in FX: by 2004, one third of their credit was denominated in foreign currency (line 5 of Table 1). In this way, the deregulation of international financial flows in Hungary improved credit conditions for domestic firms. In the next sections, I study how this decrease in the asymmetric access to capital markets affected firms' investment in technology and market competition.

4 Data

I test the model's predictions using two firm-level databases: APEH, which contains data on firms' balance sheets reported to the tax authorities and is provided by the Statistical Department of the National Bank of Hungary, and the Business Environment and Enterprise Performance Surveys (BEEPS) of the World Bank and the European Bank for Reconstruction and Development.

The APEH database covers the population of manufacturing firms and spans the period 1992-2008. These are panel data, which allow me to track the evolution of firms over time. Firm size varies significantly in the database, spanning from single-employee firms to corporations employing

thousands of workers. The database is mainly populated by small firms: from a total of 25,286 firms only 30% reported more than ten employees in 2001.

This database contains information on value added, sales, output, stock of capital, employment, wages, materials, exports, and ownership structure. I use these variables to construct firms' capital intensity (capital per worker), labor productivity (value added per worker), RTFP, markup, and ownership status. To obtain real values, I use price indexes at four-digit NACE industries for materials, investment, value added, and production. The RTFP measure is computed using the Olley and Pakes (1996) method to estimate the parameters of the production function. I estimate markups as a wedge between the firm's labor share and the labor elasticity of production. I present several robustness tests for different estimations of RTFP and markups in Appendix B. Following the standard literature, I define a firm as foreign if more than 10% of their shares belong to foreign owners. From 1999, firms were asked to report short-term debt undertaken with financial institutions. I use this information to assess changes in firms' leverage, which I proxy with the short-term debt-to-sales ratio. Unfortunately, since providing this information is optional, only few firms filled it in and the sample of non-missing observations shrinks by approximately 50%.

The firm-level analysis in Sections 5.3-5.5 focuses on a balanced panel of 5,548 firms present over the period 1998-2004 and for which there is information on output, employment, materials and capital so as to compute the RTFP measure. Since smaller firms are more subject to measurement error problems, I retain firms with five or more employees. This balanced panel accounts for 77% of value added and 70% of employment in the manufacturing sector. Additionally, I employ the unbalanced panel over the entire population of firms to conduct several robustness tests. The industry- and aggregate-level analysis in Sections 5.6 and 5.7 analyze the impact of the deregulation of international financial flows across the entire population of firms, and use the years 1992-2008 to control for pre-exiting trends and to test for a structural break in 2001.

I assess changes in firms' innovation activities using the BEEPS surveys. Specifically, I use the surveys from 2002 and 2005, corresponding to the years 2001 and 2004, for Hungary. These surveys provide information of all economic activities, excluding sectors subject to government price regulation and prudential supervision, and employ stratified random sampling to ensure that they are representative of the population of firms. The samples include very small firms with a minimum of two employees up to firms with thousands of workers. BEEPS surveys report information on innovation activities and firms' expenditures in R&D for 774 firms (250 in the first survey and 524 in the second). Regarding innovation activities, the surveys ask whether the firm has undertaken any of the following initiatives in the last three years: successfully developed a major product line, upgraded an existing product line, acquired a new production technology, obtained a new licensing agreement, or obtained a new quality accreditation. All these measures of innovation follow the recommendations of the Oslo Manual developed by the OECD and Eurostat for innovation surveys. This definition of innovation focuses on new and improved product and processes that are "new to the firm",[29] and this emphasis on "what is new to the firm" is of special interest to this study.

[29]See Gorodnichenko and Schnitzer (2010), Mairesse and Mohnen (2010) for more discussion.

As Hungary is a developing economy, the easing of credit conditions might have encouraged more domestic firms to adopt frontier technologies rather than develop new ones. Importantly, the majority of firms (75%) have reported that these activities were a critical contributor to their growth. I construct a dummy variable, hereafter *Innovation*, if the firm has undertaken any of these activities. As concerns R&D, the surveys ask firms to report their expenditures in these activities. However, since the questions regarding the level of R&D expenses are not comparable across surveys, I construct a dummy variable if the firm reports positive R&D spending, hereafter $R\&D$.[30] BEEPS surveys also contain information on firms' financing terms. In particular, firms are asked to report the cost of loans and the value of the collateral required as a percentage of the total loans. In Section 5.4, I use this information to test econometrically whether domestic firms' financing terms improved following the reform.

To test the financial channel, I use data on sector dependence on external finance. These data come from Raddatz (2006), who re-estimated the financial dependence index of Rajan and Zingales (1998) for US firms at the four-digit industry level. The Rajan and Zingales (1998) index measures the amount of investment that cannot be financed through internal cash flows.[31]

5 Empirics

Throughout this section, I test the predictions of the theoretical model. In Section 5.1, I present sectoral and aggregate patterns in Hungary before the reform. In Section 5.2, I describe the identification strategy. Section 5.3 tests whether domestic firms expanded more in terms of investment in technology (proposition 1). In Section 5.4, I assess whether this expansion correlates with a higher use of external finance, a reallocation effect. I also investigate the presence of pro-competitive forces by evaluating whether foreign firms react to the threat of competition. Section 5.5 evaluates whether deeper competition leads to reductions in foreign firms' markups (proposition 2). Section 5.6 analyzes changes in the productivity gap between foreign and domestic firms across sectors (proposition 3). In Section 5.7, I test whether aggregate productivity growth accelerates following the liberalization (proposition 4). Finally, I explore the sources of aggregate TFP growth and investigate how they relate to the expansion in firms' productivity.

[30] While the survey in 2002 asks interviewees to report how much the company has spent as a percentage of total sales, the 2004 survey asks for the precise amount of R&D expenditures. These different manners to formulate the question do not allow comparing the exact efforts undertaken in R&D activities.

[31] More precisely, for a representative sample of US firms during the 1980s, Rajan and Zingales (1998) define need of external finance as firms' capital expenditures minus cash flows from operations divided by capital expenditures. Then, they use the sector median value across the 1980s to construct the dependence of external finance of each industry at the three-digit level. As capital markets are largely advanced in the United States, this index is widely used as a benchmark to capture the technological need for external finance of industries worldwide. Furthermore, the use of this index avoids endogeneity concerns.

5.1 Patterns in Aggregate Data Before the Reform

As discussed in Section 3, regulations in force prior to 2001 created asymmetries in the access to international borrowing between foreign and domestic firms. Whereas the former had access to foreign funds, domestic firms only financed themselves locally in a tighter credit market. A main thesis of this paper is that this distortion undermines competition. In line with this hypothesis, prior to the reform the Hungarian manufacturing sector presented high levels of market concentration. As shown in Table 2, foreign firms' share in total value added was 74%, and the Lerner index of industry concentration was high at 0.22.[32] Furthermore, foreign firms' market share was positively correlated with high levels of RTFP and markup dispersions, as well as with the Lerner index of industry concentration (Table 3).[33] Importantly, the financial openness in Hungary correlates with an increase in market competition. Three years following the liberalization, in 2004, foreign firms' market share had dropped six percentage points and the Lerner index had shrunk by 10%.[34]

5.2 Identification Strategy

This section first presents the identification strategy of the effect of the financial openness on firms' main outcomes. Next, it discusses possible concerns regarding the empirical analysis, as for example: differences in firms' initial characteristics and previous growth trends, differences in industrial patterns of growth, sample selection and reverse causality issues.

The identification strategy of the effect of financial openness is based on the asymmetric access to international capital markets for domestic and foreign firms prior to the reform. In particular, my firm-level analysis exploits this source of cross-sectional variation to test the two channels proposed in this paper. I test the first channel, namely whether financial openness encourages home firms to invest more in technology, in two steps. First, I estimate the differential impact of the reform on domestic firms' investments in technology. Second, I test the financial channel by adding another source of cross-sectional variation: sector financial needs. In this way, I exploit three sources of variation: time, sector reliance on external finance, and firms' access to international borrowing prior the reform, and test whether home firms with greater needs of external finance expand more after the reform. I complement this analysis by using direct information on firms' leverage and financing terms to test whether home firms use bank credit more intensively after the liberalization. To test the second channel -whether financial openness fosters pro-competitive forces- I exploit variations in terms of sector reliance on external finance. In particular, as the asymmetric access to international borrowing should have distorted competition more in sectors

[32]The Lerner index is computed as the firm's price-cost margin weighted by its market share at three-digit NACE industries. See also Aghion, Bloom, Blundell, Griffith, and Howitt (2005); Nickell (1996); and Lerner (1934).

[33]See Section 5.6 for a detail definition of RTFP and markup dispersions, and for the analysis of their changes at industry-level following the reform.

[34]The Herfindahl index, which also indicated high levels of concentration before the reform, shows a deepening of competition after it, decreasing by 7.5% (Table 2).

in which domestic firms had greater needs of external finance, market competition should deepen relatively more in those sectors. In this way, my firm-level analysis uses variations in sector reliance on external finance to identify the pro-competitive forces of financial liberalization.

To identify the effect of the reform, it is important to determine whether domestic and foreign firms differed in characteristics that could involve heterogeneous patterns of investment and productivity growth. If these differences were not accounted for, the estimated coefficients could be biased. Table 4 disaggregates data into domestic and foreign firms and presents sample means in the initial year by type of firm (1998). Prior to the reform, foreign firms were older, and larger in terms of value added, employment, labor productivity and RTFP. As stated in the model, they also enjoyed higher markups. Interesting, firms also differed in their innovation behavior. As Table 5 shows, foreign firms had higher probability of conducting innovation and R&D activities than home firms. Since the difference in means in these variables is statistically significant, in my reduced-form regressions I control for them.

A main assumption of the empirical strategy is that before the reform, firms shared similar growth trends. Indeed, a first glance at the data confirms that domestic and foreign firms saw similar pattern of growth over the five years preceding the reform (1996-2001). Figure 2 plots the evolution of the main outcomes analyzed: labor productivity, RTFP, capital intensity, markups and leverage. Values are normalized to their initial levels. Remarkably, these parallel patterns of growth observed before the reform were reversed after it. In line with the theory proposed in this paper, following the liberalization, the average domestic firm has grown faster in terms of labor productivity, RTFP, capital intensity and leverage. Also, consistent with the model's predictions, foreign firms' markups shrank faster. The analysis of the sample means confirms that the growth rates of foreign and domestic firms were not statistically different over the five years before the deregulation (Table 6).

The previous paragraph discussed the concern over firms' pre-existing growth trends. If domestic firms were correlated with some industry characteristics, however, it would be necessary to control for them so as to rule out possible sources of bias. I estimate the equations in first differences, so that time-invariant industry characteristics are differenced out. However, if sectors with different initial characteristics were on different trends, the estimated coefficient could capture some omitted industry-level time-dependent variable. I tackle this issue in three different ways. First, to account for sectoral pre-existing growth trends, I include the capital intensity and productivity growth at the four-digit NACE industry level in Hungary before the reform (1996-1997). Second, since sectors' investments and productivity could be growing at a different pace in the global economy, I also control for capital intensity and productivity growth in the United States. Third, as a robustness test, I also consider sector and sector-year fixed effects at four-digit NACE industry level.

A critical hypothesis underlying the study is that the sample is not subject to selection issues; this is, pro-competitive forces may not only affect firms' outcomes, but also the probability of a firm being observed. If this probability differed between domestic and foreign firms over time, the conditional expectations on the OLS residuals would be different from zero and the estimated

coefficients would be biased (see, for example, Heckman 1974 and Heckman 1979). To assess whether this missing data problem challenges my estimations, I check whether there are differences in the probability of domestic and foreign firms being observed. In particular, I define a surviving firm if it existed the year before the reform (2000) and did not exit within the three years following it. Then, I compute the survival ratio of domestic and foreign firms and test whether there are differences in their means. The results show no statistically significant difference between the survival probability of domestic and foreign firms. This suggests that this missing data problem does not affect the estimated coefficients (Table B1).

The general context around the reform and its timing make it likely to be exogenous with respect to the main outcomes analyzed, i.e. changes in home firms' investments in technology. The reform was driven by the accession of transition economies to the European Union.[35] The requirements to join the EU were predetermined by the Copenhagen Criteria in 1993, and have been equal for all accessing countries since then. In this sense, the content of the reform was exogenous to the country political choice. Furthermore, as the agenda was jointly determined by the European Council and the candidate countries, it is unlikely to have been driven by political pressure from Hungarian firms.[36]

Even though the preceding points address the reverse causality problem, any event occurring in the years of the reform and affecting firms' investment choices differentially could affect the estimated coefficients. To accurately identify the effect of the reform, I restrict the analysis to the three years preceding and following it. In addition, during this period no other significant event that could affect firms' investment in technology differentially occurred in Hungary. First, the economy was growing at a steady pace, with no significant shock during that period. Notably, real external flows, as trade and foreign direct investment, remain constant during the period under analysis.[37] Second, major reforms had already taken place during the early 1990s (such as privatization of public companies, bank deregulation or competition laws).[38] Third, the EU did not require any further reform that could affect the development of the manufacturing sector. Finally, the Hungarian economy was already deeply integrated with the EU. This integration was remarkable in the manufacturing sector, which exports to the EU already accounted for 80% of total exports in 2001 (see Figure B1). It is worth mentioning that the patterns of capital inflows observed in Hungary

[35] In the late 1990s, 14 candidates initiated the negotiations to join the EU, of which only 10 joined in 2004: Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia.

[36] It is worth mentioning that, given the speed of the reform, it is unlikely that firms have anticipated it, and have undertaken investments in advanced. In December 2000, the European Council defined the timing for the accession vote and the last requirements to be met by each candidate. The reform had to take place before the accession vote in December 2002. Soon after the European Council meeting, in March 2001, Hungary deregulated the remaining controls on financial flows.

[37] During the period preceding and following the reform, foreign direct investment remained constant, and even showed a small slowdown in the years following the deregulation (see Figure B3). Moreover, Hungarian external trade did not seem to have particularly suffered from the world recession in 2001. As shown in Figure B4, the volume of exports and imports continued to grow during that period.

[38] Major privatization programs occurred in the early 1990s. By 1997, the share of public companies in manufacturing value added was only 2%. Banking deregulation had already started in the 1980s, and was fully achieved in 1997. The Competition Act entered into force in 1997. According to the Hungarian Competition Authority, the accession to the EU did not cause a major change in this field.

cannot be attributed to the joining of the EU, as the timing does not coincide with the accession and other similar candidates with already deregulated financial accounts -as Czech Republic or Poland- do not show the pattern of capital inflows observed in Hungary (see Figure B2). Notice that Hungary did not join the Euro zone and, hence, did not have to fulfill any monetary or fiscal criteria.

5.3 Impact on Home Firms' Investments

The model showed that a reduction in the distortion in the access to capital markets induced by the liberalization fosters firms' investments in technology. In particular, as stated in proposition 1, domestic firms should expand relatively more. In this section, I investigate this prediction in two steps. First, I study whether domestic firms increase more their capital and productivity. Second, I test whether they expand more in terms of R&D and innovation activities.

Investment in Capital and Productivity

I analyze the differential impact of the liberalization of international financial flows on domestic firms' capital and productivity using the following model:

$$y_{it} = \delta_0 H_i + \delta_1 T_t + \delta_2 (H_i \,\mathrm{x}\, T_t) + \varepsilon_{it}, \tag{6}$$

where i indexes firms, t denotes before and after the reform, H is a dummy variable for domestic firms, T is dummy variable for the post-reform period, and y is a vector of {capital intensity, labor productivity and RTFP}. The coefficient of interest is δ_2 and captures the impact of the reform on domestic firms' outcomes.

A potential pitfall of regression (6), estimated with yearly firm-level data, is that residuals could be serially correlated - across time within firms, and across firms within sectors for a given year. Serial correlation in the error term might understate the OLS standard errors and induce a type II error, i.e. accepting the null hypothesis when this is true. To account for this source of bias of the OLS standard errors, I use one of the solutions proposed by Bertrand, Duflo, and Mullainathan (2004) and remove the time series dimension of the data. More precisely, I aggregate the data into pre- and post-reform periods, defined as the three years before and after the deregulation.[39] The dependent variable is computed as the average value between 1998 and 2000, and between 2002 and 2004,

$$\Delta\, y_i = \log(\frac{1}{3}\sum_{2002}^{2004} y_{it}) - \log(\frac{1}{3}\sum_{1998}^{2000} y_{it}).$$

Equation (6) in first differences becomes:

[39]Since the reform took place during 2001, I omit this year to avoid possible sources of biases.

$$\Delta y_i = \delta_1 + \delta_2 H_i + \Delta\varepsilon_i. \tag{7}$$

I cluster the OLS standard errors at four-digit NACE industries to take into account the correlation across firms within sectors. Regression (7), in first differences, removes firm- and sector-fixed effects, and therefore controls for time unvarying unobserved characteristics at the firm and industry levels. However, the fixed effects do not absorb individual characteristics that could lead firms to benefit differently from the introduction of the reform. When estimating equation (7), therefore, I add a set of initial conditions at firm level, Z_i, as: size (employment), productivity (RTFP), and age at the initial year (1998). As sectors could be on different trends, I control for pre-existing growth trends of RTFP and capital intensity at four-digit NACE industries between 1996 and 1997 in Hungary, X_j.[40] To account for differences in industry growth trends in the world economy, I add as controls: capital intensity and TFP growth at four-digit level in the US between 1998 and 2004, ψ_j.[41] The final statistical model I estimate is:

$$\Delta y_{ij} = \delta_1 + \delta_2 H_i + \delta_3 Z_i + \delta_4 X_j + \delta_5 \Delta\psi_j + \Delta\varepsilon_{ij}. \tag{8}$$

The estimation of equation (8) by OLS is reported in Table 7. The coefficient for capital intensity estimated in the baseline specification of column 1, where only the dummy for the domestic firm is included as a regressor, implies a differential expansion of these firms' capital intensity by 0.239 log points (t = 10.24). The estimated coefficient is not affected by the inclusion of firm-level controls in column 2 or by the inclusion of local and global trends in column 3, and remains stable across estimations. Results for labor productivity are presented in columns 4-6. The baseline specification in column 4 indicates a differential impact for domestic firms of 0.074 log points (t = 4.35). The inclusion of firm and industry controls does not significantly affect the estimated coefficient, which stands at 0.053 log points (t = 3.36). The estimates for RTFP confirm the greater expansion in productivity for home firms. After controlling for firm and sector characteristics, the estimated coefficient in column 9 shows a differential increase of 0.032 logs points (t = 2.03) for domestic firms.

In Table B2, I present a full set of robustness tests. I show that these results are robust to controls for: four-digit industry fixed effects (column 1), wholly foreign companies (90% of shares) (column 2), foreign firms used as export platforms (column 3), 1% of top firms (column 4), and firms that change their ownership status between the pre- and post-reform periods (column 5). It is interesting to remark that the empirical evidence do not suggest any significant difference between domestic exporters and non-exporters as they faced similar financing terms -interest rate and collateral- and leverage prior to the liberalization (Table B3), and showed non-statistically different pattern of growth of capital intensity, labor productivity or RTFP in the post-reform

[40] Econometric results are robust to considering longer pre-growth trends in Hungary, i.e. the period 1992-1997. Results are also robust to using value added and labor productivity pre-growth trends.

[41] I also use output per worker at four-digit level in the United States as proxy for productivity. Since the results remain unchanged, I only present regressions controlled for TFP.

period (Table B4). For robustness, I also compute the RTFP using the Petrin and Levinsohn (2011) and De Loecker and Warzynski (2012) methodologies to estimate the elasticities of the production function, and show that results are robust to these estimates of RTFP (Table B5).

Equation (8) pooled the estimated effect across all years before and after. To check whether the estimates are capturing the effect of the financial openness and not something else, I test whether the timing coincides with the deregulation. To this end, I interact the dummy for home firms with year dummies and re-estimate equation (8) using four-digit NACE industries fixed effects. In this way, I compare domestic and foreign firms within each four-digit industry and test whether domestic firms evolve differentially over time. Results are presented in Table B6 and plotted in Figure 3. The estimated coefficients for the interaction terms on the three outcomes -capital intensity, labor productivity and RTFP- are statistically significant, confirming that domestic firms were smaller in size than their foreign-industry competitors. Importantly, while the estimated coefficients do not change significantly before the reform, they monotonically decrease after it. These results suggest that home firms grew much faster and gradually closed the capital and productivity gaps with their foreign rivals (Figure 3). The F-test on equality of coefficients confirms these results. While the estimated coefficients for interaction terms are not statistically different from 1998 to 2000, they differ significantly when comparing the pre-reform and post-reform years (Table B6). As a further falsification test, I estimate a placebo test on the year 1998. This is, I estimate equation (8) for the period 1996-2000, with two-year gap for the period prior and following the reform. Results are presented in Table B7 and show that during this period domestic firms did not evolve differently than their foreign competitors. Finally, it is worth mentioning that results are not affected when considering the unbalanced panel of firms and four-digit industry-year fixed effects, as shown in Table B8.

R&D and Innovation Activities

The BEEPS surveys report information on a cross-section of firms' R&D and innovation activities for the years 2001 and 2004. To evaluate the differential impact of the reform on domestic firms, I estimate the following model,

$$y_{ijt} = \delta_0 H_{it} + \delta_1 T_t + \delta_2 (H_{it} \,\mathrm{x}\, T_t) + \delta_3 Z_{it} + \mu_j + \varepsilon_{ijt}, \tag{9}$$

where t denotes years 2001 and 2004; T is a dummy indicating the reform period (i.e. T=1 if 2004, and 0 otherwise) and j represents sectors, which break down into eight categories. Z_{it} is a vector of firm characteristics: age and size (employment).[42] To control for sector-specific characteristics, I add sector fixed effects: μ_j. I cluster the standard errors at sector level. Equation (9) with fixed effects cannot be consistently estimated by probit (incidental parameters problem), so I estimate

[42] As few firms report data on sales, controlling for firm's productivity (sales over employment) highly reduces the sample. Importantly, results are robust to this control.

a linear probability model. The coefficient of interest is δ_2, which identifies the change in the probability of domestic firms undertaking R&D and innovation activities after the reform.

Columns 1-3 in Table 8 report the results on R&D activities. The baseline specification suggests that the reform increased the probability of domestic firms undertaking R&D activities by 10.7 percentage points (t = 2.24). The estimated coefficient remains stable and statistically significant after the inclusion of firm- and industry-level controls (columns 2 and 3). Along the same lines, results on innovation activities in columns 4-6 also suggest that the reform increased the probability of domestic firms conducting these activities. The coefficient in the regression including all controls (column 6) implies an increase of 12 percentage points (t = 2.19).

The above results show that the deregulation of international financial flows in Hungary was correlated with differential increases in capital intensity, productivity and probability of undertaking R&D and innovation activities of domestic firms. In the next section, I investigate whether it was the relaxation of credit conditions induced by the liberalization that encouraged this expansion.

5.4 Investigating the Financial Channel

This section studies the financial channel in two steps. First, I assess whether domestic firms benefited from the deregulation in accordance with their needs of external finance. Additionally, I explore the presence of pro-competitive forces on foreign firms. Second, I use direct information at firm-level on financing terms and leverage to test whether home firms' expansion is due to a greater use of external funds.

Investment in Capital and Productivity

To test the financial channel, I first exploit an additional source of cross-sectional variation: sector reliance on external finance. In this way, I employ three sources of variation: time, sector reliance on external finance, and firms' access to international borrowing prior to the reform.

Notably, this third source of variation allows assessing the two forces studied in this paper, i.e. whether better financing terms promote domestic firms' investments in technology, and whether reductions in capital market distortions fosters pro-competitive forces. As regards the first force, sector financial needs allow testing whether domestic firms operating in sectors that have greater needs of external finance expand more after the deregulation. In other words, it allows testing whether those domestic firms that should be more exposed to the treatment -the liberalization of international financial flows- indeed benefit more from the reform. As concerns the second force, differences in sector financial needs allow testing whether competition tightened more in more financially dependent sectors. In particular, since the asymmetric access to international capital markets should have distorted competition more in sectors where firms relied more intensively on external funds, one would expect that competition tightens more in those sectors. In this way, this third source of cross-sectional variation allows recovering the differential impact of the reform on

foreign firms as a function of how the asymmetric access to international capital markets affected sectors differentially. Therefore, in terms of productivity, foreign firms' responses should also vary in accordance with sector financial needs. Importantly, as the distortion affected domestic firms more (proposition 1), conditional on the sector, these firms should expand relatively more.

To evaluate these two channels, I include sector financial needs in equation (6) and consider the following model:

$$y_{it} = \delta_0 H_i + \delta_1 T_t + \delta_2 (H_i \,\mathrm{x}\, T_t) + \delta_3 (FD_j \,\mathrm{x}\, T_t) + \delta_4 (H_i \,\mathrm{x} FD_j \,\mathrm{x}\, T_t) + \delta_5 FD_j + \delta_6 (H_i \,\mathrm{x}\, FD_j) + \varepsilon_{it}, \quad (10)$$

where j denotes four-digit NACE industries and FD_j is the index of external finance of Rajan and Zingales (1998) at four-digit NACE industries. Coefficient δ_3 in equation (10) -where the dummy for the home firm is equal to zero- captures the differential impact of the reform on foreign firms across sectors. A positive and significant coefficient would imply that foreign firms expanded more in sectors where the need for external finance was greater. Coefficient δ_4 absorbs the differential impact of the reform on domestic firms in accordance with sector financial needs. Importantly, it indicates whether home firms expand more than their foreign competitors with the same level of reliance on external funding. In this way, equation (10) allows identifying the expansion of foreign firms and the potential differential growth of home firms in accordance with sector financial needs.

As discussed earlier, a potential pitfall of estimating equation (10) using yearly firm-level data is that residuals could be serially correlated. To avoid serial correlation in the error term, I estimate equation (10) in first differences. After the inclusion of firm-level and sector controls, the final model I estimate is,

$$\Delta y_{ij} = \delta_1 + \delta_2 H_i + \delta_3 \, FD_j + \delta_4 \, (H_i \,\mathrm{x}\, FD_j) + \delta_5 Z_i + \delta_6 X_j + \delta_7 \, \Delta\psi_j + \Delta\varepsilon_{ij}. \quad (11)$$

Similarly to equation (10), coefficient δ_3 captures the effect of the reform on foreign firms across sectors. δ_4 absorbs the differential effect of domestic firms over their foreign rivals in accordance with sector financial needs. I control for firm-initial characteristics (size, age and productivity in 1998) and sector pre-growth trends in Hungary (capital intensity and productivity) and global trends (capital intensity and productivity in the US), as in equation (8). I cluster the standard errors at four-digit NACE industries.

Columns 1-3 in Table 9 report the main results on capital intensity. The coefficient on the interaction term for home firms δ_4 is statistically significant and robust to the inclusion of firms' initial characteristics and local and global trends (column 3). After including all controls, the estimated coefficient implies that one standard deviation increase in the index of external finance raises domestic firms' capital intensity by 0.045 log points (t = 2.02). It is important to remark on the estimated coefficient for foreign firms, δ_3. This coefficient is not statistically significant in any specification, showing that foreign firms did not expand their capital intensity in accordance with sector financial needs. Notably, this lack of correlation between needs of external financing and capital investments suggests that foreign firms were not credit constrained nor in needs of external

funds before the liberalization.

Columns 4-6 present the results for labor productivity. The estimated coefficients are consistent with the two forces proposed in this paper, implying that foreign and domestic firms should increase their productivity in accordance with sector financial needs, but home firms should expand relatively more. In particular, the coefficient δ_3 implies that foreign firms operating in one standard deviation more financially dependent sector experience a 0.09 log points (t = 2.50) larger increase in labor productivity after the inclusion of firm- and industry-level controls in column 6. As predicted by the model, the effect is even greater for domestic firms. The coefficient δ_4 implies an expansion of 0.04 log points (t = 3.17) more than their foreign competitors in the same sector. Results on RTFP confirm the pattern of growth of labor productivity (columns 7-9). After considering all controls, the estimated coefficients indicate that foreign firms in one standard deviation more financially dependent sector see a 0.08 log points (t = 3.02) larger increase in their RTFP (column 9). Just like the trends in labor productivity, the estimated coefficient implies that domestic firms expanded relatively more: their RTFP grew 0.05 log points (t = 2.48) above the increase of their foreign rivals.

These results provide support to the two forces proposed in this paper. First, consistent with the improvement in the access to capital markets, domestic firms expanded their capital intensity and productivity as a function of their needs of external funds. Second, in line with the presence of pro-competitive forces, in sectors where competition was initially more distorted, foreign firms increased their productivity, while they did not increase their capital intensity. These results suggest that these firms might not have been initially credit constrained, but they might be responding to the tougher competition.

To ensure that these results are robust, I undertake two further empirical exercises. First, I re-estimate equation (10) non-parametrically by splitting the sample into quartiles of dependence on external finance. Results presented in Table B9 confirm that home firms expand monotonically with the level of financial dependence, and that the increase is significantly larger for the third and fourth quartiles. Second, to test whether the response of foreign firms corresponds to a tighter competition and not to financial constraints on these firms, I estimate whether their responses vary when considering different ownership structures. In particular, one would expect that the presence of pro-competitive forces remains true even when considering foreign firms that have tight links with their parent companies and, thus, are less likely credit constrained. To test this, I estimate regression (11) on foreign firms with more than 50% foreign shares.[43] Results presented in Table B10 show that the estimated coefficients on labor productivity and RTFP remain positive and statistically significant even for this group of foreign firms. Together with the fact that these firms do not increase their capital intensity, they are consistent with the interpretation of this paper that pro-competitive forces induce foreign firms to expand their productivity. Importantly, this evidence is also consistent with previous industry-level studies reporting that increases in competition induce incumbent firms to raise their productivity (see for example, Holmes and Schmitz 2010).

[43]Results are also robust to considering larger shares of foreign ownerships as 75% and 90%.

Financing Terms and Leverage

As discussed above, the liberalization of financial flows in Hungary was followed by the expansion of the local credit supply. In this section, I ask in two steps whether this expansion benefited mostly domestic firms. First, I employ BEEPS survey to evaluate whether financing terms improved for domestic firms. Second, I use information on firms' short-term debt with banks from the APEH database to investigate whether domestic firms increased their use of external funding.

The BEEPS surveys ask firms to report the interest rate paid on loans and the value of the collateral required as a percent of the loan. I use this information as outcome variables and examine whether these values decreased for domestic firms after the reform. Table 10 reports the estimated coefficients of regression (9) on these outcomes. The coefficient on home firms is positive and significant before the reform, indicating that domestic firms did face tighter financing terms than foreign companies prior to the reform. After the inclusion of firm-level controls and sector-fixed effects, the estimated coefficients indicate that domestic companies paid interest rates 3.7 percentage points (t = 3.55) higher. Likewise, the value of the required collateral as a percentage of the total loan was 52 percentage points (t = 4.63) greater than that for foreign companies (columns 3 and 6). As expected, the liberalization of international financial flows improved financing terms for home firms: the coefficients of both the interest rate and value of the collateral are negative and statistically significant in all specifications. Regressions including all controls of columns 3 and 6 show that their interest rate fell by 3.9 percentage points (t = 3.67) and the value of the collateral by 31.2 percentage points (t = 2.86).

I examine changes in firms' leverage by using APEH database to estimate regression (8) on the debt-to-sales ratio. Results presented in Table 11 confirm that domestic firms use bank credit more intensively after the reform. The baseline regression, where only a dummy for domestic firm is included, indicates a differential increase of 0.16 log points (t = 2.17) for domestic firms (column 1). The inclusion of firm- and industry-level controls suggests a slightly larger increase of 0.23 log points (t = 2.61). I assess the financial channel using equation (11) on firms' leverage. Column 4 shows that, as expected, the increase in leverage is larger for firms operating in sectors with greater needs for external finance: one standard deviation increase in the index of financial dependence raises domestic firms' leverage by 0.15 log points (t = 1.98). Importantly, consistent with the interpretation of the previous section that foreign firms were not credit constrained before the liberalization, foreign firms did not increase their leverage in accordance with sector financial needs. Instead, the estimated coefficient is negative and statistically significant. Notice that this decrease could indicate a reallocation of financial funds towards domestic firms, as suggested above.

To test whether the expansion of domestic firms' debt really coincides with the timing of the financial openness, I estimate the effect by year. Results plotted in Figure 3 show that the increase in domestic firms' leverage only starts in 2001 and monotonically increase after it. The F-test of equality of coefficients presented in Table B11 confirms these results. While prior to the liberalization the estimated coefficients on domestic firms' leverage were not statistically different, following the liberalization they significantly and gradually differ.

Throughout this section, I have assessed the financial channel implied by the financial openness. I have first shown that domestic firms with greater needs of external finance expanded the most. I have then demonstrated that financial terms improved substantially for domestic firms, and that they expanded their leverage accordingly -particularly in more financially dependent sectors. In addition, the empirical evidence argues for the presence of pro-competitive forces, as foreign firms responded to the deeper competition in more financially dependent sectors by also increasing their productivity. In the next section, I advance the analysis of pro-competitive forces by studying changes in foreign firms' markups.

5.5 Foreign Firms' Markups

The model showed that, by removing asymmetries in the access to international capital markets, financial openness deepens market competition and reduces foreign firms' markups. In particular, as shown in equations (1), foreign firms' markups stem from two sources: the difference in the borrowing costs and the technological advantage with their local competitors. Proposition 2 have formally shown that both of these decline following the financial openness. First, less distorted capital markets raises the competitive pressure of domestic firms, which undermines foreign firms' ability to set higher prices and to obtain higher markups. Second, the greater investments of home firms reduces the technological gap with their foreign rivals, which undermines foreign firms' markups. As a result, financial openness is associated with a decline in foreign firms' markups. In this section, I test this prediction against the data.

To compute markups, I follow De Loecker and Warzynski (2012) and derive them from the firm's optimal labor demand equation,

$$w_{(t)}\, l_{(i,j,t)} = \beta_j\, y_{(i,j,t)} \frac{\left(\frac{w_{(t)}}{\beta}\right)^{\beta} \left(\frac{R_{(t)}}{\alpha}\right)^{\alpha}}{q_{(i,j,t)}}.$$

$$\xi_{(i,j,t)} = \frac{1}{\theta_{(i,j,t)}}\, \beta_j, \tag{12}$$

where l is the firm's optimal labor demand and y is its production; β_j is the estimated labor elasticity of the production function in sector j; w denotes the wage and R the interest rate; q expresses firm's productivity; and θ represents the firm's labor share. As shown in equation (12), markups ξ are defined as a wedge between the firm's labor share and the labor elasticity of production. Then, I test for the differential decline in foreign firms' markups using the following model,

$$\Delta\xi_{ij} = \delta_1 + \delta_2 F_i + \delta_3 Z_i + \delta_4 X_j + \delta_5 \Delta\psi_j + \Delta\varepsilon_{ij}, \tag{13}$$

where F_i is a dummy for foreign firms. In this model, δ_2 captures the differential impact of the

reform on foreign firms' markups. I control for firms' initial characteristics, local and global trends, and cluster the standard errors at the four-digit industry level as in equation (8).

Column 1 in Table 12 regresses changes in markups on a dummy for a foreign firm. As predicted by the model, the estimated coefficient suggests a greater decrease of foreign firms' markups of 0.017 log points (t = 1.9) relative to domestic firms. The inclusion of firm- and industry-level controls does not significantly alter the results: on average, foreign firms' markups drop by 0.026 log points (t = 2.26). This relative decrease of foreign firms' markups is consistent with the evidence presented in the previous sections and the model's implications. As domestic firms increase their productivity relative to foreign firms, foreign firms' cost advantage decreases and, therefore, their markups fall relatively more. Note as well that the magnitude of the relative drop in foreign firms' markups (0.026 log points) is in line with the relative increase in domestic firms' RTFP (0.032 log points).

For robustness, I also compute markups using the elasticities of the production function estimated with the Petrin and Levinsohn (2011) and De Loecker and Warzynski (2012) methodologies. Table B5 confirms the decline in foreign firms' markup following the liberalization of international financial flows. Results are also robust to using the price-cost margin as a proxy for markups (see column 3 of Table B5). Additionally, I estimate equation (13) by year and test whether this decline coincides with the timing of the reform. Results plotted in Figure 3 and presented in Table B12 confirm the decrease of foreign firms' markups since 2001. As demonstrated by the F-test, the estimated coefficients on foreign firms' markups were not statistically different between 1998 and 2000, but they monotonically and significantly differ in the years following the financial openness. Finally, I estimate a falsification test for the year 1998 and show that foreign firms' markups did not change differently regarding their local competitors (Table B13).

Importantly, as discussed above, asymmetries in the access to international capital markets should have distorted competition more in sectors with greater needs for external finance. As firms in those sectors use external funds more intensively, the difference in the borrowing costs should have undermined the competitive pressure of domestic firms relatively more, allowing foreign companies to set higher prices and obtain higher markups. Therefore, financial openness should be associated with a greater decline of foreign firms' markups in more financially dependent sectors. To assess this implication, I test whether foreign firms' markups in these sectors decreased relatively more by interacting the dummy for foreign firms with the financial dependence index of Rajan and Zingales (1998). The estimated equation is,

$$\Delta y_{ij} = \delta_1 + \delta_2 F_i + \delta_3 FD_j + \delta_4 (F_i \,\mathrm{x}\, FD_j) + \delta_5 Z_i + \delta_6 X_j + \delta_7 \Delta\psi_j + \Delta\varepsilon_{ij}, \tag{14}$$

where δ_4 absorbs the differential effect on foreign firms in more financially dependent sectors. The estimated coefficients are reported in column 4 of Table 12. In line with the hypothesis that asymmetries in the access to international borrowing distort competition more in sectors with greater needs for external finance, the reform is associated a relatively greater decline in foreign firms' markups in those sectors. Foreign firms operating in one standard deviation more financially dependent sector experience a 0.05 log points (t = 4.74) larger decline in their markups. Note that

this greater decline of foreign firms' markups in more financially dependent sectors is consistent with the greater expansion of domestic firms in those sectors. It is interesting that the coefficient on financial dependence for domestic firms δ_3 is positive and significant, suggesting that their markups rose in sectors with higher financial needs. This result is in line with their greater expansion in productivity observed in those sectors. As domestic firms' productivity grew more, so did their markups.

Firm-Level Evidence: Taking Stock

The main thesis of this paper is that, by removing capital market distortions, financial openness promotes competition and encourages economy-wide investments in technology. Throughout this section, I have presented two sets of results supporting this argument. First, I have shown that the deregulation of international financial flows in Hungary is associated with increases in domestic firms' capital intensity, labor productivity and RTFP. These results are consistent with a rise in their probability of undertaking R&D and innovation activities. Importantly, the higher increase in domestic firms' productivity points to a reduction in the technology gap with their foreign competitors. I have provided direct evidence that domestic firms' expansion is associated with an improvement in financing terms and a greater use of bank credit. In this line, I have shown that home firms with greater needs of external funds expanded the most. Second, empirical results also point to the presence of pro-competitive forces. Importantly, foreign firms' markups decreased, specially in more financially dependent sectors that are sectors where competition was initially more distorted as home firms were more affected by the asymmetric access to capital markets. Furthermore, in those sectors foreign firms expanded their labor productivity and RTFP, while they did not increase in parallel their capital intensity or leverage, suggesting that foreign firms might not have been initially credit constrained, but responding to the tighter competition of domestic firms in those sectors. Overall, these results argue for the two channels proposed in this paper, namely by relaxing financing terms of discriminated firms, financial openness unchains pro-competitive forces that lead all firms to increase their productivity.

5.6 Industry-Level Evidence: Technological Gap and Concentration

The model states that the greater increase in domestic firms' innovation efforts yields a decline in the productivity gap with their foreign rivals. In particular, proposition 3 predicts that this decline is greater in sectors where the initial productivity gap is largest. The previous sections have shown that domestic firms have expanded their productivity relatively more than their foreign competitors, arguing for a reduction in the productivity gap among them. In this section, I test proposition 3 formally and investigate whether this decline works together with changes in the industry concentration.

Before turning to the empirical test of proposition 3, it is worth mentioning that this proposition refers to the gap in physical productivity between foreign and domestic firms. Unfortunately, the lack of information on firms' prices does not allow recovering their physical productivity and, thus, assessing this proposition directly against the data. However, through the lens of the model two other measures reflecting the productivity gap can be used: markups and RTFP. Concerning the first measure, the model implies that firms with a greater technological advantage set higher prices and obtain greater markups. In fact, as shown in equations (1) and (2), markups are proportional to firms' productivity advantage. As regards RTFP, it can be shown that this measure is proportional to firms' markups and, then, to the productivity gap.[44] Therefore, I use differences in markups and RTFP between foreign and domestic firms as proxies for the physical productivity gap. To assess whether the productivity gap between foreign and domestic firms decreases relatively more in initially more dispersed sectors -as stated in proposition 3-, one could estimate the following regression,

$$\Delta\kappa_j = \alpha + \beta\kappa_j + \varepsilon_j, \tag{15}$$

where κ_j denotes the markup or RTFP difference between the 50th percentile foreign and home firms in each three-digit industry j before the reform (1998-00), and Δ denotes the change between before and after (1998-00 and 2002-04). A negative β will give support to proposition 3.

A potential drawback of regression (15) is that it does not consider pre-existing trends within sectors. If the markup and RTFP gaps were already falling, the regression would attribute this to the liberalization process. To account for pre-existing trends, I include a third period of analysis 1996-97, and estimate the following model:

$$\Delta\kappa_{jt} = \alpha + \beta_1\kappa_{jt} + \beta_2 T_t + \beta_3(\kappa_{jt} * T_t) + \varepsilon_{jt}, \tag{16}$$

where j and t denotes three-digit NACE industries and period, respectively; κ_{jt} denotes the level at the beginning of each period (1996-97 and 1998-00); $\Delta\kappa_j$ represents the change in the variable from one period to another (1996-97 to 1998-00, and 1998-00 to 2002-04); and T_t is a dummy indicating the reform period (1998-00 and 2002-04). The change after the reform, taking into account pre-existing trends, is then captured by the coefficient β_3 of the interaction term.

Table 13 presents the results for the dispersion of RTFP and markups. Column 2 reports the estimation of regression (15) for the reform period. In line with proposition 3, it shows a greater decrease in the RTFP gap in sectors where its initial level was larger. The estimated coefficient is -0.202 (t = 2.57) and implies that an increase in one standard deviation in the initial RTFP dispersion lowers 14% the RTFP gap between foreign and domestic firms following the reform. Note that the inclusion of pre-existing trends, as in equation (16), does not affect the estimated coefficient (column 3). Column 4 reports the estimated coefficient for markups in the late 1990s. The negative and significant coefficient, -0.419 (t = 6.59), suggests that the markup gap was already shrinking in highly dispersed sectors. Remarkably, this trend accelerated after the liberalization

[44] More precisely, $RTFP_j = [(\frac{w}{1-\alpha})^{1-\alpha}(\frac{R^*}{\alpha})^{\alpha}]\xi_j$.

of international financial flows: the estimated coefficient is substantially greater and statistically significant, -0.73 (t = 5.40) (column 5). The interaction term reported in column 6 confirms this larger decline in the aftermath of the reform: one standard deviation increase in the initial markup dispersion, decreases the markup gap between foreign and home firms by 13%.

As discussed above, asymmetric access to external finance distorts market competition, leading to higher levels of industry concentration. By removing capital market distortions, financial openness deepens market competition and affects the industry concentration. This reduction in industry concentration, however, should be heterogeneous. Intuitively, following the decline in the productivity gap, the fall in concentration should be larger in initially high concentrated sectors. To test this, I follow the standard literature and use the Lerner index as a measure of concentration (see Nickell 1996, Aghion, Bloom, Blundell, Griffith, and Howitt 2005, among others). Column 9 in Table 13 including pre-existing trends confirms this hypothesis and shows that the reform caused a larger decrease of the Lerner index in initially more concentrated sectors. The estimated coefficients imply that one standard deviation increase in the initial Lerner index decrease the level of concentration by 3% following the reform.

5.7 Aggregate Productivity Growth

In the previous sections, I have shown that the deregulation of international financial flows in Hungary was associated with increases in firms' productivity. In this section, I test whether this expansion is consistent with an increase in aggregate productivity growth as stated in proposition 4. Next, to understand the source of this growth, I break it down into improvements in within-firm growth and reallocation effects across firms.

To assess proposition 4, I use the entire sample period over 1992-2008. I follow Petrin and Levinsohn (2011) and define aggregate RTFP as the difference between the aggregate value added and aggregate expenditures on labor and capital. I normalize its value to the initial year of the database (1992), and test for a structural break in its growth trend. In particular, I follow Perron and Zhu (2005) and estimate,

$$RTFP_t = \alpha + \beta_1 TR_t + \beta_2 SB_t + \varepsilon_t, \tag{17}$$

where t denotes year; TR is a time-trend; and $SB = \text{year} - 2001$ if year ≥ 2002 and 0 otherwise, and represents the structural break in slope. Coefficient β_1 absorbs the time trend in aggregate RTFP, and coefficient β_2 captures the change in its trend following the financial liberalization. Column 1 in Table 14 reports the results of a regression where only the time trend is included. The estimation of equation (17) is presented in column 2. The coefficient β_2 is positive and statistically significant at the one percentage point level, confirming the acceleration in the RTFP growth rate after the reform. Columns 3-6 present a set of robustness tests. Column 3 includes as a regressor a variable absorbing changes in levels after the reform. Column 4 tests for a change in the slope of

RTFP growth after the trade liberalization in 1996. Columns 5 and 6 include falsification tests for structural breaks in slopes in 1998 and the year of joining the EU. None of these controls affects the estimated coefficient for the acceleration of aggregate RTFP following the financial liberalization.

Sources of Aggregate Productivity Growth

Results presented above associate the financial openness in Hungary with an acceleration of aggregate RTFP growth. To understand the source of this expansion, I now turn to break down this growth between reallocation effects across firms and increases in within-firm productivity.

With this end, I follow Petrin and Levinsohn (2011) and first define aggregate productivity growth as the change in aggregate value added minus the change in aggregate expenditures on labor and capital. Next, I break this down into a component related to aggregate changes in technical efficiency (TE) and a component aggregating reallocation effects (RE). The technical efficiency component is straightforward and reflects the contribution to aggregate productivity of increases in firms' efficiency, holding inputs constant. More precisely, this term is the sum of changes in firm's RTFP weighted by the firm's share in total value added. The reallocation term aggregates changes in input allocation across firms. As is well established in the literature, firm-level distortions create wedges between the input elasticities and input shares in production (Restuccia and Rogerson 2008; Hsieh and Klenow 2009, among others). In the presence of these wedges, reallocation of inputs across firms can affect aggregate RTFP. In particular, the reallocation term is the sum of the net gain in the allocation of inputs across firms weighted by the firm's share in value added. Therefore, as in Petrin and Levinsohn (2011), aggregate RTFP growth can be expressed as,

$$\Delta\, RTFP_t = TE_t + RE_t = \sum_{i,t}^{N_t} D_{it}\, \Delta RTFP_{it} + \sum_{i,t}^{N_t} \sum_{i,z,t} D_{it}(\varepsilon_{izt} - \theta_{izt})\Delta Z_{izt}, \tag{18}$$

where i and t denote firm and year; N_t denotes the total number of firms in the economy; D_{it} is the firm's share in total value added, where the weight is computed as the average between t and $t-1$; $\Delta RTFP_{it}$ is firm's RTFP growth; Z denotes inputs: capital and labor; ε is the input elasticity; and θ is the input share in value added.

Table 15 Panel A presents the mean growth rate of aggregate RTFP and its components in the three years preceding and following the reform (1998-00 and 2002-04). Panel B reports the contribution of RTFP components to aggregate growth. Remarkably, in the years before the liberalization, within-firm productivity growth was only 1% yearly, and aggregate RTFP growth (5.8%) was mostly explained by reallocation effects, which accounted for 4.8% per year (columns 2 and 3). Crucially, this pattern of growth was sharply reversed after the financial openness. In the three years following the reform, within-firm productivity grew at an average pace of 7.9% per year and the reallocation term decreased to 1.7% per year. Thus, in the post-reform period within-firm productivity explained the bulk of the expansion in aggregate RTFP: 82%. The rise in within-firm productivity is mostly explained by the balanced panel of firms used above, which follows from the large market share of these firms in the economy (column 4). This large increase in within-firm

productivity is consistent with previous studies highlighting its importance vis-à-vis reallocation effects following structural reforms, as for example Bollard, Klenow, and Sharma (2013).

What can create these two opposite patterns of growth before and after the financial openness? Or, put differently, why did within-firm productivity grow at such a low pace before the reform and at a high pace after it? The conjecture that emerges from this paper is that it is the change in all firms' incentives to invest in technology that raises it. In particular, according to the mechanism studied in this paper, distortions in the access to capital markets undermine competition and economy-wide innovation incentives. It is then natural that before the reform, within-firm productivity grew at a low pace. By reducing distortions in the access to international capital markets across firms, financial openness relaxes financing terms of discriminated firms and unchains pro-competitive forces that lead all firms to invest more in technology. As shown by the model, not only do firms that gain access to international funds invest more in technology, but so do their market rivals. It is the tighter competition that leads the latter to do so. In this way, it is the reallocation of capital towards previously discriminated firms, which leads all firms to invest more in technology and explains the broad expansion in within-firm productivity. From this perspective, reallocation and within-firm theories are not alternative explanations of the increase in aggregate productivity, but two-sides of the same economic process as the reallocation of resources unchains within-firm productivity growth.

6 Conclusion

This paper shows that the effect of capital market distortions on aggregate productivity can be magnified through its negative effect on competition. Using firm-level census data around a liberalization episode, which reduced asymmetries in the access to international borrowing across firms, this paper has tested this mechanism against the data.

I have started by showing that financial openness relaxes financing terms of previously discriminated firms. However, despite the resulting reallocation of resources, I have also shown that the increase in within-firm productivity explains the bulk of the increase in aggregate TFP following financial liberalization. I have argued that these two seemingly contradictory forces can be reconciled by the presence of pro-competitive forces. It is precisely the reallocation of resources towards previously discriminated firms, which - by deepening competition - leads all firms to invest more in technology. From the perspective of this paper, reallocation and within-firm theories are not alternative explanations for the increase in aggregate productivity but two sides of the same economic process that jointly operate during financial openness.

Once one starts to think about the impact of firm-level distortions on competition, other questions emerge. Can other policy distortions undermine competition and, through this channel, affect aggregate productivity? For example, can producer-specific licenses or subsidized credit to state-owned companies affect the market structure and, through competition, amplify the effect of the

misallocation on aggregate productivity? This paper has studied how a particular policy - creating asymmetries in the access to international capital markets - undermined economy-wide incentives to invest in technology. More work is required in order to understand whether and how policy distortions affect market structure more generally, thereby magnifying the effect of the misallocation of resources on aggregate TFP via the pro-competitive channel stressed here.

References

Acemoglu, D., and U. Akcigit (2011): "State-Dependent Intellectual Property Rights Policy," *MIT Department of Economics Working Paper*.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt (2005): "Competition and Innovation: An Inverted U Relationship," *The Quarterly Journal of Economics*, pp. 701–728.

Aghion, P., and P. Howitt (2009): *The Economics of Growth*, vol. 1 of *MIT Press Books*. The MIT Press.

Askenazy, P., C. Cahn, and D. Irac (2013): "Competition, R&D, and the cost of innovation: evidence for France," *Oxford Economic Papers*, 65(2), 293–311.

Atkeson, A., and A. T. Burstein (2010): "Innovation, Firm Dynamics, and International Trade," *Journal of Political Economy*, 118(3), 433–484.

Beck, T., R. Levine, and N. Loayza (2000): "Finance and the sources of growth," *Journal of Financial Economics*, 58(1-2), 261–300.

Bekaert, G., C. R. Harvey, and C. Lundblad (2011): "Financial Openness and Productivity," *World Development*, 39(1), 1–19.

Benhabib, J., and M. M. Spiegel (2000): "The Role of Financial Development in Growth and Investment," *Journal of Economic Growth*, 5(4), 341–60.

Bertrand, M., E. Duflo, and S. Mullainathan (2004): "How Much Should We Trust Differences-in-Differences Estimates?," *The Quarterly Journal of Economics*, 119(1), 249–275.

Bloom, N., M. Schankerman, and J. V. Reenen (2012): "Identifying Technology Spillovers and Product Market Rivalry," CEP Discussion Papers dp0675, forthcoming, Econometrica.

Bollard, A., P. Klenow, and G. Sharma (2013): "India's Mysterious Manufacturing Miracle," *Review of Economic Dynamics*, 16(1), 59–85.

Bond, S., D. Harhoff, and J. V. Reenen (2010): "Investment, R&D and Financial Constraints in Britain and Germany," in *Contributions in Memory of Zvi Griliches*, NBER Chapters, pp. 433–460. National Bureau of Economic Research, Inc.

Bonfiglioli, A. (2008): "Financial integration, productivity and capital accumulation," *Journal of International Economics*, 76(2), 337–355.

Buera, F. J., J. P. Kaboski, and Y. Shin (2011): "Finance and Development: A Tale of Two Sectors," *American Economic Review*, 101(5), 1964–2002.

Caballero, R., K. Cowan, and J. Kearns (2004): "Fear of Sudden Stops: Lessons from Australia and Chile," NBER Working Papers 10519, National Bureau of Economic Research, Inc.

Chinn, M., and H. Ito (2008): "A New Measure of Financial Openness," *Journal of Comparative Policy Analysis*, 9, 309–322.

Crepon, B., E. Duguet, and J. Mairesse (1998): "Research Investment, Innovation and Productivity: An Econometric Analysis at the Firm Level," Papiers d'Economie Mathematique et Applications 98.15, Universite Pantheon-Sorbonne (Paris 1).

Desai, M. A., C. F. Foley, and K. J. Forbes (2008): "Financial Constraints and Growth: Multinational and Local Firm Responses to Currency Depreciations," *Review of Financial Studies*, 21(6), 2857–2888.

Desai, M. A., C. F. Foley, and J. R. Hines (2003): "A Multinational Perspective on Capital Structure Choice and Internal Capital Markets," NBER Working Papers 9715, National Bureau of Economic Research, Inc.

Edmond, C., V. Midrigan, and D. Y. Xu (2014): "Competition, Markups, and the Gains from International Trade," .

Farhi, E., and I. Werning (2012): "Dealing with the Trilemma: Optimal Capital Controls with Fixed Exchange Rates," NBER Working Papers 18199, National Bureau of Economic Research, Inc.

Foster, L., J. Haltiwanger, and C. Syverson (2008): "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?," *American Economic Review*, 98(1), 394–425.

Gorodnichenko, Y., and M. Schnitzer (2010): "Financial constraints and innovation: Why poor countries don't catch up," NBER Working Papers 15792, National Bureau of Economic Research, Inc.

Grossman, G. M., and E. Helpman (1991): "Trade, knowledge spillovers, and growth," *European Economic Review*, 35(2-3), 517–526.

Heckman, J. J. (1974): "Shadow Prices, Market Wages, and Labor Supply," *Econometrica*, 42(4), 679–94.

——— (1979): "Sample Selection Bias as a Specification Error," *Econometrica*, 47(1), 153–61.

Holmes, T., and J. Schmitz (2010): "Competition and productivity: a review of evidence," Staff Report 439, Federal Reserve Bank of Minneapolis.

Hsieh, C.-T., and P. Klenow (2009): "Misallocation and Manufacturing TFP in China and India," *Quarterly Journal of Economics*, 124(4), 1403–1448.

IMF (1998): "Hungary: Economic Policies for Sustainable Growth," Discussion paper, International Monetary Fund.

Kalemli-Ozcan, S., and B. E. Sorensen (2012): "Misallocation, Property Rights, and Access to Finance: Evidence from Within and Across Africa," Working Paper 18030, National Bureau of Economic Research.

King, R. G., and R. Levine (1993a): "Finance and Growth: Schumpeter Might Be Right," *The Quarterly Journal of Economics*, 108(3), 717–37.

King, R. G., and R. Levine (1993b): "Finance, entrepreneurship and growth: Theory and evidence," *Journal of Monetary Economics*, 32(3), 513–542.

Klette, T. J., and S. Kortum (2004): "Innovating Firms and Aggregate Innovation," *Journal of Political Economy*, 112(5), 986–1018.

Lerner, A. (1934): "The Concept of Monopoly and the Measurement of Monopoly Power," *The Review of Economic Studies*, 1, No 3, 157–175.

Levine, R. (2001): "International Financial Liberalization and Economic Growth," *Review of International Economics*, 9(4), 688–702.

Loecker, J. D., and F. Warzynski (2012): "Markups and Firm-Level Export Status," *American Economic Review*, 102(6), 2437–71.

Mairesse, J., and P. Mohnen (2010): "Chapter 26 - Using Innovation Surveys for Econometric Analysis," in *Handbook of the Economics of Innovation, Volume 2*, ed. by B. H. Hall, and N. Rosenberg, vol. 2 of *Handbook of the Economics of Innovation*, pp. 1129 – 1155. North-Holland.

Midrigan, V., and D. Y. Xu (2014): "Finance and Misallocation: Evidence from Plant-Level Data," *American Economic Review*, 104(2), 422–58.

Mulkay, B., B. H. Hall, and J. Mairesse (2000): "Firm Level Investment and R&D in France and the United States: A Comparison," NBER Working Papers 8038, National Bureau of Economic Research, Inc.

Nickell, S. (1996): "Competition and Corporate Performance," *Journal of Political Economy*, 104(4), 724–46.

Olley, G. S., and A. Pakes (1996): "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 64(6), 1263–97.

Perron, P., and X. Zhu (2005): "Structural breaks with deterministic and stochastic trends," *Journal of Econometrics*, 129(1-2), 65–119.

Peters, M. (2013): "Heterogeneous Mark-Ups and Endogenous Misallocation," *Mimeo*.

Petrin, A., and J. Levinsohn (2011): "Measuring Aggregate Productivity Growth Using Plant-Level Data," NBER Working Papers 11887, RAND Journal of Economics.

Raddatz, C. (2006): "Liquidity needs and vulnerability to financial underdevelopment," *Journal of Financial Economics*, 80(3), 677–722.

Rajan, R. G., and L. Zingales (1998): "Financial Dependence and Growth," *American Economic Review*, 88(3), 559–86.

Restuccia, D., and R. Rogerson (2008): "Policy Distortions and Aggregate Productivity with Heterogeneous Plants," *Review of Economic Dynamics*, 11(4), 707–720.

——— (2013): "Misallocation and productivity," *Review of Economic Dynamics*, 16(1), 1–10.

Schindler, M. (2009): "Measuring Financial Integration: A New Data Set," *IMF Staff Papers*, 56(1), 222–238.

Smith, R. C., I. Walter, and G. DeLong (2012): *Global Banking*. Oxford University Press.

Stokey, N. L. (1995): "R&D and Economic Growth," *Review of Economic Studies*, 62(3), 469–89.

Tirole, J. (1988): *The Theory of Industrial Organization*, vol. 1 of *MIT Press Books*. The MIT Press.

Weller, C. E., and M. Scher (2001): "Multinational Bank Credit in Less Industrialized Economies," *Journal of International Business Studies*, 32(4), 833–851.

Weller, C. E., and M. J. Scher (1999): "Multinational banks and development finance," ZEI working paper B 16-1999, ZEI working paper, Bonn.

Wooldridge, J. M. (2009): "On estimating firm-level production functions using proxy variables to control for unobservables," *Economics Letters*, 104(3), 112–114.

Figures and Tables

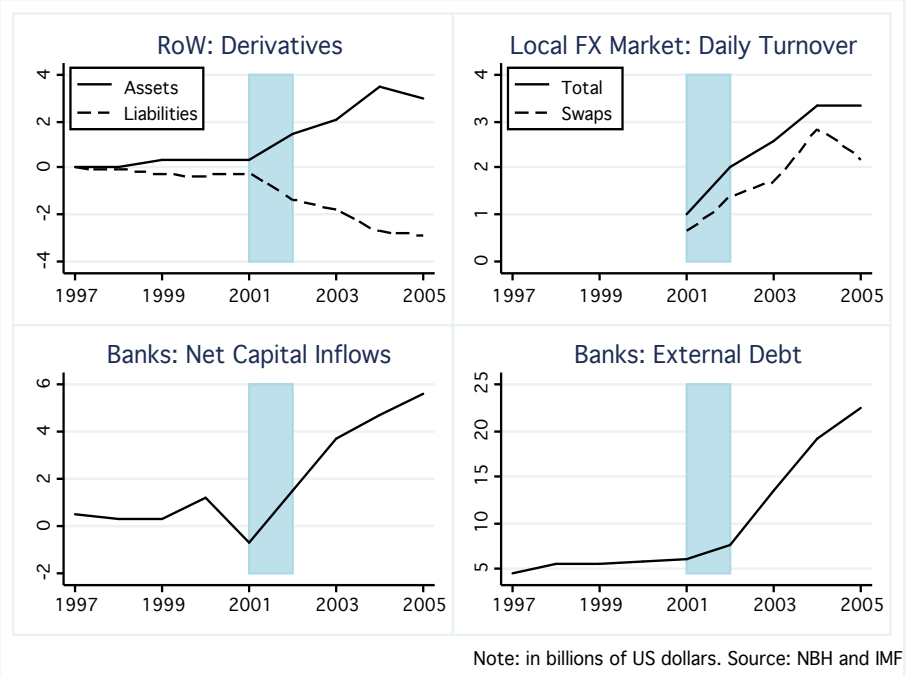

Figure 1: International Borrowing of Financial Institutions

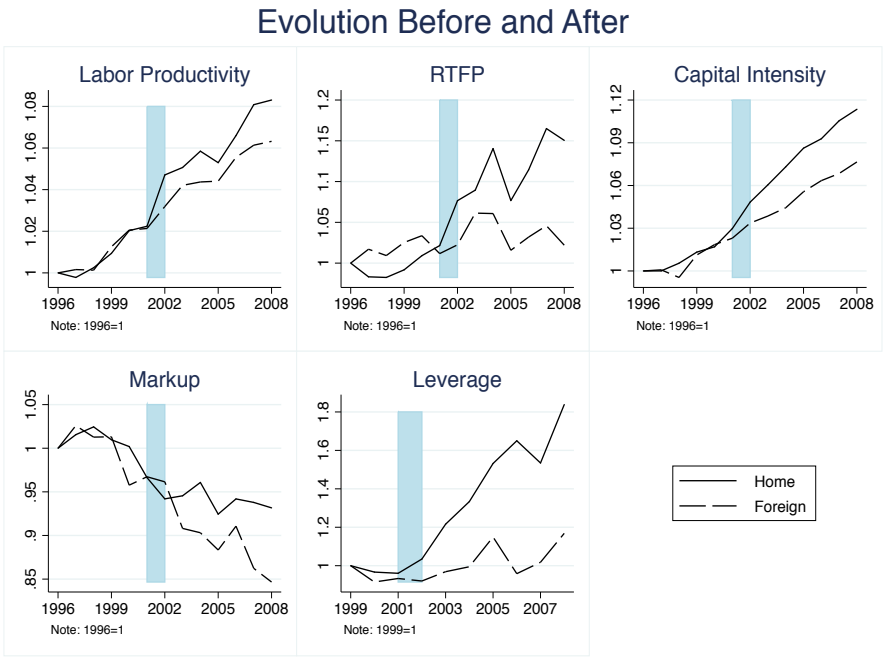

Figure 2: Evolution of Main Variables Before and After the Reform

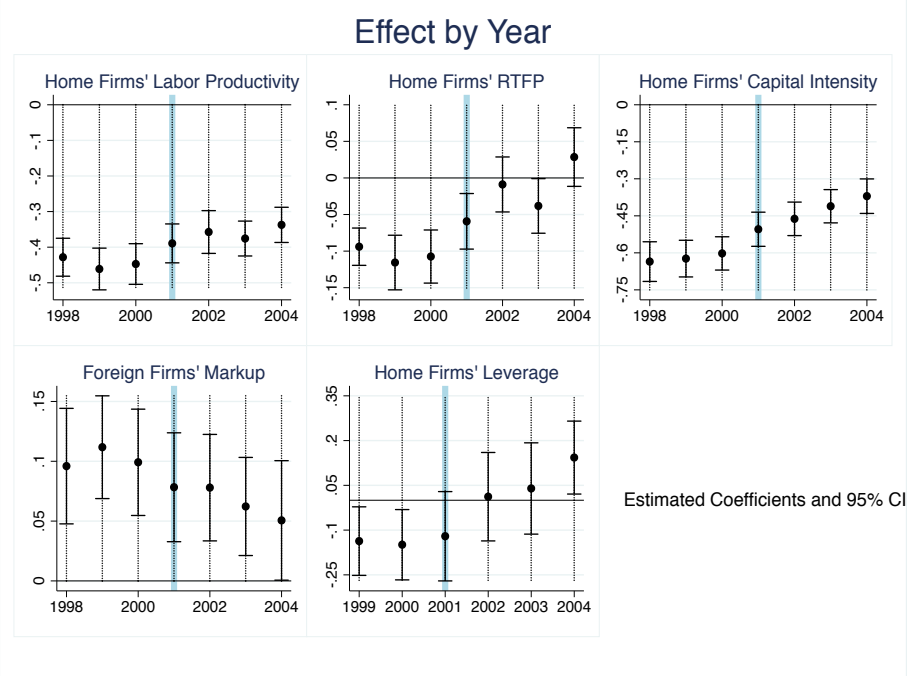

Figure 3: Effect by Year

Table 1: Credit Market Before and After the Liberalization

Aggregate Economy (in%)	Before	After
Credit-to-GDP ratio	27	44
Credit-to-deposit ratio	83	113
Lending interest rate	12.8	7.5
Firms		
Credits to SME	34	51
SME debt in FX	0	33
Interest rate differential b. Home and Foreign	3.2	0.65
Differential in collateral b. Home and Foreign	58	11

Notes: For rows 1-5 the source is National Bank of Hungary, and data corresponds to December 2000 and December 2004. Rows 6-7 come from Business Environment and Enterprise Performance Survey of the World Bank and EBRD, for the years 2001 and 2004.

Table 2: Market Concentration Before and After the Reform

	Before	After
Market Share of Foreign Firms	0.74	0.68
Lerner Index	0.22	0.20
Herfindahl Index	0.40	0.37

Table 3: Concentration, RTFP and Markup Dispersions Before the Reform

	Mean (1)	RTFP Dispersion (2)	Markup Dispersion (3)	Lerner Index (4)
Market Share of Foreign Firms	0.74	0.3568*** (0.0003)	0.2184** (0.0335)	0.2394** (0.0118)
N	82	82	78	82

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Column 1 is the mean market share of Foreign firms in the industry value added. Column 2-4 are 3-digit NACE industries correlations before the reform (1998-2000). Source: APEH.

Table 4: Mean Characteristics of Home and Foreign Firms (1998)-APEH Database

	Foreign	Home	Difference in Means
	(In logs)		
Value Added	10.6549	9.0769	1.5779***
	(0.0525)	(0.0226)	(0.0500)
Employment	3.8952	2.8602	1.0349***
	(0.0429)	(0.0191)	(0.0418)
Labor productivity	6.7596	6.2167	0.5429***
	(0.0263)	(0.0131)	(0.0278)
RTFP	1.4093	1.1959	0.2133***
	(0.0267)	(0.0139)	(0.0291)
Markup	0.2391	0.1774	0.0617***
	(0.0159)	(0.0098)	(0.0197)
Age	1.6167	1.4777	0.1390***
	(0.0136)	(0.0090)	(0.0179)
Quantity of Firms	1,283	4,165	5,448

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Source: APEH.

Table 5: Mean Characteristics of Home and Foreign Firms (2001)-BEEPS Database

	Foreign	Home	Difference in Means
Probability of Innovation	0.5946	0.3521	0.2425***
	(0.0818)	(0.0328)	(0.0858)
Probability of R&D	0.3206	0.1675	0.1532***
	(0.0647)	(0.0267)	(0.0614)
Interest Rate Paid	9.0667	13.3198	-4.2531***
	(0.9200)	(0.5845)	(1.2687)
Required Value of Collateral	124.2105	185.2874	-61.0768***
	(13.7504)	(11.5619)	(25.6236)
Quantity of Firms	53	197	250

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Source: BEEPS.

Table 6: Growth Rates Preceding the Reform

Balanced Panel	Home	Foreign	Difference in Means
Capital Intensity	0.0235	0.0289	-0.0054
	(0.0032)	(0.0040)	(0.0061)
Labor Productivity	0.0554	0.0697	-0.0143
	(0.0043)	(0.0074)	(0.0087)
RTFP	0.0264	0.0395	-0.0132
	(0.0041)	(0.0071)	(0.0082)
Markup	-0.0076	0.0058	-0.0133*
	(0.0040)	(0.0068)	(0.0080)
Indebtedness Ratio	-0.0077	0.0364	-0.0441
	(0.0345)	(0.0644)	(0.0692)
N	17,765	5,654	23,419

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. The table reports the mean of the variable growth rate within the five years prior to the reform (1996-2000). Source: APEH.

Table 7: Investment in Capital and Productivity

	Δ Capital Intensity			Δ Labor Productivity			Δ RTFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Home	0.239***	0.253***	0.252***	0.074***	0.051***	0.053***	0.098***	0.032**	0.032**
	(0.023)	(0.025)	(0.025)	(0.017)	(0.017)	(0.016)	(0.015)	(0.014)	(0.016)
Firm-level controls		yes	yes		yes	yes		yes	yes
Local trends			yes			yes			yes
Global trends			yes			yes			yes
R^2	0.019	0.030	0.030	0.004	0.027	0.040	0.008	0.075	0.088
N	5,448	5,448	5,448	5,448	5,448	5,448	5,448	5,448	5,448

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. All regressions include a constant term. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Source: APEH.

Table 8: R&D and Innovation Activities

	R&D Activities			Innovation Activities		
	(1)	(2)	(3)	(4)	(5)	(6)
Home	-0.153***	-0.058	-0.032	-0.242***	-0.158**	-0.090
	(0.028)	(0.032)	(0.030)	(0.057)	(0.054)	(0.056)
Home*Reform	0.107*	0.083**	0.090*	0.176**	0.167**	0.122*
	(0.048)	(0.033)	(0.044)	(0.066)	(0.055)	(0.056)
Reform	0.023	0.046	0.023	-0.084	-0.071	-0.099
	(0.055)	(0.052)	(0.043)	(0.063)	(0.075)	(0.081)
Firm-level controls		yes	yes		yes	yes
Sector-fixed effects			yes			yes
R^2	0.019	0.064	0.081	0.014	0.037	0.069
N	774	774	774	774	774	774

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered industry level. All regressions include a constant term. R&D is a dummy if the firm reports positive R&D expenditures. Innovation is a dummy if a firms reports any of the following activities: developed successfully a major product line, upgraded an existing product line, acquired a new production technology, obtained a new licensing agreement, and obtained a new quality accreditation. Firm-level controls are age and size. Source: BEEPS.

Table 9: Financial Dependence: Investment in Capital and Productivity

	Δ Capital Intensity			Δ Labor Productivity			Δ RTFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Home	0.210***	0.221***	0.219***	0.058***	0.017	0.015	0.083***	-0.010	-0.016
	(0.021)	(0.024)	(0.024)	(0.017)	(0.015)	(0.017)	(0.018)	(0.023)	(0.023)
Home * Fin.Dep.	0.142*	0.156*	0.155*	0.093*	0.155***	0.147***	0.087	0.181**	0.167**
	(0.080)	(0.076)	(0.077)	(0.053)	(0.045)	(0.046)	(0.072)	(0.080)	(0.067)
Fin. Dep.	-0.084	-0.061	-0.053	0.276**	0.320**	0.334**	0.162	0.222**	0.277***
	(0.064)	(0.070)	(0.077)	(0.124)	(0.124)	(0.134)	(0.107)	(0.10)	(0.092)
Firm-level controls		yes	yes		yes	yes		yes	yes
Local trends			yes			yes			yes
Global trends			yes			yes			yes
R^2	0.020	0.031	0.031	0.034	0.074	0.081	0.022	0.111	0.120
N	5,143	5,143	5,143	5,143	5,143	5,143	5,143	5,143	5,143

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. All regressions include a constant term. Financial Dependence is the Rajan and Zingales' (1998) index. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Source: APEH.

Table 10: Financing Terms

	Interest Rate			Value of Collateral		
	(1)	(2)	(3)	(4)	(5)	(6)
Home	4.253***	3.707***	3.729***	60.789***	49.174**	52.106***
	(1.132)	(1.027)	(1.051)	(15.391)	(15.727)	(11.263)
Home*Reform	-3.879**	-3.858***	-3.947***	-37.653*	-35.438*	-31.170**
	(1.134)	(1.018)	(1.076)	(17.130)	(17.104)	(10.911)
Reform	-0.026	-0.159	-0.221	20.968	19.574	13.368
	(0.951)	(0.830)	(0.890)	(12.571)	(13.192)	(11.635)
Firm-level controls		yes	yes		yes	yes
Sector- fixed effects			yes			yes
R^2	0.175	0.202	0.217	0.035	0.045	0.103
N	415	415	415	399	399	399

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered industry level. All regressions include a constant term. Firm-level controls are age and size. Source: BEEPS.

Table 11: Leverage

	Δ Leverage			
	(1)	(2)	(3)	(4)
Home	0.160**	0.239***	0.230***	0.238**
	(0.073)	(0.085)	(0.088)	(0.100)
Home* Fin. Dep.				0.526**
				(0.266)
Financial Dependence				-0.595**
				(0.234)
Firm-level controls		yes	yes	yes
Local trends			yes	yes
Global trends			yes	yes
R^2	0.002	0.006	0.007	0.015
N	2,742	2,742	2,742	2,742

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. All regressions include a constant term. Financial Dependence is the Rajan and Zingales (1998) index. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Source: APEH.

Table 12: Foreign Firms' Markups

	Δ Markups			
	(1)	(2)	(3)	(4)
Foreign	-0.017*	-0.025**	-0.026**	0.030*
	(0.009)	(0.011)	(0.012)	(0.016)
Foreign*Fin.Dep.				-0.205***
				(0.043)
Financial Dependence				0.212***
				(0.069)
Firm-level control		yes	yes	yes
Local trend			yes	yes
Global trends			yes	yes
R^2	0.000	0.023	0.024	0.057
N	5,376	5,376	5,376	5,086

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. All regressions include a constant term. Financial Dependence is the Rajan and Zingales (1998) index. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Source: APEH.

Table 13: Markup and RTFP Dispersions and Industry Concentration

	Change in RTFP Dispersion			Change in Markup Dispersion			Change in Concentration		
	Late 90s	Reform	Accounting for Pre-trends	Late 90s	Reform	Accounting for Pre-trends	Late 90s	Reform	Accounting for Pre-trends
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Initial Value	-0.076	-0.202**	-0.076	-0.419***	-0.730***	-0.419***	-0.177***	-0.317***	-0.177***
	(0.064)	(0.079)	(0.077)	(0.063)	(0.135)	(0.079)	(0.075)	(0.085)	(0.060)
Initial Value *T			-0.222**			-0.310**			-0.245***
			(0.107)			(0.140)			(0.091)
T			0.186			0.134**			0.211***
			(0.128)			(0.054)			(0.072)
R^2	0.018	0.074	0.100	0.354	0.280	0.325	0.101	0.145	0.223
N	82	82	164	78	78	156	82	82	164

Notes: all regressions include a constant term. *, **, *** significant at 10, 5, and 1 percent. Std errors in parenthesis. 3-digit NACE industries correlations. Source: APEH.

Table 14: Acceleration of RTFP Growth

	Cumulative RTFP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Time trend	17.586***	13.884***	13.523***	14.468***	13.845***	13.625***
	(0.630)	(0.537)	(0.601)	(3.319)	(1.019)	(0.574)
Structural break in slope		8.992***	8.407***	9.115***	8.897***	11.083***
(Financial Openness, 2001)		(1.120)	(1.194)	(1.351)	(2.368)	(2.100)
Structural break in level			7.015			
(Financial Openness, 2001)			(5.620)			
Structural break in slope				-0.673		
(Trade Liberalization, 1996)				(3.769)		
Structural break in slope					0.116	
(Falsification test,1998)					(2.527)	
Structural break in slope						-3.513
(Falsification test, 2004)						(2.999)
R^2	0.981	0.997	0.997	0.997	0.997	0.997
N	17	17	17	17	17	17

Notes: all regressions include a constant term. *,**, *** significant at 10, 5, 1%, respectively. Source: APEH.

Table 15: Contribution to Aggregate RTFP Growth

	Total Sample			Balanced Panel
	ΔRTFP	Reallocation	Within-Firm	Within-Firm
	(1)	(2)	(3)	(4)
	A- Mean Growth Rate			
Before	5.8	4.8	1.0	0.9
After	9.7	1.7	7.9	7.3
	B- Contribution to Aggregate RTFP Growth (column 1)			
Before	100.0	83.4	16.5	16.5
After	100.0	18.0	82.0	75.4

Appendix A Model: Comparative Statics

Proposition 1. $\frac{\partial x^o_{(F)}}{\partial \tau} < 0$ and $\frac{\partial x^o_{(H)}}{\partial \tau} < 0$. This can be directly seen from equations (3). Furthermore, $|\frac{\partial x^o_{(F)}}{\partial \tau}| < |\frac{\partial x^o_{(H)}}{\partial \tau}|$.

Proposition 2. As equations (1) demonstrate, foreign firms' markups stem from two sources: the technology gap with their local competitors and the difference in financing terms. Both of them decrease in τ. To see this, consider first how the reduction in distortions in international capital markets affects the technology gap between foreign and home firms. Notice that, at the end of the period, the technology gap between foreign and home firms within an industry will be:

$$\begin{cases} \Delta + 1 & \text{with probability} \quad x^o_{(F)} \\ -1 & \text{with probability} \quad x^o_{(H)} \\ \Delta & \text{with probability} \quad (1 - x^o_{(F)} - x^o_{(H)}). \end{cases} \tag{19}$$

Under the law of large numbers, the expected technology gap between F and H firms Δ^e becomes:

$$\Delta^e = \Delta + x^o_{(F)} - (1 + \Delta) x^o_{(H)}. \tag{20}$$

As $\frac{\partial \Delta^e}{\partial \tau} > 0$, reductions in distortions in capital markets reduce the productivity gap between foreign and home firms. Recall that foreign firms' expected markups are given by:

$$\xi^e_{(F,\Delta)} = \tau\, \lambda^{\Delta+1} x_{(F)} + \tau\, \lambda^{\Delta} (1 - x_{(F)} + x_{(H)}). \tag{21}$$

Using equations (20) and (21), the change in foreign firms' expected markups is:

$$\frac{\partial \xi^e_{(F,\Delta)}}{\partial \tau} = \underbrace{\lambda^{\Delta} \left(1 + x^o_{(F)}(\lambda - 1) - x^o_{(H)}\right) \left(1 + \tau \ln(\lambda) \frac{\partial \Delta^e}{\partial \tau}\right)}_{>0} + \underbrace{\tau \lambda^{\Delta} \left((\lambda - 1) \frac{\partial x^o_{(F)}}{\partial \tau} - \frac{\partial x^o_{(H)}}{\partial \tau}\right)}_{>0} > 0.$$

Therefore, foreign firms' markups decrease following the reduction in distortions in international capital markets.

Proposition 3. From equation (20), it can be directly seen that $\frac{\partial \Delta^e}{\partial \tau \partial \Delta} > 0$.

Proposition 4. The sign of $\frac{\partial g_q}{\partial \tau}$ results directly from proposition 1.

Additional Figures, Robustness Tests, and Model's Additional Derivations and Extensions

(Not for publication)

Appendix B Additional Figures

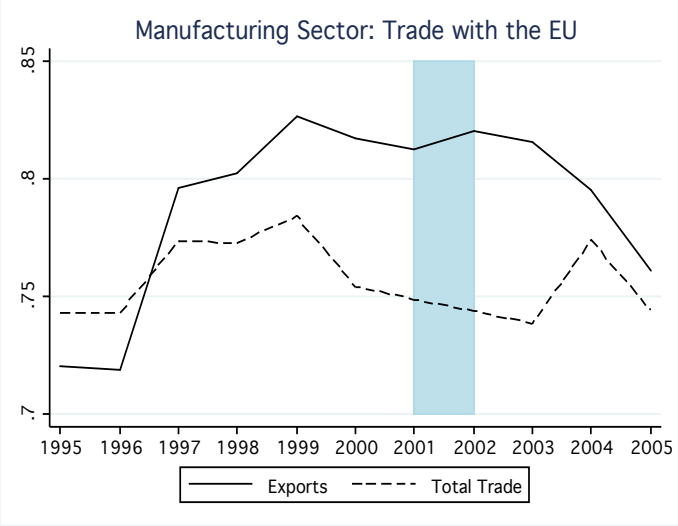

Figure B1: Total trade and exports with the European Union

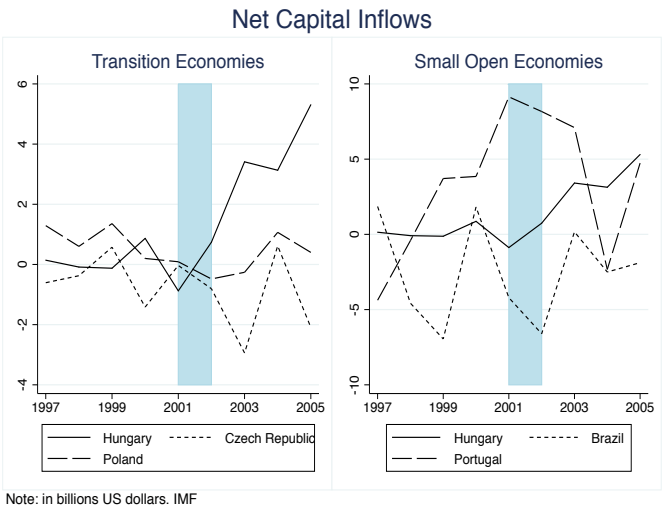

Figure B2: Net Capital Inflows to Transition and Small Open Economies. Comparison

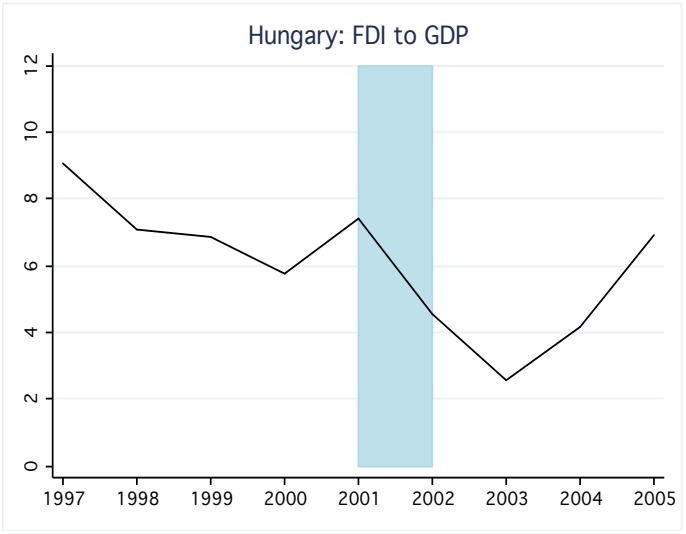

Figure B3: Evolution of Foreign Direct Investment

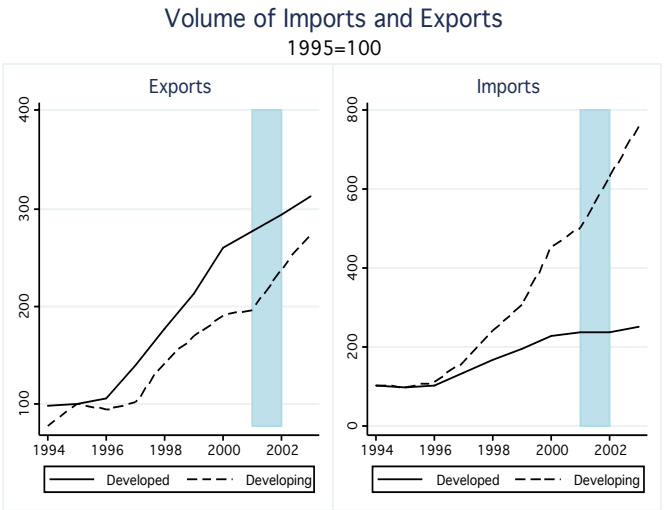

Figure B4: Evolution of Trade

Additional Tables: Robustness Tests

Table B1: Firm Survival

	Firm Survival		
	Home	Foreign	Difference in Means
Survival Ratio	0.8672	0.8579	0.0092
	(0.0026)	(0.0060)	(0.0064)
N	16,826	3,323	20,149

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors in parenthesis. The table reports the mean of a dummy variable on surviving after the reform. In particular, for all existing firms prior to the reform (in 2000), surviving = 1 if the firm did not exit within the three years following the reform (2002-2004), and 0 otherwise. Source: APEH.

Table B2: Robustness Test: Investment in Capital and Productivity

	Δ Capital Intensity				
	(1)	(2)	(3)	(4)	(5)
Home	0.249***	0.171***	0.254***	0.241***	0.282***
	(0.026)	(0.031)	(0.027)	(0.026)	(0.026)
Firm-level controls	yes	yes	yes	yes	yes
Sector-fixed effects	yes				
Local trends		yes	yes	yes	yes
Global trends		yes	yes	yes	yes
R^2	0.060	0.019	0.029	0.029	0.031
N	5,448	4,747	4,950	4,881	5,158
	Δ Labor Productivity				
	(1)	(2)	(3)	(4)	(5)
Home	0.046***	0.070***	0.052***	0.061***	0.060***
	(0.015)	(0.020)	(0.018)	(0.016)	(0.017)
Firm-level controls	yes	yes	yes	yes	yes
Sector-fixed effects	yes				
Local trends		yes	yes	yes	yes
Global trends		yes	yes	yes	yes
R^2	0.235	0.040	0.039	0.029	0.040
N	5,448	4,747	4,950	4,881	5,158
	Δ RTFP				
	(1)	(2)	(3)	(4)	(5)
Home	0.032*	0.057***	0.031*	0.039**	0.039**
	(0.016)	(0.020)	(0.018)	(0.017)	(0.018)
Firm-level controls	yes	yes	yes	yes	yes
Sector-fixed effects	yes				
Local trends		yes	yes	yes	yes
Global trends		yes	yes	yes	yes
R^2	0.155	0.088	0.086	0.077	0.087
N	5,448	4,747	4,950	4,881	5,158

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors are clustered at 4-digit NACE industries. All regressions include a constant term. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and TFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Column 1 controls for four-digit industry fixed effects. Column 2 removes those foreign firms whose foreign shares exceed more than 90% of total shares on average between 1998 and 2000. Column 3 restrict the analysis to foreign firms that are not used as export platforms (more than 90% of exports). Column 4 removes the top 1 percentile of firms (in value added). Column 5 controls for firms that change the ownership status between the pre- and post-reform periods. Source: APEH.

Table B3: Credit Market Before the Liberalization: Home Firms

	Exporters	Non-Exporters	Difference in Means
Paid Interest Rate	13.3250	13.2015	0.1234
	(1.5917)	(0.6585)	(1.5478)
Required Collateral	4.8618	5.0060	-0.1441
	(0.1301)	(0.0479)	(0.1134)
Leverage	0.0952	0.0977	0.0025
	(0.0058)	(0.0054)	(0.0086)

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Rows 1 and 2 come from Business Environment and Enterprise Performance Survey of the World Bank and EBRD, for the years 2001 and 2004. Row 3 uses APEH data. The ratio debt-to-sales is computed using the short-term debt over sales. Row 2 is in logs.

Table B4: Investment in Capital and Productivity: Home Exporters vs Non-Exporters

	Δ Capital Intensity	Δ Labor Productivity	Δ RTFP
	(1)	(2)	(3)
Home	0.255***	0.060***	0.034*
	(0.027)	(0.019)	(0.018)
Home*Exporter	-0.012	-0.023	-0.004
	(0.025)	(0.025)	(0.020)
Firm controls	yes	yes	yes
Local trends	yes	yes	yes
Global trends	yes	yes	yes
R^2	0.030	0.041	0.088
N	5,448	5,448	5,448

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. All regressions include a constant term. Exporter is defined as having an average export share larger than 0.05 between 1998 and 2000. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Source: APEH.

Table B5: Robustness Test: RTFP and Markups

	Δ RTFP		Δ Markups		
	WLP	DLTL	PCM	WLP	DLTL
	(1)	(2)	(3)	(4)	(5)
Home	0.028***	0.081***			
	(0.009)	(0.026)			
Foreign			-0.127**	-0.034***	-0.024*
			(0.051)	(0.011)	(0.013)
Firm-level controls	yes	yes	yes	yes	yes
Local trends	yes	yes	yes	yes	yes
Global trends	yes	yes	yes	yes	yes
R^2	0.034	0.065	0.006	0.028	0.019
N	4,864	4,839	5,029	4,864	4,839

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors are clustered at 4-digit NACE industries. All regressions include a constant term. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and TFP growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Column 1 reports the RTFP measure with the coefficients of the production function estimated following Wooldridge (2009) and Petrin and Levinsohn (2011) methodology. Column 2 reports the RTFP of the translog production function using the De Loecker and Warzynski (2012) methodology to estimate the elasticities of the factor of production. Column 3 reports the price-cost margin estimated as in Aghion, Bloom, Blundell, Griffith, and Howitt (2005). Column 4 and 5 present the markup estimated using the elasticities computed for columns 1 and 2, and following equation (12). Source: APEH.

Table B6: Falsification Test: Effect by Year

	Log Capital Intensity	Log Labor Productivity	Log RTFP
	(1)	(2)	(3)
1998*Home	-0.636***	-0.428***	-0.094***
	(0.041)	(0.027)	(0.013)
1999*Home	-0.623***	-0.461***	-0.116***
	(0.038)	(0.030)	(0.019)
2000*Home	-0.602***	-0.447***	-0.107***
	(0.034)	(0.029)	(0.018)
2001*Home	-0.504***	-0.389***	-0.059***
	(0.035)	(0.028)	(0.019)
2002*Home	-0.462***	-0.357***	-0.009
	(0.035)	(0.031)	(0.019)
2003*Home	-0.411***	-0.376***	-0.038**
	(0.034)	(0.025)	(0.019)
2004*Home	-0.370***	-0.337***	0.029
	(0.036)	(0.025)	(0.020)
Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Firm-Level controls	Yes	Yes	Yes
Global trends	Yes	Yes	Yes
R^2	0.971	0.989	0.894
N	38,136	38,136	38,136
F Tests on Equality of Coefficients			
F-stat: 1998*Home=2000*Home	0.41	0.24	0.37
pvalue	0.5216	0.6257	0.5413
F-stat: 2000*Home=2002*Home	8.83	4.76	14.45
pvalue	0.0030	0.0293	0.0002
F-stat: 2000*Home=2003*Home	16.58	3.66	7.20
pvalue	0.0000	0.0558	0.0074
F-stat: 2000*Home=2004*Home	23.67	8.57	25.47
pvalue	0.0000	0.0035	0.0000

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at year and 4-digit NACE industries. Global industry controls include capital intensity and TFP of the 4-digit NACE industries in the United States between 1998 and 2004. Firm-level controls are employment, labor productivity and age in the initial year (1998). All regressions include 4-digit industries fixed-effects. Source: APEH.

Table B7: Falsification Test-Year 1998: Investment in Capital and Productivity

	Δ Capital Intensity			Δ Labor Productivity			Δ RTFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Home	0.012	0.027	0.023	-0.018	-0.025	-0.022	0.020	-0.017	-0.016
	(0.022)	(0.021)	(0.020)	(0.020)	(0.021)	(0.021)	(0.017)	(0.018)	(0.018)
Firm controls		yes	yes		yes	yes		yes	yes
Local trends			yes			yes			yes
Global trends			yes			yes			yes
R^2	0.000	0.011	0.018	0.000	0.048	0.062	0.000	0.118	0.121
N	4,366	4,366	4,366	4,366	4,366	4,366	4,366	4,366	4,366

Notes: *, **, *** significant at 10, 5, and 1 percent. Period 1996-2000. Std. errors are clustered at 4-digit NACE industries. All regressions include a constant term. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the US between 1996-00. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the early 90s. Firm-level controls are age, employment and RTFP in the initial year (1996). Source: APEH.

Table B8: Panel Regressions: Investments in Capital and Productivity

	log Capital Intensity			log Labor Productivity			log RTFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Home*Reform	0.208***	0.251***	0.231***	0.062***	0.070***	0.043***	0.076***	0.056***	0.051***
	(0.015)	(0.015)	(0.016)	(0.012)	(0.016)	(0.014)	(0.012)	(0.017)	(0.014)
Reform	0.017			0.099***			0.020		
	(0.016)			(0.017)			(0.015)		
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Sector*Year FE		yes	yes		yes	yes		yes	yes
Balanced Panel	no	no	yes	no	no	yes	no	no	yes
R^2	0.880	0.882	0.871	0.784	0.791	0.805	0.809	0.814	0.826
N	59,976	59,976	38,136	60,864	60,864	38,136	59,771	59,771	38,136

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at year and 4-digit NACE industries. All regressions include firm-fixed effects. Regressions (2), (3), (5), (6), (8), (9) include 4-digit NACE industries-year fixed effects. Regressions (1), (2), (4), (5), (7) and (8) includes all firms with 5 or more employees. Regressions (3), (6) and (9) are estimated for the balance panel employed in Table 7. Source: APEH.

Table B9: Quartiles of Financial Dependence: Investment in Capital and Productivity

	Δ Capital Intensity			Δ Labor Productivity			Δ RTFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Home*1(Fin.Dep.=1)	0.225***	0.234***	0.234***	0.058***	0.017	0.034	0.087***	-0.009	-0.014
	(0.033)	(0.035)	(0.035)	(0.013)	(0.034)	(0.031)	(0.015)	(0.027)	(0.028)
Home*1(Fin.Dep.=2)	0.226***	0.226***	0.228***	0.089*	0.057**	0.052*	0.089*	0.024	0.022
	(0.050)	(0.047)	(0.046)	(0.043)	(0.028)	(0.029)	(0.044)	(0.042)	(0.042)
Home*1(Fin.Dep.=3)	0.271***	0.285***	0.279***	0.067***	0.051*	0.051*	0.083***	0.042*	0.036*
	(0.056)	(0.055)	(0.054)	(0.020)	(0.026)	(0.026)	(0.021)	(0.022)	(0.022)
Home*1(Fin.Dep.=4)	0.253***	0.292***	0.298***	0.077**	0.080**	0.091**	0.156***	0.083**	0.075**
	(0.041)	(0.040)	(0.042)	(0.030)	(0.031)	(0.035)	(0.047)	(0.038)	(0.036)
1(Fin.Dep.=2)	0.014	0.033	0.028	0.132	0.160***	0.172***	0.118	0.138**	0.134**
	(0.057)	(0.054)	(0.054)	(0.086)	(0.051)	(0.051)	(0.071)	(0.064)	(0.061)
1(Fin.Dep.=3)	-0.007	0.004	-0.010	0.139*	0.160***	0.180***	0.106	0.125**	0.119**
	(0.043)	(0.044)	(0.046)	(0.078)	(0.054)	(0.052)	(0.068)	(0.051)	(0.051)
1(Fin.Dep.=4)	-0.018	-0.015	-0.034	0.163*	0.190***	0.187***	0.055	0.124**	0.143**
	(0.056)	(0.059)	(0.072)	(0.088)	(0.057)	(0.061)	(0.080)	(0.058)	(0.057)
Firm-level controls		yes	yes		yes	yes		yes	yes
Local trends			yes			yes			yes
Global trends			yes			yes			yes
R^2	0.020	0.031	0.032	0.030	0.069	0.082	0.022	0.109	0.114
N	5,143	5,143	5,143	5,143	5,143	5,143	5,143	5,143	5,143

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at 4-digit NACE industries. All regressions include a constant term. Financial Dependence is the Rajan and Zingales' (1998) index. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Source: APEH.

Table B10: Financial Dependence: Investment in Capital and Productivity-Robustness Test

	Δ Capital Intensity			Δ Labor Productivity			Δ RTFP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Home	0.246***	0.253***	0.252***	0.061***	0.019	0.016	0.080***	-0.015	-0.023
	(0.028)	(0.031)	(0.031)	(0.021)	(0.016)	(0.015)	(0.018)	(0.025)	(0.025)
Home* Fin. Dep.	0.117	0.163*	0.162*	0.080	0.158***	0.154***	0.120	0.218***	0.208***
	(0.093)	(0.083)	(0.084)	(0.069)	(0.054)	(0.049)	(0.086)	(0.084)	(0.072)
Fin. Dep.	-0.066	-0.071	-0.059	0.285***	0.322***	0.329**	0.129	0.193*	0.245***
	(0.059)	(0.067)	(0.073)	(0.083)	(0.108)	(0.122)	(0.098)	(0.098)	(0.089)
Firm-level controls		yes	yes		yes	yes		yes	yes
Local trends			yes			yes			yes
Global trends			yes			yes			yes
R^2	0.022	0.034	0.034	0.035	0.075	0.082	0.022	0.115	0.124
N	4,915	4,915	4,915	4,915	4,915	4,915	4,915	4,915	4,915

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors are clustered at 4-digit NACE industries. All regressions include a constant term. Regressions only include foreign firms whose foreign owned shares exceed the 50%. Financial Dependence is the Rajan and Zingales (1998) index. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the United States between 1998 and 2004. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the late 90s. Firm-level controls are age, employment and RTFP in the initial year (1998). Source: APEH.

Table B11: Falsification Test: Effect by Year

	Log Leverage
	(1)
1999*Home	-0.137**
	(0.055)
2000*Home	-0.149**
	(0.056)
2001*Home	-0.121
	(0.072)
2002*Home	0.012
	(0.071)
2003*Home	0.039
	(0.073)
2004*Home	0.143**
	(0.059)
Year FE	Yes
Sector FE	Yes
Firm-Level controls	Yes
Global trends	Yes
R^2	0.830
N	16,452
F Tests on Equality of Coefficients	
F-stat 1999-00	0.05
pvalue	0.8220
F-stat 2000-02	6.05
pvalue	0.0231
F-stat 2000-03	5.60
pvalue	0.0281
F-stat 2000-04	12.71
pvalue	0.0019

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at year and 4-digit NACE industries. Global industry controls include capital intensity and TFP of the 4-digit NACE industries in the United States between 1998 and 2004. Firm-level controls are employment, labor productivity and age in the initial year (1998). All regressions include 4-digit industries fixed-effects. Source: APEH.

Table B12: Falsification Test: Effect by Year

	Log Markup
	(1)
1998*Foreign	0.096***
	(0.023)
1999*Foreign	0.112***
	(0.021)
2000*Foreign	0.099***
	(0.021)
2001*Foreign	0.078***
	(0.022)
2002*Foreign	0.078***
	(0.021)
2003*Foreign	0.062***
	(0.020)
2004*Foreign	0.051**
	(0.024)
Year FE	Yes
Sector FE	Yes
Firm-Level controls	Yes
Global trends	Yes
R^2	0.190
N	37,632
F Tests on Equality of Coefficients	
F-stat 1998-00	0.08
pvalue	0.7870
F-stat 2000-02	3.49
pvalue	0.0766
F-stat 2000-03	12.62
pvalue	0.0020
F-stat 2000-04	9.10
pvalue	0.0068

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors are clustered at year and 4-digit NACE industries. Global industry controls include capital intensity and TFP of the 4-digit NACE industries in the United States between 1998 and 2004. Firm-level controls are employment, labor productivity and age in the initial year (1998). All regressions include 4-digit industries fixed-effects. Source: APEH.

Table B13: Falsification Test-Year 1998: Markups

	Δ Markups		
	(1)	(2)	(3)
Foreign	-0.003	-0.007	-0.006
	(0.012)	(0.014)	(0.014)
Firm controls		yes	yes
Local trends			yes
Global trends			yes
R^2	0.000	0.024	0.028
N	3,953	3,953	3,953

Notes: *, **, *** significant at 10, 5, and 1 percent. Std errors are clustered at 4-digit NACE industries. All regressions include a constant term. Global industry controls include capital intensity and TFP growth rates of the 4-digit NACE industries in the US between 1996-00. Local industry controls are capital intensity and RTFP average growth rates at 4-digit level in Hungary in the early 90s. Firm-level controls are age, employment and RTFP in the initial year (1996). Source: APEH.

Appendix C Model: Additional Derivations and Extensions

C.1. Additional Derivations

(i) *Firms' Markups and Profits.* In the model firms make two types of decision. First, at the beginning of the period, they decide their optimal innovation efforts. Next, after learning the result of the innovation process, they decide whether to produce. I solve firms' optimal innovation efforts by backward induction. This is, I first compute firms' profits at the end of the period and, then, their optimal innovation intensities.

Given the optimal demand for sector j: $y_{(j)} = \frac{Y}{p_{(j)}}$, the active firm's profit at the end of the period is $\Pi_{(j)} = (p_{(j)} - MC_{(j)})\, y_{(j)} = (1 - \xi_{(j)}^{-1})Y$, where $MC_{(j)}$ is the firm's marginal costs and $\xi_{(j)}$ its markup. I turn next to show how foreign and domestic firms' markups and profits are determined in equilibrium.

$\rightarrow$ *Foreign firms.* If the foreign firm succeeds in improving the existing technology and is the industry leader in equilibrium, its markup will be:

$$\xi_{(F,j)}^{post} \equiv \frac{p_{(j)}}{MC_{(F,j)}^{post}} = \frac{MC_{(H,j)^{pre}}}{MC_{(F,j)}^{post}} = \left(\frac{R}{R^*}\right)^{\alpha} \frac{q_{(F,j)}^{post}}{q_{(H,j)}^{pre}} = \tau\, \lambda^{\Delta_{(j)}+1}. \tag{22}$$

where $MC_{(F,j)}^{post}$ is foreign firm's marginal cost if the innovation succeeds, and $MC_{(H,j)}^{pre}$ is the home firm marginal costs in absence of innovation.[45] Recall that under Bertrand competition, the leader firm sets its price equal to the marginal cost of the closer industry competitor. In this case, the foreign firm sets its price equal to the marginal cost of the home firm in that industry. Notice that, after minimizing production costs, firms' marginal costs are given by: $MC_{(F,j)}^{post} = \frac{(\frac{R^*}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}}{q_{(F,j)}^{post}}$ and $MC_{(H,j)}^{pre} = \frac{(\frac{R}{\alpha})^{\alpha}(\frac{w}{1-\alpha})^{1-\alpha}}{q_{(H,j)}^{pre}}$.

If the foreign firm does not succeed in improving the existing technology and keeps its initial productivity level, its markup will be:

$$\xi_{(F,j)}^{pre} \equiv \frac{p_{(j)}}{MC_{(F,j)}^{pre}} = \frac{MC_{(H,j)^{pre}}}{MC_{(F,j)}^{pre}} = \left(\frac{R}{R^*}\right)^{\alpha} \frac{q_{(F,j)}^{pre}}{q_{(H,j)}^{pre}} = \tau\, \lambda^{\Delta_{(j)}}. \tag{23}$$

Given equations (22) and (23), foreign firm's post- and pre-innovation profits are:

$$\Pi_{(F,j)}^{post} = (1 - \frac{1}{\tau\, \lambda^{\Delta_{(j)}+1}})Y \quad \text{and} \quad \Pi_{(F,j)}^{pre} = (1 - \frac{1}{\tau\, \lambda^{\Delta_{(j)}}})Y. \tag{24}$$

Equations (22)-(24) show that if foreign firms are active in equilibrium their markups and profits are augmented by τ, namely the preferential access to capital markets. As discussed above, the

[45] As in the standard model, I assume that the probability of two firms innovating at the same time is negligible. Since these are two independent events, their joint probability is of second order and thus close to zero.

reason is that the higher borrowing costs that home firms pay increase their marginal costs, which allow foreign firms to set higher prices. As foreign firms set higher prices, they obtain greater markups and profits than what they would in a symmetric economy with perfect capital markets where both firms pay the same price for their capital.

→ *Home firms.* If the home firm succeeds in improving the existing technology and becomes the industry leader, its markup will be:

$$\xi^{post}_{(H,j)} \equiv \frac{p_{(j)}}{MC^{post}_{(H,j)}} = \frac{MC_{(F,j)^{pre}}}{MC^{post}_{(H,j)}} = \left(\frac{R^*}{R}\right)^{\alpha} \frac{q^{post}_{(H,j)}}{q^{pre}_{(F,j)}} = \frac{\lambda}{\tau}. \tag{25}$$

Otherwise, it will still have higher marginal costs than an F firm and remain out of the market. Home firm post-innovation profits will be:

$$\Pi^{post}_{(H,j)} = (1 - \frac{\tau}{\lambda})Y. \tag{26}$$

Differently from foreign firms, equations (25) and (26) show that the home firm's markup and profit are reduced by asymmetric access to international capital markets. The reason for this is that even if the home firm manages to obtain the frontier technology and the lowest marginal cost, it still faces higher borrowing costs than in the case where both firms had symmetric access to capital markets. Then, their markups and profits would also be lower than with perfect capital markets. Notice that in equations (22)-(26) the technology gap between foreign and home firms in each industry is the only industry-specific payoff-relevant variable, to simplify notation I drop the dependence on industry j and denote each industry as a function of the productivity gap.

(ii) *Firms' Innovation Efforts.* At the beginning of the period, firms choose their optimal innovation efforts, $x_{(F,\Delta)}$ and $x_{(H,\Delta)}$, so as to maximize their expected profits net of the innovation costs. Given the research technology, foreign and home firms maximization programs are:

$$\text{Max}_{x_{(F,\Delta)}}\, x_{(F,\Delta)}\, \Pi^{post}_{(F,\Delta)} + (1 - x_{(F,\Delta)} - x_{(H,\Delta)})\, \Pi^{pre}_{(F,\Delta)} - w\, \Gamma(x_{(F,\Delta)}, \Delta_{(\Delta)}) \tag{27}$$

$$\text{and} \qquad \text{Max}_{x_{(H,\Delta)}}\, x_{(H,\Delta)}\, \Pi^{post}_{(H,\Delta)} - w\, \Gamma(x_{(H,\Delta)}).$$

where w represent the wage. Firms' optimal innovation efforts become:

$$x^o_{(F)} = \frac{1}{\tau}\, \frac{\phi(1 - \lambda^{-1})}{w} Y \qquad \text{and} \qquad x^o_{(H)} = \frac{\phi(1 - \tau\, \lambda^{-1})}{w} Y.$$

As discussed above both firms' optimal innovation intensities are reduced by the asymmetric access to international capital markets. Furthermore, notice that firms' innovation intensities are constant across industries and they only differ with firms' borrowing costs (τ), i.e. if firms enjoyed similar access to capital markets, their innovation efforts would be equal.

(iii) *Aggregate Productivity Growth.* As each innovation raises productivity by a factor of λ and home and foreign firms innovate at rates $x^o_{(H)}$ and $x^o_{(F)}$, aggregate productivity growth is given by,

$$g_q = \ln(\lambda)\ (x^o_{(F)}\ +\ x^o_{(H)}) \tag{28}$$

Note that aggregate productivity at the beginning of the period is $\ln Q^{initial} = \int_0^1 \ln(q_{(j)})dj$. The increase in aggregate productivity during the period, $(x^o_{(H)} + x^o_{(F)})\ \ln(\lambda)$, is determined by the rate of both home and foreign firms advancing in the technological frontier. Therefore, aggregate productivity at the end of the period becomes $\ln Q^{end} = (x^o_{(H)} + x^o_{(F)})\ \ln(\lambda) + \ln Q^{initial}$. The difference between productivity at the end and at the beginning of the period gives equation (28).

C.2. Credit Constraints for Innovation Activities

In the paper, I have considered that domestic and foreign firms did not face credit constraints for innovation activities. In this appendix, I study this possibility and show that credit constraints for innovation reinforce the mechanism proposed in this paper. In presence of financial constraints, distortions in the access to capital markets affect firms' innovation incentives more.

One way to study how credit constraints affect innovation activities is by considering that firms have to pay their inputs in advance. To pay them, firms raise external funds. In this framework, firms' expected profits net of innovation costs become:

$$\text{Max}_{x_{(F,j)}}\ x_{(F,j)}\,\Pi^{post}_{(F,j)} + (1 - x_{(F,j)} - x_{(H,j)})\,\Pi^{pre}_{(F,j)} - (1+r^*)w\,\Gamma(x_{(F,j)}, \Delta_{(j)}) \tag{29}$$

$$\text{and} \qquad \text{Max}_{x_{(H,j)}}\ x_{(H,j)}\,\Pi^{post}_{(H,j)} - (1+r)w\,\Gamma(x_{(H,j)}). \tag{30}$$

As in the paper, firms choose their optimal innovation efforts so as to maximize their expected profits net of innovation costs, i.e. (29) and (30). They optimal innovations efforts become:

$$x^o_{(F)} = \frac{1}{\tau}\,\frac{\phi(1-\lambda^{-1})}{(1+r^*)\,w}Y \qquad x^o_{(H)} = \frac{\phi(1-\tau\,\lambda^{-1})}{(1+r)\,w}Y. \tag{31}$$

Credit constraint for innovation activities affect firms' incentives to invest in technology through two channels. First, similar to the mechanism presented in the paper, both foreign and home firms' innovation efforts are reduced by τ the distortion in the access to international capital markets. Note, however, that τ is higher than in the paper: $\tau \equiv 1+\tilde{\tau}$. The reason for this is that, in the paper, the distortion in the access to external finance solely concerned capital expenditures and, thereby,

τ was adjusted by α (i.e. $\tau \equiv (1+\tilde{\tau})^{\alpha}$). As now firms have to pay both inputs for production activities in advance, the distortion in capital markets affects both of them. Notice that the impact of the distortion is greater and affects firms' profits and innovation efforts relatively more. Second, differences in the interest rates also affect firms' innovation activities directly. As equations (31) show, both firms' innovation efforts are discounted by the interest rates. Importantly, the higher interest rate paid by domestic firms reduces their innovation intensities relatively more.

In this way, the difference in the access to capital markets affects firms' optimal innovation efforts through two channels. First, it increases firms' innovation costs heterogeneously, which directly affects their innovation efforts. Second, as shown in the paper, it distorts firms' end-of-the-period profits, which indirectly affects their innovation incentives. Importantly, this distortion affects home firms' innovation efforts relatively more. Note finally that while the reduction in the distortion, fosters domestic firms' innovation efforts through these two channels, foreign firms' innovation efforts only rises through the second channel. As such, financial openness encourages domestic firms' innovation activities more.

C.3. Firms' Innovation Costs

In the model, I have assumed that larger firms enjoyed lower innovation costs. In particular, I have let innovations of foreign firms be easier when their technological advantage was greater. In this section, I remove this assumption and show that all the model's predictions remain true when home and foreign firms have equal innovation costs. Let firms' innovation costs be determined by:

$$\Gamma(x_{(F,j)}) = \frac{1}{\phi}\frac{x_{(F,j)}^2}{2} \quad \text{and} \quad \Gamma(x_{(H,j)}) = \frac{1}{\phi}\frac{x_{(H,j)}^2}{2}.$$

After choosing their innovation efforts so as to maximize their profits net of the innovation costs (equations (27)), home and foreign firms' optimal innovation intensities are:

$$x_{(F,\Delta)}^{o} = \frac{\phi}{\tau\lambda^{\Delta}}(1-\lambda^{-1})\frac{Y}{w} \qquad \text{and} \qquad x_{(H)}^{o} = \frac{\phi(1-\tau\,\lambda^{-1})}{w}Y, \tag{32}$$

where foreign firms' innovation efforts depend now on the technology gap with the local competitors. Notice that the greater the initial technology gap between foreign and domestic firms, the lower are foreign firms' innovation efforts.

Proposition 1: Firms' innovation intensities*. By reducing the distortion in the access to capital markets (decreases in τ), financial openness increases economy-wide innovation intensities. Notably, innovation intensities increase relatively more for home firms.*

From equations (32), it is straightforward to see that $\frac{\partial x^o_{(F,\Delta)}}{\partial \tau} < 0$ and $\frac{\partial x^o_{(H)}}{\partial \tau} < 0$. In addition, $|\frac{\partial x^o_{(F,\Delta)}}{\partial \tau}| < |\frac{\partial x^o_{(H)}}{\partial \tau}|$. Notice as well that the far ahead the foreign firm is regarding its local competitor, the lower is its increase in the innovation efforts.

Proposition 2: Foreign firms' markups*. A decrease in τ reduces foreign firms' markups.*

The proof is similar as in the main text. Under the law of large number, a continuum of industries ensures that the foreign firm's markup will be equal to its expected value. More precisely,

$$\xi^e_{(F,\Delta)} = \tau\, \lambda^{\Delta+1} x_{(F,\Delta)} + \tau\, \lambda^{\Delta}(1 - x_{(F,\Delta)} + x_{(H)}),$$

and $\frac{\partial \xi^e_{(F,\Delta)}}{\partial \tau} > 0$.

Proposition 3: Change in the productivity gap between home and foreign firms*. Reductions in τ lead to decreases in the productivity gap between home and foreign firms. In particular, this reduction is greater in sectors where foreign firms were technologically far ahead of their local competitors.*

From proposition 1, as home firms invest more in technology, the technology gap with their foreign competitors drops, i.e. $\frac{\partial \Delta^e}{\partial \tau} > 0$. Furthermore, this fall is larger, the greater the initial gap with their foreign rivals $\frac{\partial \Delta^e}{\partial \tau \partial \Delta} > 0$.

Proposition 4: Aggregate productivity growth. *Declines in τ increase aggregate productivity growth.*
Aggregate productivity growth is given by:

$$g_q = \ln(\lambda) \sum_{i=1}^{\infty} \mu_{(i)}(x_{(H)} + x_{(F,\Delta)}) = \ln(\lambda)(\mu_{(1)} x_{(H)} + \sum_{i=1}^{\infty} \mu_{(i)}\, x_{(F,\Delta)}).$$

As now foreign firms' innovation efforts depend on the initial technology gap with their local competitors (equations (32)), aggregate productivity growth depends on the distribution of technology gaps in the economy, i.e. $\sum_{i=1}^{\infty} \mu_{(i)}$. It can be shown that $\frac{\partial g_q}{\partial \tau} < 0$, i.e. the decrease in the distortion in the access to international capital markets raises aggregate productivity growth. What is new here is that the increase in aggregate productivity growth stems from 2 sources. First, similar as before, as both home and foreign firms invest more in technology (proposition 1), productivity increases. Second, the decrease in the dispersion of the distribution of productivity gap raises aggregate productivity growth. To be more precise, as home firms undertake greater innovation

efforts than their foreign competitors, the amount of sectors where foreign firms were far ahead local firm decreases; i.e. μ_1 increases. Since the innovation efforts of foreign firms in technologically dispersed sectors were lower (equations (32)), the lower scale of those sectors in the economy raises aggregate productivity growth. This can be directly seen from the distribution of productivity gaps:

$$\dot{\mu} = \begin{cases} -\mu_{(1)} x_{(F,1)} + x_{(H)}(1 - \mu_{(1)}) & \Delta = 1, \\ (x_{(F,\Delta)} + x_{(H)})\mu_{(\Delta)} + x_{(F,\Delta)}\mu_{(\Delta-1)} & \Delta \geq 2 \end{cases}$$

For the distribution to be stationary, $\dot{\mu} = 0$ and therefore $\mu_{(1)} = \frac{x_{(H)}}{x_{(F,1)}+x_{(H)}}$. As $\frac{\partial \mu_{(1)}}{\partial \tau} < 0$, a decrease in the distortion in the access to capital markets raises the fraction of $\mu_{(1)}$ sectors, and decreases the fraction of sectors where foreign firms were far ahead of their local competitors.